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GLOSSARY OF ABBREVIATIONS

AAS	Atomic Absorption Spectrophotometer
AAKK	Ajaokuta-Abuja-Kaduna-Kano
AEPB	Abuja Environmental Protection Board
AGI	Above Ground Installation
AIES	Atlas International Engineering Services Nigeria Limited
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
APHA	American Public Health Association
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
BMP	Best Management Practice
BOD_5	Biochemical Oxygen Demand
Ca	Calcium
CASHES	Community Affairs, Safety Health Environment and Security
CE	Civil Engineer
CEC	Cation Exchangeable Capacity
CEMS	Continous Emission Monitoring System
cfu/g	Colony forming units per gramme
Cl^-	Chloride ion
CL	Inorganic Clays of Low to Medium Plasticity
CITES	Convention on International Trade in Endangered Species (Fauna and Flora)
cm	Centimeter
CO	Carbon Monoxide
CO_2	Carbon dioxide
CO_X	Oxides of carbon
COD	Chemical Oxygen Demand
Cond.	Conductivity
Cr	Chromium
Cu	Copper
dB (A)	decibel (Scale)
DCS	Distributed Digital Control System
DI&M	Directed Inspection and Maintenance
DPR	Department of Petroleum Resources
EA	Environmental Assessment
EPL	Envirochem Patnas Limited
EIA	Environmental Impact Assessment
EAu	Environmental Audit
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EMS	Environmental Management System

EPC	Engineering Procurement and Construction
ESI	Environmental Sensitivity Index
Fe	Iron
FGN	Federal Government of Nigeria
F&G	Flare and Gas
FLT	Federal Lighter Terminal
FEPA	Federal Environmental Protection Agency
FMENV	Federal Ministry of Environment
Ft	Feet
GC	Gas chromatography
GE	General Engineering
g	gramme
GLC	Gas Liquid Chromatography
GHG	Green house gases
GPS	Global Positioning System
Ha	Hectare
HC	Hydrocarbon
HDD	Horizontal Directional Drilling
HNO_3	Nitric acid
HP	High Pressure
H.R.H	His Royal Highness
HRSGs	Heat Recovery Steam Generator
HSE	Health Safety and Environment
h	hour
HUM	Hydrocarbon utilizing microorganisms
Hz	Hertz
IEE	Initial Environmental Evaluation
IP	Intermediate Pressure
ISAS	Instrument and Service Air Systems
ISO	International Standard Organization
ITCZ	Inter Tropical Convergence Zone
ITD	Inter Tropical Discontinuity
IUCN	International Union for Conservation of Nature (now the World Conservation Union)
KCl	Potassium Chloride
KOH	Potassium hydroxide
K	Potassium
KW/h	Kilowatt per hour
KW	Kilowatt
KVA	Kilovolts Ampere
LBVS	Line Break Valve Stations
LCD	Liquid Crystal Display
LFN	Low Frequency Noise
LPG	Liquid Propane Gas

LGA	Local Government Area
LGC	Local Government Council
LP	Low Pressure
LUA	Land use Act
m	meter
Mg	Mega gram 10^6 gram
ms^{-1}	meters per seconds
mg	milligram or 10^{-3} gram
Mg	Magnesium
mg/kg	milligram per kilogram
mg/l	milligram per litre
ml	millilitre
mm	millimeter
mmscfd	million standard cubic feet per day
m/s	Meter per second
Mpa	Megapascal
MW	Megawatts
MVA	Megavolts Ampere
MAVR	Modular Automatic Voltage Regulator
NA	Not Applicable
Na	Sodium
NCF	Nigerian Conservation Foundation
ND	Not detected
NES	Nigerian Environmental Society
NG	Natural Gas
Ni	Nickel
NIGP	National Integrated Gas Project
NNPC	Nigerian National Petroleum Corporation
NOSCP	Nigerian Oil Spill Contingency Plan
NO^-_3	Nitrate ion
NOx	Oxides of Nitrogen
NS	Not Specified
OJT	On the Job Training
OL	Organic clay of low to medium plasticity
O&M	Operation and Maintenance
Pb	Lead
PDB	Petroleum Degrading Bacteria
PHCN	Power Holding Company of Nigeria
PO^{3-}_4	Phosphate ion
POSCO E&C	Pohang Steel Company Engineering & Construction
ppm	part per million
PPMC	Petroleum Product Marketing Company
pH	Hydrogen ion concentration
p.s.i	Pounds Per Square Inch Gram

PTS	Permit to survey
QA/QC	Quality Assurance/Quality Control
RH	Relative humidity
ROW	Right of Way
QA/QC	Quality Assurance/Quality Control
RH	Relative humidity
RO	Reverse Osmosis
RoW	Right of Way
SC	Clayey sand
SCADA	Supervisory Control and Data Acquisition
SDV	Slow Down Valve
SM	Silty sand
SO_2	Sulphur dioxide
SO^{2-}_4	Sulphate ion
SOx	Oxides of Sulphur
SP	Poorly graded sand
Sq.km	Square Kilometer
SPM	Suspended Particulate Matter
SS	Suspended Solids
T	Tonne
TCF	Trillion Cubic Feet
TDS	Total Dissolve Solids
TGS	Terminal Gas Station
TSP	Total Suspended Particulates
TD	Total depth
TC	Tropical Continental
TM	Tropical Maritime
T/h	Tonne per hour
TSP	Total Suspended Particulates
T.Alk.	Total Alkalinity
TH	Total Hardness
THC	Total Hydrocarbon Content
TOC	Total Organic Carbon
TOR	Terms of Reference
µS/cm	micro Siemens per centimeter
µohmS/cm	micro ohms per centimeter
USCS	Unified Soil Classification System
UNFCCC	United Nations Framework Convention on Climate Change

Prefix Symbols and Multiples

G	giga = x 10^{9}
M	mega = x 10^{6}
k	kilo = x 10^{3}
h	hecto = x 10^{2}
da	deca = x 10
d	deci = x 10^{-1}
c	centi = x 10^{-2}
m	milli = x 10^{-3}
µ	micro = x 10^{-6}
n	nano = x 10^{-9}

Units

A	Ampere (electrical current)
bar	bar = 105 Pa (pressure)
cal	calorie (energy)
°C	degree Centigrade (temperature)
dB	decibel (sound pressure)
g	gramme
h	hour (time)
Hz	Hertz (frequency)
K	degree Kelvin (temperature)
kg	kilogram (mass)
J	Joule (energy)
l	litre
m	metre (length)
ppm	parts per million
ppb	parts per billion
Pa	Pascal (pressure)
s	second (time)
t	tonne = 103 kg (mass)
V	Volt (electrical potential)
W	Watt (power)
Wh	Watt hour (energy)

PROJECT/STUDY TEAM

The EIA study and report preparation were carried out by a multidisplinary team of consultants from **Atlas International Engineering Services.** The principal consultants that undertook the study are listed below:

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EXECUTIVE SUMMARY

PROJECT BACKGROUND

Natural gas is known to be associated gas produced from underground accumulations, the composition of which varies from field to field. Most natural gas consists largely of methane (CH_4) and other light hydrocarbons. Natural gas has been commercially used as fuel for 180 years in America and for centuries in China. The production, processing and distribution of natural gas have become an important segment of many countries' economy and a major factor in the world markets.

Nigeria has an estimated 176 trillion cubic feet (tcf) of proven natural gas reserves, making the country one of the top ten natural gas endowments in the world and the largest in Africa. Abundant gas reserves exceed foreseeable needs of the domestic, regional and export markets.

Due to limited gas distribution infrastructure, Nigeria today flares about 2.6 bcf/d of gas, representing 12.5% of all globally flared gas and the balance of the current production is utilized for power generation, export projects and other domestic uses.

The impediments to natural gas development in Nigeria include among others; inadequate gas gathering and supply infrastructure, inappropriate/ unrealistic pricing of gas, especially for domestic use, low level of industrialization and inadequate consumptive capacities

There is no national gas distribution system, but gas pipelines do link Lagos with Benin City, Ajaokuta, Escravos and fields in the Warri River region. Pipelines link Aba with the fields in the Port Harcourt region and Bonny Island. Links also exist between the Ngo/Ima and Oso offshore gas fields and Bonny Island and the Qua Ibo terminal.

Nigeria major pipeline system includes: Escravos-Lagos trunk pipeline (LP) for supplies to the western parts of the country and to Oban-Ajaokuta pipeline, which is the back bone for supplies to the North and Alakiri -Obigbo-Ikot Abasi for the Eastern trunk.

The Federal Government of Nigeria in 2008 approved new gas pricing and domestic supply obligation regulations that include short-term, medium-term and long term gas supply targets.

A combination of new government incentives and pressure from the environment ministry to end flaring, coupled with rising domestic industrial demand for gas have now encouraged operators to go into gas projects.

The Ajaokuta-Abuja-Kaduna-Kano Gas Pipeline (Phase I) Project is the Phase 1 of the Trans-Nigeria Gas Pipeline Project that is driven by availability of additional gas supplies from Assa Gas Plant and the need of gas supply to the Northern / Eastern States through Obigbo-Umuahia-Ajaokuta pipeline and Ajaokuta-Kaduna-Kano pipeline.

This project is taking place against the backdrop of the new gas pricing and domestic supply context in Nigeria.

The feed gas into the pipeline system is expected to be 3,500 mmscfd of dehydrated wet gas sourced from various gas gathering projects in the southern region.

Hydrocarbon liquids from this process shall in part be further processed at Ajaokuta to produce liquefied petroleum gas (LPG) while the remaining shall be transported via pipeline parallel to the dry gas to serve as feed stock for planned new petrochemical facilities at Abuja, Kaduna, Kano and Katsina.

The project development will involve the following:

- Surveying and clearing the right –of –way (ROW)
- Hauling and Stringing of Pipe(s)
- Bedding of Pipe(s)
- Welding
- Digging of trench
- Lowering of pipe and backfilling
- Installation of valves and special fitting and joint coating
- Pipeline crossings on rivers, road, streams and other pipelines
- Testing –Non destructive testing (NDT)

Surveying and right-of-way preparation will lead to vegetation clearing, loss of biodiversity, and loss of farmlands, crops, habitat and migration of wildlife.

Removal of vegetation will further expose the soil to excessive weather conditions and soil erosion. Measures to ameliorate the ecological impact includes use of existing routes for survey , use of existing ROW during construction and avoidance of excessive land take and bush clearing.

NNPC will enforce no- hunting ban during bush cleaning restriction of clearing within the ROW habitats

THE PROJECT PROPONENT

The Nigerian National Petroleum Corporation intends to construct and operate a 740km Ajaokuta-Abuja-Kaduna-Kano 48’’ dual Natural Gas Pipeline Project. The proposed pipeline shall be supplied with pipeline quality gas at a minimum pressure of 1,000 psig at the Ajaokuta tie-in and delivered to Kano also at a minimum pressure of 1,000 psig.

The Pipeline routing shall follow the major existing ROW of PPMC crude oil/product Pipeline to Kaduna and some part as new solo route. The pipeline shall traverse Kogi State, Abuja, Niger State, Kaduna State and Kano State. The pipeline shall cross 7 major rivers and 10 major roads.

NNPC intends to bring this key strategic project, which will secure and guarantee sufficient high-quality Natural Gas-Based energy supplies and also strengthen the Nigerian gas supply system by creating new point of supply for gas in northern Nigeria.

Project Process and Description

The gas transmissions pipelines shall comprise of dual pipes, each with a diameter of 48’’ and length of 740km along the route. The pipeline shall have three spur lines from the Abuja Node to the Abuja TGS, a distance of approximately 13.6km, from Kaduna node to Kaduna TGS approximately 200m and from Kano node to Kano TGS approximately 8.14km; respectively.

The Abuja and Kaduna spurs shall be sized for 500 mmscfd each leaving up to 2,250 mmscfd available at Kano for local distribution and export to the future trans-Saharan pipeline.The project shall be constructed and operated by Nigerian National Petroleum Corporation (NNPC).

The pipeline diameter will be as follows;

- From Ajaokuta Tie-In Station to Kano TGS 2 x 48” pipelines.
- From Abuja Node to Abuja TGS 2 x 20” pipelines.
- From Kaduna Node to Kaduna TGS 2 x 20” pipelines

The pipe shall be supported by three booster compressor stations, each station comprising of two turbo compressor trains in operation with one spare train. Each operating train shall normally pump the contents of one of the dual pipelines. The spare train shall be provided to be lined up to either pipeline in the event of a problem occurring with one of the normally operating trains.

The compressor power requirement shall be within the range of standard heavy duty Frame 5 gas turbines. The Booster Compressor Stations shall be of similar design and feature the following process components:

- Incoming pipeline tie-ins
- Slug Catchers
- Pig Receivers
- Turbo compressors Package
- Pig Launchers
- Outgoing pipeline tie-ins

- Node receivers/pig launchers
- Utilities - Fuel Gas, Service Water, Fire Water, Drains, Emergency Flare System

The optimum locations of the Booster Compressor stations shall be at 60km, 147 km and 440 km from Ajaokuta

Laying procedure

The pipes will be offloaded along ROW using wood sleepers with rubber pads or bags filled with sawdust, soft earth or sand is used as ridges to hold the line pipes on the ground. The line pipes are strung in such a way that there is access for personnel & equipment using side booms and excavators. The strung line pipes are then inspected to ensure that they align properly according to specification and then closed with end-caps. All pipe laying operations shall be in accordance with ASME B31.8, and DPR P-1P "Guidelines and Procedures for the Design, Construction, Operation and Maintenance of Oil and Gas Pipeline Systems in Nigeria - 2007".

The depth of which the pipeline would be laid is 1.5m for dry and swampy terrain, 1.5m for rocky terrain and 2m for railway and road crossings

To reduce the overall impact on the environment, all pipeline road/railway and river crossings will be by thrust boring and Horizontal Directional Drilling (HDD) method respectively.

The HDD method involves drilling a pilot hole under the water body and banks and then enlarging the hole through successive reaming until the hole is large enough to accommodate a prefabricated segment of pipe. Throughout the process of drilling and enlarging the hole, a drilling mud shall be circulated through the drilling tools to lubricate the drill bit, remove drill cuttings, and keep the hole open.

While this drilling is in progress, the line pipe sections shall be strung out on the far side of the crossing for welding. Once welded, the joints are X-rayed, coated, hydrostatically tested, and then placed on rollers or padded skids in preparation for being pulled through the drilled-out hole.

Segmentation and testing

Upon completion of the pipe-laying, the pipeline will be tested in segments. Test lengths shall not be less than l000 meters or as long as practicable and locations of test points will be set out in the Test Plan. The test plan will also take account of the location of suitable water supplies and disposal facilities and allowable elevation difference.

The procedure will involve isolating the pipe segment with valves/ test manifolds, filling the line with water, applying pressure to 125% of the maximum allowable operating pressure (MAOP) for that pipeline and then maintaining that pressure for a period of 8 hours. The pipeline was designed with the maximum allowable operating pressure of 1000 psig and class location. Each valve will be checked for fluid bye-pass by visual, audible or remote means.

The water used in hydrostatic testing shall be drawn from the local river, stream within the pipeline ROW or may be taken from municipal supplies and trucked to the site. The source to be used however depends on the location of the pipeline. Water for hydrostatic testing shall be obtained from surface water sources through specific agreements with communities and in accordance with Federal, State, and Local regulations.

If leaks are found, the leaks will be repaired and the section of pipe retested until specifications are met. Once a test section successfully passes the hydrostatic test, the water will be tested prior to discharge to the environment. Discharge shall be to a designated point in accordance with the test plan to be provided and will be controlled to ensure that all parameters meet the applicable discharge limit of DPR and FMENV respectively.

The total volume of water required for hydro-testing of the entire length of 740km is estimated at 63,055.4m^3 if there is no failures, based on the standard 852.1m^3/km.

Treatment of the internal profile and external part of the pipe

The inner profile is treated by a process called pigging while the outer part of the pipe is factory coated with polyvinyl chloride (PVC) and so no further treatment will be required. No chemical would be used during the construction and commissioning of the pipe except fusion-bond epoxy (RISERCLAD®, USA) which will be used in coatings for field joints. Prior to application, the coating crew shall thoroughly clean the bare pipe with a power wire brush or a sandblast machine to remove any dirt, mill scale, or debris

The project will be operated with emphasis on operational safety efficiency and flexibility with a view to providing industrial standard, remote supervision and control.

It is proposed that this project shall play a significant role in addressing current shortfalls in Nigeria’s electricity requirements and natural gas utilization.

The project development has been scheduled from conceptualization to completion and commissioning. The project life span is 25years.

This report presents the Environmental Impact Assessment (EIA) of Ajaokuta-Abuja-Kano Gas Pipeline System. The project requires an Environmental Clearance from Federal Ministry of Environment Housing and Urban Development in line with EIA Act No. 86 of 1992 of Federal Government of Nigeria and DPR approval.

NNPC employed the services of AIES to carry out the Environmental Impact Assessment (EIA) study and preparation of Environmental Management Plan (EMP) for the project

The EIA is to understand the impact of the proposed project on various facet of the project environment and proffer appropriate mitigation measures.

The EIA of the gas pipeline system has been conducted in line with the Environmental Impact Assessment Sectoral Guidelines for Oil and Gas Industry projects of the Federal Ministry of Environment, Environmental Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN) Revised Edition 2002 of the Department of Petroleum Resources (DPR).

TERMS OF REFERENCE FOR EIA OF AJAOKUTA-ABUJA-KADUNA KANO GAS PIPELINE (PHASE I) PROJECT

The Terms of Reference (TOR) of the EIA for the Ajaokuta-Abuja-Kano gas pipeline system was defined at the initial stages of the EIA process. The TOR includes:

- The general scope of the EIA study and the legal and administrative framework for the Environmental Impact Assessment.
- Project aspects that may have significant environmental impact.
- Framework for incorporation of the project team views with that of the Regulators, host communities and indeed all stakeholders.
- Establish the protocols for identification and assessment of associated and potential impacts their mitigation measures.
- Environmental Management Plan (EMP) for the project.

EIA OBJECTIVES

The objectives of the EIA are as follows:

- Establish the existing biological, physical, and socio-economic conditions of the project area.
- Characterize the environment thereby identifying the resultant hazards (including social) associated with Oil and Gas pipeline project construction and operation.
- Assess proactively the potential impact and associated impact (including health and socio-economic impacts) of the proposed construction project on the project area.
- Make recommendations to eliminate/mitigate/control the magnitude and significance of the hazards and effects.

- Recommend control techniques to eliminate/minimize the severity of the effects and to manage it.
- Recommend plans and procedures to manage the consequences.
- Ensure proper consultation with the communities bordering the proposed construction site in line with FMENV and DPR guideline

EIA METHODOLOGY

The EIA study involved a combination of multidisciplinary standard methods spanning the field of engineering, Natural sciences, and social sciences**.** The assessment methodologies adopted in this EIA study are in accordance with the FMENV, DPR, affected States and other international guidelines.

NEED FOR THE PROJECT

Domestic consumption and export of gas are relatively small compared to the scale of gas resource base. As a result, about 2BCF is flared daily, which represent over 60% of the daily gas production. This accounts for over 20% of the total daily flaring of gas globally, while the nation loses US $2billion dollars as a result of these flares.

Nigeria is a mono – cultural economy dependent on the export of crude petroleum for over 90% of its export earnings. The country’s aspiration is to raise crude oil reserves to 40billion barrels by 2010, in order to buoy her economic growth.

PROJECT BENEFIT

The project will expand the gas supply system in the North to meet the growing gas and energy demands in the region. The Project will open up new areas of opportunities in the project area thereby reducing gas flaring (by improving environmental and safety standards).

The project will open-up opportunities for construction of power plants in the north and generally improve the power situation of the country. It is also expected to encourage the use of gas by existing cement, fertilizer and steel factories in the project area and stimulate the construction of new ones.

PROJECT COMPONENTS

The project primary components are; pipeline system and valves, tie-In / Scraper Launcher Station, Intermediate Scraper Receiver / Launcher Stations in Abuja and Kaduna with check valves, pig launchers and receivers and Terminal Gas Stations in Abuja, Kaduna and Kano respectively

PROJECT SUSTAINABILITY

The sustainability of the project was reviewed under the technical, environmental and financial sustainability. The proposed project is envisaged to be economically sustainable in view of the fact that natural gas that was traditionally flared at oil extraction sites for years has increasingly been recognized as an enormous income-generating resource for Nigeria and now being captured for processing and sale both locally and internationally.

Economically, the project is sustainable because after successful completion, not many financial ventures are needed to sustain gas transmission. The Federal Government has approved new gas pricing and domestic supply obligation regulations. These regulations will ensure financial sustainability of the project as gas will be sold to customers: power plants, fertilizer industries, and domestic use etc and profit accrued from the sales of the natural resources to maintain and operate the project.

PROJECT DEVELOPMENT OPTIONS

Three (3) major development options were considered for Proposed Ajaokuta-Abuja-Kaduna-Kano Gas Pipeline (Phase I) Project namely:

The Implement Project Option is the proposed option for NNPC to carry-out the construction and operations of the pipeline project. This option will guarantee speedy economic development, increase revenue generation and eliminate gas flaring among other benefits.

The Delay Project Option sanctions the postponement of the project to a future date. This is the option of choice in time of severe economic or political crises, war or resentment to project by host communities or present unsustainably of the project.

There is conducive economic and political atmosphere for the project in Nigeria at the moment. Thus delaying it will delay all benefits associated with the project implementation.

The No Project Option disallows the construction of the pipeline. This scenario will hinder the realization of the FGN dream of improved power supply, affect the expected revenue generation from sale of gas and negatively impact on the expected economic growth of the gas sector in Nigeria and further put to hold the commencement of the independent power plant project. This option was not chosen in view of the above disadvantages

PIPELINE ROUTE SELECTION

The final route of the Proposed Pipeline has been determined and; it will follow majorly the existing PPMC pipeline route. New route will be taken where settlements and development have encroached the existing route. The route selection was carried out in two phases by a multi disciplinary team.

The phase I identified potential pipeline routing corridor options. Several alternatives were identified and subjected to coarse evaluation to determine which of them had serious technical, financial or socio-economic constraints likely to compromise their desirability. Two major options – Alternative 1 passing through towns while avoiding difficult terrain and Alternative 2, avoiding major towns and passing through existing ROW were chosen for the further analysis.

The Phase II process further evaluated the 2 selected routes using fine screening methodology after which Alternative 2 above was chosen as the preferred option.

LEGAL AND ADMINISTRATIVE FRAMEWORK

The EIA study was carried out within the framework of the local and international guidelines, conventions, laws and bye-laws. The legal and administrative framework within which the EIA was carried out includes the following:

- The Procedural guidelines of the Federal Ministry of Environment (FMENV) concerning Oil and Gas activities in Nigeria.
- The regulations, guidelines and standards of the Department of Petroleum Resources (DPR)
- The regulations, guidelines and standards of the Abuja Environmental Protection Board (AEPB)
- The regulations, guidelines and standards of the Kogi State Environmental Protection Agency and Kogi State Ministry of Environment
- The regulations, guidelines and standards of the Niger State Environmental Protection Agency and Niger State Ministry of Environment
- The regulations, guidelines and standards of the Kaduna Environmental Protection Agency and Kaduna State Ministry of Environment
- The regulations, guidelines and standards of the Kano State Ministry of Environment
- All International Conventions on Environmental Protection to which Nigeria is a party.
- United Nations Framework Convention on Climate Change (UNFCCC) of 1992.
- National Inland Water Ways Authority Act No 13 of 1993.
- EIA Act No 86 of 1992
- Federal and States Forestry Laws.

WASTE MANAGEMENT STRATEGY

Waste management is an integral part of this project and a plan to handle the large volume of waste during construction, operation and decommissioning of the project will be taken into consideration. Waste management for the project shall be carried out in consultation and in line with the waste management guidelines of all the affected States Waste management board and shall be disposed at the affected States approved waste disposal sites.

NNPC and its contractors shall take all reasonable and cost effective measures to minimize the generation of wastes, through process of optimization and efficient procedures and good housekeeping.

The management of waste material generated during construction, operation and decommissioning will be dealt with in accordance to the principles of the waste and resource management hierarchy by employing the four R's (Reduce, Reuse, Recycle, and Recovery). The source, characteristics / nature, estimated quantity, potential impact, management and destination of each waste is described.

The hydrotest water management procedures will aim to maximize the efficiency of testing, taking into consideration the timing of construction and commissioning, and will follow good environmental practice.

Disposal to land will only occur where an assessment of water quality meets relevant criteria and relevant approvals have been obtained.

PROJECT SCHEDULE

The overall developmental schedule for this project is not definite at this stage of the study. The EIA presently forms a part of the defined first stage of the project. However, NNPC estimated that the completion, commissioning and handover time for the project is the 3rd Quarter of 2019

ENVIRONMENTAL SETTING OF THE STUDY AREA

The baseline environmental status was assessed based on primary and secondary data collected either through in-situ field observation or obtained from agencies such as NIMET, and existing baseline report of the area.

Baseline field investigation was carried out for dry season between 14th and 22nd December 2009 and under the supervision of Federal Ministry of Environment. To cover the wet season hydrological regime of the study area, an existing wet season data of the study area from a study carried out by Korean National Oil Company (KNOC, 2008) was used; these were aimed at covering of two hydrological regime of the project area.

The baseline status collated from analysis of secondary and primary data is summarized below:

- **Climate and Meteorology**

The study area receives South west rainfall (1999 -2008) in the range of 0.0mm to 604.7mm with the majority of the rain falling between June and September. On an average, the temperature in the area range from 20.7^oC to 40.5^oC with Kano area showing the highest temperature**.** The relative humidity of the study area ranges from 9% to 89%. Winds are generally moderate ranging from 0.9m/s to 13.8m/s.

- **Air Quality**

Ambient air quality was monitored at selected 58 locations within the study area. SO_2, CO and NO_2 at all location were zero. SPM indicated concentration that is less than 105.71µg/m^3 in the study area. In dry season SPM indicated range of 20.40µg/m^3 to 105.71µg/m^3 and also 1.476µg/m^3 to 28.610µg/m^3 wet season.

- **Noise Level**

The noise level in the study area ranges from 31.5 dB (A) to 76.8dB (A) in dry season and the wet season data (EPL 2008) showed range of 36.2 dB (A) to 70.2 dB (A). The highest range occurs in the settlement areas and near roads

- **Soil Quality**

In dry season the distribution of soil grains in the study area show 25.3% to 79.5 % sand in the surface layer and 21.7% to 79.5% sub layer, Silt of 18.5% to 53.7% in the surface and 17.1% to 56.8% sub and 3.5% to 58.6% surface and 1.9% to 29.8% clay and gravel surface of 0.1% to 13.2% and sub 0.1% to 23.6%.

The wet season data indicate particle size distribution of 32.6 % to 57.6 % sand in the surface layer and 36.1% to 60.2% sub layer, silt of 24.1% to 42.9% in the surface and 16.9% to 44.1% sub and clay 9.8% to 28.2% surface and 0.0% to 30.1% sub layer and gravel 0.0% to 14.0% surface and 0.1% to 24.5% sub layer.

In dry season the percent moisture content for topsoil ranged from 0.7% to 17.5% while that for subsoil ranged from 1.3% to 22.4%.

Wet season percent moisture content (EPL Field Data, 2008) indicates topsoil and subsoil ranging from 10.5% to 29.1% for topsoil and 9.0% to 26.9% for subsoil.

The bulk density and permeability constant of soils of the study area indicate range of 1.334mg/m^3 to 2.369mg/m^3 and 1.07x10^{-6}K(ms^{-1}) to 7.10x10^{-6}K(ms^{-1}) respectively in dry season.

Soil pH range of 6.41 – 7.38 indicating slight acidity to neutral characteristics; surface soil ranged from 6.42 to 7.38 and sub soil 6.41 to 7.36.

In wet season the surface layer range from 6.80 to 7.28 and 6.90 to 7.38 in sub soil while the soil organic matter in dry season varied between 0.05% and 4.62% with the top soil showing 0.09% and 4.62% and sub soil 0.05% and 3.97% in sub soils. In wet season it ranged from 0.19% and 1.48% (0.20% and 1.62% in topsoil and 0.19% to 1.48% in subsoil).

The oil and grease content of soil samples generally indicated zero concentration, but areas were it occurred it varied between 0.0mg/kg and 0.021mg/kg; top soil 0.0mg/kg to 0.021mg/kg and sub soil 0.0mg/kg to 0.016mg/kg. The oil and grease content decrease with soil depth.

The soil nutrients showed low concentration in the study area; nitrate concentration ranged from 0.01mg/kg to 0.67mg/kg in both topsoil and subsoil and in dry season; and in wet season it decreased ranging from 0.01 mg/kg to 0.19 mg/kg and decreasing generally from top to subsoil.

The distribution of exchangeable Na ranged from 0.68mg/kg to 110.0mg/kg, with top soil showing range of 0.68mg/kg to 110.0mg/kg and sub soil 0.82mg/kg to 86.2mg/kg; Na content in soil of the area tended generally to decrease from surface to subsurface in dry season and increased from surface to sub soil.

Zinc in soil samples varies between 0.01mg/kg and 5.45mg/kg with topsoil showing range of 0.02mg/kg to 5.45mg/kg and subsoil 0.01mg/kg to 4.54mg/kg. In wet season Zn ranges from 0.00mg/kg to 24.16mg/kg.

Nickel and Vanadium were not detected in the soil samples. Pb indicated presence in few locations and ranging from 0.00mg/kg to 0.04mg/kg in dry season and 0.00mg/kg to 0.01mg/kg in wet season. Cr was also present in very few locations, ranging from 0.00mg/kg to 0.02mg/kg in dry season.

The predominant species of micro-organism in surface soils of the study area include: *Bacillus* spp; *Pseudomonas* spp; *Rhizopus stolonifer*; *Clostridium* spp; *Flavobacterium* spp; *Penicillium* spp, *Aspergillus flavus*; and *Trichoderma* spp. The sub soils indicated *Corynebacterium* spp; *Micrococcus* spp; *Aspergillus niger*; *Bacillus* spp; *Fusarium* spp; *Nocardia* spp; and *Penicillium notatium*.

The total Heterotrophic bacteria of the study area in dry season varies between $1.10 x 10^7$cfu/gm and $10.2 x 10^7$cfu/gm in surface soil and $1.70 x 10^7$cfu/gm to $8.7 x 10^7$cfu/gm sub and in wet season surface soil is $1.20 x 10^7$cfu/gm to $4.90 x 10^7$cfu/gm and subsoil $1.50 x 10^7$cfu/gm to$5.9 x 10^7$cfu/gm.

The total heterotrophic fungi in the surface soil ranges from $2.00 x 10^4$cfu/gm to $25.0 x 10^4$cfu/gm and sub soils $4.0 x 10^4$ cfu/gm to $15.0 x 10^4$cfu/gm in dry season.

- **Surface Water Quality**

The surface water system along the proposed pipeline route comprises primarily rivers and streams. In dry season majority of the rivers and streams have low flow, in some cases do not flow and in most cases dry. Climatic variables affect rivers and streams.

The rivers and streams sampled generally showed pH range of 5.9 to 9.5 in dry season; Ofunene stream showed 6.0 in downstream and 5.9 upstream, Kaduna River indicated 9.2 in downstream and 9.5 upstream. The rivers and streams in the study area showed range of 6.65 to 7.81 in wet season.

The alkalinity of rivers and stream sampled ranges from 37mg/l to 160mg/l in dry season l in dry season and 32 mg/l to 540mg/l in wet season. In dry season BOD values ranged from 2.0mg/l to 10.0mg/l and wet season 2.0mg/l to 8.0mg/l. Dissolved oxygen values ranged from 4.7 mg/l to 5.8mg/l, in dry season and 4.1mg/l to 5.6mg/l in wet season. Turbidity indicated range of 0.0NTU to 15.0NTU in dry season and 0.0NTU to 378NTU in wet season.

Overall, the surface water quality in dry season showed concentration that is less than 0.06mg/l; Ofunene stream (upstream) indicated content of 0.06mg/l. In wet season oil and grease content ranges from 0.0mg/l to 0.08mg/l.

Ni was not detected in any of the samples in both wet and dry season. In dry season chromium, cadmium and lead were present in the range of 0.00mg/l to 0.03mg/l;
In Oguro Cd and Cr both showed content of 0.03mg/l and Pb 0.01mg/l. Also Cd indicated concentration of 0.02mg/l and 0.01mg/l in downstream and upstream of Kwaita River respectively.

In wet season the heavy metal concentration ranged from 0.0ppm to 43.12ppm; Pb, Cr, Cd were all indicated in Rivers Oguro and Reka and Kpako and Tasawariki Stream. Lead indicated 0.02ppm, 0.01ppm, 0.05ppm and 0.08ppm in Kpako, Oguro, Reka and Tasawariki Stream respectively. Chromium showed 0.02ppm, 0.03ppm, 0.02ppm and 0.02ppm in Kpako, Oguro, Reka and Tasawariki Stream respectively while Cadmium is 0.04ppm, 0.02ppm, 0.04ppm and 0.02ppm respectively.

- **Groundwater Quality**

Groundwater yield of the area is poor and is mostly tapped by hand-dug wells for agricultural and domestic purposes.

The pH of the groundwater is near neutral (6.50-7.91) for both wet and dry season. Electrical Conductivity (EC) values vary between 0.00 and 0.50 µS during the wet season and 0.69 and 444 µS during the dry season.

The hardness values of the groundwater in the study area ranges from 0.0mg/l to 95.0mg/l.Sarkin Pawa groundwater indicated zero content. The turbidity values of the ground water vary between 0.0mg/l to 0.06mg/l in dry season and 0.05mg/l and 2.56mg/l in wet season.

Calcium values for groundwater samples indicated range of 1.8 to 24.5 mg/l in the dry season with Izom and Bonu showing 24.5mg/l and 20.2mg/l respectively.

The groundwater samples showed Sodium concentrations that range from 5.0mg/l to 56.5mg/l; Izom ground water showed the highest content. In wet season Na content was less than 55.8 mg/L.

Cd, Cr, Ni, Pb and Hg concentration in the groundwater samples generally indicated zero. Fe, Cu, Mn and Zn were present in all samples; Mn ranged from 0.01mg/l to 0.30mg/l, with Geregu showing the highest concentration, Zn ranged from 0.20mg/l to 1.36mg/l and Fe 0.02mg/l to 0.54mg/l. In wet season Fe concentration vary between 0.01ppm and 2.42ppm.

The ground water generally showed percentage hydrocarbon utilizers within the heterotrophic communities that are generally less than 1.0. Indigenous microbial population in groundwater includes *Bacillus spp; Fusarium spp; Aspergillus flavus; Aspergillus niger* in both seasons. In groundwater samples the total coliform showed zero concentration in both wet and dry season.

- **Hydrology**

The study area is well drained with a reasonably close network of rivers and streams, most of these rivers, however are seasonal with the exception of Kaduna, Niger, Gurara, Echun, Reka and Tiga Rivers.

The rivers flow through or are impacted on by towns, villages in and outside the study area. The rivers flow in a south-easterly direction.

The rivers and their flood plain are subjected to various potential impacts via anthropogenic activities including the proposed pipeline. These activities can therefore be a source of sediment load to the rivers. The associated reduction in aquatic and terrestrial life in the ecosystem associated with digging and pipeline crossing will be effectively ameliorated by the use of Horizontal Directional Drilling (HDD) method in river crossing, use of silt traps to control impact on water system and carrying out excavation during the dry in areas close to the river banks,

Farming activities that take place in the study area include both agriculture and livestock. Crops such as maize, guinea corn, millet are planted in the area. Cattle are also farmed extensively in the rich gracing provided by the flood plain (Fulani camps). These activities can also be a source of sediment load to the rivers. The topography of the area makes the rivers natural drainage end points of flood plains of the study area.

The Rivers generally showed poorly graded sand with Reka and Tiga Rivers indicating silty sand in wet season. River Niger sediment showed Light brown, and with trace of gravel and silt in both upstream and downstream; the ranges of moisture, sand, gravel and silt contents are 16.9% to 17.4%, 96.0% to 98.0%, 1.7% to 3.7% and 0.3% respectively in dry season. Reka River sediment is Dark grey, gravelly sand with moisture content of 14.5% to 18.2%, sand 47.2% to 87.5%, gravel 1.2% to1.6% and silt 24.2% to 28.6%.

Wet season showed moisture content of 12.4% to 25.3% upstream and 12.9% to 23.4% downstream.

The sediment samples showed pH range of 6.35 to 7.22 indicating slight acidic to near neutral characteristics; River Niger showed range of 7.21 and 7.22 and other samples generally indicated pH below 7 and above 5. In wet season it ranges from 6.18 to 6.80 and generally increased in dry season up to 6.98.

The sediments oil and grease content varied between 0.00mg/kg and 0.01mg/kg in dry season and 0.00mg/kg and 0.06mg/kg in wet season.

The heavy metal content of the sediments varies between 0.00mg/kg and 2.51mg/kg in dry season and 0.00mg/kg and 3.70mg/kg in wet season. In dry season only River Echun showed presence of Ba and it ranged from 0.02mg/kg to 0.04mg/kg. Pb and Cr were not detected in dry season.
All the sediment samples showed presence of Zn (0.02mg/kg), Cu (0.02mg/kg to 2.51mg/kg) and Fe (0.01mg/kg to 0.06mg/kg). In wet season Pb and Cr ranged from 0.01ppm to 0.02ppm.

The total coliforms of River sediments showed seasonal variations, ranging from $1.00x10^3$ cfu/m 1 to$1.40x10^3$ cfu/ml in wet season and showing no presence in dry season. A similar situation happened for *E. Coli. Stapylococcus spp; Micrococcus spp and Saccharomyces spp.* The *Bacillus spp; Aspergillus flavus; Penicillium spp and Fusarium spp* were predominant in both seasons.

- **Aquatic Biology**

In dry season a total of nineteen (19) plankton species were recorded at the downstream and upstream of River Niger, Kazai River, Gurara River, Tiga River, Kaduna River, Kurara River and Reka River; total number of species recorded ranged from 2 to 9. The key plankton species identified in the rivers are *Actinoptychus splendens* Ehrenberg.

Also, in wet season a total of eleven (11) species were recorded at the downstream and upstream of the rivers; with the total number of species recorded ranging from 2 to 4. The key species occurring in the rivers for wet season were *Aulacoseira granulata* var. *angustissima* Muller.

Zooplankton recorded a total of four (4) species at the downstream and upstream of the rivers in dry season and three (3) species and 1 juvenile stage in wet season. Zooplankton species occurring for the rivers in dry season were *Daphnia* sp. Other species were Bosmina sp (**ORDER - CLADOCERA**) and *Enterpina* sp. (**ORDER - HARPACTICOIDA**) and in wet season *Daphnia* sp., *other species were* Bosmina sp (**ORDER - CLADOCERA**) and *Enterpina* sp. (**ORDER - HARPACTICOIDA**).

The species of fish that commonly occur in the rivers are *Tilapia sp*, *Clarias sp* and *Chrysichthys sp* (cat fishes) and *Cyprinid minnows and Alestes sp*.

- **Wildlife**

The wildlife habitat types identified along the gas pipeline right-of-way and study area include; guinea and Sudan savannah vegetation, agricultural land, surface water and Riparian.None of the wildlife is rare or endemic to the study area or Nigeria or listed in the IUCN (International Union for Conservation of Nature) Red List of Threatened Species Categories.

- **Vegetation**

The vegetation within the study area is of the Guinea and Sudan Savanna vegetation. The vegetation of the study area is characterised by xerophytes, epiphytes, lianas, fungi and parasitic plants.

The expanse of the ROW encompasses farmlands, plantations, fallowed lands and forest. The original primary vegetation of the study area was identified to be depleted due to many decades of farming, timber and firewood exploitation, overgrazing and bush burning.

None of the plant species recorded during field surveys of the study area are declared ‘threatened’ species under Convention on International Trade in Endangered Species of Wild Fauna and Flora, CITES.

- **Topography and Landform**

The project ROW traverses cities, towns and communities with varying landforms, shapes, physical features and process in play. Across the pipeline route, the elevation, landforms and other topographic features differed marginally except the vegetation and soil type which remained almost similar with little or no variation.

- **Land Use**

The major use of land in the study area revolves around agriculture, vegetation, rivers/streams, settlements and provision of social needs such as railway line, gas and PP pipeline, transmission lines and road. Vacant land (vegetation) has the largest land use category in the study area followed by agriculture. The control and management of land in the study area is the responsibility of the State Governors.

- **Infrastructural Services**

The level of infrastructures in the rural communities' in the study area is very low compared to some of the other places in the urban areas in the study area. Most of the rural communities depend on other villages/communities to enjoy some infrastructures. Almost all the communities in the study area have electricity supply from PHCN, except in Katchi Tsoho and Kaida Sabo, Kassanki (both in Gwagwalada Area Council), Kazai Kadara (Munya LGA, Kaduna State), Kigimin Gobirawa (Igabi LGA, Kaduna State) and Ungwan Samaila (Makarfi LGA, Kaduna State). In the villages there are no refuse or sewerage system; domestic wastes are disposed by burning, burying and dumping.
Majority of the rural communities in the study area do not have either primary or secondary schools. Some of them have primary but no secondary schools. For those of them that have none or at least one, their children have to trek 2-4km to the neighboring village/communities where the schools are located.

- **Socio-economics**

A total of 47 communities were identified as being located within (or partly encroaching into) a 2km corridor of the project ROW. Five communities falls within Kogi State, 14 in FCT , 6 in Niger State, 16 in Kaduna State and 6 in Kano State. The communities in Kogi State include Ajaokuta, Iloshi, Zango Daji, Koton Karfe and Sensenyi.

Most of the communities are rural in nature, few has urban setting. The rural communities can be accessed through the major roads leading to the urban areas but most rural communities' roads are unpaved and some can only be accessed in the dry season (Kassanki).

The communities generally have the following ethnic origins; Igalas, Igburra, Bassange, Igbirra, Koto, Ganagana, Bassa Komo, Gbagi, Nupe, Koro, Kadara, Bajju, Kataf, Ikulu, Mangu, Idoma.
The traditional administrative structure of the communities in the study area is such that the village Head/Magajis oversees the smaller villages while the ward Heads/Mai ungwa oversees more villages headed by the village Heads/Magajis

The cultural and social setting of the communities along the study area is typically that of the Northern setting.

In some of the communities visited, it was discovered that Animists cohabits side by side with the Christians and Muslims. These traditional worshippers have traditional shrines where they worship their ‘gods’.
The communities in the study area that celebrate traditional festivals include Iloshi, Dafa, Kassanki, Kaida Sabo, Bonu and Sarkin Pawa

Christianity and Islam are all having keen follower-ship in communities. Some of the communities are dichotomized in religion with majority being either Christians or Muslims while in the urban centers, mixture of the two religions and a negligible number of “animists”.

The occupation of most of the people in the study area is farming. There is generally a high level of unemployment in the study area although all communities surveyed have members who would be available for temporary work. They have skills that will be useful for the project construction, like engineers, drivers and welders. The people have a positive attitude towards the development of the project.

The income in the study area is generated mostly from the sales of agricultural products ranging from the roots and tuber crops, grains and cereal products, vegetables and fruits and animal husbandry.

The literacy level in most of the rural communities in the study area is very low compared to those in the urban areas

POTENTIAL IMPACTS EVALUATION

Environmental impacts due to the various stages of the proposed project were identified and evaluated using Leopold matrix including engineering judgment and expert opinion.

The assessment showed that the majority of the impacts will be associated with the construction phase. Potential construction impacts will be mitigated through the implementation of good construction practice, adherence to management plans, and through the application of localized measures to protect specific or sensitive receptors. The operation of the pipeline will result in minimal localized impacts.

Consultation revealed that most communities are generally positive towards the project. Their perception is that any disruption will be temporary and offset by potential economic benefits both to their community and to Nigeria.

There will be a number of socio-economic benefits associated with the project. These include:

- Direct employment – there will be a limited number of opportunities for direct employment on the project, primarily short term jobs during construction, with fewer long term, vacancies during operation.
- Opportunity for provision of goods and services to the project
- Skills development and training, increasing the employment chances of people after the pipeline construction period
- Enterprise development, a transfer of business knowledge and skills
- Infrastructure improvement – including temporary and permanent upgrade of some roads.

In all, the workforce for this project is estimated at 400 personnel comprising of skilled and unskilled labor. NNPC will put in a place a mechanism to ensure that qualified indigenes of the host communities are favored in the job recruitments during the execution and operation of the project.

The issue of employment opportunities and expenditure on local goods and services by construction workers are the major positive impact to locals during construction phase.

MITIGATION MEASURES CONSIDERED

Project activities that could result in impacts to existing environmental and social conditions, was assessed to be of very low and of low significance. Mitigations were developed for each of the significant impacts to accentuate any positive benefits and to minimize or remove any negative impacts.

The mitigation measures to be adopted by NNPC or its contractor include;

- Enforce restriction on encroachments on vegetation for trees, waste disposal etc
- Impose restriction on working hours (especially for road construction)
- Ensure that dumping site is not located in vegetation areas
- Locate stockpiles of materials at least 100m away from water front
- Provide employment to host communities
- Continuously consult the host community throughout the life span of the project.

ENVIRONMENTAL MANAGEMENT PLAN

Adequate environmental management measures have been proffered to be incorporated during the entire planning, construction and operation stages of the project to minimize any negative environmental impact and assure sustainable development of the area. A monitoring plan was provided for the project and the required institutional arrangement for implementation of the management and monitoring plan.

At the end of life cycle, the pipeline shall be decommissioned and abandoned in conformity with a plan that meets local and international regulatory requirement and standards.
A plan that will ensure a safe, environmental friendly and efficient decommissioning /programme was formulated. The plan shall cover:

- Facilities to be decommissioned or recovered
- Environmental aspect of the decommissioning activity
- Methods for facility re-use, recycling, disposal or removal
- Proper consultation with all stakeholders (communities, other land users and regulators)
- Efforts to integrate negative environmental impacts and appropriately rehabilitate site
- Programmes for restoring the environment in accordance with national and international best practices and regulatory requirement.
- Scope of work to assess possible residual impacts of the plant in the environment.

CONCLUSION
Based on the environmental assessment, the associated potential adverse environmental impacts can be mitigated to an acceptable level by adequate implementation of the measures in the mitigation measures and EMP in the report.

The project will generally have high significant impact but appropriate mitigation measures have been proffered that will enhance the beneficial impacts and ameliorate negative impacts of the project.

We therefore appeal to FMENV to approve this EIA to enable NNPC proceed with the implementation of the proposed project by NNPC.

CHAPTER ONE

1.0 INTRODUCTION

1.1 General

This report presents the Environmental Impact Assessment (EIA) of Ajaokuta-Abuja-Kano Gas Pipeline System proposed by the Nigerian National Petroleum Corporation (NNPC).

The feed gas into the pipeline system is expected to be 3,500 mmscfd of dehydrated wet gas sourced from various gas gathering projects in the southern region.

The EIA of the gas pipeline system has been conducted in line with the Environmental Impact Assessment Sectoral Guidelines for Oil and Gas Industry projects of the Federal Ministry of Environment, Environmental Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN) Revised Edition 2002 of the Department of Petroleum Resources (DPR).

1.2 Project Background

Natural gas is known to be associated gas produced from underground accumulations, the composition of which varies from field to field. Most natural gas consists largely of methane (CH_4) and other light hydrocarbons. Natural gas has been commercially used as fuel for 180 years in America and for centuries in China. The production, processing and distribution of natural gas have become an important segment of many countries' economy and a major factor in the world markets.

Nigeria has an estimated 176 trillion cubic feet (tcf) of proven natural gas reserves, making the country one of the top ten natural gas endowments in the world and the largest in Africa. Abundant gas reserves exceed foreseeable needs of the domestic, regional and export markets.

Due to limited gas distribution infrastructure, Nigeria today flares about 2.6 bcf/d of gas, representing 12.5% of all globally flared gas and the balance of the current production is utilized for power generation, export projects and other domestic uses.

The impediments to natural gas development in Nigeria include among others; inadequate gas gathering and supply infrastructure, inappropriate/ unrealistic pricing of gas, especially for domestic use, low level of industrialization and inadequate consumptive capacities

There is no national gas distribution system, but gas pipelines do link Lagos with Benin City, Ajaokuta, Escravos and fields in the Warri River region. Pipelines link Aba with the fields in the Port Harcourt region and Bonny

Island. Links also exist between the Ngo/Ima and Oso offshore gas fields and Bonny Island and the Qua Ibo terminal.

Nigeria major pipeline system includes: Escravos-Lagos trunk pipeline (LP) for supplies to the western parts of the country and to Oban-Ajaokuta pipeline, which is the back bone for supplies to the North and Alakiri -Obigbo-Ikot Abasi for the Eastern trunk.

The Federal Government of Nigeria in 2008 approved new gas pricing and domestic supply obligation regulations that include short-term, medium-term and long term gas supply targets.

A combination of new government incentives and pressure from the environment ministry to end flaring, coupled with rising domestic industrial demand for gas have now encouraged operators to go into gas projects.

The proposed 740km Ajaokuta- Abuja –Kaduna - Kano gas pipeline project is taking place against the backdrop of the new gas pricing and domestic supply context in Nigeria.

1.3 The Project Proponent

The gas pipeline shall be constructed and operated by Nigerian National Petroleum Corporation (NNPC). The project ROW lies within grid reference of N 07^{o} 28'—N 1I^{o} 52' Latitude and E 006^{o} 39' - 008^{o} 31' Longitude.

NNPC intends to bring this key strategic project, which will secure and guarantee sufficient high-quality Natural Gas-Based energy supplies and also strengthen the Nigerian gas supply system by creating new point of supply for gas in northern Nigeria.

The project of this magnitude requires environmental clearance from the Federal Ministry of Environment (FMENV) in line with EIA Act 86 of 1992. The prerequisite to environmental clearance is conducting an EIA study and thereafter obtaining a Certification of the EIA final report from FMENV.

NNPC engaged the consultancy services of Atlas International Engineering Services Nigeria Limited (AIES) to prepare the Environmental Impact Assessment report in line with FMENV, DPR and other International guidelines.

The Pipeline route cutting across Kogi, Abuja, Niger, Kaduna and Kano is shown in Figure 1.1: Map of Nigeria showing the Pipeline route,

Figure 1.1: Map of Nigeria showing the Pipeline route

1.4 Terms of Reference for EIA of Ajaokuta-Abuja-Kano gas pipeline system

The Terms of Reference (TOR) of the EIA for the Ajaokuta-Abuja-Kano gas pipeline system was defined at the initial stages of the EIA process. The TOR includes:

- The general scope of the EIA study and the legal and administrative framework for the Environmental Impact Assessment.
- Project aspects that may have significant environmental impact.
- Framework for incorporation of the project team views with that of the Regulators, host communities and indeed all stakeholders.
- Establish the protocols for identification and assessment of associated and potential impacts their mitigation measures.
- Environmental Management Plan (EMP) for the project.

1.5 EIA Objectives

The objectives of the EIA are as follows:

- Establish the existing biological, physical, and socio-economic conditions of the project area.
- Characterize the environment thereby identifying the resultant hazards (including social) associated with power generation project.
- Assess proactively the potential impact and associated impact (including health and socio-economic impacts) of the proposed construction project on the project area.
- Make recommendations to eliminate/mitigate/control the magnitude and significance of the hazards and effects.
- Recommend control techniques to eliminate/minimize the severity of the effects and to manage it.
- Recommend plans and procedures to manage the consequences.
- Ensure proper consultation with the communities bordering the proposed construction site in line with FMENV and DPR guideline

1.6 Eia Scope of Work

The EIA work scope includes an extensive literature review and a two season detailed site investigation carried out to generate comprehensive baseline data on the project area. Specifically, the work scope includes but not limited to:

- Undertake consultations with the national/local officials of regulatory bodies

- To undertake characterization of the past and present environment likely to be affected by the project, covering the physico-chemical components, the biological components, and the socio-economic, health, cultural and political conditions, and the corresponding allowable risks associated with the project and in wet and dry season.
- Conduct of a socio-economic and perception survey to determine the effects and acceptability of the project among residents in the immediate vicinity of the project.
- Assess and study the climate, terrain, atmosphere, land and resource use, soil and geologic conditions of the site and conduct appropriate analyses.
- Review hydrological data of the project area and determine the natural drainage patterns, water flows and groundwater quality. Similarly, conduct baseline water quality measurements/analyses within the project areas.
- Undertake the assessment of the future quality of the environment with or without the project.
- Conduct impact assessment along with mitigation, control and/or abatement measures to be adopted in the design, construction and operation of the proposed project.
- Specific recommendations for environmental protection shall be developed and presented.
- Develop a waste management plan (WMP) and strategies for implementation during the execution of the project
- Formulate an Environmental Management Plan and Environmental Monitoring Programme, and make proposals for social development.
- Conduct consultation with affected communities, persons and stakeholders with a view to gathering their input in the project planning.
- Prepare draft and final EIA reports that meet regulatory authorities requirements

1.7 EIA Methodology

The EIA study involved a combination of multidisciplinary standard methods spanning the field of engineering, Natural sciences, and social sciences**.** The assessment methodologies adopted in this EIA study are in accordance with the FMENV, DPR, affected States and other international guidelines. The methodology includes the following: initial site verification and reconnaissance survey, Literature review, baseline data collection, review of proposed project, identification of environmental aspect, and characterization of potential impact and mitigation measures.

1.7.1 Site Identification

The general geography and other relevant information of the project area were obtained using Google Earth®, existing maps, charts, previous EIA reports in the area.

1.7.2 Literature Review

Review of existing literature particularly, from reports of previous EIA studies and other relevant studies on the environmental characteristics of the project area. Materials reviewed include textbooks, reports, survey maps, aerial photographs, articles and other international journals and the internet.

1.7.3 Baseline data collection

Field survey was carried out to gather baseline data on ecological and socio-economic environments to complement information obtained from literature review. The existing

1.7.4 Reconnaissance Survey

A reconnaissance survey of the study area was carried out and it helped in the concept design of field investigation execution.

1.7.5 Consultation with stakeholders

In line with FEPA (now FMENV) 1995 and procedural and sectoral guidelines for EIA in Nigeria, DPR guideline, consultations with the affected communities, local authorities and experts in the field of engineering, science, law, health and other interests were undertaken. This was to gather information and opinion and integrate such into the EIA report. The stakeholders consulted include:

- Federal Ministry of Environment
- Department of Petroleum Resources (DPR)
- Federal Ministry of Agriculture and Rural Development
- Ajaokuta Local Government Area
- Kogi Local Government Area
- Dawakin Kudu Local Government Area

- Adavi Local Government
- Kwali Area Council
- Karfi Local Government Area
- Abaji Local Government Area
- Gwagwalada Local Government Area
- Gurara Local Government Area
- Paikoro Local Government Area
- Munya Local Government Area
- Chikun Local Government Area
- Igabi Local Government Area
- Kudan Local Government Area
- Makarfi Local Government Area
- Zaria Local Government Area
- Ikara Local Government Area
- Bebeji Local Government Area
- Garin Mallam Local Government Area
- Kura Local Government Area
- Dawakin Local Government Area
- Kudu Local Government Area
- Kiru Local Government Area
- Nigerian Environmental Society

The affected communities are shown in **Table 1.1** below:

Table 1.1: Affected communities

COMMUNITIES	LOCAL GOVERNMENT	STATE
Ajaokuta	Ajaokuta	Kogi
Iloshi	Ajaokuta	Kogi
Zango Daji	Adavi	Kogi
Koton Karfe	Koton Karfe	Kogi
Sensenyi	Koton Karfe	Kogi
Abaji	Abaji Area Council	FCT
Agyana	Abaji Area Council	FCT
Dangara	Kwali Area Council	FCT
Dafa	Kwali Area Council	FCT
Gwagwalada	Gwagwalada Area Council	FCT
Kassanki	Gwagwalada Area Council	FCT
Katchi Tsoho	Gwagwalada Area Council	FCT
Kaida Sabo	Gwagwalada Area Council	FCT
Izom	Gurara	Niger
Lambata	Gurara	Niger
Bonu	Gurara	Niger
Kaffin Koro	Paikoro	Niger
Kaazai Kadara	Munya	Niger
Sarkin Pawa	Munya	Niger
Gwagwada	Chikun	Kaduna
Ligari	Chikun	Kaduna
Mando	Igabi	Kaduna
Kigimin Gobirawa	Igabi	Kaduna
Jaji	Igabi	Kaduna
Zango Aya/Lamban Zango	Igabi	Kaduna
Pangurza Gari	Igabi	Kaduna
Zaria	Zaria	Kaduna
Likoro	Kudan	Kaduna
Ungwan Samaila Kutakure	Markafi	Kaduna
Rahaman Wali	Markarfi	Kaduna
Gimi Gari	Markafi	Kaduna
Rumin Mamuda	Ikara	Kaduna
Kunkumi Rumi	Ikara	Kaduna

COMMUNITIES	LOCAL GOVERNMENT	STATE
Zakau	Ikara	Kaduna
Gangarida Ikara	Ikara	Kaduna
Nasarawan Kofa Gwarmai	Bebeji	Kano
Tashan Alhaji	Kiru	Kano
Kunan Dandogari	Kiru	Kano
Chiromawa	Garin Mallam	Kano
Karfi	Kura	Kano
Tamburawa	Dawakin Kudu	Kano

1.7.6 Environmental aspects of the gas pipeline system

Identification of environmental sensitive areas, important species, rare species and socio-political were undertaken in order to identify all aspects of the pipeline project that can interact positively or negatively with the environment at the various phases of the proposed project.

1.7.7 Mitigation measures

The mitigation measures were proffered for the identified environmental aspects of the proposed project. This was in accordance with the Health, Safety and Environmental standards and codes for design, construction, operation, and decommissioning/abandonment as well as FMENv, DPR, UNEP, and WHO Guidelines and Standards. Professional judgement, knowledge of the ecosystem and consensus opinions was applied in determining the appropriate impact mitigation.

Environmental monitoring has been designed into the Environmental Management Plan (EMP) of the proposed gas pipeline project to give room for on-going improvement in the practices.

1.8 Legal and Administrative Framework

The legal and administrative framework within which the EIA was carried out is based on the following regulations, guidelines and standards;

1.8.1 State Regulations, Guidelines and Standards

The Nigerian Constitution allows States to make legislation, laws and edicts on the environment. The EIA Act No.86 of 1992 recommends the setting up of state environmental agencies/ministries to participate in regulating the consequences of project development on their environment.

The state Agencies functions include among other things to:

- Advise the Government on State environmental policies and priorities and scientific and technological activities affecting environment and ecosystem in the state;
- Monitor and survey water including underground water, air, land and soil environments and ecosystem and determine pollution levels and collect baseline data from them
- Conduct pre and post environmental impact assessment of projects and make recommendations for corrective measures;

Based on above, the EIA will be conducted in accordance with regulation of all the states and FCT as stated below:

- The regulations, guidelines and standards of the Abuja Environmental Protection Board (AEPB)
- The regulations, guidelines and standards of the Kogi State Environmental Protection Agency and Kogi State Ministry of Environment
- The regulations, guidelines and standards of the Niger State Environmental Protection Agency and Niger State Ministry of Environment
- The regulations, guidelines and standards of the Kaduna Environmental Protection Agency and Kaduna State Ministry of Environment
- The regulations, guidelines and standards of the Kano State Ministry of Environment.

1.8.2 The Federal Ministry of Environment EIA Requirements

The Federal Environmental Protection Agency (FEPA) was set up by Decree No. 58, 1988. With this, the Federal Government of Nigeria established FEPA (now Federal Ministry of Environment (FMENV)) to protect, restore and preserve the ecosystems of the Federal Republic of Nigeria. In addition, FMENV Regulation S.1.8 and S.1.9 and S.1.15 of 1991 provided National Guidelines and Standards for industrial effluents, gaseous emissions, and hazardous wastes management for Nigeria.

The onus of enforcement of Decree No. 86 of 1992 which makes EIA mandatory for all new major public and private projects in Nigerian also falls on the FMENV. The EIA Decree sets out to achieve the following objectives:

- To consider the likely impacts, and extent of these impacts on the environment before embarking on any project or activity.
- To promote the implementation of appropriate policy in all federal lands consistent with all laws and decision making processes through which the goal of the decree may be realized and;

- To 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 Decree gives specific power to FEPA (now FMENV) to facilitate environmental assessment of projects.

In September1995, FEPA published the EIA sectoral Guideline for Oil and Gas Industry Projects. The Guidelines are intended to assist in the proper and detailed execution of EIA of oil and gas projects in consonance with the EIA Decree of 1992.

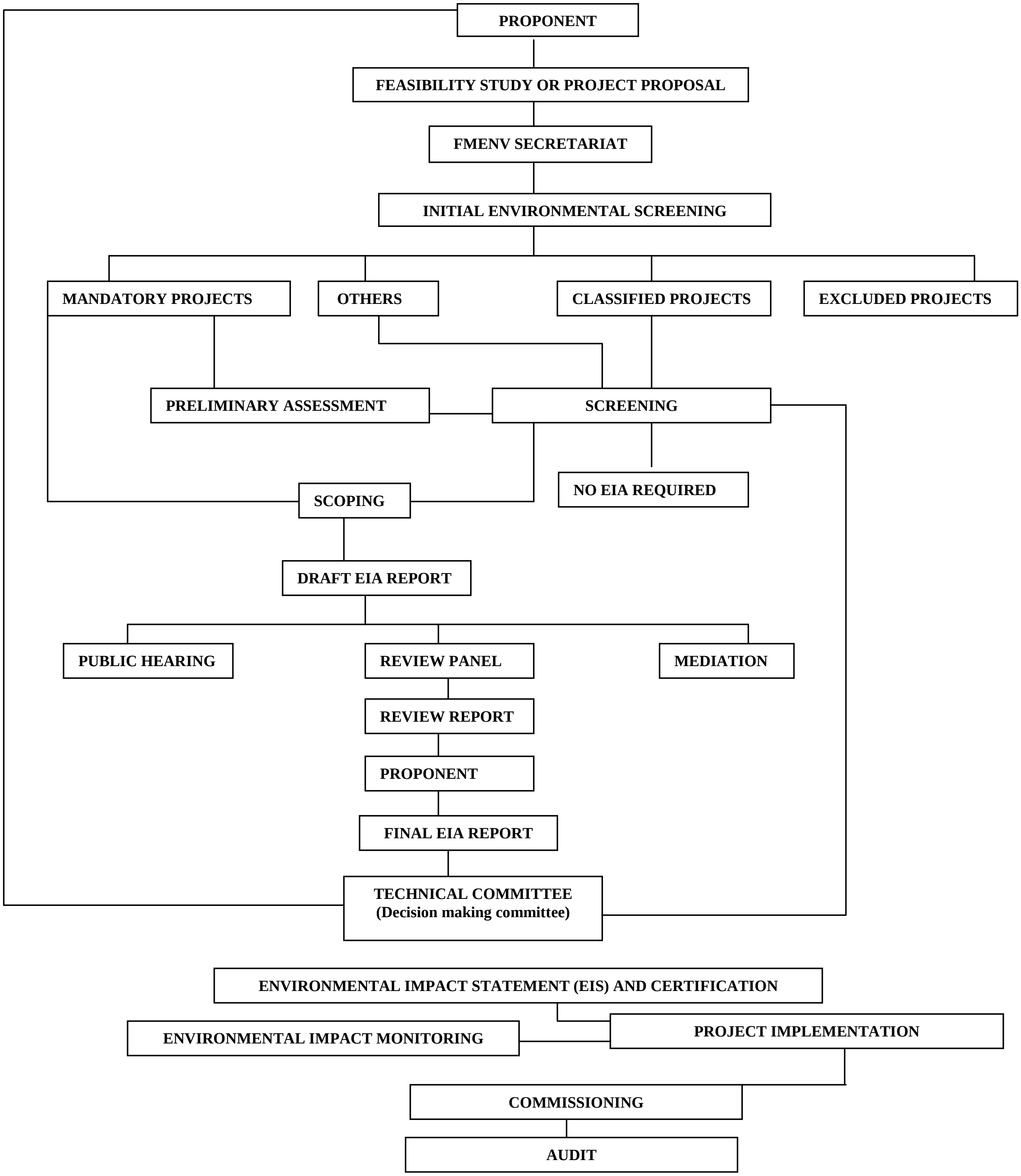

Figure 1.2: FMENV EIA management procedure

1.8.3 Department of Petroleum Resources (DPR) (Environmental Guidelines and Standards for Petroleum Industries in Nigeria, 1991)

The Department of Petroleum Resources in the Nigerian National Petroleum Corporation was set up by Section 191 of NNPC Decree 1979. The Decree empowers DPR to ensure that petroleum industry operators in Nigeria do not degrade the environment in the course of their operations. This therefore vested the power of supervision of all operations of the oil industry on DPR.

The principal decrees and regulations that mandated DPR to issue license and permits, and establish guidelines, standards and procedures for environmental controls include: petroleum Act of 1969, Section 8(i) b (iii) which empowers the Minister of Petroleum Resources to make regulations for the conservation of petroleum resources, prevention of pollution of water courses and atmosphere.

DPR requires by legislation, that holders of exploration ,prospecting, exploitation, refining, transportation and marketing licenses of petroleum resources take/adopt practical precaution s and all steps practical to prevent pollution, and cause as little damage as possible to the environment in their areas of operation. The use EIA as an environmental management tool is mandatory and is adopted as an additional enforcement strategy by DPR.

Other National legislations pertaining to environmental protection in the area of Oil and Gas operation includes the following:

- The Petroleum (Drilling and Production) Regulation of November 27, 1969.
- Oil in Navigable waters Act No 34 of 22 April 1968
- Oil in Navigable waters Regulations- Regulations of 22 April 1968
- Petroleum Pipeline Act,1965
- The National Environmental Protection (Effluent Limitation) Regulations –Regulation of August 15, 1991
- Environmental Impact Assessment Act 86, 1992.
- Waste Management and Hazardous Waste Regulations (S.1. 15) 1991.
- FMENV EIA Sectoral Guidelines on Infrastructure, 1995

1.8.4 National Policy on Environment

The National policy on Environment was launched in 1989 by the Federal Government of Nigeria to achieve a sustainable development in Nigeria and particularly to:

- Secure for all Nigerians a quality environment, adequate for their health and well-being.
- Restore, maintain and enhance the ecosystems and ecological process essential for the functioning of the biosphere to preserve biological diversity and the principle of optimum sustainable yield in the use of their natural resources and ecosystem.
- Raise public awareness and promote understanding of essential linkages between environment and development and to encourage individual and community participation in environmental improvement efforts.

1.8.5 Regulation S.1.9: National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes Regulations 1991 (FMEH&UD 1991.c)

- No industry shall release toxic substance into the air, water and land of the Nigerian Environment, beyond permissible limits.
- It is mandatory for all industries to have industrial pollution monitoring capabilities within their own set up. Preferably they should have on-site pollution control unit or assign it to a consultant/contractor approved by the Federal Ministry of Environment Housing and Urban Development.
- All manufacturers should draw up a contingency plan against accidental releases of pollutants.
- For the present point and non-point sources of industrial pollution, all industries with potential for the release of gaseous, particulate, liquid or solid untreated discharge is mandated to install into their system, appropriate pollution abatement equipment in accordance with the prescribed guideline.
- All discharges of effluent with constituents beyond permissible limits into public drains, stream, rivers, lakes, sea or underground infection are unacceptable and are prohibited unless a permit is obtained in writing from Federal Ministry of Environment (FMENV) or any organization so designated by FMENV.
- Solid waste generated by industry including, sludge and all bye-products resulting from the operation of pollution abatement equipment should be disposed off in an environmentally safe manner.
- The general aesthetic sanitary conditions of factories and surroundings shall be adequately maintained.
- Within limits of the provisions by the National policy on Environment, the safety of workers from exposure to hazardous conditions in the work place shall be guaranteed.

- The collection, transport and final disposal of waste should be the responsibility/capability of the company generating the waste, which shall be liable for clean-up, remediation, restoration and where necessary, compensation to all affected parties.
- Environmental Auditing (EA) of existing industries and Environmental Impact Assessment (EIA) of new industries and major developmental projects shall be mandatory.

1.8.6 The Nigerian Urban and Regional Planning Act 1992

- Act 88 of 1992 established a Development Control Department (DCD) charged with the responsibility for matters relating to development control and implementation of physical development plans at Federal, State and Local Government levels within their respective jurisdiction.
- Approval of the relevant DCD shall be required for any land development
- A developer shall submit a development plan for the approval of the DCD of local Government, State or Federal Government.
- A developer (whether private or government) shall apply for a development permit in such manner using such forms and providing such information including plans, designs, drawings and any other information, as may be prescribed.
- A developer shall at the time of submitting his application for development submit to an appropriate Control Department a detailed Environmental Impact Statement (EIS) for an application for:
- A residential land in excess of 2 hectares or
- Permission to build or expand a factory or for the construction of an office building in excess of four floors of 5000 square meters of a lettable space or
- Permission for a major recreational development

1.8.7 Federal Forestry Laws

- The principal legislation in force for the regulation of the forest sector in Nigeria is the Forestry Act 1958 at the Federal level and representative states Forestry Laws or Edicts level.
- The Forestry Law CAP 51 of 1994 is the only substantive legislation applicable to all parts of the federation. The law prohibits any act that may lead to the destruction or cause injury to any forest produce, forest growth or forest property. The law prescribes the administrative framework for the management, utilization and protection of forestry recourse in Nigeria.

1.8.8 Land Use Act, 1978

- The Nigerian Land use Act 1978 was promulgated in March 1978. It vests all land in each state of the federation (except land already vested in the Federal Government or its agencies) in the Governor of the State. It makes the state government the authority for allocating land in all urban areas, for residential, agricultural, commercial and other purposes while it (the Act) confers similar powers regarding non-urban areas on the Local Government in such area. The Governor of a State can revoke a Right of Occupancy (statutory customary) for overriding public interest.

1.8.9 International Agreements/Conventions

Nigeria is signatory to several international agreements affecting the environment; some of which include:

1.8.9.1 Geneva Convention on the High Seas (1958)

This convention which had been revised several times as Convention on the Prevention of Marine Pollution required every coastal nation to promulgate municipal laws and regulations to prevent the pollution of the seas and waterways. Such laws are to prohibit the discharge of oil from ships and discharge of waste and/or oil from other facilities connected with petroleum activities. The Oil in Navigable Waters Act of 1968 and the Petroleum Act of 1969 in Nigeria are the follow-up of this convention.

1.8.9.2 Vienna Convention for the Protection of the Ozone Layer, including the Montreal Protocol and the London Amendment.

The objectives of this convention are to protect human health and the environment against adverse effects resulting or likely to result from human activities, which changes or alter are likely to modify the ozone layer and to adopt agreed measures to control human activities found to have adverse effects on the ozone layer.

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

The Bonn Convention’s field of action is conservation and management of migratory species (including waterfowl and other wetland species) and promotion of measures for their conservation, including habitat conservation. Conservation of these habitats is one of the principal actions taken for endangered species or groups of species, which are subject of agreements under the Bonn Convention. This was adopted in 1979.

1.8.9.4 Convention on Biological Diversity

The Convention on biological diversity was opened for signature at the 1992 Rio Earth Summit. The objectives of this Convention were among other things conservation, sustainable use of biodiversity resources and fair and equitable sharing of benefits arising from the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.

1.8.9.5 Convention Concerning the Protection of the World Cultural and Natural Heritage or World Heritage Convention (1978)

This Convention sets aside areas of cultural and natural heritage. Natural heritage here is defined as areas with outstanding universal value from the aesthetic, scientific and conservation points of view.

1.8.9.6 International Convention for the Prevention of Pollution from Ships (MARPOL)

One of the most prominent international agreements on the protection of the marine environment is the International Convention for the Prevention of Pollution from Ships or the MARPOL convention, signed in 1973 and amended in 1978 by a protocol, of which Nigeria is a signatory. This provides an international framework for controlling accidental and deliberate pollution of the marine environment by discharges from ships. Special concerns listed under this convention are offshore platforms and associated vessels, including all fixed or floating platforms engaged in exploitation or exploration of seabed mineral resources and all vessels alongside or within 400m of such platforms.

1.8.9.7 Endangered Species Act 11, 1985

In pursuance of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, CITES, the Federal Government of Nigeria enacted Endangered Species (Control of International Trade and Traffic) Act 11,1985 which makes among others, provisions for the conservation, management and protection of some of the country’s endangered species.

Section 1 absolutely prohibits the hunting or capture or trading in the threatened animal species. The list of endangered species include reptiles, bird (Aves) and mammals (insectivores, primates, rodents, carnivores)

1.8.9.8 Convention on wetlands of International Importance, Especially as Waterfowl Habitat (RAMSAR Convention, 2001)

The Convention's mission is "“the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world”. It calls upon contracting parties to recognize the interdependence of humans and the environment as well as the ecological functions of wetlands, such as wildlife habitat, nutrient cycling, and flood control.

1.8.9.9 African Convention on Conservation of Nature and Natural Resources, 1968

The Convention is to encourage 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.

1.8.9.10 UN Framework Convention on Climate Change, 1992

The Convention on Climate Change sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases

1.8.10 International Guidelines

World Bank Operational Directive 4.01: "Environmental Assessment of 1991" which classifies projects according to nature and extent of their environmental impacts.

- African Development Bank borrowing Requirement
- WHO Standards for Surface Water/Underground Water For Drinking

1.9 NNPC HSE Policy

NNPC is committed to conducting its activities in a manner that promotes the Health and safety of her employees, assets and the public as well as the protection of the environment.

NNPC is committed to continual improvement in her operations to eliminate personal and industrial accidents as it pursues the goal of no-harm to people and no-harm to environment in all its operations and facilities

To this end NNPC shall:

- Focus on HSE to safeguard its people and assets.
- Adopt Health, Safety and Environmental best practices in the design, construction and operations of her facilities.
- Comply with National and applicable International standards and laws on Health, Safety and Environment in the conduct of her operations
- Demonstrate social and ethical responsibility by working together with all relevant stakeholders to promote harmonious HSE complaint relationship.
- Engage and consult with employees and others on Health, Safety and Environmental conditions and provide Occupational Health Services.
- Maintain emergency response capability to minimize the impact of unfavorable negative incidents related to her operations.
- Liaise closely with relevant government agencies in the formulation of Health, Safety and Environmental protection, legislation, regulations or

policies that may significantly impact the Group's business returns to shareholders

- Publicly report on her HSE performance.
- Ensure that all staff has the right and duty to intervene and stop any unsafe acts and conditions or activities which are not in compliance with HSE policy and commitments.
- Ensure that its Customers, Partners, Visitors and other stakeholders comply with this HSE Policy**.**

1.10 NNPC Waste Management Policy

The overall aim of the NNPC's HSE Policy is to reduce volume of waste at source through minimisation, re-use or recycling with incineration/landfill as the last disposal option. All wastes shall be managed in compliance with the HSE premises. NNPC recognizes that correct management of waste is essential to ensure compliance with legislation, international standards and good industry practices and incorrect segregation and disposal of waste could lead to environmental damage, cause harm to people and affect Company reputation.

NNPC follows the concept of "Duty of care", whereby generators of waste are required to demonstrate that all reasonable steps were taken to ensure that their waste products are efficiently handled and disposed of.

NNPC approach is based upon the following principles:

- Waste minimisation at source, to reduce the possibility of deterioration or obsolescence
- Procure non-hazardous products or Substitute with less hazardous materials where possible
- Robust waste disposal management through FME approved contractors

1.11 Structure of the Report

The EIA report is presented in Eight (8) chapters

The content includes the following:-

- Chapter one gives project background information, administrative and terms of reference and legal framework.
- Chapter two provides the justification for the project that includes the need, value and sustainability of the project.
- Chapter three describes the project/process, it provide a detailed explanation and description of the project actions and present brief

information on the associated in-built or to-be-built impact control measures in the project.

- Chapter four gives a description of the environmental setting of the project area and outcome of the consultation process
- Chapter five gives the environmental changes (negative and positive) that might result from installation and accompanying processes of the project development and mitigation measures that will protect the environment from adverse effect of the project actions.
- Chapter six proffers mitigative and ameliorative measures for adverse impacts
- Chapter seven presents cost effective environmental management plan (EMP) to be adopted throughout the entire project cycle. This includes environmental monitoring and waste management programmes and decommissioning/ abandonment plan.
- Chapter eight highlights the key findings of the EIA study in a conclusion.

A list of reference and other materials including applicable codes and standards for facilities design and construction are included after chapter eight.

CHAPTER TWO

2.0 PROJECT JUSTIFICATION

2.1 Need for the project

Nigeria is a gas surplus nation, with gas reserve estimate of 159TCF, comprising 85TCF of associated gas (AG) and 74TCF of non – associated gas (NAG). In the last 40 years, since the start of active petroleum activities in Nigeria, about 23TCF of gas have been produced. The commercial demand of gas is about 0.33TCF of associated gas per year, which stands at about 1000MMSCF/D. Liquefied Natural Gas (LNG) exports accounts for 40% of the quantity, while domestic users led by the power sector account for 60%.

Domestic consumption and export of gas are relatively small compared to the scale of gas resource base. As a result, about 2BCF is flared daily, which represent over 60% of the daily gas production. This accounts for over 20% of the total daily flaring of gas globally, while the nation loses US $2billion dollars as a result of these flares.

Nigeria is a mono – cultural economy dependent on the export of crude petroleum for over 90% of its export earnings. The country's aspiration is to raise crude oil reserves to 40billion barrels by 2010, in order to buoy her economic growth.

Since the country is a gas surplus country, the nation's cardinal objective to increase crude reserves in turn has the direct consequence of increased associated gas production.

With regards to gas, and in consonance with the national flare-down target, there is need to embark on wide range of gas utilization facilities.

In 2001, Government of Nigeria embarked on a programme to encourage private investments in oil and gas industries in order to sustain long-term economic growth. The reform plans includes gas recovery and processing plant as well as natural gas and Independent Power Plant (IPP). Also part of the reforms was a review of the downstream Gas act and the instituting a gas regulatory commission with responsibility to develop and regulate the downstream sector. The reforms have opened up the sector for investment.

Gas field development and associated gas usage is playing a very important role in Nigeria energy industry. To enhance investment in this sector, the government enacted a gas policy with fiscal and tax incentives to expand utilization of natural gas and encourage investments in the sector. It addresses all the different phases of the gas chain; production, transmission, distribution and end-user consumption.

Government also plans to ensure that gas significantly contribute to power sector target of generating 25,387MW by 2015, considering the deplorable energy situation in the country. The plan includes an approval of a new gas pricing and domestic supply obligations regulation including short-term, medium-term and long term gas supply targets

One of the medium-term major domestic gas transmission systems is the first South - North gas transmission line that will take dry gas through Akwa Ibom/Calabar facilities to Ajaokuta, Abuja, Kaduna and Kano. The line will also serve the south-east states of Anambra, Abia, Ebonyi, Enugu and Imo.

The long-term target of the project is to supply gas internationally through the Trans-Sahara Gas Project (TSGP). The TSGP is a ‘’golden opportunity for Nigeria to exploit her gas potentials and utilize its gas resources to enable her earn as much revenue from it as it is earning from oil. This will enable Nigeria meets her nagging domestic gas utilization; eliminate gas flaring and in the long run help the country meet global greenhouse gases/climate change policy requirements’’.

The Proposed Ajaokuta-Abuja-Kaduna-Kano Gas Pipeline (Phase I) Project construction and operation is a further step within the government policy as it will help guarantee supplies network in the North and South of Nigeria and as well as reduce environmental impact associated to gas flaring.

2.2 Project Benefit

The project will expand the gas supply system in the North to meet the growing gas and energy demands in the region. The Project will open up new areas of opportunities in the project area thereby reducing gas flaring (by improving environmental and safety standards) and creating job opportunities:

Power Sector: About 300MMSCF/D of gas goes into production of 65% of Nigeria’s 111Kw/cap of electricity. It is anticipated that Nigeria’s power needs will grow at an estimated 2.5 percent every 10 years. Hence, it is expected that gas consumption by Nigeria Power Sector could potentially increase to 1, 350 and 1, 380 MMSCF/D by 2010 and 2020 respectively.

The project will open-up opportunities for construction of power plants in the north and generally improve the power situation of the country.

Cement Sector: Nigeria imports 50% of her 6 million tons per year requirements, making the nation the highest importer of cement in Sub-Sahara Africa. It is anticipated that at 7% annual growth rate, cement imports can be eliminated by 2020. This will involve conversion of existing plants and addition of new ones, with projected gas utilization increase from the current 28 MMSCF/D to about 300 MMSCF/D by 2020.

The project will encourage the use of gas by existing cement factories in the project area and construction of new ones.

Fertilizer Sector: Nigeria with 13Kg/ha application has a total fertilizer consumption of about 800,000 metric tons per year and an anticipated growth rate of about 6-7 percent per annum. The project will encourage the construction of fertilizer plants in the project area, which will expand farming activities and reduce Nigeria food imports.

Steel Sector: Nigeria's steel demand currently stands at about 0.4 million tons per annum compared with the less than 1% capacity utilization of installed capacity of about 2.3 million tons per annum. Full recovery of the steel sector is expected to account for gas utilization increase from 0.2 MMSCF/D (2002) to 130MMSCF/D by 2020. It is expected that this project will encourage investment in the construction of steel plants in the north.

Export and Other Projects: Other anticipated and planned key growth sectors are projected to involve gas utilization increase from the current 100MMSCF/D to 410MMSCF/D by 2020. Industry experts predict that export - oriented projects could grow to about 4000MMSCF/D by 2020. The expected revenue from export through the Trans-Sahara gas pipeline will greatly improve the country's economy and project Nigeria to the competitive international gas market presently dominated by Qatar and Russia.

2.3 Project Sustainability

The sustainability of this project was studied under the following:-

2.3.1 Technical Capacity

- The life span of the project pipeline is about 25 years which is primarily determined by the life expectancy of the cathodic protection / anticorrosion system.
- To ensure the life expectancy of the pipeline, there will be regular corrosion inspection and remediation of the corroded pipes.
- The project contractor shall be versed in operating and monitoring high standard in health and safety of pipelines.

2.3.2 Environmental Sustainability

The final route of the Proposed Pipeline has been determined and; it will follow majorly the existing PPMC pipeline route. New route will be taken where settlements and development have encroached the existing route.

Threats to the environmental integrity in areas where new route will be taken and the existing route include the following: farming, increased population pressures, hunting, and habitat loss due to agriculture, logging, and development projects. All of these processes would accelerate with the construction of the Pipeline Project.

The clearing of bushes for construction of the pipeline regardless of its route, will be detrimental to the local environment. There will be habitat loss, accidental spills, and the creation of hazardous and toxic wastes. The Project, however, does not pose a special risk.

The contractor that will be selected for the project implementation shall have the technical capacity to safely implement the project of this magnitude and complexity. With such capacity, the likelihood that the Project will have major negative environmental impacts will be minimal.

In Nigeria, there is meaningful framework to address impacts of large development projects. There are institutional structures currently existing to promote environmental cooperation across the States connected by the Project.

2.3.3 Gas Supply and Utilization

The Project operation depends on continued demand for adequate supply of natural gas. The demand is likely to continue growing due to long-term economic recovery, expected high international oil prices, and improved enforcement of environmental emission standards.

Natural gas that traditionally was flared at oil extraction sites for years has increasingly been recognized as an enormous income-generating resource for Nigeria and now being captured for processing and sale both regionally and overseas.

The total gas utilized in Nigeria increased from about 197 million scf/d in 1999 to about 573 mmscf/d in 2004. Substantial demand growth is expected in this decade. Consequently, domestic demand for natural gas is expected to increase to about 1700mmscf/d by 2010. Domestic gas consumption is expanding as a result of the ongoing power sector reforms while gas export which was non-existent prior to 1999, has received a strong boost.

The power sector currently consumes minimal percent of Nigeria's natural gas. Nigeria's Power Development Plan emphasizes diversification in its fuel mix as a measure of energy security.

Also, comprehensive and integrated gas utilization Master plan/programmes have been embarked upon, in which LNG and IPP developments are being given priority. The expected increased export earnings from LNG, coupled with adequate domestic power supply from IPPs, will strongly support the utilization of gas and broaden economic expansion and urbanization, increase the income generating capacity of Nigerians and lift the general wellbeing.

On the project gas supply, the proven and probable natural gas reserves will ensure supply for at least another 20 years. The proposed project is to promote domestic gas consumption and supply gas to the central and northern regions of Nigeria.

2.3.4 Financial

After successful completion of the project, not many financial ventures are needed to sustain gas transmission. The Federal Government has approved new gas pricing and domestic supply obligation regulations.

The regulation will ensure financial sustainability of the project as gas will be sold to customers: power plants, fertilizer industries, and domestic use etc.

The project operator will use the profits derived from the sale of the natural resources to maintain and operate the project.

2.4 Project Development Options

Three (3) development options were identified for Proposed Ajaokuta-Abuja-Kaduna-Kano Gas Pipeline (Phase I) Project namely:

2.4.1 Implement Project Option

This is the proposed option for NNPC to carry-out the construction and operations of the pipeline project. This option will guarantee speedy economic development, increase revenue generation and eliminate gas flaring among other benefits.

2.4.2 Delay Project Option:

This project option sanctions the postponement of the project to a future date. This is the option of choice in time of severe economic or political crises, war or resentment to project by host communities or present unsustainably of the project. There is conducive economic and political atmosphere for the project in Nigeria at the moment. Thus delaying the project will delay all benefits associated with the project implementation.

2.4.3 No Project Option:

This option disallows the construction of the pipeline. This scenario will hinder the realization of the FGN dream of improved power supply, affect the expected revenue generation from sale of gas and negatively impact on the expected economic growth of the gas sector in Nigeria.

It will further put to hold the commencement of the independent power plant project. Gas flaring with its numerous environmental impacts will continue and Nigeria will be eluded of the benefits of clean economy.

2.5 Pipeline Route Survey

A survey of the Ajaokuta-Abuja-Kaduna-Kano Gas Pipeline (Phase I) Project was carried out to provide information on the environmental and technical difficulties that may be encountered during the construction with a view to finding a solution.

2.6 Pipeline Route selection Process:

The route selection was carried out in two phases by a multi disciplinary team and was based on a process that included desktop studies, group discussions and ground truthing. The route survey was conducted during the earlier part of the project and a change management process was implemented by the engineering team to ensure that any change or refinement to the route based on fact-on-the-ground or constraints were taken into account.

2.6.1 Phase I – Raw Route Assessment:

Phase I was carried out to identify potential pipeline routing corridor options. Several alternatives were considered by subjecting them to coarse evaluation to determine which of them had serious technical, financial or socio-economic constraints likely to compromise their desirability.

This was done through raw route assessment walks which were taken by a team comprising of the Design Engineers, Environmental Scientists, Surveyors, and Local contacts along the different routes identified by the survey team.

The purpose of the route assessment walks were among others:

- To obtain a firsthand information on the terrain of the proposed route.
- Identify environmental values and constraints that may influence the constructability of the pipeline following the completion of alignment, optimization modeling and design

The considered alternatives include the following:

- **Alternative 1**

The pipeline route will follow alongside the existing PPMC crude pipeline and gas pipeline route that transverse Ajaokuta to Kano. The ROW parallels existing crude pipeline in almost the length of the pipeline except in few areas where it vie-off and new ROW will be created. New route will be created in those areas where there are interposing human settlements or other factors precluding the alignment.

- **Alternative 2**

Acquisition of a new ROW route from Ajaokuta tie-in bye-passing Abuja to Kaduna and straight to Kano. This route is long and the FCT will not key into the gas project. It will pass through Kaduna city affecting built-up environment and will lead to destruction of private properties and social infrastructures. Compensation issues will arise and may likely to put the project on hold.

- **Alternative 3**

A third alternative involves creation of entirely new and shorter ROW from Ajaokuta through Abuja to Kano. This will impact heavily on the cost of the project and the environment; and will lead to serious socio-economic impact since some sections of the pipeline will pass through densely populated areas.

Two major options – Alternative 1 and Alternative 3 were selected for a further **Phase II** analysis based on least interference with human settlement, nature of terrain and capital expenditure and economic impacts.

2.6.2 Phase II – Fine Screening:

The Phase II analysis further evaluated the 2 selected route alternatives using fine screening methodology based on the criteria in **Table 2.1** below:

Table 2.1: Route Selection Criteria

Categories	Criteria
Land Use	Minimize the number of land owners – farmers affected and avoid settlements
	Minimize impact on Good Quality Agricultural Land (GQAL)
	Consider the terrain – river, stream, road, railway etc crossings
	Avoid steep slopes
	Proximity to existing ROW and other petroleum facilities.
	Avoid highly flooded or flood prone areas
Environmental Factors	Mangrove/Ecosystem damage
	Long term disturbance of natural habitat and wildlife
	Adverse effects of construction footprint and site access
	Adverse effects of hydrocarbon release to the environment.
	Adverse consequences of operation.
Engineering	Consider relevant engineering, construction and operational standards
	Consider constructionability including ease of transport of construction materials
	Avoid as much as possible proximity to high voltage power lines
	Consider future/planned development

Categories	Criteria
Socio-economic Factors	Minimal impact on human settlement Minimal impact to cultural sites Minimal impact to long term agricultural activities Minimal impact on fishing Ease of acquisition of ROW Susceptibility to future encroachment on ROW Negative impact on current industrial activities Ease of decommissioning
Health and Safety Factors	Negative impact of hydrocarbon release on human health Risk to people on construction project Risk to people due to operation
Capital Expenditure	Assess construction and operation costs Relative cost of infrastructure development Consider the route of shortest length of pipeline Consider current and future market development requirement
Reliability	Minimize risk of down time Susceptibility to interference and/or damage Susceptibility to terrorism, militancy and insurrection Susceptibility to vandalism Susceptibility to illegal off takes
Economic growth	Ease of gas supply to other industry using ROW Ease of expansion of market along the ROW Constraint on the future activities caused by ROW
Constructability	Risk due to failure during construction Negative community impact due to construction Logistic constraints Minimize rock excavation

Construction difficulty and cost

No major construction difficulty was identified along the proposed route during the surveys. The route selection procedure had tried as much as possible to avoid sensitive and rigid obstructions on the proposed pipeline route. Massive rocky areas were either negotiated or carefully interfered as minimal as possible.

The route did not pass through residential area thus minimizing interference with human settlement and associated socio-economic impacts. No artifacts and archeological sites were found along the proposed pipeline route.

The new pipeline will leverage on existing ROW and other facilities thus reducing further the cost and associated risks of the project.

Security of supply and susceptibility to sabotage

The survey revealed that the proposed route is optimal in that the security of pipeline and supply is high and susceptibility to sabotage is very minimal.

Flexibility and operability

This preferred route allows for maximum flexibility and future expansion. The practical issues of operational impediments and unhindered operation of the pipeline were optimal in the proposed route.

Communities' interference

The surveys indicated that Alternative 1 route provides the least route of interference with communities and other nomadic settlements along the pipeline route thereby avoiding serious communal conflicts that may hinder the smooth execution of the project.

2.6.3 Selected Alternative - Follow existing PPMC crude pipeline and gas pipeline route (Alternative 1)

Based on the above assessment, the selected alternative was **ALTERNATIVE 1** -*the pipeline route will follow the existing PPMC crude pipeline and gas pipeline route that transverse Ajaokuta to Kano*.

Table 2.2: Comparative Assessment of Alternatives 1 and 3

Categories	**Follow existing PPMC crude pipeline and gas pipeline route (Alternative 1)**	**Create entirely new and shorter ROW from Ajaokuta (Alternative 3)**
Land Use	Low Population and low impact on agricultural lands	Highly populated Low impact on agricultural lands
Environmental Factors	Short term disturbance of wildlife Minimal Ecosystem damage	Short term disturbance of wildlife Minimal Ecosystem damage
Engineering	High constructionability Isolated and away from major cities and high voltage facilities No identifiable interference with future planned development	High constructionability Mostly built-up environment Close and within major cities and high voltage facilities Likely interference with near-future planned development
Socio-economic Factors	Low impact on human settlement	High impact on human settlement
Health and Safety Factors	Low risk of accident and harm to people during construction	High risk of accident and harm to people during construction
Capital Expenditure	Lower cost of construction	Higher cost of construction
Reliability	High susceptibility to vandalism due to remote location of facilities	Low susceptibility to vandalism
Economic growth	Little or no constraints to future development activities	Little or no constraints to future development activities
Constructionability	High construction cost due to terrain. Compensation for economic trees and farmlands	Higher construction cost due to terrain and compensation due to built-up environment

CHAPTER THREE

3.0 PROJECT DESCRIPTION

3.1 Pipeline Route/Location

Proposed Ajaokuta-Abuja-Kaduna-Kano Gas Pipeline (Phase I) Project is the Phase 1 of the Trans-Nigeria Gas Pipeline Project that is driven by availability of additional gas supplies from Assa Gas Plant and the need of gas supply to the Northern / Eastern States through Obigbo-Umuahia-Ajaokuta pipeline and Ajaokuta-Kaduna-Kano pipeline.

The Proposed Pipeline shall transport natural gas from Ajaokuta via Abuja, Niger, Kaduna to a terminal station at Kano. The pipeline system has been chosen wherever practicable by utilising existing PPMC or NGC ROW. The total length of the proposed pipeline route from Ajaokuta to Kano TGS is approximately 740 km and has **7** major river crossings and 10 major road crossings.

There shall be spur lines from the Abuja Node to the Abuja TGS and another spur line between Kaduna node and Kaduna TGS.

The Ajaokuta to Lokoja section of the pipeline route shall be a new route. The route which starts at Ajaokuta off-take station follows the existing gas line to the west for 34 km, before crude and product line, joining from the south and further leading to the north.

This section shall run in north – north – western direction from Ajaokuta tie –in station through slightly hilly terrain to existing PPMC ROW of the multiple product and crude oil pipeline. The gas line leaves the route approximately at KP 74, whereas the crude oil line continues defining the route in principle up to Kaduna, and the products pipeline up to Kano, always leading basically in north-northeastern direction.

The Lokoja to Abuja shall follow mainly the PPMC ROW of the Multiple Product and Crude Oil Pipeline in northern direction up to Abuja. The pipeline shall pass in - between the Agbaja Plateau and the Niger River.

The Abuja to South – West Kaduna pipeline route shall follow mainly the PPMC ROW of the Multiple Product and Crude Oil Pipeline from Abuja and in northern direction up to South-West of Kaduna.

From South – West Kaduna the pipeline shall follow a new route and it shall be between the end point of last location and Kaduna TGS. The proposed route shall follow northern direction and pass Kaduna city in the west direction crossing the Kaduna River up to the proposed location of Kaduna Node.

The Kaduna Node to Kano section shall follow a new pipeline route in northeast direction until its tie-in in the ROW of PPMC and then follows this ROW until the Zaria Pump Station. After the station the line shall follow up northeast the PPMC ROW until the highway crossing near the Tiga River and then a new route to Kano TGS and in between it will cross the Reka River. In the entire the route shall cross seven times the highway Kaduna-Zaria-Kano and several other minor roads.

The project ROW lies within grid reference of N 07^{o} 28'—N 1I^{o} 52' Latitude and E 006^{o} 39' - 008^{o} 31' Longitude The project ROW location is shown in Figure 3.1.

3.1.1 Pipeline Route LGA/Communities

The communities and LGAs traversed by the pipeline route are presented in **Table 3.1**:

Table 3.1: Communities and LGAs traversed by the Pipeline Route

COMMUNITIES	STATE	LOCAL GOVERNMENT AREA
Ajaokuta	Kogi	Ajaokuta
Iloshi	Kogi	Ajaokuta
Zango Daji	Kogi	Adavi
Koton Karfe	Kogi	Kogi
Sensenyi	Kogi	Kogi
Abaji town	FCT	Abaji Area Council
Naharati Village	FCT	Abaji Area Council
Agyana	FCT	Abaji Area Council
Dangara	FCT	Kwali Area Council
Dafa	FCT	Kwali Area Council
Gwagwalada	FCT	Gwagwalada A/C
Kassanki	FCT	Gwagwalada A/C
Katchi Tsoho	FCT	Gwagwalada A/C
Kaida Sabo	FCT	Gwagwalada A/C
Dobi	FCT	Gwagwalada A/C
Tsauni	FCT	Gwagwalada A/C
Pabeyi	FCT	Gwagwalada A/C
Rafin Zurfi	FCT	Gwagwalada A/C
Ibwa	FCT	Gwagwalada A/C
Izom	Niger	Gurara
Lambata	Niger	Gurara
Bonu	Niger	Gurara
Kaffin Koro	Niger	Paikoro

COMMUNITIES	STATE	LOCAL GOVERNMENT AREA
Kaazai Kadara	Niger	Munya
Sarkin Pawa	Niger	Munya
Gwagwada	Kaduna	Chikun
Ligari	Kaduna	Chikun
Mando	Kaduna	Igabi
Kigimin Gobirawa	Kaduna	Igabi
Jaji	Kaduna	Igabi
Zango Aya/Lamban Zango	Kaduna	Igabi
Pangurza Gari	Kaduna	Igabi
Zaria	Kaduna	Zaria
Likoro	Kaduna	Kudan
Ungwan Samaila Kutakure	Kaduna	Markafi
Rahaman Wali	Kaduna	Markarfi
Gimi Gari	Kaduna	Markafi
Rumin Mamuda	Kaduna	Ikara
Kunkumi Rumi	Kaduna	Ikara
Zakau	Kaduna	Ikara
Gangarida Ikara	Kaduna	Ikara
Nasarawan Kofa Gwarmai	Kano	Bebeji
Tashan Alhaji	Kano	Kiru
Kunan Dandogari	Kano	Kiru
Chiromawa	Kano	Garin Mallam
Karfi	Kano	Kura
Tamburawa	Kano	Dawakin Kudu

The areas traversed by the pipeline route are shown in Figure 3.1.

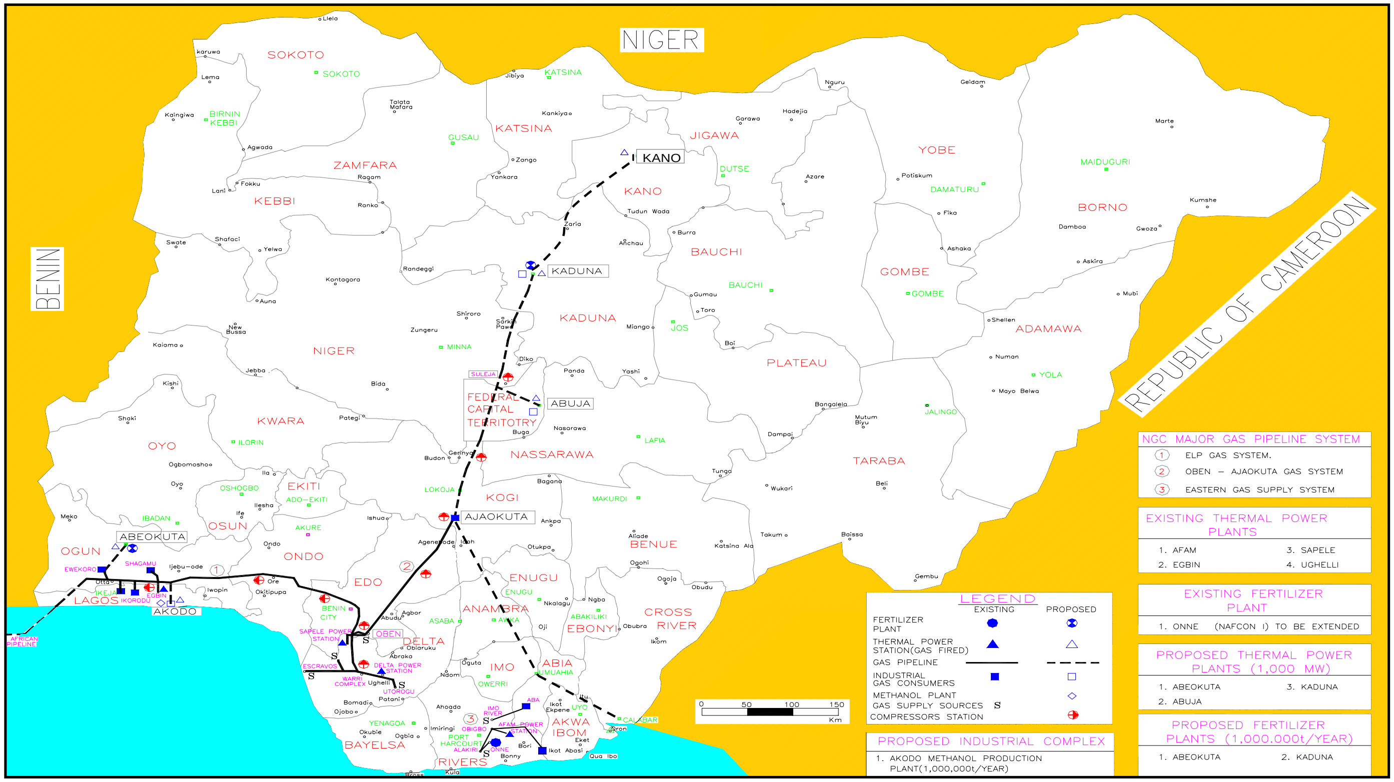

Figure 3.1: Areas traversed by the pipeline route.

3.2 Type of Project

The project shall involve the installation of a major gas transmission pipeline from a hub at Ajaokuta in the southern state of Kogi through to Kano in the north, supplying the major population centres of Abuja, Kaduna and Kano with gas for the further development of Nigerian domestic consumption. Sufficient capacity shall be built into the pipeline system to supply 2,000 mmscfd to a future trans-Saharan gas pipeline for export to European markets.

The proposed pipeline shall be supplied with pipeline quality gas at a minimum pressure of 1,000 psig at the Ajaokuta tie-in and deliver to Kano also at a minimum pressure of 1,000 psig.

In order to overcome transmission losses and enable selection of an economic pipeline diameter, a number of Compressor Booster Stations shall be installed at intermediate locations along the pipeline route.

Spur lines shall link the main pipeline with Terminal Gas Stations (TGS) at Abuja, Kaduna and Kano where the gas will be let down to a suitable pressure for consumer distribution and fiscally metering. The pipeline shall have three spur lines from the Abuja Node to the Abuja TGS, a distance of approximately 13.6km, from Kaduna node to Kaduna TGS approximately 200m and from Kano node to Kano TGS approximately 8.14km; respectively. A new ROW will be acquired for each spur line.

The pipeline shall be sized for an ultimate design capacity of 3,500 mmscfd. The Abuja and Kaduna spurs shall be sized for 250 to 500 mmscfd each leaving up to 2,500 to 3,000 mmscfd available at Kano for local distribution and export to the future trans-Saharan pipeline.

3.2.1 Gas Transmission Pipelines

The gas transmissions pipelines shall comprise dual pipes with a diameter of 48’’ and length of 740km along the route. The pipeline diameter shall be as follows;

- From Ajaokuta Tie-In Station to Kano TGS 2 x 48” pipelines.
- From Abuja Node to Abuja TGS 2 x 20” pipelines.
- From Kaduna Node to Kaduna TGS 2 x 20” pipelines

The pipe shall be supported by three booster compressor stations and consist of a strong carbon steel material engineered to meet standards set by the American Petroleum Institute (API), American Society of Testing and Materials (ASTM), and American National Standards Institute (ANSI). The consideration of dual is to cover pipeline damage or failure.
The pipeline feed gas shall meet the following base specification as shown in **Table 3.1.**

Table 3.2: Project Feed Natural Gas Specification

	Minimum	Maximum
Major and Minor Components, mole%		
Methane	75	-
Ethane	-	10
Propane	-	5
Butanes	-	2
Pentanes and heavier	-	0.5
Nitrogen and other inerts	-	4
Carbon Dioxide	-	4
Trace Components		
Hydrogen sulphide	-	24 mg/m^3
Mercaptan sulphur	-	24 mg/m^3
Total sulphur	-	460 mg/m^3
Water vapour	-	110 mg/m^3
Oxygen	-	1.0 cm^3/m^3
Other Characteristics		
Pressure kPag (psig)	6,793 (1,000)	8,517 (1,250)
Hydrocarbon dewpoint °C	-	10
Lower heating value, kJ/Nm^3 gross saturated	35,400	42,800

Liquids: Free of liquid water and hydrocarbons at delivery temperature and pressure.
Solids: Free of particulates in amounts deleterious to transmission and utilisation equipment.

The pipes shall be coated to ensure that the pipe does not corrode once placed in the ground. Also the coating shall be to protect the pipe from moisture, corrosive soils, and construction-induced defects, which cause corrosion and rusting. In addition, the pipes shall be cathodic protected.

The pipeline is designed to supply up to 2,000 mmscftd at Kano for onward transmission. The rating for the pipeline shall be specified to be 600# and at design temperature and pressure of 100 °C and 9,320 kPa (1 352 psig): ASME B16.5 (2003) respectively. The pipeline design flow capacity and pressure level is provided in Table 3.2

Table 3.3: Pipeline Flow Capacity and Pressure Level

Design Flow Capacity	
Wet Feed Gas Design Flow (Ajaokuta)	3,500 mmscfd
Dry Gas Design Flow (Ajaokuta)	2760 mmscfd
Abuja Terminal Gas Station	500 mmscfd
Kaduna Terminal Gas Station	500 mmscfd
Trans-Sahara Pipeline	2,000 mmscfd
Pressure Level	
Minimum supply pressure at Ajaokuta	1,000 psig
Distribution pressure at Abuja TGS	350 psig
Distribution pressure at Kaduna TGS	350 psig
Minimum battery limit pressure at Kano	1,000 psig

The construction corridor shall comprise of a standard working width of 28m, modified to a reduced working width of 22m in forested areas or an extended working width of 35m where terrain or other features demand.

The pipeline shall be buried to a minimum depth of 1m. The minimum cover, such as in areas of rocky terrain shall be 0.8m. Increased cover depth (as appropriate) shall be considered in areas of agricultural land. Where the pipeline traverses areas with sensitive groundwater aquifers, the depth cover shall be increased to 1.2m. The depth cover shall be increased to 1.5m at railway (3Nos) and main road (7Nos) crossings. At river crossings, the depth of burial shall be 1.5m below the calculated scour depth.

In areas of river crossings the pipeline shall be concrete coated to provide stabilization by ensuring negative buoyancy, combating the tendency for the pipeline to float. The key above ground installations (AGIs) associated with the proposed pipeline are as described below:

3.2.2 Booster Compressor Stations

The gas pipeline shall have three booster compressor stations and each station comprises two turbo compressor trains in operation with one spare train.

Each operating train shall normally pump the contents of one of the dual pipelines. The spare train shall be provided to be lined up to either pipeline in the event of a problem occurring with one of the normally operating trains.

The compressor power requirement shall be within the range of standard heavy duty Frame 5 gas turbines.

The optimum locations of the Booster Compressor stations shall be at 60km, 147 km and 440 km from Ajaokuta, yielding the pressure profile shown in Figure 3.2 below.

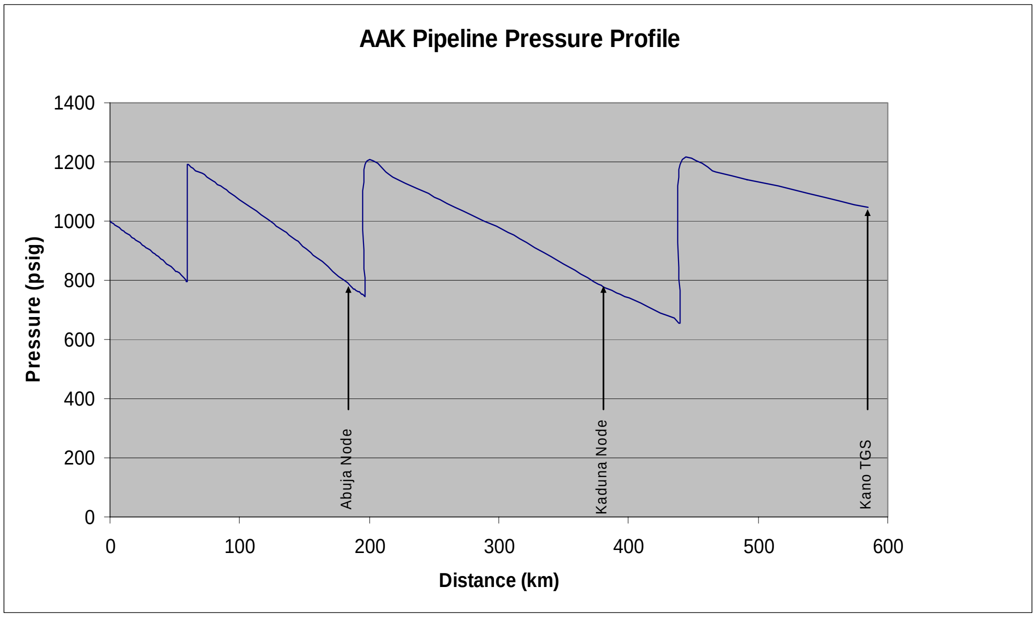

Figure 3.2 Pressure Profile of Proposed Pipeline Design

The Booster Compressor Stations shall be of similar design and feature the following process components:

- Incoming pipeline tie-ins
- Slug Catchers
- Pig Receivers
- Turbo compressors Package
- Pig Launchers
- Outgoing pipeline tie-ins

-
- Utilities:
  - Fuel Gas
  - Service Water
  - Fire Water
  - Drains
  - Emergency Flare System

3.2.2.1 Incoming Pipeline Tie-ins

Two piggable 48” ND 600# rated pipelines shall be provided to receive the feed gas supply to the Booster Compressor Stations.

3.2.2.2 Slug Catchers

Accumulation of liquid hydrocarbons in the pipelines is not anticipated except under extreme upset conditions.

However, slug catchers shall be provided to enable collection and disposal of any pipeline liquids that may occur. This will be confirmed during detailed engineering phase.

3.2.2.3 Pig Receivers

A pig receiver capable of receiving intelligent inspection tools as well as normal maintenance pigs shall be provided on each incoming pipeline tie-in.

3.2.2.4 Turbo compressors Package

Three parallel trains shall be provided at each Booster Compressor Station, two operating and one on standby. The compression duties are currently estimated at:

Booster Station 1

Altitude 150 m
Suction Flow 1491.2 mmscftd per train
Suction Pressure 772 psig @ 30 °C
Discharge Pressure 1200 psig
Power 26.85 MW @ 75% adiabatic efficiency

Booster Station 2

Altitude 400 m
Suction Flow 1235.7 mmscftd per train
Suction Pressure 736 psig @ 30 °C
Discharge Pressure 1200 psig
Power 25.66 MW @ 75% adiabatic efficiency

Booster Station 3

Altitude 700 m
Suction Flow 980.2 mmscftd per train
Suction Pressure 655 psig @ 30 °C
Discharge Pressure 1200 psig
Power 25.93 MW @ 75% adiabatic efficiency

The Turbo compressor package shall include all associated auxiliaries such as intake air filtration, lube oil systems, starter, exhaust stack, compressor interstage vessels and coolers, anti-surge valves, blowdown system etc plus an integrated turbo compressor control package.

3.2.2.5 Pig Launchers

A pig launcher capable of launching intelligent inspection tools as well as normal maintenance pigs shall be provided on each outgoing pipeline tie-in.

3.2.2.6 Outgoing Pipeline Tie-ins

The product gas from the Booster Compressor Stations shall be made to depart in two piggable 48” ND 600# rated pipelines.

3.2.2.7 Utilities

Fuel Gas

Fuel gas is required for fuelling the Gas Turbines. This shall be drawn off upstream of compression and passed through a gas conditioning, letdown and metering skid prior to routing to the Gas Turbine burners.

Service Water

It is envisioned that service water is provided via an on-site borehole. This will be filtered and treated as necessary subject to the borehole water quality.

Fire Water

A Fire Water inventory will be maintained sufficient to maintain a deluge system and foam monitors for the turbo compressor units. Make up water for this system shall be sourced from Service Water.

Drains

Accumulation of liquid hydrocarbons at this facility is not anticipated except under extreme upset conditions. However, a hydrocarbon drain system shall be provided routed to an underground drains vessel. The vessel contents can be pumped out periodically to a tanker for offsite disposal.

Emergency Flare System

An emergency flare system shall be provided for Booster Compressor Station blowdown in the event of an F&G initiated shutdown.

3.2.3 Terminal Gas Stations

The basic function of these stations shall be to meter the gas and reduce its pressure from that of the pipeline to that of the distribution to both industrial and domestic consumers.

The stations shall measure the gas flow with metering devices and reduce its pressure with pressure regulators. These devices shall control the rate of gas flow and/or pressure through the station and maintain the desired pressure or flow level in the distribution system to proposed power plants.

The Terminal Gas Stations at Abuja and Kaduna shall be of similar design and feature the following process components:

- Incoming pipeline tie-ins
- Slug Catchers
- Pig Receivers
- Dry Gas Filters
- Indirect-fired Heaters
- Pressure Letdown Stations
- Consumer Gas Metering

- Utilities:
  - Fuel Gas
  - Service Water
  - Drains

3.2.3.1 Incoming Pipeline Tie-ins

The feed gas supply to the TGS shall arrive in two piggable 20" ND 600# rated pipelines.

3.2.3.2 Pig Receivers

A pig receiver capable of receiving intelligent inspection tools as well as normal maintenance pigs shall be provided on each pipeline termination.

3.2.3.3 Dry Gas Filters

Dry gas filters shall be provided for incoming gas to be filtered and ensure the removal of solid particulate material with an efficiency of >99.95% removal of particles >10 microns. The installation shall be by a parallel arrangement of 5x25% dry gas filter units each rated for a maximum flow of 125 mmscftd.

3.2.3.4 Indirect Fired Heaters

To prevent condensation or frosting downstream of the pressure letdown stations, indirect fired heaters shall be installed to temper the gas prior to letdown.
An initial conservative estimate is a total duty of 4 MW to be accomplished by a parallel arrangement of 5 x 25% units.

3.2.3.5 Pressure Letdown Stations

Five parallel trains of letdown stations shall be installed, each rated for 125 mmscftd. Two shall serve domestic distribution, two for industrial users and one spare train which may be lined up to serve either.
The distribution pressures have yet to be confirmed, but an initial estimate has been made of 450 psig for industrial users and 160 psig for domestic distribution.
The letdown stations shall incorporate dual-redundant HIPPS shut off valves upstream of the modulating pressure control valves, actuated by dual-redundant pressure switches downstream to provide overpressure protection.

3.2.3.6 Consumer Gas Metering

Each pressure letdown station shall be followed by fiscal quality consumer gas metering prior to battery limit block valves. These metering shall allow for the monitoring, management, and accounting for the natural gas in the pipes. The metering shall measure the flow of gas along the pipeline, allowing tracking of natural gas as it flows along the pipeline. The Meter stations shall be constructed adjacent to the cleared pipeline right-of-way (ROW) at strategically located points to meter the flow and adjust the pressure of natural gas received from or delivered. The meter station shall include meter and regulator equipment, a filter separator, odorant equipment, and a control building housed within a fenced perimeter.

3.2.3.7 Utilities

Fuel Gas

Fuel gas shall be required for the Indirect Fired Heaters. This shall be drawn off downstream of the heaters and passed through a gas conditioning, letdown and metering skid prior to routing to the heater burners.

Service Water

It is envisioned that service water shall be provided via an on-site borehole. This shall be filtered and treated as necessary subject to the borehole water quality.

Drains

Accumulation of liquid hydrocarbons at this facility is not anticipated except under extreme upset conditions. However, a hydrocarbon drain system shall be provided routed to an underground drains vessel. The vessel contents can be pumped out periodically to a tanker for offsite disposal.

3.2.4 Pig Launching/Receiving Facilities

The Pigging facilities shall consist of pig launching or receiving equipment and allow the pipeline to accommodate a high-resolution internal inspection tool. Pigs are devices that are placed into a pipeline to perform certain functions. Some are used to clean the inside of the pipeline or to monitor its internal and external condition. Launchers and receivers are facilities that enable pigs to be inserted into or removed from the pipeline. The pig launcher shall be provided at the following locations:

3.2.4.1 Ajaokuta Tie-in

Scraper Launchers shall be installed to facilitate smooth intelligent and conventional pigging operations at the starting point of the Ajaokuta – Abuja - Kaduna – Gas Pipeline are at two (2 x 48”). The Scraper Launcher skids shall be located downstream of Ajaokuta Tie-In Station
The station shall comprise of following units:

- 2 x 48” Scraper Launcher Skids
- Vent Stacks
- Station Outlet Isolation Valves

Each trap shall be designed according to the respective pipeline code of ASME B31.8, with a design factor 0.5 based on DP, but with no corrosion allowance.
Scraper Launcher shall be equipped with quick opening closure, Barrel Flow Tee, by-pass with isolation valve having motorized actuator and open/close limit switches, a mainline full bore ball valve with motorized actuator and open/close limit switches, kicker line with isolation valve having open/close limit switches, cold vent & purge

connections with isolation valves, pressure safety valves and local pressure indicators & pig passage indicator.

The scraper launcher doors shall automatically be locked when the system is pressurised.

An insulating coupling (mono block type) shall be provided to isolate the aboveground pipeline section from the underground catholically protected pipeline.

Plate 3.1: Ajaokuta Tie-in area

3.2.4.2 Abuja Node Receiver/Launcher Station

Intermediate Scraper Receiver / Launcher Stations at Abuja shall be installed to facilitate smooth intelligent and conventional pigging operations.

The location of these stations shall be finalized keeping in view the travel limit specified for intelligent pigging tools and accessibility requirement.

At this station the spur lines hall branched-off the main line to Kaduna.

This Spur lines shall also have a Scraper Launcher Station.

The station shall comprise of following units:

- 2 x 48” Scraper Receiver Skids
- Station Inlet Isolation Valves
- Line Break Valves (ESD-Valves)
- 2 x 48” Scraper Launcher Skids
- 2 x 20” Scraper Launcher Skids
- Vent Stacks
- Station Outlet Isolation Valves

- Scraper Launcher / Receiver skid shall be equipped as mentioned before for the Scraper Launcher of Tie-In station.

- Temporary liquid handling facilities shall be provided during conventional and intelligent pigging.
- Scraper Launcher / Receiver shall be skid mounted, vendor supplied equipment.
- During normal operation the scraper launcher / Receiver shall remain by-passed and gas shall be passing through barrel flow tee.
- A Line break valve shall be installed in-between the Main Scraper Launcher and Receiver and the Scraper Launcher of the spur line, which will automatically shutdown pipeline system in case of any emergency or process upset.
- The valves shall also have a low pressure setting to close the downstream supply in case of a line break.
- The valves shall have the adjustable low and high-pressure settings.
- The valves shall have open/close limit switches installed for status indication.
- The vent stacks shall be sized to facilitate safe disposal of gas during conventional & intelligent pigging operation and shall have adequate height.
- The Scraper stations shall be protected by a surrounding concrete wall with a gate.
- At the top of the concrete wall an intruder wire shall be incorporated into a barbed wire fence to detect wire break, cut and elongation.

3.2.4.3 Kaduna Node Receiver/Launcher Station

Intermediate Scraper Receiver / Launcher Stations at Kaduna shall be installed to facilitate smooth intelligent and conventional pigging operations.

The location of these stations shall be finalized keeping in view the travel limit specified for intelligent pigging tools.

At this station the spur line shall branched-off the main line to Kano.

This Spur line shall have Scraper Launcher Station even the length of the spur line is short.

The station shall comprise of following units:

- 2 x 48” Scraper Receiver Skids
- Station Inlet Isolation Valves
- Line Break Valves (ESD-Valves)
- 2 x 48” Scraper Launcher Skids
- 2 x 20” Scraper Launcher Skids
- Vent Stacks
- Station Outlet Isolation Valves

Generally the Scraper Stations are facilitated and operated similar to the arrangement afore mentioned for Abuja Scraper Receiver / Launcher Station.

3.2.5 SCADA Centers

To manage the natural gas that enters the pipeline and ensure that gas is delivered timely to where it will be used, sophisticated control systems shall be installed to monitor the gas as it travels through all sections of the pipeline. To accomplish the task of monitoring and controlling the natural gas that shall be traveling through the pipeline, centralized gas control stations shall be installed to collect, assimilate, and manage the data received from TGS and power stations all along the pipeline.

Supervisory Control and Data Acquisition (SCADA) systems shall be provided to receive data from control stations.

The SCADA systems are sophisticated communications systems that take measurements and collect data along the pipeline (usually in metering stations and valves) and transmit the data to the centralized control station. Flow rate through the pipeline, operational status, pressure, and temperature readings are used to assess the status of the pipeline at any one time.

The information collected by the SCADA shall allows the proponent engineers to know exactly what is happening along the pipeline at all times, which permits quick reactions to equipment malfunctions, leaks, or any other unusual activity along the pipeline, as well as to monitoring load control.

Also, the SCADA systems allows certain equipment along the pipeline to be operated remotely; allowing engineers in the centralized control center to adjust flow rates in the pipeline immediately and easily.

The SCADA system shall be monitored 24 hours per day, 365 days a Year and it shall allow for the control or shut down portions of the pipeline in the event of an accident or for other safety reasons. They also are used to collect data at different system points as well as to feed data to other administrative function such as billing, marketing, and monitoring cathodic protection systems (at critical pipeline bond interconnect points and rectifiers).

3.2.6 Access Roads

Existing roads shall be used to provide access to the construction of the project ROW. The access roads shall be used on a temporary basis to transport personnel, equipment, vehicles, heavy trucks, and materials to project work areas. The roads that cannot support heavy construction equipment shall be used only for light truck traffic (e.g., pickup trucks).

In areas where there are no roads, access road shall be constructed. The required new access roads shall be designed with adequate slope and cross-fall drainage to channel storm water safely to off-road soak ways, thereby preventing erosion or siltation. The new roads shall be constructed with a sub – base, an asphalt base and top course in accordance with project specification.

Also, two-track and dirt roads shall be improve upon to support construction equipment, vehicles, and maintenance during the construction period, especially when rain occurs and travel over the roads degrades their condition.

Road improvements such as blading and filling shall be restricted to the existing road footprint wherever possible and where there is evidence that the road was graded previously.

3.2.7 Temporary Construction Facilities

The project temporary construction facilities shall comprise:

- Pipe Storage areas; and
- Construction camps

Pipe lengths shall be transported from the receiving port(s) and stockpiled at one or more main pipe storage areas. Pipe storage areas shall be set up at construction camps.

Constriction camps shall be constructed at various select locations. The locations of the construction camps have not been finalized including their land requirement. The construction camps shall accommodate workers, as well as visitors and third party contractors. Local workers shall be bussed to the working corridor from their villages and towns on a daily basis.

3.3 Pipeline Construction

Contractors experienced in major pipeline construction shall be selected by NNPC to undertake the construction of the pipeline, terminal and associated permanent facilities, working to the specification developed by NNPC. The pipeline and associated facilities shall be designed for a minimum period of 50 years.

Pipeline construction is a sequential process and comprises a number of distinct operations. The pipeline construction shall be achieved using a number of conventional construction spreads to accomplish pipeline installation and additional special section crews to accomplish river crossings and other specialized pipe segment installation.

The project construction procedure shall cover the following:

3.3.1 Survey and Staking

The first step of construction shall involve marking the limits of the approved work area (i.e., construction ROW boundaries, additional temporary workspace areas) and flagging the locations of approved access roads. Also, environmentally sensitive areas shall be marked or fenced for protection. Before the pipeline trench is excavated, a survey crew shall stakes the centerline of the proposed trench.

3.3.2 Clearing and Grading

Before clearing and grading activities are conducted, fences (if any) shall be braced and cut, and temporary gates and fences installed to contain livestock, if present. A clearing crew shall clear the work area of vegetation and obstacles (e.g., trees, logs, brush, and rocks). Grading shall be conducted where necessary to provide a reasonably level work surface. Extensive grading shall be carried out in steep side slopes, vertical areas, or wherever else necessary to avoid bending the pipeline excessively. The disposal points/locations of solid waste generated from clearing and grading activities shall be located at least 100m away from surface water and will be strategically sited by NNPC and approved by appropriate authorities during the construction phase.

3.3.3 Trenching

The trench shall be excavated to a depth that provides sufficient cover over the pipeline after backfilling. The trench shall be about 7m to 8m wide in stable soils and about 1.2m – 2.0m deep to the top of the pipe. Additional cover for the pipeline shall be provided at road and water body crossings, while less cover shall be required in rock.

Wheel trencher shall be used to dig the pipe trench.

When rock or rocky formations are encountered during trenching, tractor-mounted mechanical rippers or rock trenchers shall be used to fracture the rock prior to excavation. In areas where mechanical equipment can not break up or loosen the bedrock, blasting shall be used. During blasting explosives shall be used in accordance with state and federal guidelines to ensure a safe and controlled blast. Excavated rock shall be used to backfill the trench to the top of the existing bedrock profile.

In areas where there is a need to separate topsoil from the subsoil, the topsoil shall be graded prior to trenching. The topsoil over the ditch line shall be segregated for the majority of the project (unless requested otherwise). Clearing activity on the spoil side shall be limited to what is necessary for construction activity.

Topsoil shall be stored in a pile that is separate from the subsoil to allow for proper restoration of the soil during the backfilling process. Spoil shall be deposited on the nonworking side of the ROW, and gaps left between the spoil piles to prevent storm water runoff from backing up or flooding. Topsoil shall be returned to its original ground level plus some mounding to account for soil subsidence after the subsoil is backfilled in the trench.

3.3.4 Pipe Stringing, Bending, and Welding

Prior to or following trenching, sections of externally coated pipe up to 80 feet long (also referred to as “joints”) shall be transported to the ROW by truck over public road networks and along authorized private access roads and placed, or “strung,” along the trench in a continuous line.

After the pipe sections are strung along the trench and before joints are welded together, individual sections of the pipe shall be bent where necessary to allow for fitting the pipeline uniformly with the varying contours of the bottom of the trench. A track-mounted, hydraulic pipe-bending machine shall be used to shape the pipe to the contours of the terrain. The bending machine shall use a series of clamps and hydraulic pressure to make a very smooth, controlled bend in the pipe. All bending shall be performed in strict accordance with internationally prescribed standards to ensure the integrity of the bend. When a section of pipe requires multiple or complex bends, pipeline fittings such as elbows shall be installed.

Welding is the process that joins the various sections of pipe together into one continuous length. After the pipe sections are bent, the joints shall be welded together into long strings and placed on temporary supports. The pipe gang and a welding crew shall be responsible for the welding process. The pipe gang shall use special pipeline equipment called side booms to pick up each joint of pipe, align it with the previous joint, and make the first part of the weld. Additional filler passes shall be made by welders who immediately follow the stringer bead on what is called the welding firing line. Stringer, hot-pass, and capping welders shall make up the firing line, and they are followed in certain locations by tie-in welders. (On difficult-fit welds, the welder shall back-welds the pipe by welding the welds from the inside to assure the integrity of the weld.) The pipe gang shall then moves down the line to the next section and repeats the process. The welding crew shall follow the pipe stringing gang to complete each weld.

As part of the quality assurance process, each welder must pass qualification tests to work on a particular pipeline job, and each weld procedure shall be approved for use on that job in accordance with internationally adopted welding standards.

3.3.5 Lowering-in and Backfilling

The dual pipes shall be lowered in one trench; center to center distance of the pipes shall be 6.2m and distance between the edges of the pipes is 5m. Before the pipelines are lowered into the trench, they shall be inspected to be sure they are free of livestock or wildlife that may have become trapped in the trench, as well as free of rocks and other debris that could damage the pipe or protective coating. After welding is completed, the pipe crew shall install end caps (rubber expandable plugs) at the end of the pipelines to prevent debris and wildlife from entering the pipe. In areas where the trench had accumulated water since being dug, dewatering shall be carried out to allow inspection of the bottom of the trench. The pipelines shall then be lowered into the trench. On sloped terrain, trench breakers (stacked sandbags or foam) shall be installed in the trench at specified intervals to prevent subsurface water movement along the pipeline.

In rocky areas, the pipeline shall be protected with a rock shield (a fabric or screen that is wrapped around the pipe to protect it and its coating from damage by rocks, stones, roots, and other debris) or sand aggregate. In an alternative method, the trench bottom shall be filled with padding material (e.g., finer grain sand, soil, or gravel) to protect the pipeline. Topsoil shall not be used as padding material.

Skilled operators shall coordinate the lowering of welded pipe into the trench. Series of side-booms (tracked construction equipment with a boom on the side), shall be used to lift the pipe to ensure careful lowering of the welded sections into the trench. Nonmetallic slings shall protect the pipe and its coating as it is lifted and moved into position.

After lowering in, the trench shall then be backfilled using the excavated material. The backfilling crew shall take care to protect the pipe and coating as the soil is returned to the trench. The soil shall be returned to the trench in reverse order, with the subsoil put back first, followed by the topsoil. The segregated topsoil shall be restored to its original grade and contour last by using padding machine, depending on the soil makeup.

In areas where the ground is rocky and coarse, crews shall either screen the backfill material to remove rocks, bring in clean fill to cover the pipe, or cover the pipe with a material to protect it from sharp rocks. Once the pipe is sufficiently covered, the coarser soil and rock can be used to complete the backfill.

3.3.6 Hydrostatic Testing

The pipeline will be tested in segments. Test lengths and locations of test points shall be set out in the Test Plan and shall take account of the location of suitable water supplies and disposal facilities and allowable elevation difference.

The procedure will involve isolating the pipe segment with valves/ test manifolds, filling the line with water, applying pressure to 125% of the maximum allowable operating pressure (MAOP) for that pipeline and then maintaining that pressure for a period of 8 hours. The pipeline was designed with the maximum allowable operating pressure of 1000 psig and class location. Each valves will be checked for fluid bye-pass by visual, audible or remote means.,

The water used in hydrostatic testing shall be drawn from the local river, stream within the pipeline ROW or may be taken from municipal supplies and trucked to the site. The source to be used however depends on the location of the pipeline. Water for hydrostatic testing shall be obtained from surface water sources through specific agreements with communities and in accordance with Federal, State, and Local regulations.

If leaks are found, the leaks will be repaired and the section of pipe retested until specifications are met. Once a test section successfully passes the hydrostatic test, the water will be tested prior to discharge to the environment. Discharge shall be to a designated point in accordance with the test plan to be provided and will be controlled to ensure that all parameters meet the applicable discharge limit of DPR and FMENV respectively.

The total volume of water required for hydro-testing of the entire length of 740km is estimated at 63,055.4m^3 if there is no failures, based on the standard 852.1m^3/km. (**Stelpipe, 1991**).

The following safety precautions will be taken by NNPC or its Contractor for safety of workers and the general public during hydrostatic test.

- A site specific test plan for each test section shall be developed in addition to the following:
    - Place warning signs in or near populated areas.
    - Restrict access to the area involving the hydrostatic test (i.e. test shelter, manifolds, pressure pumps, instruments, etc.) to only those personnel engaged in the testing operations.
    - Prohibit major pipeline work not directly associated with the test operations around the pipeline sections being tested.
    - While the pipeline facilities are being pressurized and during the test, personnel not required for direct operations (checking for leaks, tightening gaskets, checking valve status, operating pumps, recording data, etc.) will be restricted from the area where the pipeline is being tested.
    - Provide and maintain a reliable transportation and communication system during the test operations whereby personnel directly involved in the test will be able to communicate test status or problems that develop during the test.
    - Check hoses, fittings, connectors, and valves for proper pressure rating.
    - Restrain and secure fill and discharge lines/hoses.

Prior to filling a test section with water, the Contractor would make a final check to verify the following:

- Valve body drain plugs have been removed, carefully cleaned, taped (Teflon) and replaced; all mainline valve assembly cross-overs are in open position (valves are isolated) (Do not test through mainline valves)
- Valves have been greased, stroked, and the packing tightened;
- Valve stops are properly set;
- All pipe and bolt connections are tight;
- Test manifolds are properly fabricated and tested;
- Pumps and compressors are in good working condition;
- Instruments are ready for use (proper charts installed, clocks wound, instrument calibration records validated, etc.); and
- Pigs are properly installed

3.3.7 Final Tie-in

Following successful hydrostatic testing, test manifolds shall be removed and the final pipeline tie-ins made and inspected.

3.3.8 Commissioning

After final tie-ins are complete and inspected, the pipeline shall be cleaned and dried by using mechanical tools (pigs) that shall be moved through the pipeline containing pressurized dry air. The pipeline shall be dried to minimize the potential for internal corrosion. Once the pipe is dried sufficiently, pipeline commissioning commences. Commissioning activities shall involve verifying that the equipment has been properly installed and is working, that controls and communications systems are functional, and that the pipeline is ready for service. In the final step, the pipeline shall be prepared for service by purging the line of air and loading the line with natural gas.

3.3.9 Cleanup and Restoration

After backfilling, final cleanup begins as soon as weather and site conditions permit. Trash and construction debris shall be cleaned up both during and after construction. Construction debris shall be cleaned up and disposed in approved waste disposal sites (for each affected state), and work areas final-graded. The crews shall restore the work areas to preconstruction contours. Appropriately spaced breaks shall be left in the mounded topsoil and spoil piles to prevent interference with groundwater runoff and irrigation. Segregated topsoil shall be spread over the surface of the ROW, and permanent erosion controls shall be installed.

The restoration crew shall carefully grade the ROW and, in hilly areas, install erosion-prevention measures such as interceptor dikes, which are small earthen mounds constructed across the ROW to divert water. The restoration crew also shall install riprap, which consists of stones or timbers, along streams to stabilize soils.

After permanent erosion control devices are installed and final grading has been completed, all disturbed work areas shall be attended to; reseeding to stabilize the soil, improve the appearance of the area disturbed by construction, and, in some cases, restore native flora.

Access along the ROW shall be restricted by using barriers to minimize unauthorized entry by all-terrain vehicles. Pipeline markers shall be installed at fence, waterway, and road crossings to show the location of the pipeline. Markers shall identify the owner of the pipeline and provide emergency information. Special markers shall also be installed to provide information and guidance to aerial patrol pilots.

3.4 Special Construction Procedures

In addition to standard pipeline construction methods, special construction techniques shall be used such as when constructing across paved roads, highways, railroads, steep terrain, and water bodies, and when blasting through rock. The techniques are described below.

Additional construction areas, or temporary extra workspaces, shall be required for construction at road crossings, railroad crossings, crossings of existing pipelines and utilities, stringing truck turnaround areas, horizontal directional drilling (HDD) entrance and exit pits, and open-cut water body crossings. These extra workspaces shall be located adjacent to the construction ROW and shall be used for such purposes as spoil storage, staging, equipment movement, material stockpiles, and pull-string assembly associated with HDD installation. Individual extra workspaces shall be returned to their preconstruction condition and former use following completion of construction activities.

3.4.1 Road, Highway, and Railroad Crossings

Major paved roads, highways, and railroads shall be crossed by boring beneath the road or railroad (see Table 3.3). Boring requires excavating a pit on each side of the feature, placing the boring equipment in the pit, and then boring a hole under the road at least equal to the diameter of the pipe. Once the hole is bored, a prefabricated pipe section shall be pushed through the borehole that will consist of either extra-heavy wall-thickness carrier pipe or two pipes consisting of an outer casing pipe and the inner carrier pipe. For long crossings, sections shall be welded onto the pipe string just before being pushed through the borehole. Boring activities shall result in minimal or no disruption to traffic at road, highway, or railroad crossings.

Smaller unpaved roads and driveways shall be crossed using the open-cut method where permitted by local authorities or private owners. The open-cut method shall require temporarily closing of road to traffic and establishing detours. In instances where a reasonable detour is not feasible, at least one lane of traffic shall be kept open except during brief periods when it is essential to close the road to install the pipeline. Posting signs shall be undertaken to help ensure safety and minimize traffic disruptions.

Table 3.3: Pipeline Major Crossings

Name of Crossings	GPS reading	Tentative Use of Crossing
Major Road		
Ajaokuta-Okene	N828345 E242246	Major road to, state, towns and communities
Kaduna-Zaria	E332453 N1175049	Major road to, state, towns and communities
	E347515 N1201483	
Zaria Kano	E357719 N1229411	Major road to, state, towns and communities
	E360821 N1231853	
	E3628041233346	

Name of Crossings	GPS reading	Tentative Use of Crossing
	E393408 N1256260	
	E4371151N1295973	
	E446119 N1308025	
Railway Line		
Before Kaduna River	E319467 N1142510	Transportation
Zaria area	E349068 N1206702	
	E358776 N1230591	
Towards Kano	E362838 N1233343	
Existing Pipeline	E241166 N836076	Petroleum Product transportation
	E238145 N851484	
	E238141 N854409	
	E241446 N872452	
	E255760 N898122	
	E257343 N906669	
	E259102 N908721	
	E266330 N921776	
	E271132 N926628	
	E273020 N928809	
	E273760 N931283	
	E272624 N962164	
	E274393 N973083	
	E273886 N981826	
	E272916 N991278	
	E284000 N1038000	
	E287445 N1061306	
	E288352 N1064943	
	E292000 N1078000	
	E296582 N1105143	
	E297246 N1107326	
	E308187 N112845	
	E310000 N1130000	
Rivers		
Oguro	E240771 N835530	Drinking, fishing and sand mining
Osara	E238360 N864824	
Niger	E273079 N984745	
Gurara	E280556 N1023000	

Name of Crossings	GPS reading	Tentative Use of Crossing
Kaiza	E292574 N1080946	
Kaduna	E315452 N1161424	
Tiga	E432319 N1287457	
Transmission Line	E292447 N1079946	Transmission of power to the North
	E295872 N1097870	
	E301252 N1115861	
	E320460 N1108803	
	E419448 N1275794	

3.4.2 Steep Terrain

Additional grading shall be required in areas where the proposed pipeline route crosses steep slopes. Steep slopes shall be graded down to a gentler slope to accommodate pipe-bending limitations. In areas where the proposed pipeline route crosses laterally along the side of a slope, cut-and-fill grading shall be carried out to obtain a safe, flat, work terrace.

On steep side slopes, soil from the high side of the ROW shall be excavated and moved to the low side of the ROW to create a safe and level work terrace. Under these circumstances, the topsoil shall be stripped from the entire width of the ROW. After the pipeline is installed, the soil from the low side of the ROW shall be returned to the high side, the topsoil shall be replaced, and the slope's original contours restored. In steep terrain, temporary sediment barriers such as silt fences and certified weed-free straw bales shall be installed during clearing to prevent the movement of disturbed soil off the ROW.

Temporary slope breakers that consist of mounded and compacted soil shall be installed across the ROW during grading, and permanent slope breakers also installed during cleanup.
Following construction, seed shall be applied to steep slopes, and the ROW shall be mulched with certified weed-free hay or non-brittle straw or covered with erosion-control fabric. Sediment barriers shall be maintained across the ROW until permanent vegetation is established. The elevation profile of the proposed main pipeline route is indicated Figure 3.3 below.

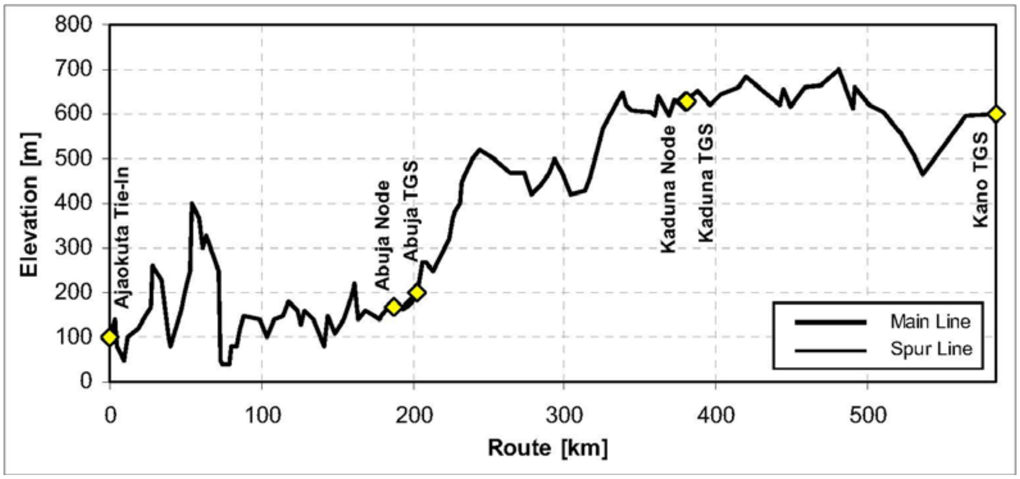

Figure 3.3: Pipeline Elevation Profile

3.4.3 Water body Crossings

The project water body crossing (see Table 3.3) shall involve the use of open-cut and HDD methods.

The preferred method of crossing a water body that is flowing at the time of construction is HDD compared to the open-cut method; HDD's low cost and lack of environmental impact makes it preferable.

The open-cut crossing method involves trenching through the water body while water continues to flow through the trenching area. If no water is flowing at the time of construction, the water body shall be crossed using conventional upland cross-country construction techniques.

The open-cut crossing method involves excavating a trench across the bottom of the river or stream to be crossed with the pipeline. Depending on the depth of the water, the construction equipment shall be placed on barges or other floating platforms to complete excavation of the pipe trench. If the water is shallow enough, the water flow shall be diverted with dams and flume pipe, which can allow backhoes working from the banks or the streambed to dig the trench.

The pipe shall be prepared for the crossing by stringing it out on one side of the stream or river and then welding, coating, and hydrostatically testing the entire pipe segment.

After crossing, concrete weights or concrete coating shall be installed to ensure that the pipe will stay in position at the bottom of the trench once the flotation devices are removed.

The HDD method involves drilling a pilot hole under the water body and banks and then enlarging the hole through successive reaming until the hole is large enough to accommodate a prefabricated segment of pipe. Throughout the process of drilling and enlarging the hole, a drilling mud shall be circulated through the drilling tools to lubricate the drill bit, remove drill cuttings, and keep the hole open.

While this drilling is in progress, the line pipe sections shall be strung out on the far side of the crossing for welding. Once welded, the joints are X-rayed, coated, hydrostatically tested, and then placed on rollers or padded skids in preparation for being pulled through the drilled-out hole.

Once the drilling operation is complete, the cutting head shall be removed and the drill string is attached to the welded pipeline segment. Drilling rig, winches, or dozers shall be used to pull the pipeline segment through the drilled hole, where it is then connected into the pipeline on both ends. Once the hole is bored, a prefabricated pipe section is pushed through the borehole that consists of either extra-heavy wall-thickness carrier pipe or two pipes consisting of an outer casing pipe and the inner carrier pipe.

Regardless of which crossing method is used, additional temporary workspace areas shall be required on both sides of all water bodies to stage construction, fabricate the pipeline, and store materials. For most crossings, these workspaces shall be located at least 50 feet away from the water's edge, except where the adjacent upland consists of actively cultivated or rotated cropland or other disturbed land.

Before construction, temporary bridges (e.g., clean rock fill over culverts, timber mats supported by flumes, railcar flatbeds, etc) shall be installed across all perennial water bodies to allow construction equipment to cross. Construction equipment shall cross by using the bridges, with the exception of the clearing crew, which is allowed one pass through the water bodies before the bridges are installed.

3.4.4 Blasting

Blasting operations shall be conducted under the direct and constant supervision of personnel legally licensed and certified to perform such activity in the jurisdiction where blasting occurs. Prior to any blasting activities, NNPC or its contractor shall provide appropriate information documenting the experience, licenses, and permits associated with blasting personnel.

Blasting-related operations including obtaining, transporting, storing, handling, loading, detonating, and disposing of blasting material, drilling, and ground-motion monitoring shall comply with applicable Federal, State, and Local regulations, permit conditions and the construction contract.

Blasting activity shall be performed during daylight hours and in compliance with manufacturers' prescribed safety procedures and industry practices. After blasting, the remnants shall be removed by backhoes or similar construction equipment.

No blasting will occur within 3 meters of existing pipelines or other structures. All blasting located along adjacent power line rights-of-way shall be conducted in a manner that will not cause damage to the power company property and facilities. The blast area will be backfilled or covered by blasting mats and/or other material as needed to protect nearby existing facilities, structures, highways, railroads or significant natural resources from thrown rock fragments.

Prior to any blasting, a site-specific blasting plan shall be developed.

Blasting operations will be carried out using any of the following explosives and method as the situation may require:

Dyno Nobel Unimax®

An extra gelatin dynamite with a specific gravity of 1.51 and a detonation rate of 19,600 feet per second (unconfined). The cartridge size will generally be 2" x 8" (1.25 lbs/cartridge) or 2" x 16" (2.50 lbs/cartridge).

Dyno Nobel Unigel®

A semi-gelatin dynamite with a specific gravity of 1.30 and a detonation rate of 14,200 feet per second (unconfined). The cartridge size will generally be 2" x 8" (1.15 lbs/cartridge) or 2"x 16" (2.30 lbs/cartridge).

Dyno Nobel Dynomax Pro™

A propagation resistant dynamite, with a specific gravity of 1.45 and a detonation rate of 19,700 feet per second (unconfined). The cartridge size will generally be 2" x 8" (1.225lbs/cartridge) or 2" x 16" (2.45lbs/cartridge).

Safety procedures

Strict safety precautions shall be followed if blasting is required to clear the ROW and fracture the ditch. Extreme care shall be exercised to avoid damage to underground structures, cables, conduits, pipelines, and underground watercourses. Adjacent landowners or communities shall be provided adequate notice in advance of blasting so they can protect their property and livestock.

The amount of explosives per borehole will be limited by the proximity of existing structures and utilities.

No flame, heat, radio transmitter or spark-producing device shall be permitted in or near explosives during handling, transport or use.

No person shall be allowed to handle, use or work in the area while under the influence of liquor, narcotic or dangerous drugs.

Explosives shall be accounted for at all times. Explosives not in use shall be kept in locked, approved storage magazines. A running inventory shall be maintained at all times. Appropriate authorities shall be notified of any loss or theft.

No explosives shall be abandoned.

No fires shall be fought where contact with explosives is imminent. All personnel shall be cleared and area guarded against other intruders.

When blasting in areas of congestion or in close proximity of other structures or services, special precaution will be taken to avoid damage or personal injury.

Every reasonable precaution shall be used to notify others of use of explosives (visual, audible, flags, barricades, etc.).

No onlookers or unauthorized personnel will be permitted within 305 meter during loading or blasting. Flaggers shall be stationed on roadways that pass through the danger zone to stop traffic during blasting operations.

Environmental Concerns

All residents within 232 meters of the blast will be notified one day before the blast day. All residents within 15.5 meter feet of the blasting operation shall be given five days notice to evacuate their residence during the loading, and blasting and one hour following the blast.

It is expected that all evacuated personnel could return to their homes by 6:00 pm.
All necessary measures will be taken to exclude livestock from the blasting area.

During the normal safety check prior to blasting, the area will be checked for both livestock and wildlife.

The blast will not be initiated until the area is clear.

Misfires

If there are any misfires, all employees shall remain away from the suspected misfire area for at least 15 minutes. Misfires shall be handled under the direction of the person in charge of the blasting. All leads shall be carefully traced and a search made for unexploded charges.

If a misfire is found, the blaster shall provide proper safeguards for excluding all employees from the danger zone.

No other work shall be done except that necessary to remove the hazard of the misfire and only those employees necessary to do the work shall remain in the danger zone.

No excavation, digging or picking shall be permitted until all missed holes have been detonated or the authorized representative has approved that work can proceed.

Prior to the end of the working day, any misfires shall be located and rendered safe.

3.4.5 Rugged Topography

The proposed pipeline route shall traverse areas containing side slopes and rolling terrain that could require the "two-tone" construction technique to provide for safe working conditions. In the two-tone construction technique, the uphill side of the construction ROW shall be cut during grading. The material removed from the cut shall be used to fill the downhill side of the construction ROW to provide a safe and level surface from which to operate heavy equipment; the pipeline trench shall then be excavated along the newly graded ROW.

The two-tone construction technique shall require extra workspace areas to accommodate the additional volumes of fill material generated by using this technique.

3.4.6 Construction Immediately Adjacent to Other Pipelines

Notification shall be sent to the company that owns the existing pipeline before construction begins in the vicinity of its facilities. No construction or excavation activities of any kind, including blasting, shall be carried out in the areas of existing pipeline's ROW before the actual locations of all affected facilities and the limits of the ROW is established. Personnel from the existing pipeline company shall be present during any construction or excavation activities.

In areas of existing pipeline, mats, dirt pads, or other approved protective materials shall be installed to adequately protect the existing pipeline from potential damage by heavy equipment crossing the ROW. The existing pipeline's personnel shall evaluate all proposed road crossings of buried facilities. Any additional overburden shall be removed after construction unless directed otherwise by the existing pipeline's owner.

In cases of blasting within 300 feet of existing pipeline facilities, it shall be submitted to the attention of the existing pipeline's owner in advance, along with a blasting plan outlining the proposed activity.

There will be no blasting until the existing pipeline's owner provides written confirmation that it does not object to such blasting.

Any directional drilling or boring proposed under the existing pipeline's buried facilities shall be submitted to the existing pipeline company for review and approval.

Adequate clearance shall be maintained from the existing facilities, and additional excavations done to ensure adequate clearance.

The proposed pipeline shall be constructed 40 feet from the existing pipelines wherever possible. In locations where this is not feasible, the new pipeline shall be located within 20 feet or less of one or both of the existing pipelines, generally between the two existing pipelines. The existing pipeline operator shall be contacted to restrict flows or reduce pressure in the existing pipeline during construction periods to allow heavy equipment to work over the existing line. Spoil from the ditch or trench shall be cast away from the existing pipeline, and no equipment shall move back and forth over the existing pipeline. Once construction is completed, flows and/or pressures in the existing pipeline shall resume at normal levels.

3.4.7 Aboveground Facility Construction Procedures

The aboveground facilities shall be constructed concurrent with pipeline installation, but construction shall be conducted by special fabrication crews that generally work separately from the pipeline construction spreads.

- **Meter Stations, Valves, and Pig Launcher/Receiver Facilities**

Construction of meter and regulator stations, mainline valves, and pig launcher/receiver facilities shall entail site clearing and grading, installation and erection of facilities, hydrostatic pressure testing, cleanup and stabilization, and installation of security fencing around the facilities.

Mainline valve sites shall consist of fenced area installed within the confines of the pipeline ROW.

3.4.8 Telecommunications Towers

Tower construction shall involve erecting about 40-foot-tall, three-leg communications tower with associated microwave parabolic dish antennas, including a self-contained about 11-foot by 21-foot by 9-foot-tall concrete communications building on a simple slab foundation. A propane tank shall be installed on the site to supply fuel to a backup emergency generator located inside the building. The area shall be graveled and fenced.

3.4.9 Corrosion Protection and Detection Systems

Corrosion in pipelines is a common phenomenon, and must be controlled effectively to prevent pipeline leaks or structural problems. Corrosion occurs when an electrical current flows naturally from a pipe into the surrounding soil, causing metal loss, or corrosion.

To impede this process on the project pipeline the metal from the soil, which occurs when the pipe is coated in the manufacturing process shall be insulated. The coating shall be rechecked at the construction site using a detector that looks for imperfections or gouges that could occur during transportation. In addition a new coating shall be applied at the welded joints between pipe sections by sandblasting the weld and then applying the new coat.

A cathodic protection system shall be installed to protect all underground and submerged pipeline facilities that are constructed of metallic materials from external, internal, and atmospheric corrosion.

Rectifiers and anode “ground beds” shall be installed at strategic points along the pipeline to further protect the pipeline from corrosion. Ground beds provide cathodic protection by inducing a very small electrical current into the soil, impeding the flow of electrons to the pipe. The rectifier that induces the current into the ground bed shall be checked regularly by pipeline personnel, who shall ensure that the system is applying sufficient current to maintain cathodic protection to the pipeline.

A protective epoxy coating or mastic shall be applied to the welded joints once the welds are approved. Line pipe shall receive an external coating, which inhibits corrosion by preventing moisture from coming into direct contact with the steel. This process is normally completed at the coating mill where the pipe is manufactured or at another coating plant location before it is delivered to the construction site.

All coated pipes, however, have uncoated areas 3 to 6 inches from each end of the pipe to prevent the coating from interfering with the welding process. Once the welds are made, the coating crew shall coat the field joint, the area around the weld, before the pipeline is lowered into the ditch.

Fusion-bond epoxy (RISERCLAD®, USA) shall be used in coatings for field joints. Prior to application, the coating crew shall thoroughly clean the bare pipe with a power wire brush or a sandblast machine to remove any dirt, mill scale, or debris. The crew shall then apply the coating and allows it to dry prior to lowering the pipe in the ditch. Before the pipe is lowered into the trench, the coating of the entire pipeline shall be inspected to ensure it is free of defects. The pipeline shall be electronically inspected, or “jeeped,” for faults or voids in the epoxy coating and visually inspected for faults, scratches, or other coating defects. Damage to the coating shall be repaired before the pipeline is lowered into the trench.

The MSDS for the Epoxy (RISERCLAD®, USA) is provided in **APPENDIX 3.**

The inner profile is treated by a process called pigging while the outer part of the pipe is already PVC coated so it doesn’t need any other treatment. No other chemical would be used during the construction and commissioning of the pipe

3.5 Pipeline Operations and Maintenance

Once the natural gas pipeline is in operation, the pipeline’s control center shall electronically monitor the operations 24 hours a day, 365 days a year.

Automatic monitoring and control of the entire pipeline shall be undertaken through the Supervisory Control and Data Acquisition (SCADA) system. Monitoring and control facilities shall be available locally and remotely from the pipeline control centre.

Numerous measures shall be built into the design of the pipeline to enhance the level of safety of routine operation. The measures shall include an increased design factor at all crossings (river, road, rail and fault), increased pipe wall thickness in sensitive areas and the strategic location of location of block valve stations, which shall serve to isolate sections in the case of pipeline rupture. In the event of a major incident involving the pipeline, the emergency response plan shall be set into immediate operation to mitigate adverse impact.

The maintenance programme shall be implemented to sustain smooth operation and to preserve the integrity of the pipe. Regular pipeline survey shall be carried out using a variety of technique including line walking, aerial surveys and intelligent pigging.

Monitoring shall pay particular attention to sensitive locations including crossings.

Routine operation and maintenance shall also be performed at all aboveground facilities by qualified personnel. Safety equipment, such as pressure-relief devices, fire detection and suppression systems, and gas detection systems, shall be maintained throughout the life of each facility. Mainline valves shall also be inspected, serviced, and tested to ensure proper functioning.

Vegetation management procedures during operation shall be performed in accordance with the pipeline's plan and procedures and include regular mowing, cutting, and trimming along most of the permanent pipeline ROW. However, a corridor that does not exceed 10 feet in width centered on the pipeline shall be maintained annually in a herbaceous state as required to facilitate periodic corrosion and leak detection surveys.

During operations, there shall be regular patrol of the pipeline. The patrol programme shall include periodic aerial and vehicle patrols of the pipeline facilities. These patrols shall be conducted to survey surface conditions on and adjacent to the pipeline ROW for evidence of leaks, unauthorized excavation activities, erosion and washout areas, areas of sparse vegetation, damage to permanent erosion control devices, exposed pipe, and other conditions that might affect the safety or operation of the pipeline.

The cathodic protection system shall also be inspected periodically to ensure that it is functioning properly. In addition, pigs shall be regularly sent through the pipeline to check for corrosion and irregularities in the pipe. Developed from earlier technology (mechanical pigs used for cleaning), smart pigs carry detection and logging tools that store data on the state of the pipeline, including data on metal loss, pits, gouges, and dents, while moving through the pipeline system. The smart pig shall be launched from a pig launcher (a spur off the mainline), run through the pipeline segment, trapped, and removed from the pipeline. The data is then downloaded from the smart pig data storage unit and analyzed.

Sub-surface warning tape shall be used to mark the position of the pipeline along its entire route. Low level marker posts shall be provided at all control locations, cathodic protection test stations, road, rail track and water crossings.

Where appropriate, markers shall be in line of sight contact with adjacent markers. All marker posts shall be provided with identification plates that will include telephone contact numbers to be used in the event of a pipeline incident. Aerial markers shall be installed at intervals of up to 5km along the route to assist in aerial surveillance of the route.

3.6 Project Abandonment

The natural gas pipeline project has a design life of 50 years. However, in the event of project termination/abandonment, the aboveground structures shall be typically removed, while subsurface structures shall be abandoned in place.

The buried pipeline shall be internally cleaned, purged of natural gas, isolated from interconnections with other pipelines, and sealed without removing the pipe from underground. A positive pressure of an inert gas (e.g., nitrogen) shall be installed, in case the pipe could be used in the future or to monitor damage.

This shall minimize surface disturbance and other potential environmental impacts.

The aboveground pipeline at meter stations shall be completely removed, including all related aboveground equipment and foundations, and the station sites restored to their original condition as closely as possible.

Upon abandonment of the pipeline, in part or in whole, the ROWs associated with the abandoned facilities shall be returned to the landowners/communities.

However, on federal lands, the pipeline ROW shall be used for another utility ROW (e.g., fiber-optic lines) depending on future decisions.

Abandonment of the pipeline facilities shall be subject to the approval of the FMENV. An environmental review of the proposed abandonment shall be conducted when the application is filed with the FMENV.

3.7 Project Environmental Factors

3.7.1 Emissions

During project operation and maintenance activities, gas emission shall result from venting, ruptured pipe and fugitive emission including dust from construction activities. Operation of natural gas ancillary facilities does not result in substantial air emissions under normal operating conditions. Only minor fugitive emissions of natural gas occur from small connections at meter station and valve sites.

The project pipeline best management practices (BMPs) shall include activities such as a set of cost-effective, widely applicable methane emissions reduction opportunities/options aimed at reducing leaks and process venting from the largest sources. They include the following activities for transmission pipelines:

- Implement directed inspection and maintenance (DI&M) programmes at terminal stations and surface facilities.
- Identify and replace high-bleed pneumatic devices.
- Identify and implement additional activities or partner-reported opportunities that can reduce methane emissions profitably

3.7.2 Water Supply

The construction camps will be provided potable and non-potable water for domestic use during construction. Water supply activities for the project shall not be limited to drilling, testing, producing, loading, transporting, storing and treatment of water and subsequent disposal of all waste resulting from treatment. It is estimated that the overall usage of potable water during construction and will be approximately 220 L/person/day.

Water for use other than for drinking and domestic use shall be sourced from the local rivers, streams, municipal supplies or boreholes to be constructed in every construction camps. These boreholes shall be handed over to the communities upon closure of the camp at the completion of construction.

3.7.3 Liquid Discharges

Project liquid discharge will be from the following;

- Wastewater from hydrostatic testing
- Condensate from scrapping
- Domestic and sanitary wastewater from camp site during construction
- Wastewater form construction site

The projected work force during the construction phase for the project is 400 – 450 personnel comprising skilled and unskilled labour. In all it is expected that three (3) camps will be built along the entire 740km stretch of the pipeline with an average of 150 persons per camp. Each camp shall be provided with a proper drainage system and mini-sewage treatment plant. All project liquid discharges to the environment shall be in line with regulatory requirement.

Temporary work site facilities such as vehicle refueling facilities, waste storage area, site offices, warehouse and lay-down area, maintenance workshop, prefabrication workshop, vehicle parking area, vehicle wash down, facilities and associated infrastructure such as water storage tanks, diesel generators and portable sewage treatment facilities will also be located within the construction camps.

Workshops and other facilities will be relocatable and will be moved to follow the construction as it progresses along the RoW on a need arise basis.

3.7.4 Waste generation and management

Wastes refer to any material (solid, liquid, gaseous or mixture) that is surplus to requirements. Waste management is an integral part of this project and a plan to handle the large volume of waste during construction, operation and decommissioning of the project is hereby taken into consideration. Waste management for the project shall be carried out in consultation and in line with the waste management guidelines of all the affected States Waste management board and shall be disposed at the affected States approved waste disposal sites.

NNPC and its contractors shall take all reasonable and cost effective measures to minimize the generation of wastes, through process of optimization and efficient procedures and good housekeeping.

The management of waste material generated during construction, operation and decommissioning will be dealt with in accordance to the principles of the waste and resource management hierarchy by employing the four R's (Reduce, Reuse, Recycle, and Recovery). The source, characteristics / nature, estimated quantity, potential impact, management and destination of each waste is described.

3.7.4.1 Waste Stream and handling during Construction Phase

Waste will be generated through the construction of the pipeline and associated infrastructure. The major waste streams generated during the construction phase include those wastes listed in **Table 3.3** below

Construction of the gas pipeline and associated infrastructure will generate minor quantities of non reusable or non-recyclable wastes. Green waste and spoil material will be re-used onsite during rehabilitation and steel pipe off-cuts, packaging and general waste will be transported to the nearest waste management area for segregation, storage and transport off-site by a licensed waste contractor.

Following the construction of a section of high pressure pipeline, hydrostatic pressure testing (hydro testing) will be conducted. Use of additives in hydrotest water will be minimized and, where possible, test water will be re-used to reduce the amount of water to be managed. If re-use is not possible, the water will be tested and managed as described in the **Section 3.3.1** under Hydro testing.

The hydrotest water management procedures will aim to maximize the efficiency of testing, taking into consideration the timing of construction and commissioning, and will follow good environmental practice.

Disposal to land will only occur where an assessment of water quality meets relevant criteria and relevant approvals have been obtained.

Wastes are solid, liquid or gaseous and may be further be categorized based on the following:

- **Corrosive** - acids, bases, and anything that causes visible destruction or irreversible alterations in human skin tissue or that has a severe corrosion rate on steel.
- **Oxidizer** - substances such as chlorate, permanganate, peroxide, or a nitrate, that yields oxygen readily to the environment.
- **Poison** - Poisonous gases or liquids of such a nature that a very small amount of the gas or vapor of the liquid mixed with air is dangerous to life. Examples include hydrogen sulphide or hydrogen cyanide.
- **Flammable** - describes a flammable liquid or gas or semi-solid or solid which has a flash point below 600C (1400F).
- **Medical Waste -** includes sharps (needles, syringes, and scalpels), bandages and any other material which is contaminated with blood or other bodily fluids. Generally this waste stream will be generated from the medics clinic.
- **Radioactive Waste** - waste that displays an activity greater than 70 Bq/gram (U.N. Class7).
- **Irritant -** liquid or solid which, upon contact with fire or when exposed to air, gives off dangerous or intensely irritating fumes but is not listed as a poison.
- **Putrescible –**decaying, organic matter including food, vegetation etc

Table 3.4: Major waste streams generated during the construction phase

Waste	Source	Characteristics / nature	Potential impact	Destination
Soils	Earthworks	Inert material	Erosion and sedimentation. Surface water quality degradation due to runoff from stockpiles.	Re-used onsite.
Green waste	Clearing of vegetation for construction of pipeline and facilities	Organic material	Release of waste causing contamination of land and surface water. Fire risk	Re-used onsite during rehabilitation. Weeds to be managed in a manner consistent with the appropriate weed classification and recognized weed management strategy.
Solid inert waste	Earthworks Pipeline construction waste and materials	Inert material general waste	To be inserted once characteristics known	Transported by a licensed contractor to a suitable licensed landfill/state owned waste management facilities
Recyclable	Pipeline construction waste	Organic, inorganic and inert material, recyclable	To be inserted once characteristics known	Transported by a licensed contractor to a recycling facility where possible. Remainder transported by a licensed contractor to a suitable licensed landfill.
Hydrotest	Pipeline testing	Water with potential contaminants of silts, cleaning chemicals, traces of biocides and oxygen scavengers	Groundwater contamination. Release of hydrotest water causing erosion and degradation of biodiversity i.e. native flora and fauna.	Discharge to land.

Waste	Source	Characteristics / nature	Potential impact	Destination
Stormwater	Rainwater run-	Water with potential contaminants, including silt and possible oils from plant and equipment spills	Erosion and Sedimentation. Surface water quality degradation due to contaminated runoff.	

3.7.4.2 Waste Stream and handling during Operational Phase

The operation phase of the pipeline project will generate minimal wastes. Waste oils and greases will be generated during inspection and maintenance activities on the pipeline and from the aboveground facilities (i.e. mainline valves, scraper stations, compressor stations etc).

These wastes will be stored and bunded before being transported off-site to a suitable recycling facility or licensed landfill. Scheduled inspection and maintenance activities for the pipeline include pigging, which may result in the generation of sludge and dust.

This is classified as regulated waste and will require transport by a licensed contractor to a licensed regulated waste landfill or other waste management facility in the affected state. The major waste streams generated during the operational phase are identified in **Table 3.5** below.

Table 3.5: Major waste streams generated during the Operational phase

Waste	Source	Characteristics/ nature	Potential impact	Destination
Filters	Delivery and metering stations	General waste	Release of waste causing contamination of land and surface water. Visual amenity impacts due to poor housekeeping.	Transported by a licensed contractor to a suitable licensed landfill or other waste management facility.
Sludge and dust (pigging)	Pipeline maintenance	Regulated waste	Release of waste causing contamination of land and surface water. Releases causing degradation of biodiversity i.e. native flora and fauna. Visual amenity impacts due to poor housekeeping.	Transported by a licensed contractor to a suitable licensed landfill or other waste management facility.
Packaging	Pipeline maintenance	General and recyclable waste	Release of waste causing contamination of land and surface water. Releases causing degradation of biodiversity i.e. native flora and fauna. Visual amenity impacts due to poor housekeeping.	Transported by a licensed contractor to a recycling facility where possible. Remaining waste to be transported to licensed regulated waste landfill.

3.7.4.3 Waste Stream and handling during Decommissioning Phase

During the decommissioning phase minimal wastes will be produced provided that the pipeline is purged of gas and left in the ground. The report does not cover a detailed assessment of the type and quantity of waste generated during decommissioning of the pipeline. However, it can be expected that all aboveground facilities and equipment will be dismantled and removed.
Where feasible, the following material and equipment will be re-used.

- Mainline valves;
- Scraper stations;
- Generators.
- compressors

The material and equipment likely to be suitable for recycling includes:

- Steel;
- Electrical equipment and cabling;
- Control systems equipment; and
- Fencing.

The material and equipment likely to be unsuitable for either re-use or recycling and may require disposal includes:

- Plastic and glass fiber reinforced plastic tanks; and
- Sludge from pipelines and equipment.

3.7.4.4 Waste and resource management hierarchy principles

Waste avoidance

Waste avoidance will be targeted through adoption of alternative products and implementation of procurement processes which include the provision of contracts with companies which have documented sustainable waste management practices.

Waste reduction

Where possible, contracts will be established with companies that minimize waste through their production process, maximize recycling of waste produced and maximize recycling opportunities for the used end product and associated packaging waste. Procurement of pre-fabricated materials will be encouraged to reduce the quantity of waste generated on site.

Waste re-use

The re-use of waste will be achieved through identifying at the earliest opportunity materials which can be re-used during the construction period. Items such as timber skids, sand bags, timber pallets and hydrotest water are examples of materials that will be targeted for reuse. To maximize re-use opportunities, materials will be segregated within the designated waste storage areas along RoW.

Waste recycling

Waste recycling will be a large component of the waste management strategy. The collection of waste materials for recycling will be integral to the management of waste during construction of the project. A large percentage of the waste generated by the wider Project can be recycled, including:

- Waste oils/ Oils generated from plant and equipment maintenance
- Construction materials including pipe off-cuts and timber;
- Timber generated from pallets, skids and off cuts (once reused)
- Scrap ferrous and non-ferrous metal;
- Welding consumables; and
- Dry recyclables like paper, cardboard, plastic and glass, tins and cans.
- Ferrous and non ferrous metals generated from the pipe welding and cutting process

Other potentially recyclable materials will be treated in accordance with the principles of the waste and resource management hierarchy where opportunities exist.

Regulated waste that can be recycled will be transported off-site by a licensed contractor to an appropriate recycling facility.

Table 3.6: Outline of the recyclable products.

Recyclable product	Potential end use	Marketability
Scrap ferrous metal	Scrap metal will be managed via a third party licensed recycling contractor. The product will be removed from the site, shredded and either re-smelted or used in the smelting process. Any grade of steel can be recycled to top quality new metal.	High marketability with continual high demand from local and global market available.
Paper, cardboard, glass, some plastics, tins and cans	These recyclable wastes will be managed via a third party licensed recycling contractor. The products will be removed from site and taken to a material recovery facility to sort according to specifications, baled, shredded, crushed, or otherwise prepared for resale.	Medium marketability as the demand from Australian and global markets for these products are unstable and will fluctuate.
Waste oils	Waste oils will be managed via a third party licensed recycling contractor. The oils will be taken from the site, filtered and demineralised and distilled to produce re-refined base oil suitable for use as a lubricant, hydraulic or transformer oil.	High marketability with Queensland markets available to recycle this waste.
Decommissioning equipment	A decommissioning plan will be developed that will maximize recycling opportunities. Ferrous metals and non-ferrous metals will be managed as above. Plant and equipment will be sold.	Medium to high marketability due to high value recyclable materials generated.

3.7.4.5 Waste disposal

Disposal of wastes will only be used where there is no other option available. General waste will be transported to a local landfill for disposal in accordance with regulatory requirements. Regulated waste will be transported off-site by a licensed contractor to an appropriate regulated waste facility.

Disposal sites shall be identified in every state for where licensed waste contractors will use for the disposal of general waste.

3.8 Pipeline Project Development Schedule

The overall developmental schedule for this project is not definite at this stage of the study. The EIA presently forms a part of the defined first stage of the project. The project's first stage consist a series of pre-construction activities (See Figure 3.4 for a detailed schedule) which includes;

Milestone 1

- Completion of Optimisation Design
- Completion of Environmental Impact Assessment studies

Milestone 2

- Completion l of Detailed Engineering Design
- Approval of Flow Assurance Modelling
- Completion and approval of Design Packages

Milestone 4

- Contracting Services for the Engineering Procurement and Construction (EPC) Phase
  - Bid Preparation and Evaluation
  - Contract Award

Milestone 5

- Commencement of construction and civil work
- Completion of work
- Commissioning and handover
- Commencement of operation

SCHEDULE FOR THE ENGINEERING, PROCUREMENT & CONSTRUCTION (EPC) OF PROPOSED AJAOKUTA-ABUJA-KADUNA-KANO GAS PIPELINE (PHASE 1) PROJECT

ID	Task Name	Duration	Start	Finish	Predecessors
1	**MILESTONE 1**	**314 days**	**Mon 6/2/14**	**Thu 8/13/15**	
2	Completion of Optimisation Design	180 days	Mon 6/2/14	Fri 2/6/15	
3	Completion of Environmental Impact Assessment	180 days	Fri 12/5/14	Thu 8/13/15	
4	**MILESTONE 2**	**82 days**	**Mon 2/9/15**	**Tue 6/2/15**	
5	Completion and approval of Design Package	30 days	Mon 2/9/15	Fri 3/20/15	
6	**Contracting Services for EPC (Engineering, Procurement & Construction)**	**52 days**	**Mon 3/23/15**	**Tue 6/2/15**	
7	Bid Preparation and Evaluation	45 days	Mon 3/23/15	Fri 5/22/15	5
8	Contract Award	7 days	Mon 5/25/15	Tue 6/2/15	7
9	**MILESTONE 3**	**1740 days**	**Wed 8/1/12**	**Tue 4/2/19**	
10	Mobilisation of Construction Crew and Equipment	180 days	Wed 8/1/12	Tue 4/9/13	
11	Procurement of Major Lead items	360 days	Wed 6/3/15	Tue 10/18/16	8
12	Commencement of Construction and Civil works - Camps, Ancilliary Infrastructure, Pipe	700 days	Wed 6/3/15	Tue 2/6/18	8
13	Completion of all Construction and Civil works	300 days	Wed 2/7/18	Tue 4/2/19	12
14	**MILESTONE 4**	**153 days?**	**Wed 4/3/19**	**Fri 11/1/19**	
15	Testing and Commissioning	150 days	Wed 4/3/19	Tue 10/29/19	13
16	Handover	2 days	Wed 10/30/19	Thu 10/31/19	15
17	Commencement of Operation	1 day?	Fri 11/1/19	Fri 11/1/19	16

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Page 1

Figure 3.4: Detailed Project Completion Schedule

CHAPTER FOUR

4.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 General

This chapter shall identify and describe those environmental components that may be significantly impacted by the project. Also, it shall provide sufficient information and give a brief but clear picture of the existing environmental components and values. The components and values include:

- The physical component
- Ecological component
- Human and Economic development
- Quality of life values

4.2 Study Area

A clear delineation of the study area was carrired out prior to field Investigation and was between 13th and 14th of November 2009. This initial site verification was done to define the project area.

Visual observations and assessment of the terrestrial and surface water habitat were made during the reconnaissance to delineate the study area and sampling point were chosen to fall within 4km (two kilometer on each side of the route) corridor of proposed pipeline route.

The key features of visual assessment included:

- Location and grid referencing of areas to be extensively studied
- Nature of the areas where the project is proposed
- Ecological characteristics of natural community
- Slope, feature, drainage and other habitat parameters
- Transient and resident populations of mammals in different seasons of the year
- Gross impacts/community disturbance
- Existing resource use associated with the project areas (fisheries, tourism, cultivation, forestry practices).

Observation on settlement, ecological characteristics of the study area, faunal status, floral diversity and habitat quality were carried out within 4km corridor of the route.

Information generated during visual assessment was used to gain sufficient justification to set the limit of the study area within 2km corridor of the project route and it includes area between the project ROW and the radial distance of 1km; the area represents the hub of the major activities and is therefore likely to receive the maximum impacts of the project related activities. Most of the changes in the landscape were also expected to occur in this area. Area outside the corridor is outside the impact of project related disturbance.

4.3 Environmental Baseline Study Methodology

A multi-displinary approach was employed in the acquisition of baseline data for the study area, from terrestrial and aquatic system to socio-economics of the study area. The different methods deployed are further discussed below.

4.4 Literature Review

This involved searching relevant published and unpublished information, research publications, previous reports, technical presentations on the geographical, geological, meteorological and hydrological features of the project area. Information were collected from different Government departments and agencies' records; National Meteorological Agency, Ministry of Forestry, Ministry of Lands and used to define scope of field work.

Existing studies of the project area was collected (KNOC, Field Data, 2008) and used to form an important source of data for wet season baseline data.

4.5 Field observation

Field observations were documented using visual records and photographs. Features observed include; land features, infrastructures, community and settlement pattern, entonomology, landuse, archealogical, sacred places, shrines and vegetation cover.

4.6 Field Investigation Methods

Following the reconnaissance survey and delineation of study area, field Investigation was carried out for dry season between 14th and 22nd December 2009 under the supervision of Federal Ministry of Environment (FMENV); to cover the wet season data of the study area. The fieldwork activities were carried out in accordance with the FMENV, DPR and other international standards and guidelines

The wet season data (2nd and 13th of June 2008) used in the preparation of the report came from a study on the same route by Korean National Oil Company (KNOC) with permission from FMENV.

The physical component, ecological component, human and economic development and quality of life values of the study area were invesKanoted.

GPS and locals (including security men of existing NNPC pipeline) aided in the tracking of existing line, which was used to access and locate the proposed line and subsequent sampling and consultation with affected community.

The sampling locations are shown in **Table 4.1** and **Figure 4.1**. The sample custody form is shown in **Appendix-4-1**.

The sampling procedures adopted were designed to achieve scientific accuracy. The following methods were considered: -

- Phasing of samples to identify the areas of interestCollection of soil samples: surface soil (depth of 0-20cm) and sub soil depth of (20-50cm) to obtain data on the quality of soil.
- Quantity of samples collected.
- Sample points identification/geo -referencing
- Samples storage and preservation
- Stratified random sampling

Table 4.1: Description of Field Sample Locations

Sampling Number	Sample Location Area Description	Type of Sampling	GPS Reading	Elevation (m)
AAK - 1	Ajaokuta – Start-up area, Weather	Soil, core soil sample, air quality and noise, groundwater	E0244102 N0826050	71.9
AAK – 2	Ofunene Stream Area	Soil, air quality and noise, surface water, Flora and Fauna, plankton, sediment	E0241723 N0826062	73.6
AAK – 3	Geregu Power Station	Air quality and noise, groundwater	E0241507 N0826561	76.3
AAK - 4	Oguro River	Surface water, Flora and Fauna	E0240606 N0835465	42.0
AAK - 5	Agbada village area	Air quality, noise, core soil sample, Flora and Fauna	E0240102 N0842863	91.5
AAK - 6	Vegetation area between Agbada and Osara River	Soil, air quality and noise, Flora and Fauna	E0239226 N0864547	130
AAK - 7	Osara River	Surface water, sediment	E0240149 N0867947	93.1
AAK - 8	Zango Dagi Area	Soil, air quality and noise, core soil sample, Vegetation, groundwater	E0242134 N0876215	170
AAK – 9	River Niger Area	Soil, air quality and noise, core soil sample, Vegetation,	E0251748	53.1

Sampling Number	Sample Location Area Description	Type of Sampling	GPS Reading	Elevation (m)
		Weather	N0893365	
AAK - 10	River Niger and River Niger Area	Soil, air quality and noise, flora and fauna, surface water, plankton, sediment	E0252417 N0893428	40.3
AAK - 11	Korton Karfi Area	Soil, air quality and noise, core soil sample, flora and fauna, groundwater	E0258752 N0908356	150.3
AAK - 12	Sensenyi Area	Soil, air quality and noise, flora and fauna, groundwater	E0271675 N0927585	180
AAK – 13	Abaji Area	Soil, air quality and noise, core soil sample, flora and fauna groundwater	E0271821 N0938827	185
AAK – 14	Dangara area	Soil, air quality and noise, flora and fauna groundwater	E0269998 N0949997	114.4
AAK - 15	Kwaita River	Plankton, Air quality and noise and surface water and sediment	E0271892 N0959353	101
AAK - 16	Dafa Area	Soil, air quality and noise, flora and fauna	E0275195 N0973146	135
AAK – 17	Kurara River	Plankton and surface water and sediment	E0273067 N0984738	130
AAK - 18	Kassanki Village Area Tie in to Gwagwalada	Soil (surface and sub), air quality and noise, groundwater	E0272946 N0991336	175.2
AAK - 19	Echun River	Plankton and surface water and sediment	E0273933 N0999209	157
AAK - 20	Kaida village Area	Soil, air quality and noise, flora and fauna groundwater, Weather	E0273999 N0999309	155
AAK - 21	Gurara River	Plankton, sediment and surface water	E0280690 N1022878	235.1
AAK - 22	Bonu area	Soil (surface and sub), air quality and noise groundwater	E0280802 N1031814	382
AAK - 23	Before Kaiza area	Soil (surface and sub), air quality and noise	E0286084 N1050058	523
AAK - 24	After Kaiza area	Soil (surface and sub), air quality and noise groundwater	E0288260 N1064521	497
AAK - 25	Kazai (Kaffin Koro) area	Soil, air quality and noise	E0286127 N1052531	526.0

Sampling Number	Sample Location Area Description	Type of Sampling	GPS Reading	Elevation (m)
AAK - 26	Kazai River	Surface water and Biological and sediment	E0292652 N1080778	422.1
AAK - 27	Sarkin Pawa River	Surface water air quality and biological and sediment	E0296751 N1105835	405.5
AAK - 29	Gwagwada Area	Soil, air quality and noise, core soil sample groundwater and flora and fauna	E0312747 N1134952	637.3
AAK - 30	Before Ligari area	Soil, air quality and noise	E0316637 N1139293	635.3
AAK - 31	Ligari road area	Soil, air quality and noise, core sample and flora and fauna groundwater	E0315756 N1155899	608.5
AAK - 32	River Kaduna	Biological, surface water and air quality and sediment	E0321568 N1159842	561.4
AAK - 33	Kawo/Mando, near NDA new site	Soil, air quality and noise, core sample groundwater	E0322435 N1171125	622.0
AAK - 34	Kaduna: outskirt	Air quality, Noise	E0332476 N1174196	614.0
AAK - 35	Ka Gini	Soil, air quality and noise, core sample and flora and fauna	N0344373 N1185643	643.0
AAK - 36	Jaji area	Soil, air quality and noise, groundwater, Weather	E0346537 N1196818	656.2
AAK - 37	Zangon Aya Area	Soil, air quality and noise, groundwater	E0348985 N1209302	686.7
AAK - 38	Fangonzan Gari Area	Soil, air quality and noise, groundwater	E0349808 N1208976	693.6
AAK - 39	Zaria	Soil, air quality and noise,	E0353810 N1224520	674.0
AAK - 40	Before Likoro	Soil, air quality and noise,	E0363675 N1233697	636.0
AAK - 41	Likoro Area	Soil, air quality and noise, groundwater	E0368985 N1237735	647.1
AAK - 42	Ungwan Samaila Area	Soil, air quality and noise, groundwater	E0378302 N1246917	665.2
AAK - 43	Rahman Wali Area	Soil, air quality and noise, core sample	E0381396 N1248907	657.4

Sampling Number	Sample Location Area Description	Type of Sampling	GPS Reading	Elevation (m)
AAK - 44	Gimi Area	Soil, air quality and noise, flora and fauna groundwater	E0384132 N1252135	665.2
AAK - 45	Rumi Area -1	Soil, air quality and noise,	E0392725 N1255850	673.4
AAK - 46	Rumi Area -2	Air quality and noise groundwater	E0392634 N1255996	675.1
AAK - 47	Kungumi	Air quality and noise groundwater	E0394145 N1256138	668.4
AAK - 48	Zakau	Air quality and noise groundwater	E0399856 N1259445	648.4
AAK - 49	Sabo Gida	Air quality and noise groundwater	E0404670 N1262535	635.0
AAK - 50	Nasarawan Koba/Gwarmai Area	Soil, air quality and noise and core soil sample	E0419157 N1275445	609
AAK - 51	Before Kano River	Soil, air quality and noise,	E0422695 N1279786	541
AAK – 52	Kano River	Biological, air quality and surface water and sediment	E0432335 N1283552	467.4
AAK – 53	Chiromawa	Air quality and ground water	E0435888 N1287457	492.8
AAK - 54	Before Karfi	Soil, air quality and noise,	E0443094 N1305515	448.0
AAK – 55	Karfi	Air quality and noise, ground water, Weather	E0444752 N1306956	445.8
AAK – 56	Challawa River	Flora and fauna, air quality and surface water and sediment	E0448993 N1312097	437.0
AAK – 57	Tamburawa	Air quality and noise and groundwater	E0449036 N1312264	451.1
AAK – 58	Pipeline Terminal point Area	Soil, air quality and noise, flora and fauna and core soil sample	E0443688 N1317164	472

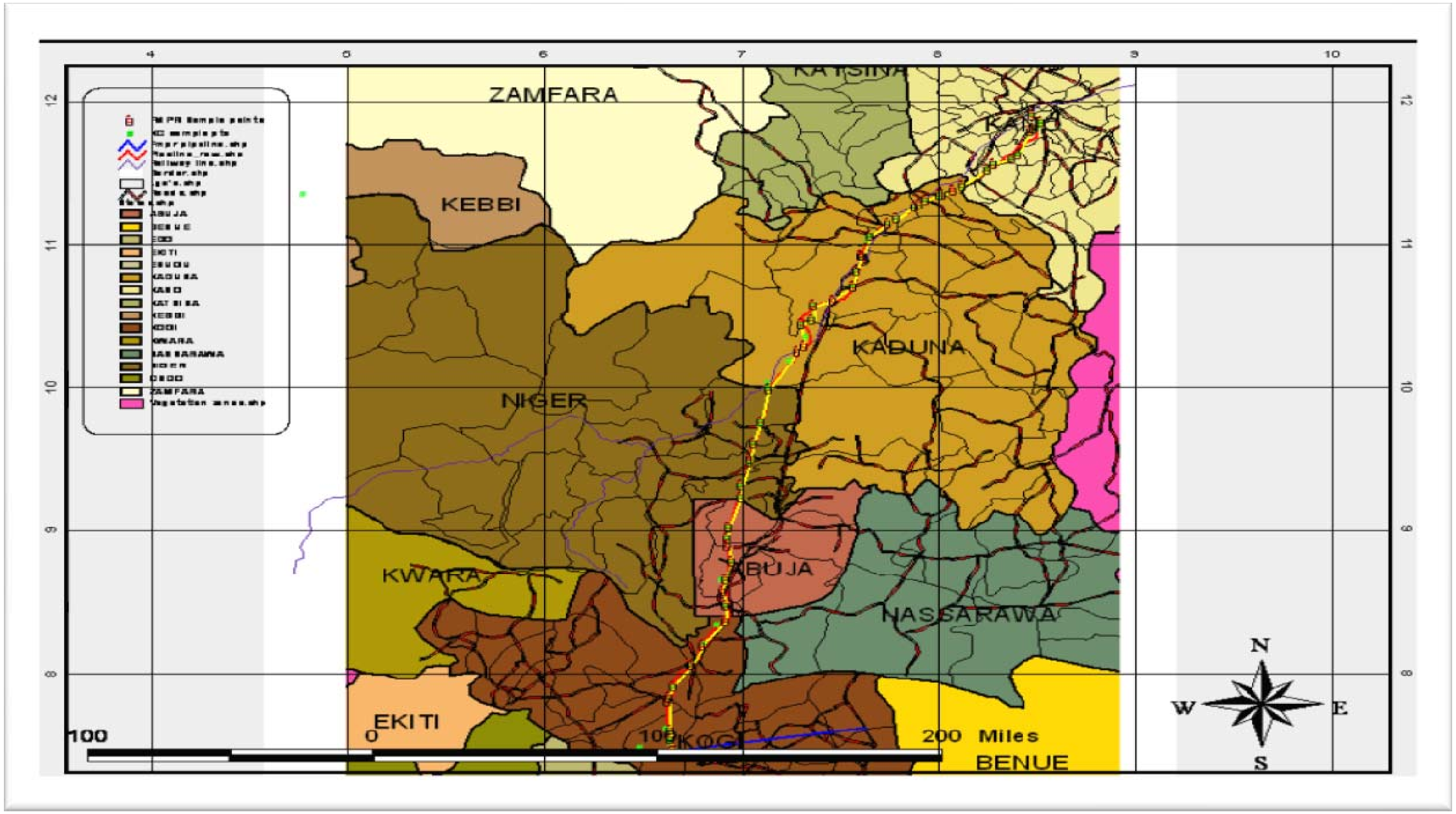

Figure 4.1: Map showing Sampling points

4.7 Physical Environment

4.7.1 Weather Condition

Davis Weather Station was mounted in five locations and used to take weather conditions of the study area that include maximum and minimum temperature, wind direction and wind speed, humidity, and atmospheric pressure. The five locations were randomly selected to cover the affected states.

4.7.2 Air Quality and Noise Level

To cover the ambient air quality of the study area, sensitive receptors and air pollution sources were identified and these formed the basis for in-situ sample locations.

Fifty eight (58Nos.) sample positions within the study area were randomly chosen based on three broad categories: locations where human, commercial activities occur (e.g., urban areas), locations where there are settlements (villages) and areas where there are no human activity (vegetative areas). GPS (Global Positioning System) were used to determine the coordinates of the sample points (see Table 4.1). Air quality and noise parameters that include NO_2, SO_2, H_2S, CO, NH_3, VOC, Suspended Particulate Matter (SPM) and Sound level**,** were measured in-situ (see **Table 4.2**).

Two, sequential one-hour sample periods were used in the air measurement and it was between 0900 - 1101 and 1600 - 1801. Air quality measurement equipments were calibrated before use.

Plate 4.1: Field Team (AIES, FMENV and FMPR Monitoring Team)

Table 4.2 Air Quality Monitoring Equipments

Parameter	Equipment	Detection Limit	Unit	Model
NO_2	NO_2-Meter	0-20	ppm	Toxi RAE Single Gas Monitor (NO_2)
SO_2	SO_2-Meter	0-20	ppm	Toxi RAE Single Gas Monitor (SO_2)
CO	CO-Meter	0-1999	ppm	Toxi RAE Single Gas Monitor (CO)
NH_3	NH_3-Meter	0-50	ppm	Toxi RAE Single Gas Monitor (NH_3)
Noise	Noise Meter	0-130	dB(A)	Rion Sound level meter NA model
SPM	Dust Monitor	0 - 500	$\mu g/m^3$	PDR-1000 personal dust meter
H_2S	H_2S-Meter	0-50	ppm	Toxi RAE Single Gas Monitor (H_2S)
VOC	VOC-Meter	0-50	ppm	MiniRAE 2000

4.7.3 Soil, Topography and Geology

Soils of the study area were sampled at the surface or from within 0-20cm of the surface and 20-50cm below the surface with Dutch auger of uniform cross section.

Thirty five soil sample locations were randomly established across the study area to represent the soil zones or ecoregions in the project areas (along (ROW). A trowel was used to recover surface soil samples Dutch auger of uniform cross section was used to ensure that uncontaminated and reproducible unit of soil samples were collected. Also, surface liters of undecomposed plant materials were removed to ensure that uncontaminated soil samples were collected.

Soil profile samples were collected with permeability tube to represent the dominant soil type and characteristics of the project area; twelve core soil samples were collected.

Small and equal portions of soil samples were taken from the surface and below the surface. The samples were transferred into laboratory cleaned labeled polyethylene bag, preserved and transported to the laboratory in accordance with Standard Procedures of ASTM (Anon, 1994), FMENV (1991) and APHS (1975).

Physical observation, information on existing borehole and literature were used to determine the geology and topography of the area.

4.7.4 Water Sampling

4.7.4.1 Surface Water

Major rivers and streams flowing (not fully dry) across and adjacent to the project route were identified and sampled. The rivers include Oguro, Osara, Niger, Kwaita, Kurara, Echun, Kaduna, Gurara, Kazai, Sarkin Pawa, Kano, Challawa and Ofunene stream.

Water samples were collected all the rivers and the stream. Surface water samples were collected using stainless steel water –trap sampler. Samples collected at the sampling points and at various depths were used to make up a composite sample. A total of 26 water samples were collected upstream and downstream of surface water respectively.

The flow rates of identified rivers were determined by the use of pin ball and stopwatch and in-situ sampling of pH, Conductivity, TDS, Turbidity and Temperature were carried on each stream and river identified (see **Table 4.3**). A weighted bottle sampler was used to sample the rivers.

Samples were collected with 1 litre glass bottle with glass stoppers to check for physico-chemical parameters and 1 liter plastic bottle with plastic cover to check for heavy metal. Sample collected were preserved in ice-chest in the field and later taken to the laboratory and refrigerated at 4^0C. For trace (heavy) metal analysis sample collected were acidified with 1ml Conc. HNO_3 for preservation and to inhibit precipitation of metal ions.

Important use of the rivers such as domestic, industrial intake, economical, recreational, agricultural and fishes were determined by physical observation.

Sediment and water samples for microbiology inventory were separated from the pool by transferring 5-10g or 10ml portion into sterile MC Cartney bottles.

4.7.4.2 Ground Water

The ground water samples were obtained from existing wells in the study area and an in-situ measurement was carried out using underlisted equipments. The average depths of wells were 9m.

Existing boreholes identified in the study area were used to study the underground water of the area and a total of 33 water samples were collected. Also, in-situ analysis of pH, Conductivity, TDS, Turbidity and Temperature were carried out on each borehole water sample.

Before sampling in-situ equipment were checked to be in working condition and properly decontaminated. The in-situ sampling equipment is laboratory cleaned and wrapped in aluminum foil and sealed. The equipment remained wrapped until it is needed.

Table 4.3: Water Sample In-situ Equipments

Parameter	Equipment	Unit	Model
pH	pH-Cond.-Temp-TDS-Meter		Hanna
Conductivity	pH-Cond.-Temp-TDS-Meter	µS	Hanna
Temperature	pH-Cond.-Temp-TDS-Meter	^{o}C	Hanna
TDS	pH-Cond.-Temp-TDS-Meter	Mg/l	Hanna
Turbidity	Turbidity Meter	NTU	2020 LaMotte

4.8 Soil Sampling

At each sampling stations, random soil samples were obtained using a hand Auger. The random samples are composited to a representative sample taken for laboratory analysis.

Physico-chemical characteristics of the soil (pH, moisture content, Total Organic Content (TOC), N_2-NO_3, PO_4, and SO_4) were determined as shown in **Table 4.4**.

Metals: - The sample were first digested in a fume cupboard with cone HCl and heated before determination of the concentration of exchangeable cations (Na, Fe, Ca, and Mg) and heavy metals in an atomic Absorption Spectrophotometer, AAS.

Particulate Size: dry sieving and the percentage of sand, silt and clay determined using a hydrometer.

Permeability was determined using a felling head permeameter in which water is passed through a soil sample and the hydraulic gradient, and quality of water flowing into /through the sample and measured.

4.9 Sediment Analysis

Sediment samples were collected using Eckman grab; from the same points where surface water samples were collected. At least four successful grab bites of sediments were collected at every location and later divided into sub-samples and stored in apprioprate container.

Soil and sediment samples for hydrocarbon content analysis were collected in glass containers with screw cap lined with Teflon and stored at $4^{0}C$.

Samples for physic-chemical analysis were collected in plastic bags and stored at $4^{0}C$.

Sediments and water sample for microbiological studies were separated from the pool right from the field by transferring 5-10g or 10 ml portion into sterile McCartney bottles. The sample were transported to the laboratory in iced container (cooler) and stored in the refrigerator at 4^oC prior to analysis.

4.10 Grain size analysis

A sample of oven-dried sediment from each location was passed through a graded series of standard sieves of aperture sizes 1000µm, 500µm, 350µm, 250µm, 90µm, 63µm and shaken. The fractions retained in each serve (fine, gravel, very coarse sand, coarse sand, medium fine sand, very fine sand and very, very fine sand) were weighed and recorded. The portion which passed through the 63µm sieve was mud (silt and clay) (Friedmgnn and Johnsn, 1982).

4.11 Total Heterotrophic bacteria and Total Coliforms

Heterotrophic bacteria and total coliforms were enumerated by adopting the standard plate count technique using spread plate method.

Appropriate dilutions of samples were plated out on Nutrient agar plates for heterotrophic bacteria and MacConkey agar plates for total coliforms. The plates were made in duplicate and incubated aerobically at 37^oC for 24hours (bacteria) while that of coliforms were incubated aerobically at 37^oC, 44^oC for 24hours and 48hours respectively. At the end of the incubation periods, the number of colonies on the agar plates were counted and enumerated after screening.

The relative abundance (i.e the population density estimate) of the organism was obtained by multiplying the plate count per ml for each organism by the dilution factor used (Nwachukwu and Ugoji, 1995).

The growth on the agar plates were noted with regards to the following characteristics: form, pigmentation or colour, texture and elevation. Based on these, some or most micro-organisms were identified. Each bacterial culture was identified based on its morphological characteristics using gram reaction.

4.12 Ecological Environment

4.12.1 Aquatic Biology

Twenty three separate sample squares of each 300m x 300m were randomly selected and in areas where river were identified ensuring that they straddle rivers, to enable the aquatic biota in the area to be sampled. GPS was used to locate the sampling points and the 300m x 300m squares were marked out using red and yellow ribbons, 100m tape and a compass. Transects at every 50 m were marked by the yellow ribbon, while the corners of the square were marked with red ribbon.

4.12.2 Plankton analysis

In the laboratory five drops of the concentrated (centrifuged) sample (10ml) were invesKanoted at different magnifications (50X, 100X and 400X) using a Wild II binocular microscope with calibrated eye piece and the average recorded. The microtansect drop count method described by Lackey (1938) was employed.

Since each drop is 0.1ml the results on abundances were multiplied accordingly to give the values as numbers of organisms per ml which is the standard unit. Appropriate materials were used to aid identifications (Final data were presented as number of organisms (cells, filaments, colonies).

Appropriate texts were used to aid identification (**Phytoplankton**-Hendey 1958, 1964; Wimpenny, 1966; Patrick and Reimer, 1966, 1975; Whitford and Schmacher, 1973; Vanlandingham, 1982; Nwankwo, 1990, 1995, 2004; **Zooplankton**- Newell and Newell, 1966; Olaniyan, 1975, Barnes *et al.,* 1993 and Waife and Frid, 2001).

Specimens were identified to species level where possible. The fauna were enumerated and results were used to compute for the following indices, using the DIVERSE routine within Primer® software package (Clark and Warwick 1994)

4.12.2.1 Community structure analysis

The following diversity indices were used for biological data analysis.

Species Richness Index (d)

The Species richness index (d) according to Margalef (1951) is a measure of diversity and was used to evaluate the community structure. The equation below was applied and results were recorded to two decimal places.

This index is also refered to as Margalef index.

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

Where:

d = Species richness index
S = Number of species in a population
N = Total number of individuals in S species.

Menhinick's Index (D)

Menhinick's Index (D) (Ogbeibu, 2005).

$$\mathbf{D} = \frac{S}{\sqrt{N}}$$

S = Number of species in a population
N = Total number of individuals in S species.

Shannon and Weiner diversity index (Hs) (Ogbeibu, 2005).

Shannon and Weiner (1963) diversity index (H) Hs = $\sum$ Pi 1n Pi

Where

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

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

Species Equitability (j) (Ogbeibu, 2005)

Species Equitability (j) = $\dfrac{Hs}{\log_2 S}$

Where

j = Equitability index

Hs = Shannon and Weiner index

S = Number of species in a population

Simpsons dominance index (C) (Ogbeibu, 2005).

$C = \Sigma\, (n/N)^2$

Where n = the number of species in the ith species.

N = the total number on individuals.

4.13 Vegetation Cover, Forestry

The Botanist walked along each transect listing the names of each significant plant species one (1) meter on each side of transect except the first and the last ones when only plants one meter inside the square are listed. In the quadrant in each transect the number of stands of each significant species were noted in appropriate columns of the data sheet.

4.13.1 Terrestrial Wildlife

4.13.1.1 Macro-invertebrates

GPS was used to locate sample points and help tag squares and transects. Expert walked the transects noting macro-invertebrates seen, heard, or caught one (1) m. on each side of transects except first and last transects when only one (1) m. inside the square was observed. Specimens caught were measured and weighed. The specimens caught were released after identification, or preserved for future identification. Insect net were used to make swoops on insect, counting specimens caught in each swoop. All particulars were noted appropriately in columns of data sheet. A new data sheet was used for each transect; more than one data sheet was used per transect.

4.13.1.2 Mammals and Birds

The GPS was used to locate sample points (**See Table 4.1**) and help tag squares and transects. The Zoologist walked each transect quietly noting every animal (Mammal/bird) about 10m away on each side except first and last transects, when only animals within the square are listed. He stopped for about 5 minutes at every 50m along each transect to listen for and observe animal movements and/or call. All animals seen (Mammals and birds) or heard were listed and described, on Data sheets, noting track and trails. Binoculars were used to observe birds in flight to aid identification.

Droppings and tracks of animals were observed and identified. Local hunters were interviewed for more information. The wildlife were also ascertained from interviews with local hunters, drawings and photograph of snakes, birds and mammals in Cansdale (1991), Nason (1992) and Booth (1991) respectively, for their confirmation of their presence in the project area and their local (local) names.

Plate 4.2: Experts using Binoculars to observe birds in flight in study area

4.14 Fisheries

The GPS were used to locate sample points (See **Table 4.1**) and help tag squares and transects. Net Appropriate traps were set in aquatic and terrestrial habitats noting location and time. Each species caught in traps, nets, were counted, measured and weighed. Traps were inspected twice daily by aid of local fishermen. Eye spotting was done in square straddling rivers. All transects were walked noting, on Data Sheet, all reptiles and amphibians along each transect at least one (1) m on either side, except the first and last ones, when only one (1) m inside the square was observed.

Local fishermen were interviewed for more information.

Further information on the fisheries was obtained through inspection of catches by local fishermen both in the field and in fishing camps, interviews of fishermen regarding catch species composition and fishing methods and survey of the fishes on sale (both dried and fresh) within the project environment, and interview with the fisheries middlemen about the source of their fishes.

All other fisheries data such as spawning grounds, breeding habits and migration pattern and routes were ascertained from literature reviews.

Plate 4.3: Fish Sampling

4.15 Laboratory Analysis

Standard analytical methods were used to analyse all samples brought to the laboratory. The summary of the analytical techniques for the parameters are shown in **Table 4.4** below:

Table 4.4: Analytical methods and equipment used in analysis of water and soil

S/NO	PARAMETERS DETERMINED	EQUIPMENT/ TECHNIQUE
1	Salinity % or ppt	Salinometer
2	Dissolved Oxygen, mg/l	DO meter, wrinkler's
3	Transparency (m)	Secchi disc
4	Grain size	Granulometry and sedimentation
5	BOD_5 mg/l	Hach BOD track
6	NH_4 mg/l	Nessler's reagent
7	NO_3 mg/l	Phenoldisulphionic acid
8	PO_4 mg/l	Colorimetry with molybdenum blue solution
9	SO_4 mg/l	Turbidometry and photometry
10	THC mg/l	Capillary GL
11	Aliphatic and Aromatic mg/l	GC-MS
12	TOC %	Graphite furnace and gravity
13	N%	Graphite furnace and gravity
14	TSS mg/l	Gravimetry after drying to constant weight
15	Heavy Metal mg/l or ppm	AAS, UNICAM 939, after digestion
16	Soil Moisture Content %	Gravimetry after drying to constant weight
17	Soil permeability	Falling heed permeability test
18	Exchangeable cations mg/l	AAS, after digestion

4.16 Quality Assurance and Quality Control

AIES has well established QA/QC guidelines covering all aspects of the field work and was distributed to all team members before mobilization. The guideline covers sample collection, preservation, storage and transportation.

The quality control for laboratory analyses is in accordance with ASTM recommended method and includes blank analyses to establish analytic level, duplicate analysis to establish analytical precision, spiked and blank samples analyses to determine analytical accuracy.

In-situ measurement of some unstable physico-chemical parameters like pH, and conductivity were carried out. This is to ensure reliability and accuracy of the analysis. All field instruments were regularly cleaned and recalibrated after each use.

4.17 Human and Economic Development

4.17.1 Land Use

Physical observation and interviews were used to determine the land use pattern of the study area.

4.17.2 Infrastructural Services

The communities' and Government infrastructures present in the project area were identified by physical observation and interview.

4.17.3 Waste Management

4.17.3.1 Sources of Wastes

The types of wastes generated in the project areas includes domestic, industrial and wastes. Human/animal faecal deposits constitute further sources of wastes.

4.17.3.2 Waste Inventorisation

The inventory of wastes generated from various sources in the area are provided in

Table 4.5: Waste inventory in project areas

Waste Sources	Waste Types
Domestic activities	Ashes, cassava peels, yam peels, food remains, rags, kitchen waste water, vegetable, fish and meat waste parts, , plates, polythene bags, plastic containers, sticks, wire gauze, paper, foot wears,deformed unidentifiable solid objects, animal feeds (arawa) detergent containers etc.
Wastes from agricultural activities	Maize, rotten/spoilt yam tubers, sticks, leaves, fishing nets/hooks, spoilt tools, old cutlases and hoes etc
Wastes from commercial activities	Papers and cartons, nylon bags, jute bags, cans/tins, polythene bags, paper, crates, detergents packs bottles, wigs, plastic kegs, iron scraps from blacksmiths, etc
Human/animal faecal waste	Human feaces, Urine, cow dungs, goat and fowl excreta, etc

4.17.3.3 Waste Disposal Methods

Wastes are disposed in the project areas by the following methods:

- Open dumping
- Bush dumping
- Pit latrine
- Burying – dead animals and decomposing food items

- Rivers, streams/creeks

There was no organized pattern of waste disposal in any of the communities. The generated wastes were dumped indiscriminately around residential areas and nearby bushes, and streams.

Domestic wastes were collected in baskets, old basins or buckets, nylon bags, and paper cartons. Wastes from agricultural activities were collected and disposed off at farms, riverbanks, bushes and open dumpsites.

Also on the disposal method for human excreate, the method is disposal in nearby bushes while some interviewed also affirmed that they occasionally dug holes in the bush to defaecate. Pit latrines were only present in few communities but defaecation into water bodies is common in riverine areas. Few water closet (WC) types are found in the community.

4.17.3.4 Waste Recycling Techniques

There was no organized form of waste recycling in the communities. Wastes were not segregated at source into decomposable/non-decomposable types before disposal. But excrete of domestic animals are spread on farmlands and allowed to decompose as organic manure.

No waste scavengers were seen in any of the project areas.

4.17.4 Quality of Life Values

4.17.4.1 Socio-Economic Values

Baseline socio-economic information of the study area was collected in consultation with members of the communities whose land, farming activities etc will be affected within 2km corridor of the project route and it covers both existing conditions and their attitude towards the project.

A total of 43 interviews were held with community leaders and 250 different interviews with identified communities' members. Two types of questionnaire were administered; community and the household level questionnaire. The community level questionnaire was administered to the community leaders while household questionnaire was administered to the members of the communities at the household level.

The household questionnaire was designed to capture information about the household and their perception in each village consulted.

The number of household questionnaire administered in each community varies between 3 - 6 depending on the size of the community. The households in each community were carefully selected to represent all sector of the village.

The questionnaire was structured to collect the baseline socio-economics of the area and it covered the following:-

- General
- Traditional and administrative structure
- Culture, religion and archaeology
- Population
- Economic system
- Educational level
- Industries and business activity
- Facilities
- Groups/associations

In all a total of 250 questionaire were completed and returned to our field interviewers.

4.17.5 Community health

Interviews with locals and communities' health clinic officials were used to determine the health status and disease inventory of the area. Also, samples of communities' wells/borehole were collected to check for suitability for drinking and domestic use.

4.17.6 Archeology

Consultation and interviews with locals were used to identify and describe the social anthropology of the study area; shrines, burial sites and various aspects of the local culture, customs, religious beliefs and sacred place.

4.17.7 Visual and Aesthetic Resources

The existing visual aesthetics of the study area were described by physical observation.

4.18 Description of the Environment

4.18.1 Climate

The climate of the study area is governed by two air masses, the south-westerlies and the north east harmattan dry wind. The former are due to hot and humid tropical maritime air mass blowing in from the Atlantic Ocean while the latter is due to tropical continental air mass that is a cold, dusty and dry air mass from the Sahara desert.

The northeast winds of the study area are characterized by the dry season, which lasts from November to March, also the wet season begins in April and ends in November and is characterized by southwest wind.

National Meteorological Agency has collected rainfall, wind speed and direction, humidity and temperature data in States were the project route traverses, over the period of January 1999 to December 2008. Daily meteorological data was compiled from that record and total monthly records over the period were developed. Also, in-situ weather measurements were carried out in the study area to determine fast changing atmospheric condition of the area.

Plate 4.4: AIES Staff measuring weather conditions of the study area

In situ measurements collect near-continuous weather data with data storage devices integrated into data loggers. The on- the- spot measurements are then compared to similar data colleted by NIMET previously, to determine whether significant climate changes have occurred during the past few years. This will be utilized in predicting the future atmospheric changes.

Appendix- 4-2 summarizes recorded monthly rainfall, Temperature, Wind speed and direction, Relative humidity recorded for the period of 1999 to 2008 while Table **4.6** provided the in-situ weather conditions of the study areas.

4.18.2 Temperature

Ambient temperature is a key parameter as it indirectly governs the dilution capacity of the atmosphere. Generally, temperature controls the reaction rate of pollutant as well as how fast the surface dries out. If the temperature is high, the moisture in the surface will evaporate, exposing the surface to effects of wind erosion thereby increasing dust emissions. Temperature near the surface also controls the buoyant component of turbulence (vertical motion). Heat from the earth's surface heats the air near the ground causing it to rise. This phenomenon reaches a maximum in early afternoon and is a minimum near sunrise and sunset.

In the study area, temperature is usually higher during the dry season and lower during the wet season. The ambient temperature of the area rises gradually in the early morning hours and attains its peak value between 13hour and 15hours. The in-situ weather measurement result showed that the minimum temperature varies between 28.6^{o}C and 34.1^{o}C and the maximum temperature 30.5^{o}C and 42.6^{o}C (see Table 4.6).

The NIMET Data (1996-2008) showed that the minimum temperature of the area ranges from 13.8^{o}C to 30.3^{o}C and the maximum 27.5^{o}C to 39.4^{o}C. Highest values are recorded in February and March which is the end of dry season. The area indicates low temperature from July to September that rises in November to April. The highest temperature period is in the dry season up to beginning of wet season.

The mean annual (minimum and maximum) temperature is 17.0^{o}C to 36.7^{o}C in Kogi 22.8^{o}C to 34.25^{o}C in Abuja area, 22.65^{o}C to 32.85^{o}C in Minna, 20.65^{o}C to 30.9^{o}C in Kaduna area, 12.2^{o}C to 40.5^{o}C in Kano area.

4.18.3 Wind Speed and Direction

Wind direction and speed govern the dispersion of pollutant. Wind direction is the direction from which wind blows and is based on surface observation. Over the course of a year, wind usually blows in all directions, with varying frequencies. Prevailing wind directions is when certain directions occur more frequently than others.

The wind patterns of the study area follows the ITD, thus it is mainly south-west during the wet season and north-east during the dry season. In general, the southwest swell is prevalent. There are winds blowing from different directions during the year namely NE, E, SE, S, SW, W, NW and N. The wind direction of the study area (from Ajaokuta to Kano) is majorly Westerly and occurring in wet season and Easterly in dry season.

The in-situ weather measurement generally showed southwest direction with the the exception of Kaduna that showed southeast direction. Also the wind speed varied between 1.0m/h to 13.0m/h (**see Table 4.6**).

A review of the records (1996 to 2008) reveals that the winds blow is generally Southwesterly and Northeasterly in Minna area, with mean velocity range of 2.4m/s to 7.7m/s in Kogi, 1.6m/s to 6.2m/s in Abuja area, 1.9m/s to 13.8m/s in Minna area, 2.5m/s to 10.0m/s in Kaduna area and 0.9m/s to 13.0m/s in Kano area.

Pollutant concentration decreases with increasing wind speed as a part of the dispersion process. However, when wind speeds are high, while there is good dispersion of gases and particles, there is more potential for re-suspending surface dusts. When wind speeds are near zero, local circulations may lead to very high pollutant concentration near ground. Wind speed increases with height as surface friction reduces.

4.18.4 Rainfall

Seasonal variations in rainfall are controlled by the seasonal displacement of the Inter Tropical Convergence Zone ITCZ (Hastenrath, 1985).

Rainfall plays a role in the miKanotion of pollutants from air to land, and can minimize or eliminate wind erosion.

The average annual rainfall range from 0.00mm to 400.1mm in Kogi, 0.0mm to 487.8mm in Abuja area, 0.00mm to 360.5mm in Minna area, 0.00mm to 406.6mm in Kaduna area and 0.00mm to 604.7mm in Kano area. The period from May to October is the rainy season, with the rainfall accounting for 85% of annual total, and from November to March is the dry season. Construction activities occurring in December to March will have least of pollutant removal by rainfall and high dust generation due to dry soil conditions.

4.18.5 Relative Humidity

The in-situ measurement of the study area showed minimum humidity range of 14% to 39% and maximum range of 22% to 44%. (See **Table 4.6**)

The relative humidity of the study area ranges from 9% to 89%; high values are recoded between June and October while lowest values occur from November to March. Period of very low humidity occurs in January to February during harmattan spell.

The relative humidity ranges from 29% to 86% in Kogi area, 27% to 89% in Abuja area, 22% to 88% in Minna area, 9% to 89% in Kaduna area and 15% to 83% in Kano area.

Table 4.6: In-situ Weather Measurement Result of the Study Area

Sample Location	MaxTemp°C	Min. Temp°C	Max. Humidity %	Min. Humidity %	Atmospheric Pressure mmhg	Wind Speed mph	Wind Direction
AAK-1	42.6	34.1	42	38	29.76	2.0	SW
AAK-16	38.5	32.6	44	39	29.79	5	SW
AAK-25	31.8	30.3	22	20	29.92	13	SW
AAK-36	30.5	30.2	25	14	29.90	11	SE
AAK-55	31.4	28.6	32	19	29.86	1	SW

4.18.6 Air Quality

4.18.6.1 Identified Sources of Air Emission in the Study Area

Activities identified to generate emissions in the the study area include vehicular movement, commercial activities and use of generators, cooking with firewood, grain processing machine and bush burning in dry season. The impacts from these sources were captured in the levels of pollutants measured in the site-specific background air quality monitoring study conducted in the study area.

4.18.6.2 Air Quality Measurement

Fifty eight sampling locations (see **Table 4.1**) within the study area were sampled to cover the overall air quality status of the area. The identified sensitive receptors within the study area are settlements in close proximity to the project ROW and surface water within study area.

Ambient quality of the following parameters CO, SO_2, NO_2, SPM, VOC and H_2S were measured in dry season while existing data for wet season was used for wet season description of the study area.

Emissions in the study area are dispersed by wind speed. CO, SO_2, VOC and NO_2 in the study area indicated zero concentration and in dry and wet season data (EPL 2008) also, indicated zero concentration.

SPM indicated concentration that is less than 105.71µg/m^3 in the study area, indicating level that is within limit. In wet season SPM indicated range of 1.476µg/m^3 to 28.610µg/m^3 and also 20.40µg/m^3 to 105.71µg/m^3 in dry season. The SPM concentration trend indicates general increase northwards. The highest SPM occurred in vegetation/bush/farm areas; this is as a result of fugitive dust on vegetation leaves and in most cases raised by wind. The lowest occurred in villages.

Details of ambient air quality of the study area in dry season are shown in **Table 4.7** while the wet season result is provided in **Appendix-4-3**.

Plate 4.5: AIES Staff measuring ambient air quality and noise level of study area

4.18.7 Ambient Noise Quality

4.18.7.1 Sources of Noise Emissions

Activities identified to generate noise in the study area include vehicular movement, commercial activities and use of generators, grain processing machine and logging of wood activity. The impacts from these sources were captured in the levels of pollutants measured in the site and specific background noise level monitoring study conducted in the study area.

4.18.7.2 Noise Quality Monitoring

Ambient noise measurement was also conducted at the same location with air quality.

The project ROW shall be located in forested/vegetation and rural areas where ambient noise levels are expected to be low. The noise level in the study area showed ranged of 31.5 dB (A) to 76.8dB (A) in dry season and the wet season data (EPL 2008) showed range of 36.2 dB (A) to 70.2 dB (A). The highest range occurs in the settlement areas and near roads.

The relative high noise in the settlement areas is caused by road traffic, domestic activities and commercial activities. In bushes/vegetation/farm noise environment is dominated by logging and farming activities. The noise level of the study area is shown in **Table 4.7** and **Appendix-4-3**.

Table 4.7: Dry Season Air Quality and Sound Level Results of Study Area

Sampling location	NO_2 (ppm)	H_2S (ppm)	SO_2 (ppm)	NH_3 (ppm)	CO (ppm)	VOC (ppm)	Sound Level dB (A)	Susp. parti. Matter (SPM) (ug/m^3)
AAK 1	0.0	0.0	0.0	0.0	0.0	0.0	38.0	20.40
AAK 2	0.0	0.0	0.0	0.0	0.0	0.00	39.2	55.01
AAK 3	0.0	0.0	0.0	1.0	0.0	0.00	55.5	45.08
AAK 4	0.0	0.0	0.0	1.0	0.0	0.00	41.2	35.95
AAK 5	0.0	0.0	0.0	0.0	0.0	0.00	39.7	38.79
AAK 6	0.0	0.0	0.0	0.0	0.0	0.00	38.0	54.96
AAK 7	0.0	0.0	0.0	0.0	0.0	0.00	36.2	62.02
AAK 8	0.0	0.0	0.0	0.0	0.0	0.00	45.3	52.77
AAK 9	0.0	0.0	0.0	0.0	0.0	0.00	64.0	62.39
AAK 10	0.0	0.0	0.0	0.0	0.0	0.00	38.8	66.65
AAK 11	0.0	0.0	0.0	0.0	0.0	0.00	53.6	68.52
AAK 12	0.0	0.0	0.0	0.0	0.0	0.00	43.4	65.21
AAK 13	0.0	0.0	0.0	0.0	0.0	0.00	39.4	60.84
AAK 14	0.0	0.0	0.0	0.0	0.0	0.00	48.3	45.10
AAK 15	0.0	0.0	0.0	0.0	0.0	0.00	47.3	53.89
AAK 16	0.0	0.0	0.0	0.0	0.0	0.00	37.6	54.78
AAK 17	0.0	0.0	0.0	0.0	0.0	0.00	61.8	65.62
AAK 18	0.0	0.0	0.0	0.0	0.0	0.00	49.7	45.85
AAK 19	0.0	0.0	0.0	1.0	0.0	0.00	59.9	40.48
AAK 20	0.0	0.0	0.0	0.0	0.0	0.00	39.6	17.95
AAK 21	0.0	0.0	0.0	0.0	0.0	0.00	45.6	30.22
AAK 22	0.0	0.0	0.0	0.0	0.0	0.00	39.1	15.43
AAK 23	0.0	0.0	0.0	0.0	0.0	0.00	38.4	10.85
AAK 24	0.0	0.0	0.0	0.0	0.0	0.00	39.1	42.47
AAK 25	0.0	0.0	0.0	0.0	0.0	0.00	41.3	46.53
AAK 26	0.0	0.0	0.0	0.0	0.0	0.00	39.6	46.89
AAK 27	0.0	0.0	0.0	0.0	0.0	0.00	45.3	57.47
AAK 28	0.0	0.0	0.0	0.0	0.0	0.00	46.3	106.50
AAK 29	0.0	0.0	0.0	0.0	0.0	0.00	31.6	100.00
AAK 30	0.0	0.0	0.0	0.0	0.0	0.00	52.2	104.63
AAK 31	0.0	0.0	0.0	0.0	0.0	0.00	51.8	103.54

Sampling location	NO_2 (ppm)	H_2S (ppm)	SO_2 (ppm)	NH_3 (ppm)	CO (ppm)	VOC (ppm)	Sound Level dB (A)	Susp. parti. Matter (SPM) (ug/m^3)
AAK 32	0.0	0.0	0.0	0.0	0.0	0.00	65.1	96.76
AAK 33	0.0	0.0	0.0	0.0	0.0	0.00	76.8	51.65
AAK 34	0.0	0.0	0.0	0.0	0.0	0.00	54.9	82..31
AAK 35	0.0	0.0	0.0	0.0	0.0	0.00	36.2	61..31
AAK 36	0.0	0.0	0.0	0.0	0.0	0.00	31.5	88.00
AAK 37	0.0	0.0	0.0	0.0	0.0	0.00	34.4	98.39
AAK 38	0.0	0.0	0.0	0.0	0.0	0.00	45.6	95.351
AAK 39	0.0	0.0	0.0	0.0	0.0	0.00	52.2	99.82
AAK 40	0.0	0.0	0.0	0.0	0.0	0.00	42.5	93.65
AAK 41	0.0	0.0	0.0	0.0	0.0	0.00	46.2	105.71
AAK 42	0.0	0.0	0.0	0.0	0.0	0.00	52.9	91.15
AAK 43	0.0	0.0	0.0	0.0	0.0	0.00	57.0	87.14
AAK 44	0.0	0.0	0.0	0.0	0.0	0.00	42.7	92.26
AAK 45	0.0	0.0	0.0	0.0	0.0	0.00	44.5	96.45
AAK 46	0.0	0.0	0.0	0.0	0.0	0.00	43.9	93.25
AAK 47	0.0	0.0	0.0	0.0	0.0	0.00	51.6	89.86
AAK 48	0.0	0.0	0.0	0.0	0.0	0.00	36.7	90.25
AAK 49	0.0	0.0	0.0	0.0	0.0	0.00	47.2	94.25
AAK 50	0.0	0.0	0.0	0.0	0.0	0.00	42.5	86.15
AAK 51	0.0	0.0	0.0	0.0	0.0	0.00	36.9	79.65
AAK 52	0.0	0.0	0.0	0.0	0.0	0.00	42.9	92.39
AAK 53	0.0	0.0	0.0	0.0	0.0	0.00	41.5	83.34
AAK 54	0.0	0.0	0.0	0.0	0.0	0.00	55.1	94.76
AAK 55	0.0	0.0	0.0	0.0	0.0	0.00	66.8	45.01
AAK 56	0.0	0.0	0.0	0.0	0.0	0.00	54.9	82.31
AAK 57	0.0	0.0	0.0	0.0	0.0	0.00	42.5	96.51
AAK 58	0.0	0.0	0.0	0.0	0.0	0.00	36.9	95.25
FMENV LIMIT	**75-113**	**0.05**	**260**	**<1.0**	**11.20**	**-**	**90**	**600**

4.18.8 Water Resources

Water resources studies include both surface and ground water systems. A study of the surface water features and groundwater was undertaken to identify potential environmental constraints such as watercourses, groundwater aquifers, existing water abstraction and discharge points, and private water supplies.

4.18.9 Surface Water

The surface water system along the proposed pipeline route comprises primarily rivers and streams. The pipeline will cross 7 rivers and 5 streams. The rivers and streams described in this section are those identified to have water in both dry and wet seasons.

In dry season majority of the rivers and streams have low flow, in some cases do not flow and in most cases dry. Climatic variables affect rivers and streams. In dry season, increase temperature and general drying of watershed increase evaporation rates, causing dryness of stream as witness in some streams in the study area and reduced flow regime of rivers.

Plate 4.6: Challawa River

The route of the pipeline crosses several large and small rivers all of which connect into and are tributaries to River Niger and Benue River except for rivers in Kano drain into Lake Chad. Also, the streams/watercourses connects to the rivers, the source of these watercourses is rainfall.

Most of the rivers and streams crossed by the pipeline were dry during the sampling period of dry and wet season; this was attributed to climatic changes. A total of 26 water samples were collected from rivers and streams in wet and dry season. Upstream and downstream water samples of the river and stream were carefully collected with plastic containers that had earlier been evacuated and fully sterilized.

4.18.9.1 Physico-chemical Characteristics of Surface Water Crossed by the project

1. pH

The intensity of acidity or alkalinity of water is based on the pH scale which actually measures the concentration of hydrogen ions present (Tebbutt, 1992). pH values of 7.2 to 8.7 mg/l are appropriate for aquatic organisms (Subbamma and Rama Sarma,1922. and Kelein,1973).

The identified rivers and stream crossed by the project generally showed pH range of 5.9 to 9.5 in dry season; Ofunene stream showed 6.0 in downstream and 5.9 upstream, Kaduna River indicated 9.2 in downstream and 9.5 upstream. River Niger showed 8.6 downstream and 8.8 upstream. In wet season (EPL, 2008), the rivers and streams in the study area showed range of 6.65 to 7.81 in wet season.

2. Alkalinity

Alkalinity is a measure of the quantity of compounds that shift the pH to the alkaline side of neutrality (above 7) or it is a measure of the capacity of water to neutralize acids.

A range of 100 to 250 mg/l for river water is considered normal. If the alkalinity of water is too high, the water can be turbid, which inhibits the growth of underwater plants. Too high alkalinity raises the pH level, which in turn harm or kill fish and other river organisms.

The alkalinity of rivers and stream sampled ranges from 37mg/l to 160mg/l in dry season; Osara, River Niger, Kwaita, Gurara and Kurara showed range of 40mg/l to 90mg/l. Oguro, Kaduna, Echun, Kano and Challawa Rivers and Ofunene stream showed alkalinity that is above 100mg/l (120mg/l to 165mg/l).

In wet season alkalinity of surface water in the study area showed range of 32 mg/l to 540mg/l (EPL, 2008). Tasawariki Stream showed concentration of 540mg/l.

Plate 4.7: AIES personnel collecting water and sediment samples from River Niger

3. Biological Oxygen Demand (BOD)

Biological oxygen demand is a measure of the oxygen in water that is required by the aerobic organisms. Rivers with low BOD have low nutrient levels; therefore, much of the oxygen remains in the water. Unpolluted, natural waters have a BOD of 5 mg/l or less.

The samples of surface water crossed by the gas pipeline showed BOD values that range from 2.0mg/l to 10.0mg/l with the upstream of Challawa River showing concentration of 10.0mg/l. Ofunene, Kurara and Challawa (downstream) indicated 5.0mg/l.

In wet season the BOD values (**EPL Field Data, 2008**) ranged from 2.0mg/l to 8.0mg/l; Kpako stream (6mg/l), Osara River (7mg/l) and Tasawariki Stream (8mg/l). The value of BOD levels (above 5.0mg/l) in rivers and stream indicates the presence of organic pollution sources.

4. Chloride

Chlorides are binary compounds of chlorine. A chloride is made of chlorine chemically combined with a metal. The presence of chloride, where it does not occur naturally, indicates possible water pollution. Chloride contaminates rivers and groundwater and can make it unsuitable for humans to drink. High levels of chloride kill plants and wildlife. The normal range of chloride for river surface water is 45mg/l to155mg/l.

The surface water(s) sampled showed chloride content range of 6.0mg/l to 50.0mg/l with Kano River showing chloride content of 50.0mg/l. River Niger indicated 8.0mg/l in downstream and 6.0 upstream while River Kaduna indicated 26.0mg/l in both up and downstream.

In wet season (**EPL Field Data, 2008**), the chloride content of the rivers in the study area ranged from 12.0mg/l to 236mg/l. Tasawariki Stream showed the highest content of chloride in wet season. The stream receives wastewater discharges from Kano State; in dry season the stream remained dry at the point of sample area. The Tasawariki Stream empties into Challawa River that showed chloride content of 58.0mg/l in upstream and 55.6mg/l downstream in wet season.

The average value of chlorides in other surface with the exception of Tasawariki Stream stream indicates the absence of pollutants in the study area. Maximum chloride content has been correlated with high degree of organic pollution and eutrophication (Goel et al 1980).

5. COD

Chemical oxygen demand indicates the oxygen required for chemical oxidation of organic matter in river and stream. The COD values of the surface water(s) crossed by the project varied between 2.0mg/l and 10.0mg/l with Challawa River showing the highest concentration of 10.0mg/l. Also, Ofunene stream showed 9.0mg/l downstream and 10.0mg/l upstream.

In wet season (**EPL, 2008**), the rivers and streams in the study area indicated the range of 2.0mg/l and 40.0mg/l. Tasawariki Stream indicated concentration of 40mg/l (**see Appendix-4-4**)

Plate 4.8: Osara River (in dry season)

6. Dissolved Oxygen (DO)

Dissolved oxygen is a measure of the amount of oxygen freely available in water. Oxygen is the single most important gas for most aquatic organisms; free oxygen (O_2) or DO is needed for respiration. DO levels below 1 mg/l will not support fish; levels of 5 to 6 mg/l are usually required for most of the fish population.

The rivers and stream sampled indicated dissolved oxygen values that range from 4.7 mg/l to 5.8mg/l, with Kurara and Challawa Rivers showing 5.8mg/l. and Ofunene stream and Oguru River showing values of 4.7mg/l and 4.8mg/l respectively.

The Rivers and streams in the study area indicate DO range of 4.1mg/l to 5.6mg/l in wet season (EPL, Field Data, 2008). Gurara, Kaduna and Niger rivers showed 4.6mg/l.

7. Turbidity

Turbidity is caused by the dissolved matter that disperses and absorbs light. The surface water(s) indicated range of 0.0NTU to 15.0NTU in dry season. Ofunene stream indicated 15.0mg/l and River Niger downstream indicated 10.0mg/l and downstream 6.0mg/l.

In wet season the surface water(s) showed turbidity range of 0.0NTU to 378NTU. The wet season values are influenced by rain water surface runoff. The most turbid sample was Challawa River in Kano with 378 NTU; the high value is attributed to sand mining activities in the river.

8. Nitrates and Phosphate

In normal conditions, water always provides enough elements for plant growth. The rate of of growth is limited by the supplies of nitrogen and phosphorus. When surface water contains concentrations of nitrates and phosphates higher than normal, algae flourish and and produce a bloom, a green scum which is accompanied by unpleasant odour in the water. The lowering of oxygen concentration leads to death of fish. The sources of nitrates and phosphates are sewage and fertilizers. WHO recommends that the level of nitrogen in the form of nitrates should not exceed 50mg/l.

Also, phosphate can enter surface water from detergents. Phosphates are added as builders to improve the cleaning power of synthetic detergents. To inhibit the growth of algae in surface water, the level of phosphate in water shall not exceed 0.5mg/l.

The nitrate content of surface water(s) sampled ranged from 0.04mg/l to 1.74mg/l; Oguru River showed concentration of 1.74mg/l, Kwaita River indicated 1.38mg/l downstream and 1.35mg/l upstream, Sarkin Pawa River 0.06mg/l downstream and 1.60mg/l upstream, River Niger indicated 0.09mg/l downstream and 0.04mg/l upstream.

In wet season (**EPL, 2008**) the rivers and streams showed concentration range of 0.24mg/l to 24.72mg/l Tasawariki Stream indicated the highest concentration of 24.72mg/l in wet season.

The phosphate level of surface water(s) in dry showed the range of 0.01mg/l to 0.65mg/l, with Oguru River indicating the highest of 0.28mg/l. River Niger upstream indicated 0.03mg/l and downstream 0.01mg/l.

9. Sulphate

Sulphates in the river are primarily related to the types of minerals in the soil and bedrock, and the acid rain, which falls. Sulphate content of the rivers in dry season showed content range of 0.0mg/l to 5.0mg/l. The wet season data of rivers in the study area indicated range of 0.0mg/l to 40.0mg/l.

10. Total Solids

Total solids are the combined weight of both total dissolved solids and suspended solids. All natural waters contain dissolved and suspended inorganic and organic substances. In dry season the TDS of surface water samples ranged from 0.0mg/l to

17.6mg/l and TSS, 0.0mg/l to 148.0.0mg/ with Challawa River indicating the hieghest concentration 148.0mg/l.

In wet season (**EPL, 2008**) TSS varied between 0.0mg/l and 62.0mg/l and TDS 0.02mg/l and 0.81mg/l; the highest TDS and TSS occurred in Tasawariki Stream.

11. Magnesium

The main sources of Magnesium to rivers are leaching of rocks and it is an important component in the exoskeletons of arthropods and shells in mollusks (Piska, 2000). The range of magnesium in surface waters in the study area in dry season is 0.0mg/l to 10.0mg/l; the highest concentration was shown in Gurara River.

In wet season it varied between 0.0mg/l and 22.0mg/l and highest value occurred in Tasawariki Stream.

12. Oil and Grease Content

Overall, the surface water quality in dry season showed concentration that is less than 0.06mg/l; Ofunene stream (upstream) indicated content of 0.06mg/l.

In wet season oil and grease content ranges from 0.0mg/l to 0.08mg/l; Tasawariki Stream showed 0.08mg/l content while other surface waters showed content that is less than 0.02mg/l.

The dry season physico-chemical characteristics of surface water(s) in the study area is shown in the Table 4.8 while the wet season is provided in **Appendix 4-4**

Table 4.8: Dry season physico-chemical characteristics of surface water(s) in the study area

Sample Location / Parameters	AAK 2	AAK 4	AAK 7	AAK 10	AAK 15	AAK 17	AAK 19	AAK 21	AAK 26	AAK 27	AAK 32	AAK 52	AAK 56	FMENV
Downstream														
Colour (Pt-Co)	5.0	4.0	3.0	12.0	8.0	5.0	4.0	2.0	2.0	15.0	0.0	18.0	20.0	**15.0 ***
pH	6.0	8.6	6.3	8.6	7.9	8.2	6.1	7.4	7.8	6.4	9.2	8.8	6.4	**6.0- 9.0***
Temp °C	28.3	28.6	36.3	29.9	29.6	27.2	28.9	26.5	27.4	31.2	26.0	26.2	24.3	**20-23***
Salinity (‰)	0.02	0.02	0.01	0.01	0.05	0.01	0.01	0.02	0.02	0.01	0.05	0.09	0.05	**<80[R]**
Turbidity(NTU)	15.0	0.0	0.0	10.0	0.0	2.0	7.0	0.0	0.0	0.0	0.0	9.0	2.0	**<55[R]**
Cond. (µS)	286	246	170	63	240	238	326	111	121	127	180	192	195	
TDS (mg/l)	135	176	0.01	0.32	1.20	139	0.0	12	101	0.0	90	120	122	**3000[L]**
Appearance	not clear	clear	clear	not clear	not clear	not clear	not clear	clear	clear	clear	clear	Not clear	not clear	**clear**
Odour	odourless	odour	odourless	odourless	odour	odour	odourless	odourless	odour	odourless	odour	odourless	odour	**odourless**
Cl^- (mg/l)	10.0	12.0	8.0	8.0	26.0	12.0	6.0	12.0	12.0	8.0	26.0	50.0	20.0	**250[D]**
COD (mg/l)	9.0	8.0	3.0	7.0	3.0	3.0	7.0	2.0	2.0	3.0	2.0	7.0	10.0	**1000 [L]**
BOD_5^{20} (mg/l)	5.0	4.0	2.0	3.0	4.0	5.0	4.0	2.0	2.0	3.0	2.0	4.0	5.0	**4.0***
TSS (mg/l)	12.0	5.0	ND	8.0	1.0	10.0	5.0	ND	0.0	38.0	0.0	148.0	6.0	**>10***
NO_3^- (mg/l)	0.44	1.74	0.16	0.09	1.38	0.28	0.40	0.04	0.22	0.06	0.35	0.93	0.10	**1.0***
PO_4^{3-} (mg/l)	0.05	0.28	0.03	0.01	0.06	0.05	0.04	0.01	0.03	0.01	0.02	0.14	0.05	**>5***
SO_4^{2-} (mg/l)	4.0	2.0	2.0	2.0	2.0	0.0	2.0	ND	1.0	4.0	1.0	5.0	0.0	**500**
DO (mg/l)	4.8	4.7	5.2	4.9	5.1	5.8	5.0	5.4	5.4	5.6	5.6	5.1	5.8	**6.0***
NH_3 (mg/l)	ND	0.0	ND	ND	0.0	0.0	ND	ND	0.0	ND	0.0	ND	0.0	**0****

Sample Location Parameters	**AAK 2**	**AAK 4**	**AAK 7**	**AAK 10**	**AAK 15**	**AAK 17**	**AAK 19**	**AAK 21**	**AAK 26**	**AAK 27**	**AAK 32**	**AAK 52**	**AAK 56**	**FMENV**
S^{2-} (mg/l)	ND	0.0	ND	ND	0.0	0.0	ND	ND	0.0	ND	0.0	ND	0.0	
Phenols (mg/l)	ND	0.0	ND	ND	0.0	0.0	ND	ND	0.0	ND	0.0	ND	0.0	**1.0***
O&G (mg/l)	0.05	0.0	ND	ND	0.0	0.0	0.02	ND	0.0	0.05	0.0	ND	0.0	**0.05***
Alkalinity(mg/l)	120.0	160	60.0	50.0	90	85	120.0	30.0	120	40.0	150	40.0	168	
CN^- (mg/l)	ND	0.0	ND	ND	0.0	0.0	ND	ND	0.0	ND	0.0	ND	0.0	**0.1***
THC (mg/l)	ND	0.0	ND	ND	0.0	0.0	ND	ND	0.0	ND	0.0	ND	0.0	
Detergent(mg/l)	ND	0.0	ND	ND	0.0	0.0	ND	ND	0.0	ND	0.0	ND	0.0	**NA**
Sodium (mg/l)	4.5	5.8	7.1	7.5	7.3	6.6	8.0	5.6	5.6	5.0	11.6	7.0	7.8	**200***
Potassium(mg/l)	0.22	0.12	0.19	0.20	0.21	0.05	0.07	0.08	0.07	0.20	0.54	0.10	0.28	**NA**
Calcium (mg/l)	14.0	32.0	2.0	2.0	3.0	3.0	20.0	2.0	4.0	7.0	5.0	2.0	2.0	**NA**
Magnesium(mg/l)	6.6	10.0	3.0	5.0	2.0	0.0	10.0	0.0	0.0	2.2	0.0	0.0	0.0	**0.05***
Pb (mg/l)	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.05***
Cu (mg/l)	0.09	0.44	0.03	0.05	0.58	0.02	0.08	0.04	0.03	0.04	0.02	0.12	0.06	**0.1***
Zn (mg/l)	0.62	2.12	0.20	0.18	1.36	0.27	0.56	0.12	0.78	0.05	0.74	1.54	0.30	**5.0***
Mn (mg/l)	0.03	0.10	0.01	0.0	0.07	0.01	0.02	0.02	0.02	0.01	0.02	0.05	0.20	**0.05***
Fe (mg/l)	0.04	1.12	0.06	0.02	0.32	0.04	0.05	0.02	0.07	0.02	0.16	0.07	0.03	**1.0***
Cd (mg/l)	0.0	0.03	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.01***
Cr (mg/l)	0.0	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.05***
Ni (mg/l)	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	**0.05***
Upstream														
Colour (Pt-Co)	5.0	-	3.0	14.0	8.0	5.0	4.0	2.0	2.0	15.0	0.0	15.0	21.0	**15.0 ***

Sample Location / **Parameters**	**AAK 2**	**AAK 4**	**AAK 7**	**AAK 10**	**AAK 15**	**AAK 17**	**AAK 19**	**AAK 21**	**AAK 26**	**AAK 27**	**AAK 32**	**AAK 52**	**AAK 56**	**FMENV**
pH	5.9	-	6.5	8.8	8.6	8.5	6.3	7.6	7.5	6.6	9.5	8.6	6.7	**6.0- 9.0***
Temp ^oC	26.3	-	35.2	31.3	29.2	27.8	28.9	27.1	28.0	31.8	28.3	26.9	24.8	**20-23***
Salinity (‰)	0.02	-	0.01	0.01	0.03	0.02	0.01	0.01	0.02	0.02	0.05	0.03	0.02	**<80^R**
Turbidity(NTU)	15.0	-	0.0	6.0	0.0	2.0	7.0	0.0	0.0	0.0	0.0	1.0	2.0	**<55^R**
Cond. (mS)	277	-	168	126	63	238	320	113	125	120	180	190	187	
TDS (mg/l)	133	-	0.01	0.98	0.32	130	0.0	12	102	0.0	92	125	120	**3000^L**
Appearance	not clear	-	clear	Not clear	Not clear	Not clear	not clear	clear	clear	Not clear	clear	Not clear	Not clear	**clear**
Odour	odourless	-	odourless	odourless	odour	odour	odourless	odour	odour	odour	odour	odour	odour	**odourless**
Cl^- (mg/l)	10.0	-	8.0	6.0	25.0	15.0	8.0	10.0	13.0	16.0	26.0	50.0	20.0	**250^D**
COD (mg/l)	10.0	-	3.0	5.0	2.0	2.0	5.0	2.0	2.0	2.0	2.0	5.0	5.0	**1000 ^{L}**
BOD_5^{20} (mg/l)	5.0	-	2.0	2.0	3.0	3.0	4.0	5.0	2.0	2.0	2.0	5.0	10.0	**4.0***
TSS (mg/l)	10.0	-	ND	30.0	2.0	9.0	10.0	0.0	0.0	0.0	0.0	8.0	15.0	**>10***
NO_3^- (mg/l)	0.45	-	0.16	0.04	1.35	0.25	0.45	0.20	0.22	1.60	0.36	0.20	0.25	**1.0***
PO_4^{3-} (mg/l)	0.06	-	0.03	0.03	0.06	0.07	0.04	0.01	0.03	0.65	0.02	0.01	0.04	**>5***
SO_4^{2-} (mg/l)	4.0	-	2.0	2.0	2.0	0.0	2.0	0.0	1.0	2.0	1.0	0.0	0.0	**500**
DO (mg/l)	4.7	-	5.2	5.5	5.0	5.8	5.0	5.8	5.6	5.2	5.4	5.0	5.8	**6.0***
NH_3 (mg/l)	ND	-	ND	ND	0.0	0.0	ND	0.0	0.0	0.0	0.0	0.0	0.0	**0****
S^{2-} (mg/l)	ND	-	ND	ND	0.0	0.0	ND	0.0	0.0	0.0	0.0	0.0	0.0	
Phenols (mg/l)	ND	-	ND	ND	0.0	0.0	ND	0.0	0.0	0.0	0.0	0.0	0.0	**1.0***
O&G (mg/l)	0.06	-	ND	ND	0.0	0.0	0.02	0.0	0.0	0.0	0.02	0.0	0.0	**0.05***

Sample Location / Parameters	AAK 2	AAK 4	AAK 7	AAK 10	AAK 15	AAK 17	AAK 19	AAK 21	AAK 26	AAK 27	AAK 32	AAK 52	AAK 56	FMENV
Alkalinity(mg/l)	120.0	-	60.0	60.0	0.0	83	120.0	85	120	128	148	165	165	**0.1***
CN^- (mg/l)	ND	-	ND	ND	0.0	0.0	ND	0.0	0.0	0.0	0.0	0.0	0.0	**5.0µg/l***
THC (mg/l)	ND	-	ND	ND	0.0	0.0	ND	0.0	0.0	0.0	0.0	0.0	0.0	
Detergent(mg/l)	ND	-	ND	ND	0.0	0.0	ND	0.0	0.0	0.0	0.0	0.0	0.0	**NA**
Sodium (mg/l)	4.8	-	7.1	7.6	6.2	7.0	5.0	5.6	5.6	5.0	10.8	7.2	7.5	**200***
Potassium(mg/l)	0.27	-	0.19	0.15	3.0	0.05	0.07	0.05	0.08	0.20	0.56	0.20	0.28	**NA**
Calcium (mg/l)	16.0	-	2.0	3.0	2.0	2.0	22.0	2.0	3.0	8.0	4.0	2.0	5.0	**NA**
Magnesium(mg/l)	6.8	-	3.0	5.0	2.0	0.0	10.0	0.0	0.0	2.2	2.0	2.0	3.0	**0.05***
Pb (mg/l)	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.1***
Cu (mg/l)	0.07	-	0.03	0.02	0.53	0.03	0.05	0.03	0.02	0.43	0.02	0.03	0.28	**5.0***
Zn (mg/l)	0.63	-	0.20	0.06	1.30	0.25	0.52	0.30	0.75	0.05	0.74	0.20	0.25	**0.05***
Mn (mg/l)	0.03	-	0.01	0.03	0.05	0.01	0.02	0.02	0.02	0.01	0.02	0.03	1.05	**1.0***
Fe (mg/l)	0.05	-	0.06	0.04	0.04	0.05	0.06	0.03	0.06	0.04	0.16	0.01	0.05	**0.01***
Cd (mg/l)	0.0		0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.05***
Cr (mg/l)	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.05***
Ni (mg/l)	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.06***

= FMENv Standard for Aquatic life D = FMENv Standard for drinking water R = FMENv Standard for recreational L= FMENv Standard for livestock
NA = Not available

13. Heavy Metals Characteristics

Table 4.8 showed that Nickel (Ni) was not detected in any of the samples in dry season. **Appendix-4-4** also shows that Ni was not detected in wet season.

In dry season chromium (Cr), cadmium (Cd) and lead (Pb) were present in the range of 0.00mg/l to 0.03mg/l; In Oguro Cd and Cr both showed content of 0.03mg/l and Pb 0.01mg/l. Also Cd indicated concentration of 0.02mg/l and 0.01mg/l in downstream and upstream of Kwaita River respectively.

In wet season the heavy metal concentration ranged from 0.0ppm to 43.12ppm; Pb, Cr, Cd were all indicated in Oguro and Challawa and Kpako and Tasawariki Stream. Lead indicated 0.02ppm, 0.01ppm, 0.05ppm and 0.08ppm in Kpako, Oguro, Challawa and Tasawariki Stream respectively. Chromium showed 0.02ppm, 0.03ppm, 0.02ppm and 0.02ppm in Kpako, Oguro, Challawa and Tasawariki Stream respectively while Cadmium is 0.04ppm, 0.02ppm, 0.04ppm and 0.02ppm respectively.

In dry season Fe and Zn were ubiquitous in all water samples; Fe showed range of 0.02mg/l to 1.12mg/l and Zn 0.05mg/l to 2.12mg/l; with Oguro River indicating highest concentration

In wet season zinc was also ubiquitous with Tasawariki Stream showing highest levels of 43.12mg/l. Mn was not that much occurring in the range of 0.01ppm to1.46ppm in both seasons. Apart from zinc and iron, other heavy metals show low concentration.

Iron is a chemical element and one of the most important metals in the water. The normal range for iron in freshwater is 0.1-0.5ppm.

14. Microbiology

The presence of faecal coliform bacteria indicates that the water is contaminated with faecal human or animal waste, while the total coliform counts indicate that the water is contaminated with both faecal waste and other bacteria from the soil.

Micro-organisms were identified growing virtually in all surface water, regardless of its temperature. The surface water in the study area indicated the following micro-organism *Bacillus spp; E. Coli; Staphylococcus spp; Micrococcus spp; Staphylococcus spp Fusarium spp; Flovobacterium spp; Penicillium spp; Aspergillus flavus; Pseudomonas spp; Saccharomyces spp; Aspergiluus wentii; Trichoderma spp; Geotrichum spp*; *Lactobacillus sppand Mucor spp.*

The heterotrophic bacteria of rivers varied between $1.210\text{x}10^6$cfu/ml and $4.100\text{x}10^6$ cfu/ml in dry season (see **Appendix-4-5**); the midstream of River Niger showed the highest value of $4.100\text{x}10^5$ cfu/gm and $1.01\text{x}10^5$ cfu/ml and $2.04\text{x}10^5$ cfu/ml in wet season (see **Appendix-4-6**).

Total coliform counts varied from surface water to surface water and between $0.00x10^2$ cfu/ml and $1.50x10^2$ cfu/ml, with the downstream of Osara River showing the highest value. The river that indicated very low coliform was identified to have area with less human and animal activities. The coliform count range from 0.00cfu/ml to $1.60x10^3$cfu/ml in wet season with downstream of Challawa River showing 0.00cfu/ml. The slightly high level of faecal coliform counts observed in wet season can be attributed to surface runoff caused by rain.

The percentage of hydrocarbon utilizers in the rivers sampled ranged from 0.0100cfu/ml to 0.1300cfu/ml.

The total hydrocarbon utilizing bacteria of surface water samples varied between $10.0x10^1$cfu/ml and $45.0x10^1$cfu/ml

4.18.10 Surface Water Use

The Rivers and streams generally are used for fishing, drinking and other domestic purposes by the local inhabitants of the area. In dry season, the streams in the study area are generally dried, hence their usage is reduced.

4.18.10.1 Groundwater

Generally the water supply system in the study area is primarily groundwater. Groundwater yield of the area is poor and is mostly tapped by hand-dug wells for agricultural and domestic purposes. The extensive area of the study area is covered by the crystalline rocks of the Basement Complex which are poor aquifers. The Basement Complex rocks consists mainly of igneous and metamorphic rocks, which are neither porous nor permeable except in areas where the rocks are cleaved, shattered, jointed, or fissured.

Solid rocks of the Basement Complex have porosities ranging from 1 to 3 per cent. Permeability is also small because the pores are small and disconnected.

Although folds, faults, joints and shear zones are common, they are too localized to be of significant importance as reservoirs of water. The groundwater resources so far located in the Basement Complex area occur in a perched form, perhaps because of the rapid local variations in the depth of the weathered mantle and in the occurrence of diastrophic features.

The average depth of groundwater in the study area varies between 40m and 80m depending in the area and it is generally recharged by rainfall and surface water. The study area has an elevation range of 55.5m to 693.6m and receives an annual rainfall of 0.00mm to 604.7.8m (1996-2008). The highest monthly rainfall occurs in July to September and the lowest levels are observed in May and October.

The soil of the study area generally has a medium permeable material such as silt and silty sand and includes some impermeable soil (clay). The permeability of the soil is low surface contaminant sources will be transported slowly.

Thirty existing boreholes were identified in the study area and samples were taken to determine groundwater quality.

1. Physico-chemical Characteristics

The pH of the groundwater in the study area in dry season showed neutral (7.17-7.91) characteristics and the EC varied between 0.69 and 444 µS (see **Table 4.9**). In wet season the pH varied between 6.50 and 7.17; Kaida, Izom, Bonu, Kazai, Sarkin Pawa, Zangon Aya and Mando/Kawo groundwater showed range of 6.50 to 6.89 in wet season (see **Appendix-4-7**).

The hardness values of the groundwater in the study area ranges from 0.0mg/l to 95.0mg/l.Sarkin Pawa groundwater indicated zero content. The turbidity values of the ground water vary between 0.0mg/l to 0.06mg/l in dry season and 0.05mg/l and 2.56mg/l in wet season (**EPL, 2008**).

The oil and grease content generally showed zero concentration with the exception of Sarkin Pawa (0.05mg/l) and Tambarawa (0.03mg/l).

Calcium values for groundwater samples indicated range of 1.8 to 24.5 mg/l in the dry season with Izom and Bonu showing 24.5mg/l and 20.2mg/l respectively.

The groundwater samples showed Sodium concentrations that range from 5.0mg/l to 56.5mg/l; Izom ground water showed the highest content. In wet season Na content was less than 55.8 mg/L. Chlorine concentration varied between of 10.2mg/l and 220.0 mg/l dry season. Sulphate content in the groundwater samples range from values are between 0.0mg/l and 5.0 mg/l in dry season; Karfi groundwater showed zero concentration. In wet season the sulphate content varied between 1.0mg/l and 6.0mg/l (**EPL Field Data, 2008**).

Table 4.9: Dry season results of the chemical analysis of the groundwater samples from existing borehole in the study

Parameter	pH	Turb NTU	TSS (mg/l)	Cond (uS)	TDS (mg/l)	Alk (mg/l)	TH (mg/l)	O&G (mg/l)	Cl (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)	Ca (mg/l)	NO_3 (mg/l)	SO_4 (mg/l)
Sample Location															
AAK Ajaokuta underground water	7.58	0.0	0.0	198	0.65	120	85.0	0.0	14.0	5.0	7.0	0.40	6.0	0.02	4.0
AAK Geregu underground water	7.68	0.0	0.0	186	0.98	126	80.0	0.0	19.0	4.0	5.0	0.35	8.0	1.08	5.0
AAK Zangon Daji underground water	7.17	0.05	0.0	186	139	45.0	85.0	0.0	33.0	5.0	18.8	0.62	3.0	1.04	2.0
AAK Koton karfe underground water	7.76	0.02	0.0	213	170	35.0	82.0	0.0	25.0	0.0	10.5	0.20	3.0	0.57	1.0
AAK Sensenyi underground water	7.49	0.0	0.0	187	108	32.0	85.0	0.0	30.0	2.0	15.0	0.42	3.0	0.65	1.0
AAK Abaji underground water	7.46	0.03	0.0	165	0.79	30.0	75.0	0.0	20.0	0.0	10.8	0.28	3.0	0.95	2.0
AAK Dangara underground water	7.51	0.0	0.0	179	116	35.0	76.0	0.0	33.5	3.0	18.1	0.44	5.0	0.92	2.0
AAK Dafa underground water	7.43	0.0	0.0	197	107	33.3	75.0	0.0	28.6	3.0	16.8	0.54	4.0	0.85	2.0
AAK Kassanki underground water	7.32	0.05	0.0	163	0.34	36.0	76.0	0.0	18.0	2.0	14.3	0.60	5.0	0.61	2.0
AAK Kaida underground water	7.76	0.04	0.0	138	0.95	37.2	81.9	0.0	32.2	3.0	16.2	0.34	3.0	0.26	3.0
AAK Izom underground water	7.91	0.0	0.0	168	102	35.0	95.0	0.0	220.0	8.0	56.5	0.10	24.5	0.38	1.0

Parameter	pH	Turb NTU	TSS (mg/l)	Cond (uS)	TDS (mg/l)	Alk (mg/l)	TH (mg/l)	O&G (mg/l)	Cl (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)	Ca (mg/l)	NO_3 (mg/l)	SO_4 (mg/l)
Sample Location															
AAK Ajaokuta underground water	7.58	0.0	0.0	198	0.65	120	85.0	0.0	14.0	5.0	7.0	0.40	6.0	0.02	4.0
AAK Bonu underground water	7.31	0.02	0.0	112	0.93	32.0	86.0	0.0	130.0	6.0	51.0	0.45	20.2	0.46	2.0
AAK Kazai underground water	7.28	0.0	0.0	131	061	28.9	88.5	0.0	20.6	5.0	44.6	0.68	18.6	0.22	1.0
AAK Sarkin Pawa underground water	7.69	0.0	380	444	222	40	0.0	0.05	80.0	0.0	7.1	0.16	5.0	0.35	2.0
AAK Gwagwada underground water	7.29	0.0	0.0	186	062	50.0	80.2	0.0	18.0	3.0	16.0	0.40	3.0	0.26	2.0
AAK Ligari underground water	7.28	0.0	2.0	123	0.91	41.2	89.6	0.0	22.3	2.0	16.6	0.61	3.0	0.39	2.0
AAK Kawo/Mando underground water	7.34	0.0	2.0	193	0.73	30.0	86.0	0.0	36.0	2.0	18.9	0.75	6.0	0.93	2.0
AAK Jaji underground water	7.48	0.0	0.0	0.91	0.69	50.0	90.2	0.0	182.0	9.0	9.7	0.08	18.0	0.65	1.0
AAK Jaji underground water	7.48	0.0	0.0	0.91	0.69	50.0	90.2	0.0	182.0	9.0	9.7	0.08	18.0	0.65	1.0
AAK Zangon Aya underground water	7.23	0.0	0.0	206	0.84	40.0	80.0	0.0	34.0	5.0	18.8	0.62	3.0	0.29	2.0
AAK Fangonzan Gari underground water	7.36	0.04	14.6	124	0.67	84.6	86.0	0.0	26.8	6.0	8.7	0.14	4.0	0.52	2.0
AAK Likoro underground water	7.48	0.03	26.0	126	0.81	90.0	85.9	0.0	16.0	2.0	8.3	0.06	6.0	0.28	2.0

Parameter	pH	Turb NTU	TSS (mg/l)	Cond (uS)	TDS (mg/l)	Alk (mg/l)	TH (mg/l)	O&G (mg/l)	Cl (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)	Ca (mg/l)	NO_3 (mg/l)	SO_4 (mg/l)
Sample Location															
AAK Ajaokuta underground water	7.58	0.0	0.0	198	0.65	120	85.0	0.0	14.0	5.0	7.0	0.40	6.0	0.02	4.0
AAK Rahman Wali underground water	7.29	0.0	0.0	115	073	30.2	81.3	0.0	19.6	4.0	14.6	0.63	5.0	0.60	2.0
AAK Gimi underground water	7.37	0.0	0.0	0.96	081	38.9	86.7	0.0	36.0	5.0	18.6	0.58	3.0	0.25	2.0
AAK Rumi underground water	7.78	0.01	14.0	131	101	88.6	85.0	0.0	10.2	3.0	8.0	0.16	5.0	0.30	1.0
AAK Zakau underground water	7.58	0.05	0.05	143	110	32.0	82.0	0.0	25.3	8.0	13.0	0.56	4.0	0.46	0.0
AAK Sabon Gida underground water	7.29	0.0	14.3	133	103	84.6	83.8	0.0	23.9	5.0	8.3	0.24	5.0	0.39	1.0
AAK Chiromawa underground water	7.36	0.0	0.0	0.98	0.96	230	85.0	0.0	20.0	5.0	10.4	0.18	1.8	0.40	1.0
AAK Karfi underground water	7.34	0.0	0.0	0.89	112	216.2	87.0	0.0	22.6	5.0	11.6	0.21	11.9	0.48	0.0
AAK Tamburawa underground water	7.36	0.0	0.0	131	91	22.0	90.5	0.03	23.0	6.0	13.0	0.10	12.5	0.30	1.0
FMENV Limit*	**6.5-8.5**	**1.0**	**>10**	**NA**	**500**	**-**	**1.0**	**0.05**	**250**	**-**	**200**	**-**	**-**	**-**	**-**

2. Heavy Metal

Cd, Cr, Ni, Pb and Hg concentration in the groundwater samples generally indicated zero. Fe, Cu, Mn and Zn were present in all samples; Mn ranged from 0.01mg/l to 0.30mg/l, with Geregu showing the highest concentration, Zn ranged from 0.20mg/l to 1.36mg/l and Fe 0.02mg/l to 0.54mg/l (see **Table 4.10**).

In wet season (**Appendix-4-8**) Fe concentration vary between 0.01ppm and 2.42ppm (**EPL Field Data, 2008**).

Table 4.10: Results of the heavy metal analyses of the groundwater samples from existing boreholes in the study area

Parameters/Sample Location	Pb (ppm)	Cr (ppm)	Ni (ppm)	Hg (ppm)	Mn (ppm)	Zn (ppm)	Fe (ppm)	Cu (ppm)
AAK Ajaokuta underground water	0.0	0.0	0.0	0.0	0.29	1.36	0.35	0.50
AAK Geregu underground water	0.0	0.0	0.0	0.0	0.30	1.25	0.54	0.62
AAK Zangon Daji underground water	0.0	0.0	0.0	0.0	0.10	1.15	0.38	0.60
AAK Koton karfe underground water	0.0	0.0	0.0	0.0	0.15	1.10	0.27	0.68
AAK Sensenyi underground water	0.0	0.0	0.0	0.0	0.23	1.25	0.19	0.50
AAK Akpasi underground water	0.0	0.0	0.0	0.0	0.05	1.15	0.15	0.25
AAK Abaji underground water	0.0	0.0	0.0	0.0	0.02	1.12	0.10	0.22
AAK Dangara underground water	0.0	0.0	0.0	0.0	0.01	0.50	0.06	0.01
AAK Dafa underground water	0.0	0.0	0.0	0.0	0.01	0.45	0.05	0.01
AAK Kassanki underground water	0.0	0.0	0.0	0.0	0.04	0.61	0.06	0.01
AAK Kaida underground water	0.0	0.0	0.0	0.0	0.02	0.70	0.02	0.03
AAK Izom	0.0	0.0	0.0	0.0	0.01	0.70	0.08	0.02

Parameters/Sample Location	Pb (ppm)	Cr (ppm)	Ni (ppm)	Hg (ppm)	Mn (ppm)	Zn (ppm)	Fe (ppm)	Cu (ppm)
underground water								
AAK Bonu underground water	0.0	0.0	0.0	0.0	0.01	0.58	0.04	0.01
AAK Kazai underground water	0.0	0.0	0.0	0.0	0.02	0.72	0.07	0.03
AAK Sarkin Pawa underground water	0.0	0.0	0.0	0.0	0.01	0.50	0.08	0.03
AAK Gwagwada underground water	0.0	0.0	0.0	0.0	0.03	0.65	0.15	0.05
AAK Ligari underground water	0.0	0.0	0.0	0.0	0.01	0.30	0.26	0.04
AAK Kawo/Mando underground water	0.0	0.0	0.0	0.0	0.01	0.40	0.20	0.04
AAK Jaji underground water	0.0	0.0	0.0	0.0	0.04	0.52	0.19	0.02
AAK Zangon Aya underground water	0.0	0.0	0.0	0.0	0.04	0.60	0.10	0.02
AAK Fangonzan Gari underground water	0.0	0.0	0.0	0.0	0.03	0.40	0.21	0.01
AAK Likoro underground water	0.0	0.0	0.0	0.0	0.01	0.35	0.09	0.03
AAK Ungwan Samaila	0.0	0.0	0.0	0.0	0.01	0.35	0.07	0.03

Parameters/Sample Location	Pb (ppm)	Cr (ppm)	Ni (ppm)	Hg (ppm)	Mn (ppm)	Zn (ppm)	Fe (ppm)	Cu (ppm)
underground water								
AAK Rahman Wali underground water	0.0	0.0	0.0	0.0	0.02	0.20	0.09	0.01
AAK Gimi underground water	0.0	0.0	0.0	0.0	0.01	0.20	0.04	0.01
AAK Rumi underground water	0.0	0.0	0.0	0.0	0.04	0.45	0.05	0.01
AAK Zakau underground water	0.0	0.0	0.0	0.0	0.01	0.57	0.05	0.03
AAK Sabon Gida underground water	0.0	0.0	0.0	0.0	0.02	0.40	0.04	0.02
AAK Chiromawa underground water	0.0	0.0	0.0	0.0	0.02	0.20	0.05	0.01
AAK Karfi underground water	0.0	0.0	0.0	0.0	0.03	0.40	0.06	0.03
AAK Tamburawa underground water	0.0	0.0	0.0	0.0	0.02	0.30	0.06	0.02
FMENv LIMIT	**0.05**	**0.05**	**0.05**	**0.001**	**0.05**	**5.0**	**0.1**	**0.05**

All values obtained in above tables were below the FMENV limits

3. Microbiology of Groundwater

The ground water generally showed percentage hydrocarbon utilizers within the heterotrophic communities that are generally less than 1.0; indicating non oil pollution. Hydrocarbon utilizers are widely distributed in nature and their increased incidence is attributed to environmental exposure to extraneous hydrocarbons.

Indigenous microbial population in groundwater includes *Bacillus spp; Fusarium spp; Aspergillus flavus; Aspergillus niger* in both seasons. In groundwater samples the total coliform showed zero concentration in both wet and dry season.

The non presence of faecal coliform bacteria in all the groundwater samples indicates that the water is not contaminated with faecal human or animal waste, while the total coliform counts indicate that the water is contaminated with both faecal waste and other bacteria from the soil.

Table 4.11 showed the distribution of microorganisms in groundwater of the study area in dry season while the wet season result is shown in **Appendix-4-9**.

Table 4.11: Distribution of microorganisms in groundwater of the study area in dry season

Sample location	Total Heterotrophic Bacteria (cfu/ml)	Total Heterotrophic Fungi (cfu/ml)	Total coliform (cfu/ml)	Total Hydrocarbon Utilizing Bacteria (cfu/ml)	Percentage of Hydrocarbon Utilizers (cfu/ml)	Predominant Species of Microorganisms Isolated (cfu/ml)
AAK Ajaokuta underground water	$1.48x10^5$	$3.00x10^4$	0.00	$9.00x10^1$	0.0700	*Bacillus spp; Rhizopus stolonifer;Micrococcus spp*
AAK Geregu underground water	$1.50x10^5$	$2.00x10^4$	0.00	$8.00x10^1$	0.0800	*Micrococcus spp Bacillus spp; Rhizopus stolonifer; Clostridum*
AAK Zangon Daji underground water	$1.70x10^5$	$1.00x10^4$	0.00	$10.0x10^1$	0.0500	*Bacillus spp; Rhizopus stolonifer Staphylococcus spp;*
AAK Koton karfe underground water	$1.50x10^5$	$2.00x10^4$	0.00	$9.00x10^1$	0.0700	*Bacillus spp; Rhizopus stolonifer; Micrococcus spp*
AAK Sensenyi underground water	$1.60x10^5$	$3.00x10^4$	0.00	$7.00x10^1$	0.0600	*Aspergillus niger; Bacillus spp; Rhizopus stolonifer;*
AAK Akpasi underground	$1.45x10^5$	$3.00x10^4$	0.00	$9.00x10^1$	0.0700	*Aspergillus niger; Bacillus spp; Rhizopus*

Sample location	Total Heterotrophic Bacteria (cfu/ml)	Total Heterotrophic Fungi (cfu/ml)	Total coliform (cfu/ml)	Total Hydrocarbon Utilizing Bacteria (cfu/ml)	Percentage of Hydrocarbon Utilizers (cfu/ml)	Predominant Species of Microorganisms Isolated (cfu/ml)
water						*stolonifer;*
AAK Shedemu underground water	$1.58x10^5$	$4.00x10^4$	0.00	$8.00x10^1$	0.0700	*Aspergillus niger; Bacillus spp; Rhizopus stolonifer; Staphylococcus spp;*
AAK Abaji underground water	$1.50x10^5$	$3.00x10^4$	0.00	$9.00x10^1$	0.0800	*Aspergillus niger; Bacillus spp; Rhizopus stolonifer;*
AAK Agena underground water	$1.50x10^5$	$3.00x10^4$	0.00	$7.00x10^1$	0.0600	*Aspergillus niger; Bacillus spp; Rhizopus stolonifer; Micrococcus spp Staphylococcus spp;*
AAK Dangara underground water	$1.40x10^5$	$2.00x10^4$	0.00	$10.00x10^1$	0.0600	*Aspergillus niger; Bacillus spp; Rhizopus stolonifer; Micrococcus spp*
AAK Dafa underground water	$1.30x10^5$	$3.00x10^4$	0.00	$9.0x10^1$	0.0800	*Bacillus spp;; Fusarium spp; Penicillium notatum; Aspergillus niger*

Sample location	Total Heterotrophic Bacteria (cfu/ml)	Total Heterotrophic Fungi (cfu/ml)	Total coliform (cfu/ml)	Total Hydrocarbon Utilizing Bacteria (cfu/ml)	Percentage of Hydrocarbon Utilizers (cfu/ml)	Predominant Species of Microorganisms Isolated (cfu/ml)
AAK Kassanki underground water	$1.20x10^5$	$3.00x10^4$	0.00	$8.0x10^1$	0.0900	*Bacillus spp; Fusarium spp; Penicillium notatum; Aspergillus niger*
AAK Kaida underground water	$1.25x10^5$	$4.00x10^4$	0.00	$6.0x10^1$	0.900	*Bacillus spp; Fusarium spp; Micrococcus spp Aspergillus niger*
AAK Izom underground water	$1.30x10^5$	$6.00x10^4$	0.00	$12.0x10^1$	0.0600	*Bacillus spp; Fusarium spp; Penicillium notatum; Aspergillus niger*
AAK Bonu underground water	$1.21x10^5$	$5.00x10^4$	0.00	$8.00x10^1$	0.0700	*Bacillus spp; Rhizopus stolonifer;*
AAK Kazai underground water	$1.20x10^5$	$7.00x10^4$	0.00	$9.00x10^1$	0.0800	*Aeromonas spp; Bacillus spp; Rhizopus stolonifer;*
AAK Sarkin Pawa underground	$2.01x10^5$	$1.00x10^4$	0.00	$11.00x10^1$	0.0100	*Bacillus spp; Rhizopus stolonifer; Micrococcus spp*

Sample location	Total Heterotrophic Bacteria (cfu/ml)	Total Heterotrophic Fungi (cfu/ml)	Total coliform (cfu/ml)	Total Hydrocarbon Utilizing Bacteria (cfu/ml)	Percentage of Hydrocarbon Utilizers (cfu/ml)	Predominant Species of Microorganisms Isolated (cfu/ml)
water						
AAK Gwagwada underground water	$1.80x10^5$	$2.00x10^4$	0.00	$10.00x10^1$	0.0500	*Aeromonas spp; Bacillus spp; Rhizopus stolonifer; Micrococcus spp*
AAK Ligari underground water	$1.75x10^5$	$4.00x10^4$	0.00	$12.00x10^1$	0.0400	*Bacillus spp; Staphyloccus spp; Pseudonomas spp; Asepergillus niger; Penicillium spp*
AAK Kawo/Mando underground water	$1.56x10^5$	$5.00x10^5$	0.00	$16.0x10^1$	0.1100	*Bacillus spp; Aspergillus flavu Rhizopus stolonifer; Aspergillus flavus*
AAK Jaji underground water	$1.30x10^5$	$6.00x10^4$	0.00	$16.00x10^1$	0.2100	*Aeromonas spp; Bacillus spp; Rhizopus stolonifer;*
AAK Zangon Aya underground water	$1.48x10^5$	$3.00x10^4$	0.00	$15.0x10^1$	0.2700	*Penicillium spp Bacillus spp; Rhizopus stolonifer;*
AAK Fangonzan	$1.30x10^5$	$4.00x10^4$	0.00	$20.0x10^1$	0.2800	*Penicillium spp*

Sample location	Total Heterotrophic Bacteria (cfu/ml)	Total Heterotrophic Fungi (cfu/ml)	Total coliform (cfu/ml)	Total Hydrocarbon Utilizing Bacteria (cfu/ml)	Percentage of Hydrocarbon Utilizers (cfu/ml)	Predominant Species of Microorganisms Isolated (cfu/ml)
Gari underground water						*Bacillus spp; Rhizopus stolonifer; Micrococcus spp*
AAK Likoro underground water	$1.52x10^5$	$4.00x10^4$	0.00	$22.0x10^1$	0.2100	*Penicillium spp Bacillus spp; Rhizopus stolonifer; Micrococcus spp*
AAK Ungwan Samaila underground water	$1.58x10^5$	$6.00x10^4$	0.00	$19.0x10^1$	0.2100	*Penicillium spp Bacillus spp; Rhizopus stolonifer;*
AAK Rahman Wali underground water	$1.50x10^5$	$4.00x10^4$	0.00	$21.0x10^1$	0.2000	*Penicillium spp Bacillus spp; Rhizopus stolonifer;*
AAK Gimi underground water	$1.60x10^5$	$5.00x10^4$	0.00	$25.0x10^1$	0.2200	*Penicillium spp Bacillus spp; Rhizopus stolonifer;*
AAK Rumi underground water	$1.70x10^5$	$6.00X10^4$	0.00	$21.0X10^1$	0.2300	*Fusaruim spp; Bacillus spp; Aspergillus niger*

Sample location	Total Heterotrophic Bacteria (cfu/ml)	Total Heterotrophic Fungi (cfu/ml)	Total coliform (cfu/ml)	Total Hydrocarbon Utilizing Bacteria (cfu/ml)	Percentage of Hydrocarbon Utilizers (cfu/ml)	Predominant Species of Microorganisms Isolated (cfu/ml)
AAK Zakau underground water	$1.55x10^5$	$5.00X10^4$	0.00	$24.0X10^1$	0.1900	*Fusaruim spp; Penicillium spp Bacillus spp; Aspergillus niger*
AAK Sabon Gida underground water	$1.70x10^5$	$9.00X10^4$	0.00	$20.0X10^1$	0.2000	*Fusaruim spp; Bacillus spp; Aspergillus niger*
AAK Chiromawa underground water	$1.79x10^5$	$10.00X10^4$	0.00	$2.20X10^1$	0.1900	*Fusaruim spp; Bacillus spp; Aspergillus niger Penicillium spp*
AAK Karfi Koro underground water	$1.310x10^6$	$1.00X10^2$	0.00	$15.0X10^1$	0.0100	*Lactobacillus spp; Bacillus spp; Aspergillus niger*
AAK Tamburawa underground water	$1.80x10^5$	$8.00X10^4$	0.00	$27.0X10^1$	0.2000	*Fusaruim spp; Bacillus spp; Aspergillus niger Penicillium spp*

4.18.11 Hydrology

The study area is well drained with a reasonably close network of rivers and streams. Most of these rivers however are seasonal with the exception of Kaduna, Niger, Gurara, Echun, Challawa and Kano Rivers. All the rivers in the study area are tributaries to River Niger; but Rivers in Kano are drained by Lake – Chad.

The small rivers have other streams that flow into them. The streams drain villages and generally remained dry during dry season. Sand mining operation is carried out at the major rivers especially in wet season. In the rivers where sand mining are carried out (River Niger, Kaduna River, Gurara River and Challawa River), it represents sediment sink.

4.18.12 Surface Run-Off and Flooding

Rainfall must be of sufficient intensity and duration to exceed the soil moisture absorbing capacity and travel down slope. The duration must be long enough to allow the run-off water at any location to travel down slope or over land until it reaches more defined drainage paths and the rivers. Of the rain that falls over an area, some percolates to replenish soil moisture and groundwater storage, some runs off to join streams and rivers. A substantial amount is lost through the eva-potranspiration processes.

Rainfall in the area is strongly seasonal, with wet season occurring between March and November. The greatest frequency and intensity normally occurs from June to July and September. The River Niger area of the study area has history of flood event. Other rivers in the study area are tributaries to River Niger.

The flow channels of River Niger have recorded flood event that overflow the channel and spill out into the vegetation floor. The channel of flow expands in width during wet season and reduces during dry season. Flow rate of the rivers in the study area are relatively high during wet season and reduces in the dry season. The flow rate of rivers in the study area in dry season is provided in **Table 4.12** below.

4.18.13 Sediment Sources

Sand, gravel and silt in the study area are a product of the surface drain of the land within the littoral cell. The sand and gravel are delivered to the bank of rivers and stream by surface run-off in wet season and it is high in the months of July to September. Also, sand mining in the rivers generates sediment. The various streams that flow into the rivers are considered to contribute to sediment to the bank of the rivers.

Table 4.12: The flow rates of the large rivers in the study area

River	Flow rate in Dry Season	Flow rate in Wet Season (EPL, Field Data, 2008)
Osara River upstream	0.52	0.92
Osara River downstream	0.55	0.86
Niger River upstream	0.82	0.95
Niger River downstream	0.83	0.96
Kwaita River upstream	0.92	0.98
Kwaita River downstream	0.90	0.98
Kasanki/Kurara River upstr	1.5	1.6
Kasanki/Kurara River dmstr	1.3	1.9
Gurara River upstream	0.80	1.21
Gurara River downstream	0.82	1.91
Kaduna River upstream	32.2	46.7
Kaduna River downstream	31.5	46.7
Kano River upstream	2.51	2.66
Kano River downstream	2.53	2.69
Challawa River upstream	2.20	2.36
Challawa River downstream	2.21	2.38
Kazai River upstream	0.80	0.97
Kazai River downstream	0.82	0.97
Echun River upstream	0.15	0.28
Echun River downstream	0.17	0.28
Sarkin Pawa River upstr	0.12	0.16
Sarkin Pawa River dmstr	0.13	0.15

4.18.13.1 Sediment Transport and Quality

Water flow and its energy are the major determinants of sediment erosion, transport, and deposition in a fluvial/estuarine system such as the Rivers in the study area. The unconsolidated substrate reflects therefore the relative strength of the energy present; thus grain size is a function of energy regimes of the water masses and its degree of sorting describes the persistence of this energy condition. Coarser materials are found in high-energy environments and finer materials in low-energy environments, with a mixture of both in areas of fluctuating flow conditions.

The size of the most common occurring particle represents the particle-sizes that are best transported and deposited, hence it characterize the predominant transport energy.

The rivers crosses by the project flow through or are impacted on by towns, villages in and outside the study area. The rivers flow in a south-easterly direction.

The rivers and their flood plain are subjected to various potential impacts via anthropogenic activities: construction (roads etc) as well as the associated problems caused by formal and informal settlements.

Farming activities which take place in the study area include both agriculture and livestock. Crops such as maize, guinea corn, millet are planted in the area. Cattle are also reared extensively in the rich gracing provided by the flood plain by nomadic Fulanis in camp settlements.

These activities can be a source of sediment load to the rivers. The topography of the area makes them (rivers) drainage end points of flood plains of the study area.

4.18.13.2 Physical Characteristics of River Sediments

The sediment samples were collected in the upstream and downstream sides of flowing large rivers. River Niger sediment showed Light brown, and with trace of gravel and silt in both upstream and downstream; the ranges of moisture, sand, gravel and silt contents are 16.9% to 17.4%, 96.0% to 98.0%, 1.7% to 3.7% and 0.3% respectively.

Challawa River sediment is Dark grey, gravelly sand with moisture content of 14.5% to 18.2%, sand 47.2% to 87.5%, gravel 1.2% to1.6% and silt 24.2% to 28.6%.

Wet season showed moisture content of 12.4% to 25.3% upstream and 12.9% to 23.4% downstream (see **Appendix-4-10**). The sand content of the sediments upstream ranges from 49.6% to 93.8% upstream, 47.2% to 98.7% downstream and in dry season while wet season showed upstream 70.2% to 96.2% and downstream 74.1% to 97.5%.

The summary of sediment sieve analysis result dry season is shown in **Table 4.13**.

Table 4.13: Particle size distribution and moisture content of River Sediment samples

Samples codes	Depth	Moisture content (%)	% sand	% gravel	% silt	% Clay	Description	USCS
Dry Season								
River Niger	Upstream	17.4	98.0	1.7	0.3	-	Light brown, and with trace of gravel and silt	SP
	Downstream	16.9	96.0	3.7	0.3	-	Light brown, and with trace of gravel and silt	SP
River Kaduna	Upstream	17.1	91.2	1.0	7.8	-	Grey sand with trace of silt and gravel	SP
	Downstream	18.2	93.0	2.3	5.2	-	Brown sand with trace of silt and gravel	SP
River Kurara/Kassanki	Upstream	10.1	93.8	2.5	3.7	-	Grey sand with trace of silt and gravel	SP
	Downstream	12.5	90.2	2.1	5.2	-	Grey sand with trace of silt and gravel	SP
River Kano	Upstream	24.3	95.1	–	4.9	-	Light grey, sand with trace of silt Light grey gravelly sand	SP
	Downstream	22.5	60.7	28.7	35.4	-	Light grey, sand with trace of silt Dark grey gravelly sand	SP
River Gurara	Upstream	15.6	87.1	4.5	4.7	-	Brown, sand with trace of silt	SP
	Downstream	18.4	83.2	7.3	3.8	-	Light brown sand with trace of silt	SP
Challawa River	Upstream	14.5	87.5	1.2	28.6	_	Dark grey, gravelly sand	GM

Samples codes	Depth	Moisture content (%)	% sand	% gravel	% silt	% Clay	Description	USCS
	Downstream	18.2	47.2	1.6	24.2	_	Dark grey, gravelly sand	GM
Ofunene Stream		6.3	43.8	55.3	0.9	-	Greyish brown, gravel sand , mixture of silt	SP
Sarkin Parwa River		20.0	96.9	2.1	1.0	-	Grey sand mixed with decaying plant material	SP

4.18.14 Chemical Characteristics of Sediments

The sediment samples showed pH range of 6.35 to 7.22 indicating slight acidic to near neutral characteristics; River Niger showed range of 7.21 and 7.22 and other samples generally indicated pH below 7 and above 5 (**see Table 4.14**) . In wet season (**EPL, Field Data, 2008**) it ranges from 6.18 to 6.80 (see **Appendix-4-11**).

The sediments oil and grease content varied between 0.00mg/kg and 0.01mg/kg in dry season and 0.00mg/kg and 0.06mg/kg in wet season.

Phosphate was not determined in Kaduna River sediment but it was generally present in other river sediments ranging from 0.001mg/kg to 0.074mg/kg. Sulphate varied between 1.0mg/kg and 3.0mg/kg.

The heavy metal content of the sediments varies between 0.00mg/kg and 2.51mg/kg in dry season and 0.00mg/kg and 3.70mg/kg in wet season (**EPL, 2008**). Ni and Cd were the only toxic metals that were not detected. In dry season only River Echun showed presence of Ba and it ranged from 0.02mg/kg to 0.04mg/kg. Pb and Cr were not detected in dry season.

All the sediment samples showed presence of Zn (0.02mg/kg), Cu (0.02mg/kg to 2.51mg/kg) and Fe (0.01mg/kg to 0.06mg/kg).

In wet season Pb and Cr ranged from 0.01ppm to 0.02ppm. The sediment samples indicated Fe content of 0.34ppm to 3.28ppm in wet season (**EPL Field Data, 2008**).

Table 4.14: Physico-chemical and Heavy Metal Characteristics of Sediments Samples of Rivers

Parameters	R. Niger		R. Kaduna		R.Osara		R. Challawa		R. Gurara		R. Kano		River Echun	
	Upst	Dst	Upst	Dst	Upst	Dst	Upst	Dst	Upst	Dst	Upst	Dst	Upst	Dst
PH	7.21	7.22	6.96	6.85	6.74	6.70	6.92	6.86	6.87	6.92	6.41	6.35	6.44	6.40
TOC (%)	0.12	0.13	0.04	0.03	1.37	1.32	0.04	0.06	0.03	0.02	0.24	0.27	1.76	1.72
NO^{-}_{3} (mg/kg)	0.032	0.35	2.0	2.0	0.416	0.405	8.0	7.0	6.0	3.0	0.046	0.040	0.441	0.440
PO_4^{3-} (mg/kg)	0.005	0.004	ND	ND	0.074	0.071	0.003	0.001	0.002	0.002	0.007	0.005	0.067	0.061
SO_4^{2-} (mg/kg)	3.0	2.0	0.16	0.18	2.0	4.0	0.03	0.02	0.03	0.02	1.0	1.0	1.0	1.0
THC (mg / kg)	ND	ND	0.59	0.62	ND	ND	0.18	0.14	0.05	0.005	ND	ND	ND	ND
O & G (mg / kg)	ND	ND	0.01	0.01	0.0	0.01	0.01	0.0	0.0	0.01	0.01	0.01	0.01	0.0
CN^{-} (mg/kg)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenols (mg/kg)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
E.C ((μ -Scm^{-1})	52.6	52.8	ND	ND	105.0	105.0	ND	ND	ND	ND	60.3	60.8	112.0	115.0
Red Pot (mV)	39.7	39.4	ND	ND	42.2	42.5	ND	ND	ND	ND	43.6	43.0	42.7	45.2
Ba (mg/ kg)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.04	0.02
Cd (mg/ kg)	ND	ND	ND	ND	ND	ND	0.04	0.03	ND	ND	ND	ND	ND	ND

Parameters	R. Niger		R. Kaduna		R.Osara		R. Challawa		R. Gurara		R. Kano		River Echun	
	Upst	Dst	Upst	Dst	Upst	Dst	Upst	Dst	Upst	Dst	Upst	Dst	Upst	Dst
PH	7.21	7.22	6.96	6.85	6.74	6.70	6.92	0.62	0.34	0.67	0.05	0.08	0.15	0.12
TOC (%)	0.12	0.13	0.04	0.03	1.37	1.32	0.04	0.03	0.01	0.06	0.02	0.01	0.02	0.06
NO^{-}_{3} (mg/kg)	0.032	0.35	2.0	2.0	0.416	0.405	8.0	0.01	0.01	0.03	ND	ND	0.003	0.004
PO_4^{3-} (mg/kg)	0.005	0.004	ND	ND	0.074	0.071	0.003	ND	ND	ND	ND	ND	ND	ND
SO_4^{2-} (mg/kg)	3.0	2.0	0.16	0.18	2.0	4.0	0.03	ND	ND	ND	ND	ND	ND	ND
THC (mg / kg)	ND	ND	0.59	0.62	ND	ND	0.18	ND	ND	ND	ND	ND	ND	ND
O & G (mg / kg)	ND	ND	0.01	0.01	0.0	0.01	0.01	0.18	0.04	0.02	0.06	0.05	0.13	0.15

4.18.15 Microbiological Characteristics of Sediments

The total coliforms showed seasonal variations, ranging from $1.00x10^3$ cfu/ml to$1.40x10^3$ cfu/ml in wet season and showing no presence in dry season. A similar situation happened for *E. Coli. Stapylococcus spp; Micrococcus spp and Saccharomyces spp.* The *Bacillus spp; Aspergillus flavus; Penicillium spp and Fusarium spp* were predominant in both seasons.

Total Heterotrophic Bacteria in wet season ranges from$1.03x10^5$ cfu/ml to $9.70x10^7$ cfu/ml and $5.70x10^7$ cfu/ml to$11.10x10^7$ cfu/ml in dry season. The upstream and downstream microbial characteristics of sampled Rivers' sediments are shown in **Appendix-4-12**.

4.18.16 Soil Quality

Soil quality is the capacity of a soil to function within ecosystem and land use boundaries, to sustain biological productivity, maintain environmental quality and promote plant and animal health (Doran and Parkin, 1994).The project ROW traverses the Guinea and Sudan savannah ecological zone of Nigeria

4.18.16.1 Soil Physical Characteristics

Particle-size distribution analysis of soil (surface and sub) samples of the study area commonly indicated clayey sand; also the soils showed the following characteristics silty sand, gravelly sand, sandy clay, lateritic clayey sand and lateritic sandy clay. The soils are generally of inorganic clay of low to medium plasticity, clayey sand and poorly graded sand.

In dry season the distribution of soil grains in the study area show 25.3% to 79.5 % sand in the surface layer and 21.7% to 79.5% sub layer, Silt of 18.5% to 53.7% in the surface and 17.1% to 56.8% sub and 3.5% to 58.6% surface and 1.9% to 29.8% clay and gravel surface of 0.1% to 13.2% and sub 0.1% to 23.6% (see **Table 4.15**).

The wet season data indicate particle size distribution of 32.6 % to 57.6 % sand in the surface layer and 36.1% to 60.2% sub layer, silt of 24.1% to 42.9% in the surface and 16.9% to 44.1% sub and clay 9.8% to 28.2% surface and 0.0% to 30.1% sub layer and gravel 0.0% to 14.0% surface and 0.1% to 24.5% sub layer.

In dry season the percent moisture content for topsoil ranged from 0.7% to 17.5% while that for subsoil ranged from 1.3% to 22.4%.

Wet season percent moisture content (**EPL Field Data, 2008**) indicates topsoil and subsoil ranging from 10.5% to 29.1% for topsoil and 9.0% to 26.9% for subsoil (see Appendix-4-13). The moisture content of the soils of the study area in wet and dry season indicate significant variance and it increased northward of the study area.

Table 4.15: Particle Size Distribution and Moisture Content of Soil Samples

Samples codes	Depth	% Moisture content	% sand	% gravel	% silt	% Clay	Description	USCS
AAK 1	0-20cm	3.5	79.5	0.7	20.4	3.5	Blackish grey, silty sand mixed with plant material	SM
	0-50cm	1.9	79.5	3.4	17.1	1.9	Dark grey, silty sand with trace of gravel	SM
AAK 2	0-20cm	6.9	58.2	1.9	52.5	5.8	Grey, clayey sand with trace of gravel and plant roots	SC
	0-50cm	8.9	63.5	2.2	50.6	5.7	Grey, clayey sand with trace of gravel	SC
AAK 5	0-20cm	12.5	49.5	1.8	34.5	5.6	Grey, clayey sand with trace of gravel and plant roots	SC
	0-50cm	13.8	51.2	1.2	31.7	5.3	Grey, clayey sand with trace of gravel	SC
AAK 6	0-20cm	8.5	56.6	1.9	39.2	7.0	Grey, clayey sand with trace of gravel and plant roots	SC
	0-50cm	10.2	26.7	10.6	48.9	13.9	Grey, clayey sand with trace of gravel	SC
AAK 8	0-20cm	10.7	52.5	1.9	32.6	10.8	Dark grey, clayey sand with trace of gravel and plant roots	SC
	0-50cm	11.9	38.6	3.1	45.9	14.2	Grey, clayey sand with trace of gravel	SC
AAK 9	0-20cm	9.2	54.0	1.8	36.2	8.0	Dark grey clayey sand with trace of gravel	SC
	0-50cm	12.0	23.2	13.5	47.7	15.6	Grey clayey sand with some gravel and trace of plant roots	SC
AAK 10	0-20cm	12.5	49.5	1.8	34.5	5.6	Grey clayey sand with trace of gravel	SC
	0-50cm	13.8	51.2	1.2	31.7	5.3	Grey clayey sand with some gravel and trace of plant roots	SC
AAK 11	0-20cm	10.8	58.7	1.1	38.9	8.0	Dark grey clayey sand with trace of gravel	SC
	0-50cm	13.5	33.2	1.5	49.6	13.2	Dark grey clayey sand with some gravel and trace of plant roots	SC
AAK 12	0-20cm	8.9	50.2	1.4	36.2	9.7	Dark grey clayey sand with trace of gravel	SC
	0-50cm	11.6	37.6	2.7	47.7	12.7	Grey clayey sand with some gravel and trace of plant roots	SC

Samples codes	Depth	% Moisture content	% sand	% gravel	% silt	% Clay	Description	USCS
AAK 13	0-20cm	8.4	61.5	1.5	38.2	8.6	Dark grey clayey sand with trace of gravel	SC
	0-50cm	10.5	48.1	3.6	51.2	12.6	Grey clayey sand with some gravel and trace of plant roots	SC
AAK 14	0-20cm	2.1	73.7	7.3	19.0	–	Light brown, silty sand with some gravel	SM
	0-50cm	2.2	71.3	8.0	20.7	–	Light brown, silty sand with gravel	SM
AAK 16	0-20cm	9.8	72.6	2.9	25.2	-	Dark grey silty sand with trace of plant roots	SM
	0-50cm	12.1	71.9	2.5	25.9	-	Dark brown, silty sand with trace of gravel	SM
AAK 18	0-20cm	11.2	68.2	3.6	22.7	-	Dark grey silty sand with trace of plant roots	SM
	0-50cm	9.8	72.9	2.9	26.8	-	Dark brown, silty sand with trace of gravel	SM
AAK 20	0-20cm	17.0	44.0	0.2	45.1	10.7	Dark grey silty sand with trace of plant roots	SM
	0-50cm	14.0	57.8	0.5	32.0	9.7	Dark brown, silty sand with trace of gravel	SM
AAK 22	0-20cm	0.7	68.3	13.2	18.5	-	Light brown, gravelly sand	GM
	0-50cm	1.3	59.4	23.6	17.0	-	Light brown, gravelly sand	GM
AAK 23	0-20cm	17.5	48.2	0.6	45.7	12.6	Grey clayey sand with trace of gravel	SC
	0-50cm	15.2	55.7	0.8	35.8	10.2	Grey, clayey sand with trace of gravel	SC
AAK 24	0-20cm	16.5	49.3	0.9	39.1	11.2	Grey clayey sand with trace of gravel	SC
	0-50cm	12.9	58.5	1.2	33.5	9.5	Grey, clayey sand with trace of gravel	SC
AAK 25	0-20cm	2.1	60.0	–	33..2	6.8	Light grey, clayey sand	SC
	0-50cm	5.0	72.4	0.2	27.4	–	Grey silty sand with trace of gravel	SM
AAK 29	0-20cm	1.3	71.1	0.7	28.2	–	Light grey, silty sand with trace of plant roots and gravel	SM
	0-50cm	4.9	60.6	0.2	30.0	9.2	Brown, lateritic clayey sand with	SC

Samples codes	Depth	% Moisture content	% sand	% gravel	% silt	% Clay	Description	USCS
							trace of gravel	
AAK 30	0-20cm	3.3	37.0	1.9	53.7	12.6	Dark grey clayey sand with trace of gravel	SC
	0-50cm	6.8	45.6	1.2	45.7	10.9	Dark grey clayey sand with trace of gravel	SC
AAK 31	0-20cm	12.6	25.3	0.8	45.6	31.5	Brown, sandy clay	CL
	0-50cm	21.6	21.7	0.3	49.2	28.2	Brown, sandy clay	CL
AAK 33	0-20cm	14.6	26.8	0.7	45.6	37.5	Brown, sandy clay	CL
	0-50cm	12.2	25.9	0.5	47.6	28.2	Brown, sandy clay	CL
AAK 35	0-20cm	12.7	37.8	0.5	47.7	9.8	Dark grey clayey sand with trace of gravel	SC
	0-50cm	15.3	48.3	0.9	43.1	8.5	Dark grey clayey sand with trace of gravel	SC
AAK 36	0-20cm	1.6	49.6	0.4	27.7	22.3	Brown, lateritic sandy clay with trace of gravel	CL
	0-50cm	9.2	49.4	0.1	25.9	24.6	Brown, lateritic sandy clay with trace of gravel	CL
AAK 37	0-20cm	16.5	26.2	0.5	42.5	33.8	Brown, sandy clay	CL
	0-50cm	22.4	24.3	0.2	48.4	26.9	Brown, sandy clay	CL
AAK 38	0-20cm	1.9	30.2	0.2	49.2	42.8	Brown, sandy clay	CL
	0-50cm	2.2	29.2	0.1	46.3	20.6	Brown, sandy clay	CL
AAK 39	0-20cm	14.9	30.2	0.8	46.8	35.4	Brown, sandy clay	CL
	0-50cm	21.8	26.7	0.6	49.7	29.8	Brown, sandy clay	CL
AAK 40	0-20cm	1.5	33.7	-	-	53.9	Grey, sandy clay with trace of plant root	CL
	0-50cm	2.9	31.9	-	55.1	20.6	Grey sandy clay	CL
AAK 41	0-20cm	13.8	28.8	0.5	43.9	37.1	Brown, sandy clay	CL
	0-50cm	19.5	25.1	0.3	47.6	27.5	Brown, sandy clay	CL
AAK 42	0-20cm	1.8	34.5	-	-	50.2	Grey, sandy clay with trace of plant root	CL
	0-50cm	2.5	31.9	-	56.2	18.6	Grey sandy clay	CL
AAK 43	0-20cm	16.9	29.5	0.6	44.8	32.7	Brown, sandy clay	CL
	0-50cm	20.2	25.9	0.4	47.9	25.3	Brown, sandy clay	CL

Samples codes	Depth	% Moisture content	% sand	% gravel	% silt	% Clay	Description	USCS
AAK 44	0-20cm	1.7	34.3	-	-	55.1	Grey, sandy clay with trace of plant root	CL
	0-50cm	2.1	35.9	-	54.2	21.8	Grey sandy clay	CL
AAK 45	0-20cm	1.2	31.9	-	-	54.7	Grey, sandy clay with trace of plant root	CL
	0-50cm	2.8	30.2	-	56.8	18.2	Grey sandy clay	CL
AAK 50	0-20cm	1.8	32.6	-	-	53.1	Grey, sandy clay with trace of plant root	CL
	0-50cm	2.9	31.6	-	55.9	17.8	Grey sandy clay	CL
AAK 51	0-20cm	1.5	31.0	-	-	55.8	Grey, sandy clay with trace of plant root	CL
	0-50cm	2.2	30.6	-	52.7	16.7	Grey sandy clay	CL
AAK 54	0-20cm	2.1	74.2	0.1	25.7	-	Light grey, silty sand with trace of gravel	SM
	0-50cm	5.9	78.7	–	21.3	-	Grey, silty sand	SM
AAK 58	0-20cm	1.2	38.4	-	-	58.6	Grey, sandy clay with trace of plant root	CL
	0-50cm	4.9	37.9	-	51.6	20.6	Grey sandy clay	CL

Undisturbed core soil sample were at 0.50m taken and the dry season indicates loose to medium dense silty sand, medium dense silty sand, medium dense sand clay and lateritic clayey sand. The soil colour show blackish, dark, light grey, grey and brown.

In wet season the soils of the study area showed dense silty sand, medium dense silty sand, firm dense sand, firm organic clay with trace of plant materials, firm gravelly sandy clay and dense silty clay. The soils indicate black, dark/light grey and brown colours on wet season.

The moisture content of soils ranges from ranges from 0.7% to 6.3% in dry season. Wet season data (**EPL Field Data, 2008**) show 4.7% to 20% (see **Appendix-4-14**).

The bulk density and permeability constant of soils of the study area indicate range of 1.334mg/m^3 to 2.369mg/m^3 and $1.07x10^{-6}$K(ms^{-1}) to $7.10x10^{-6}$K(ms^{-1}) respectively in dry season (see **Table. 4.16**).

The bulk density of the soils reflects its strength, competence and weight to carry the project development. The soil of the study area is relatively stable and well compact.

Plate 4.9: Expert Collecting Soil Sample

Table 4.16: The bulk density and permeability constant of soils of the study area

Samples codes	Depth (m)	Moisture content (%)	Bulk Density mg/m^3	Permeability K (ms^{-1})	Description
AAK 1	0.50	1.4	1.334	$2.24x10^{-5}$	Blackish grey, loose dense silty sand mixed with fibrous plant roots
AAK 5	0.50	1.2	2.012	$1.95x10^{-5}$	Dark brown, medium dense silty sand
AAK 8	0.50	3.5	1.902	$1.34x10^{-5}$	Dark brown, dense silty sand
AAK 9	0.50	2.6	1.982	$1.17x10^{-6}$	Grey loose to medium dense sand clay
AAK 11	0.50	1.1	1.720	$1.07x10^{-6}$	Grey loose to medium dense sand clay
AAK 14	0.50	0.50	1.765	$7.10x10^{-6}$	Light grey, loose dense silty sand with trace of gravel
AAK 29	0.50	0.7	1.809	$1.82x10^{-6}$	Dark grey, loose dense, gravelly sand with trace of plant roots
AAK 31	0.50	6.3	1.628	$2.09x10^{-6}$	Grey firm to medium dense sand clay
AAK 33	0.50	5.1	1.780	$1.85x10^{-6}$	Greyish brown firm sandy clay
AAK 36	0.50	1.6	1.535	$1.49x10^{-7}$	Brown, lateritic clayey sand (loose sand)
AAK 43	0.50	3.8	2.369	$2.09x10^{-6}$	Grey brown firm sandy clay
AAK 55	0.50	3.9	1.607	$1.2x10^{-6}$	Blackish grey, loose dense, silty sand mixed with plant materials.
AAK 59	0.50	6.1	2.092	$1.54x10^{-6}$	Grey brown firm sandy clay

4.18.17 Soil Chemical Properties

Soil samples show pH range of 6.41 – 7.38 indicating slight acidity to neutral characteristics; surface soil ranged from 6.42 to 7.38 and sub soil 6.41 to 7.36.

In wet season the surface layer range from 6.80 to 7.28 and 6.90 to 7.38 in sub soil (see **Appendix-4-15**).

The land use in the study area is generally farming and bushes (vacant land) the trend of soil low acidity (neutral characteristics) in both seasons showed that cultivation and use of acid farming inorganic fertilizers on soils for cultivation is low in the study area. The soil organic matter in dry season varied between 0.05% and 4.62% with the top soil showing 0.09% and 4.62% and sub soil 0.05% and 3.97% in sub soils.

In wet season it ranged from 0.19% and 1.48% (0.20% and 1.62% in topsoil and 0.19% to 1.48% in subsoil). The organic matter generally decreased with depth; topsoil showed higher organic matter compared to subsoil, this can be attributed to farming activities. Areas with less farming showed higher content.

The oil and grease content of soil samples generally indicated zero concentration, but areas were it occurred it varied between 0.0mg/kg and 0.021mg/kg; top soil 0.0mg/kg to 0.021mg/kg and sub soil 0.0mg/kg to 0.016mg/kg. The oil and grease content decrease with soil depth.

The soil nutrients showed low concentration in the study area; nitrate concentration ranged from 0.01mg/kg to 0.67mg/kg in both topsoil and subsoil and in dry season; (top soil range from 0.03mg/kg to 0.67mg/kg and sub soil 0.01mg/kg to 0.66mg/kg) and in wet season (**EPL Field Data, 2008**) it decreased ranging from 0.01 mg/kg to 0.19 mg/kg and decreasing generally from top to subsoil.

The phosphate concentration ranged from 0.00mg/kg to 0.125mg/kg in both top and sub soils in dry season.

The Sulphate concentration in dry season ranged from 1.0mg/kg to 8.0mg/kg, in topsoil and subsoil and in wet season top and sub soil showed range of 1.0mg/kg to 6.0mg/kg (see **Table 4.17**).

Plate 4.10: AIES Staff collecting core sample

4.18.18 Exchangeable Cation

The Potassium content in dry season range from 0.03mg/kg to 2.93mg/kg with subsoil 0.03mg/kg to 0.87mg/kg and top soil 0.06mg/kg to 2.93mg/kg. In wet season exchangeable K generally decreased from top soil to sub; top soil ranges from 0.11mg/kg to 0.46mg/kg and sub soil 0.10mg/kg to 0.29mg/kg.

The distribution of exchangeable Na ranged from 0.68mg/kg to 110.0mg/kg, with top soil showing range of 0.68mg/kg to 110.0mg/kg and sub soil 0.82mg/kg to 86.2mg/kg; Na content in soil of the area tended generally to decrease from surface to subsurface in dry season and increased from surface to sub soil.

In wet season Ca ranged from 3.07mg/kg to 13.83mg/kg for topsoil and subsoil 3.01mg/kg to 12.86mg/kg.

The concentration of exchangeable Mg decreased from the surface to the sub-surface in some areas but generally showed the reverse trend (increasing from surface to sub soil); in dry season Mg ranged from 1.12mg/kg to 3.95mg/kg for topsoil and subsoil 1.78mg/kg to 3.48mg/kg.

In wet season Mg ranged from 1.25mg/kg to 4.49mg/kg for topsoil and subsoil 1.20mg/kg to 4.19mg/kg.

The decreasing trend of Mg concentration with depth in the study area is attributed to farming activities. Continuous cultivation and use of acid forming inorganic fertilizers deplete exchangeable Ca and Mg (Saikh *et al*., 1998b; He *et al*., 1999; Aitken *et al*., 1999).

The cation exchangeable capacity (CEC) of soil in the study area for top and sub soils range from 2.26 meq/100g to 6.26 meq/100g but in wet season it decreased and ranging from 1.78meq/100g to 5.78 meq/100g.

Table 4.17: Physico-chemical Laboratory Results of Soil Samples

Samples codes	Depth	pH	TOC %	NO_3^- mg/kg	PO_4^{3-} mg/kg	SO_4^{2-} mg/kg	THC Mg/kg	O&G Mg/kg	Cond µScm^{-1}	Na Mg/kg	K Mg/kg	Ca mg/kg	Mg mg/kg	CEC meq/100g
AAK 1	0-20cm	6.42	2.05	0.67	0.121	4.0	ND	0.014	1250.0	1.56	0.07	15.12	2.30	6.20
	0-50cm	6.41	1.56	0.66	0.125	5.0	ND	0.010	130.0	1.48	0.05	16.20	2.25	5.81
AAK 2	0-20cm	6.72	1.90	0.42	0.043	7.0	ND	ND	135.0	1.62	0.08	15.10	2.39	6.16
	0-50cm	6.88	1.85	0.46	0.048	4.0	ND	ND	139.0	1.50	0.04	16.25	2.41	5.63
AAK 5	0-20cm	7.29	2.10	0.41	0.030	8.0	ND	ND	136.0	1.56	0.06	15.32	2.42	6.22
	0-50cm	7.31	1.60	0.48	0.040	6.0	ND	ND	138.0	1.58	0.05	16.26	2.46	5.76
AAK 6	0-20cm	7.27	1.60	0.40	0.036	6.0	ND	ND	115.0	1.51	0.07	15.82	2.37	6.20
	0-50cm	7.32	1.02	0.43	0.049	5.0	ND	ND	120.0	1.45	0.05	16.25	2.39	5.65
AAK 8	0-20cm	7.28	3.50	0.38	0.008	7.0	ND	ND	109.0	1.50	0.09	15.18	2.12	6.24
	0-50cm	7.15	2.12	0.41	0.007	5.0	ND	ND	112.0	1.42	0.03	16.30	2.28	5.88
AAK 9	0-20cm	7.36	4.62	0.29	0.005	4.0	ND	ND	105.0	2.42	2.71	12.52	3.15	4.56
	0-50cm	7.20	3.65	0.29	0.004	1.0	ND	ND	65.5	1.88	0.74	8.28	2.94	3.72
AAK 10	0-20cm	7.12	4.60	0.25	0.006	3.0	ND	ND	108.0	2.40	2.79	12.36	3.28	4.25
	0-50cm	7.16	3.65	0.30	0.003	2.0	ND	ND	68.8	1.82	0.70	8.48	2.50	3.50
AAK 11	0-20cm	7.22	4.62	0.21	0.005	4.0	ND	ND	85.0	2.47	2.60	12.10	3.62	4.42
	0-50cm	7.18	3.65	0.28	0.005	3.0	ND	ND	76.2	1.83	0.75	8.67	2.81	3.63
AAK 12	0-20cm	7.10	4.61	0.25	ND	5.0	ND	ND	95.6	2.32	2.93	11.69	3.95	4.82

Samples codes	Depth	pH	TOC %	NO_3^- mg/kg	PO_4^{3-} mg/kg	SO_4^{2-} mg/kg	THC Mg/kg	O&G Mg/kg	Cond μScm^{-1}	Na Mg/kg	K Mg/kg	Ca mg/kg	Mg mg/kg	CEC meq/100g
	0-50cm	7.21	3.65	0.28	0.002	3.0	ND	ND	68.7	1.63	0.76	8.60	2.68	3.68
AAK 13	0-20cm	7.25	4.62	0.27	0.005	2.0	ND	ND	80.3	2.61	2.83	6.32	3.26	4.73
	0-50cm	7.36	3.65	0.22	0.006	1.0	ND	ND	65.2	1.92	0.87	5.20	2.83	3.51
AAK 14	0-20cm	7.32	0.12	0.03	0.004	2.0	ND	ND	49.2	1.62	0.22	4.30	2.71	2.60
	0-50cm	7.30	0.08	0.02	0.002	1.0	ND	0.01	44.4	1.59	0.36	4.32	2.74	2.54
AAK 16	0-20cm	7.20	1.32	0.09	0.002	2.0	ND	0.01	7464	1.68	0.28	4.39	2.63	2.73
	0-50cm	7.28	1.26	0.18	0.004	3.0	ND	0.01	65.6	1.52	0.32	4.46	2.62	2.62
AAK 18	0-20cm	7.10	1.28	0.07	0.000	2.0	ND	ND	72.6	1.71	0.28	4.36	2.78	2.68
	0-50cm	7.25	1.22	0.21	0.000	3.0	ND	0.01	68.1	1.50	0.34	4.43	2.66	2.61
AAK 20	0-20cm	7.18	1.25	0.12	0.001	4.0	ND	ND	71.8	1.68	0.46	4.33	2.78	2.82
	0-50cm	7.15	1.22	0.26	0.003	2.0	ND	ND	65.9	1.46	0.56	5.12	1.96	2.57
AAK 22	0-20cm	7.22	4.45	0.28	0.007	5.0	ND	ND	122.0	1.85	0.85	9.00	1.72	4.15
	0-50cm	7.18	3.17	0.18	0.030	6.0	ND	ND	123.0	0.86	0.36	7.76	1.75	3.25
AAK 23	0-20cm	7.36	4.56	0.26	0.006	5.0	ND	ND	124.0	1.72	0.35	9.20	1.78	4.26
	0-50cm	7.28	3.28	0.12	0.008	7.0	ND	ND	126.0	0.80	0.38	7.52	1.81	3.30
AAK 24	0-20cm	7.32	4.38	0.20	0.007	6.0	ND	ND	120.0	1.83	0.31	9.36	1.71	4.09
	0-50cm	7.25	3.97	0.18	0.008	8.0	ND	ND	128.0	0.82	0.36	7.92	1.78	3.65
AAK 25	0-20cm	6.82	0.28	0.07	0.011	2.0	ND	0.018	62.5	1.24	0.32	6.35	2.17	2.84
	0-50cm	6.85	0.25	0.07	0.010	3.0	ND	0.016	56.0	1.16	0.45	8.48	2.26	3.86

Samples codes	Depth	pH	TOC %	NO_3^- mg/kg	PO_4^{3-} mg/kg	SO_4^{2-} mg/kg	THC Mg/kg	O&G Mg/kg	Cond μScm^{-1}	Na Mg/kg	K Mg/kg	Ca mg/kg	Mg mg/kg	CEC meq/100g
AAK 29	0-20cm	7.32	0.09	0.03	0.004	2.0	ND	ND	42.3	1.35	0.34	6.62	1.12	2.62
	0-50cm	7.30	0.07	0.03	0.004	1.0	ND	ND	40.6	1.26	0.48	8.56	2.07	3.70
AAK 30	0-20cm	7.24	4.13	0.20	0.005	1.0	ND	0.01	63.7	0.76	0.32	5.41	1.72	2.26
	0-50cm	7.21	3.65	0.23	0.008	1.0	ND	0.02	68.2	0.82	0.50	4.97	1.85	2.32
AAK 31	0-20cm	7.26	4.52	0.24	0.004	2.0	ND	0.01	60.3	0.68	0.38	5.83	1.60	2.37
	0-50cm	7.20	3.36	0.29	0.008	1.0	ND	0.01	66.5	0.88	0.57	4.62	1.82	2.41
AAK 33	0-20cm	7.31	3.82	0.14	0.005	3.0	ND	ND	72.9	0.97	0.31	5.88	3.12	3.13
	0-50cm	7.26	2.22	0.27	0.010	2.0	ND	ND	65.8	0.93	0.42	6.32	2.96	3.10
AAK 35	0-20cm	7.30	3.59	0.16	0.008	2.0	ND	ND	73.2	0.92	0.30	5.80	3.31	3.16
	0-50cm	7.22	2.27	0.22	0.014	1.0	ND	ND	62.9	0.83	0.46	6.31	2.46	3.12
AAK 36	0-20cm	7.18	0.11	0.03	0.006	1.0	ND	0.021	48.2	0.92	0.39	5.82	3.22	3.25
	0-50cm	7.26	0.05	0.01	0.002	3.0	ND	0.004	43.4	0.90	0.43	6.38	2.48	3.18
AAK 37	0-20cm	7.38	3.80	0.34	0.006	2.0	ND	ND	77.3	0.98	0.38	5.83	3.21	3.32
	0-50cm	7.14	2.18	0.46	0.009	2.0	ND	ND	69.6	0.92	0.46	6.46	2.56	3.17
AAK 38	0-20cm	7.32	3.17	0.16	0.007	3.0	ND	ND	78.1	0.95	0.30	5.76	3.45	3.18
	0-50cm	7.30	2.28	0.28	0.018	2.0	ND	ND	68.6	0.94	0.46	6.57	2.67	3.12
AAK 39	0-20cm	7.29	3.71	0.35	0.011	2.0	ND	ND	74.3	0.97	0.32	5.25	3.16	3.18
	0-50cm	7.21	2.36	0.52	0.012	2.0	ND	ND	66.2	0.97	0.40	6.26	2.35	3.14
AAK 40	0-20cm	7.30	3.71	0.17	0.009	3.0	ND	ND	72.3	0.93	0.37	5.68	3.23	3.22

Samples codes	Depth	pH	TOC %	NO_3^- mg/kg	PO_4^{3-} mg/kg	SO_4^{2-} mg/kg	THC Mg/kg	O&G Mg/kg	Cond μScm^{-1}	Na Mg/kg	K Mg/kg	Ca mg/kg	Mg mg/kg	CEC meq/100g
	0-50cm	7.26	2.23	0.23	0.020	2.0	ND	ND	62.5	0.91	0.48	6.30	2.68	3.19
AAK 41	0-20cm	7.35	3.65	0.18	0.006	3.0	ND	ND	70.4	0.99	0.35	5.16	3.42	3.20
	0-50cm	7.20	2.32	0.28	0.010	2.0	ND	ND	62.6	0.95	0.45	6.73	2.86	3.08
AAK 42	0-20cm	7.27	2.74	0.15	0.002	4.0	0.0	0.0	112.0	1.38	0.36	5.20	2.73	3.62
	0-50cm	7.21	2.80	0.02	0.008	2.0	0.0	0.0	76.5	1.46	0.28	6.26	3.28	3.76
AAK 43	0-20cm	7.30	2.40	0.15	0.003	4.0	0.0	0.0	106.0	1.31	0.38	5.28	2.91	3.78
	0-50cm	7.26	2.78	0.02	0.008	3.0	0.0	0.0	72.9	1.47	0.30	6.26	3.48	3.32
AAK 44	0-20cm	7.28	2.36	0.15	0.005	5.0	0.0	0.0	115.0	1.32	0.43	5.31	2.87	3.74
	0-50cm	7.26	2.72	0.02	0.007	4.0	0.0	0.0	71.8	1.45	0.36	6.23	3.35	3.86
AAK 45	0-20cm	7.25	2.58	0.15	0.0	5.0	0.0	0.0	89.0	1.32	0.45	5.25	2.92	3.60
	0-50cm	7.20	2.80	0.02	0.001	4.0	0.0	0.0	72.5	1.48	0.30	6.28	3.46	3.75
AAK 50	0-20cm	7.28	2.62	0.15	0.000	6.0	0.0	0.0	102.0	1.41	0.52	5.18	2.83	3.78
	0-50cm	7.26	2.86	0.02	0.001	4.0	0.0	0.0	76.9	1.46	0.37	6.19	3.47	3.85
AAK 51	0-20cm	7.24	2.57	0.15	0.000	5.0	0.0	0.0	118.0	1.35	0.48	5.14	2.97	3.72
	0-50cm	7.22	2.70	0.02	0.000	3.0	0.0	0.0	77.3	1.40	0.33	6.22	3.42	3.81
AAK 54	0-20cm	6.60	2.14	0.60	0.050	6.0	ND	0.007	ND	110.0	0.47	4.10	2.90	3.71
	0-50cm	6.80	1.20	0.03	0.034	3.0	ND	0.006	ND	86.2	0.30	3.02	3.25	3.80
AAK 58	0-20cm	7.30	3.67	0.18	0.006	3.0	ND	ND	70.4	0.99	0.37	5.10	3.40	2.60

Samples codes	Depth	pH	TOC %	NO_3^- mg/kg	PO_4^{3-} mg/kg	SO_4^{2-} mg/kg	THC Mg/kg	O&G Mg/kg	Cond μScm^{-1}	Na Mg/kg	K Mg/kg	Ca mg/kg	Mg mg/kg	CEC meq/100g
	0-50cm	7.25	2.36	0.28	0.010	2.0	ND	ND	62.6	0.95	0.40	6.71	2.15	2.28

4.18.19 Heavy Metal

Nickel and Vanadium were not detected in the soil samples. Pb indicated presence in very few locations ranging from 0.00mg/kg to 0.04mg/kg in dry season and 0.00mg/kg to 0.01mg/kg in wet season. Cr was also present in very few location (see **Table 4.18**), ranging from 0.00mg/kg to 0.02mg/kg in dry season.

Zinc in soil samples varies between 0.01mg/kg and 5.45mg/kg with topsoil showing ranging from 0.02mg/kg to 5.45mg/kg and subsoil 0.01mg/kg to 4.54mg/kg. In wet season Zn ranges from 0.00mg/kg to 24.16mg/kg.

Iron indicated concentration that range from 0.01mg/kg to 3.94mg/kg; top soil 0.01mg/kg to 2.78mg/kg and sub soil 0.03mg/kg to 3.94mg/kg and in wet season Fe showed 0.00mg/kg to 2.78mg/kg in surface soil and 0.02mg/kg to 3.94mg/kg in subsoil.

Appendix-4-16 provides the heavy metal characteristics of soil samples of the study area.

Table 4.18: Heavy Metal Laboratory Results of Soil Samples

Samples codes	Depth	Pb Mg/kg	Zn Mg/kg	Mn mg/kg	Ni mg/kg	Cd mg/kg	Fe Mg/kg	Cr Mg/kg	V Mg/kg
AAK 1		ND	0.22	0.004	ND	ND	0.07	ND	ND
	0-50cm	ND	0.24	0.004	ND	ND	0.08	ND	ND
AAK 2	0-20cm	ND	1.23	0.31	ND	ND	0.02	ND	ND
	0-50cm	ND	1.10	0.18	ND	ND	0.15	ND	ND
AAK 5	0-20cm	ND	2.36	0.23	ND	ND	0.09	ND	ND
	0-50cm	ND	1.20	0.29	ND	ND	0.06	ND	ND
AAK 6	0-20cm	ND	2.62	ND	ND	ND	0.05	ND	ND
	0-50cm	ND	2.15	ND	ND	ND	0.02	ND	ND
AAK 8	0-20cm	ND	2.48	0.02	ND	ND	0.83	ND	ND
	0-50cm	ND	1.42	0.08	ND	ND	0.92	ND	ND
AAK 9	0-20cm	0.02	3.42	0.03	ND	ND	0.04	ND	ND
	0-50cm	ND	0.34	ND	ND	ND	1.06	ND	ND
AAK 10	0-20cm	ND	2.25	0.03	ND	ND	0.06	ND	ND
	0-50cm	ND	0.26	0.02	ND	ND	2.08	ND	ND
AAK 11	0-20cm	ND	3.42	0.03	ND	ND	1.17	ND	ND
	0-50cm	ND	0.34	ND	ND	ND	2.20	ND	ND
AAK 12	0-20cm	0.01	2.82	0.02	ND	ND	1.12	ND	ND
	0-50cm	ND	2.12	0.02	ND	ND	1.82	ND	ND
AAK 13	0-20cm	0.01	3.52	0.03	ND	ND	0.82	0.01	ND
	0-50cm	0.02	3.46	0.05	ND	0.01	2.76	0.02	ND
AAK 14	0-20cm	ND	0.09	ND	ND	ND	0.03	ND	ND
	0-50cm	ND	0.08	ND	ND	ND	0.03	ND	ND
AAK 16	0-20cm	ND	1.85	ND	ND	0.01	0.08	ND	ND

Samples codes	Depth	Pb Mg/kg	Zn Mg/kg	Mn mg/kg	Ni mg/kg	Cd mg/kg	Fe Mg/kg	Cr Mg/kg	V Mg/kg
	0-50cm	ND	1.68	ND	ND	0.01	0.12	ND	ND
AAK 18	0-20cm	0.01	0.06	0.01	ND	ND	0.01	ND	ND
	0-50cm	ND	0.18	0.06	ND	0.01	0.02	0.01	ND
AAK 20	0-20cm	ND	0.26	0.02	ND	ND	1.38	ND	ND
	0-50cm	ND	0.82	0.01	ND	ND	0.21	ND	ND
AAK 22	0-20cm	0.03	4.21	0.02	ND	0.05	1.08	ND	ND
	0-50cm	0.04	4.54	0.02	ND	0.04	0.05	ND	ND
AAK 23	0-20cm	ND	1.20	0.03	ND	ND	0.04	ND	ND
	0-50cm	ND	0.04	0.04	ND	ND	0.05	ND	ND
AAK 24	0-20cm	ND	2.23	0.05	ND	ND	0.02	ND	ND
	0-50cm	ND	0.56	0.03	ND	ND	0.02	ND	ND
AAK 25	0-20cm	ND	0.20	0.04	ND	ND	0.08	ND	ND
	0-50cm	ND	0.18	0.04	ND	ND	0.05	ND	ND
AAK 29	0-20cm	ND	0.07	ND	ND	ND	0.02	ND	ND
	0-50cm	ND	0.09	ND	ND	ND	0.02	ND	ND
AAK 30	0-20cm	ND	0.03	ND	ND	0.01	ND	ND	ND
	0-50cm	ND	0.02	ND	ND	0.02	ND	ND	ND
AAK 31	0-20cm	ND	0.01	ND	ND	ND	0.06	0.01	ND
	0-50cm	ND	0.03	ND	ND	ND	0.16	0.01	ND
AAK 33	0-20cm	ND	0.03	ND	ND	ND	0.12	ND	ND
	0-50cm	0.01	0.04	ND	ND	ND	0.36	ND	ND
AAK 35	0-20cm	ND	0.05	ND	ND	ND	0.02	ND	ND
	0-50cm	ND	0.14	ND	ND	ND	0.32	ND	ND

Samples codes	Depth	Pb Mg/kg	Zn Mg/kg	Mn mg/kg	Ni mg/kg	Cd mg/kg	Fe Mg/kg	Cr Mg/kg	V Mg/kg
AAK 36	0-20cm	ND	0.17	ND	ND	ND	0.06	ND	ND
	0-50cm	ND	0.18	ND	ND	ND	0.06	ND	ND
AAK 37	0-20cm	ND	0.07	ND	ND	ND	ND	ND	ND
	0-50cm	ND	0.08	ND	ND	ND	0.08	ND	ND
AAK 38	0-20cm	ND	0.08	ND	0.0	0.0	0.04	ND	ND
	0-50cm	ND	0.05	ND	0.0	0.0	0.02	ND	ND
AAK 39	0-20cm	ND	0.02	ND	ND	ND	0.01	ND	ND
	0-50cm	ND	0.02	ND	ND	ND	0.03	ND	ND
AAK 40	0-20cm	ND	0.36	ND	ND	ND	0.27	ND	ND
	0-50cm	ND	0.15	ND	ND	ND	0.56	ND	ND
AAK 41	0-20cm	ND	4.82	ND	ND	ND	0.04	ND	ND
	0-50cm	ND	0.19	ND	ND	ND	0.13	ND	ND
AAK 42	0-20cm	ND	3.65	ND	ND	ND	0.76	ND	ND
	0-50cm	ND	0.21	ND	ND	ND	1.82	ND	ND
AAK 43	0-20cm	ND	3.05	ND	ND	ND	2.36	ND	ND
	0-50cm	ND	0.26	ND	ND	ND	2.08	ND	ND
AAK 44	0-20cm	ND	4.28	ND	ND	ND	1.09	ND	ND
	0-50cm	ND	0.08	ND	ND	ND	0.07	ND	ND
AAK 45	0-20cm	ND	3.21	ND	ND	ND	2.78	ND	ND
	0-50cm	ND	0.30	ND	ND	ND	3.94	ND	ND
AAK 50	0-20cm	ND	2.94	ND	ND	ND	0.19	ND	ND
	0-50cm	ND	0.10	ND	ND	ND	2.87	ND	ND
AAK 51	0-20cm	0.03	5.45	ND	ND	ND	ND	ND	ND

Samples codes	Depth	Pb Mg/kg	Zn Mg/kg	Mn mg/kg	Ni mg/kg	Cd mg/kg	Fe Mg/kg	Cr Mg/kg	V Mg/kg
	0-50cm	ND	2.55	ND	ND	ND	ND	ND	ND
AAK 54	0-20cm	ND	0.05	ND	ND	ND	0.02	ND	ND
	0-50cm	ND	0.06	ND	ND	ND	0.02	ND	ND
AAK 58	0-20cm	ND	0.02	ND	ND	ND	0.07	ND	ND
	0-50cm	ND	0.01	ND	ND	ND	0.06	ND	ND

4.18.20 Soil Micro-organism

Micro-organisms contribute to soil formation by slowly decomposing organic matter and forming weak acids that dissolve minerals faster than pure water. Micro organisms contribute to soil formation by contributing to the weathering of rocks mostly through chemical processes, mineralization of organic matter to release plant nutrients and the production of humus which contribute to soil colour and soil structural development.

Soil samples were examined for the presence of heterotrophic bacteria and fungi as well as hydrocarbon utilizing microorganism whose population may be affected by project activities. The predominant species of micro-organism in surface soils of the study area include: *Bacillus* spp; *Pseudomonas* spp; *Rhizopus stolonifer*; *Clostridium* spp; *Flavobacterium* spp; *Penicillium* spp, *Aspergillus flavus*; and *Trichoderma* spp. The sub soils indicated *Corynebacterium* spp; *Micrococcus* spp; *Aspergillus niger*; *Bacillus* spp; *Fusarium* spp; *Nocardia* spp; and *Penicillium notatium*.

These microbial groups have been associated with organic transformation and re-cycling in soils. The total Heterotrophic bacteria of the study area in dry season varies between $1.10x10^7$cfu/gm and $10.2x10^7$cfu/gm in surface soil and $1.70x10^7$cfu/gm to $8.7x10^7$cfu/gm sub and in wet season surface soil is $1.20x10^7$cfu/gm to $4.90x10^7$cfu/gm and subsoil $1.50x10^7$cfu/gm to$5.9x10^7$cfu/gm.

The total heterotrophic fungi in the surface soil ranges from $2.00x10^4$cfu/gm to $25.0x10^4$cfu/gm and sub soils $4.0x10^4$ cfu/gm to $15.0x10^4$cfu/gm in dry season while wet season showed $3.00x10^4$cfu/gm to $12.00x10^4$cfu/gm in surface soil and $5.00x10^4$cfu/gm to $15x10^4$cfu/gm in sub soil (see Appendix-4-17)

4.18.21 Topography and Landform

The project ROW traverses cities, towns and communities with varying landforms, shapes, physical features and process in play. Across the pipeline route, the elevation, landforms and other topographic features differed marginally except the vegetation and soil type which remained almost similar with little or no variation.

The project ROW lies within grid reference N 07^o 28'—N 1I^o 52' latitude and E 006^o 39' - 008^o 31' longitude. The elevation is gently undulating with a sudden jump at Gurara at which the topographic features evolves marginally and elaborately. This attributed to Plate tectonic and subsequent pan African progeny dated at 500-600 million years ago (Van Breemen et al 1976). The tectonic event gave rise to high elevation characterizing the topography of the subsequent route of the pipeline of North.

From Ajaokuta village in Ajaokua to Idibo village, the elevation rose gently from 210m to 468.7m and dropped gently to 50.5m at Ogbongboro village along River Niger. The elevation rose gently from there to 156.8m above sea level at Kaida village just before the Gurara water fall. The elevation rose steeply at that point producing highlands and mountain ranges.

The Gurara waterfall is a product of tectonics and faulting which created opening in the rock for underground water and subsurface water to navigate through and out of the Crevices in the rock.

In the study area the prevailing physical process in general is erosion. The soils are relatively resistant to erosion except in area of loose compaction .The predominately erosion type is sheet.

The vegetation varies lightly from guinea savannah (Ajaokuta –Koton Karfe) to Sudan savannah (Gwagwalada-Kaduna-Kano).

Settlements in the study area are dispersed and defined by accessibility to rivers/stream and spacious farmland.

The rivers and stream encountered out side Kano State are mostly tributaries to either rivers Nigeria or river Benue but Rivers in Kano empties into Lake – Chad

4.18.22 Geology

The study area is underlain by Precambrian rocks which form more than 70% of the rocks. Cretaceous to recent sedimentary and meta-sedimentary rocks overly the Precambrian rocks.

The Precambrian rocks in the study area are represented by

(A) Migmatite Gneiss Complex-

- Migmatite
- Gneiss
- Magmatised and intercalated amphibolite.

(B) Meta-sediments

- Schists
- Meta-conglomerate
- Layers and lenses of Galcgneises
- Talc
- Ferruginous quartzite

The metamorphism of the meta-sdimentary rocks is believed to be rated to the green schist facie and less frequently to the amphibolites facie series due to their mineral assembly. The undifferentiated older granites are granites rocks of plutonic and metasomatic origin whose formation is associates with the pan African Orogeny. They include; Biorite, coarse grained porphyritic granite, Biotite granite, pegmatite, porphyroblastic gneisses and Granite gneisses.

They age between 480-680milllion years (Olade 1978)

Cretaceous to recent sedimentary rocks occurs along banks of the rivers Niger. They include sandstones, clays talc, oolitic iron stones, coal measures, false bedded sands. They form part of the Benue trough sediment which ranges from Albian to Senonian. Tertiary Eocene sediments occur in the southern parts. Alluvial sediments of Quarterly to recent age are laid down in the valley of major rivers. The cretaceous to recent sediments lie sub-horizontally and show little evidence of major dislocations.

The superficial deposits in the study area are**;**

- Non- metamorphosed sedimentary Rocks
- Meta sedimentary rocks
- Clay /laterite

(A) Non- metamorphorsed sedimentary rocks

The non- metamorphosed sedimentary rocks occurs along the banks of river Niger and south. There are also few occurrences at Koton Karfi and around Abaji, and Aseni. They are cretaceous to recent with little evidence of dislocation. Tertiary Eoscene sediments occur in the southern parts. The non-meta morphosed sediments identified in the study area include;

- Oolitic iron ore: (Along banks of River Niger, Koton Karfi), it is a medium grade ore with low Fe content and low Mn with high Silica. Host rock being granite, gneis schist, amphibolite, Diorite.
-
- Talc: occur at Abaji, Aseni-.could be used as white-fillers, ceramics, talcum power
- Shale: Aseni
- Clay, coal measures, false bedded sandstones.

(B) Meta-sedimentary Rocks

These are Precambrian meta sediments which have undergone intense folding and faulting. They include metamorphosed iron ores of Ajaokuta which occur as bands and lenses of ferruginous quartzite. The bedlike ore bodies extends for distance over 5km and are developed to depths of over 300m (NSDA 1976) and are displaced by small to large faults.

The ores are mostly magnetite, haematite, magnetite-haematite, haematite-magnetite with quartz, amphibolites and biotite in the ground mass. Iron content ranges between 15% and 65% averaging 30% to 36%.

The principle rock types of the meta sedimentary complex of the study area are quartzite and quartz-schist. Outcrop of quartz-mica schist was identified at Ofunene (Ajaokuta) including quartz-schist and they are fine to medium grained and are better foliated in alternating banss of granular quartze and layers of mnscorite and biotite.

A suite of mafic-to ultramafic metsedimentaty rocks are exposed as lenticular and ovoid bodies at Kazai. Talc bearing schist also was identified to outcrop at Abaji enroute Gwagwalada.

(C) Clay /laetrile

They are found from rock like shale’s sandstones and most crystalline rocks.

The clays of the study area are richer in illite and montmorillonite but those towards south and Lokoja are richer in kaolinite. The clays have colours that varied from light brown to reddish. They have a relatively high and component which satisfies requirement of moderate plasticity for the gas project.

Beyond Gwagwalada, Kaolinite is prominent hence we have light brown colour with low Fe/Mg content. They result from poor leaching condition and alkaline nature of parent rocks.

4.18.23 Ecological Environment

4.18.23.1 Aquatic Biology

1. Aquatic Flora and Fauna

The aquatic flora and fauna of the rivers are well represented by plant and animal communities. The flora consists of phytoplantons and macrophytes, while the fauna consists of zooplankton, macrobenthos and invertebrates.

(A) Plankton Distribution

Plankta (phyto and zoo) are free-floating or weakly swimming plants and animals that form the base of the aquatic food. Plankton communities vary considerably from season to season due to changing conditions of temperature and salinity and prevailing currents.

- **Phytoplankton**

A total of nineteen (19) species were recorded at the downstream and upstream of Rivers studied in dry season; River Niger, Kazai River, Gurara River, Kano River, Kaduna River, Kurara River and Challawa River (see **Appendix-4-18**). Total number of species recorded ranged from 2 to 9. River Niger upstream recorded the highest number of species while Kurara and Challawa recorded the lowest.

River Niger upstream recorded the highest abundance of species (per ml) while Kazai river and Challawa river recorded the lowest. Total phytoplankton abundance varied between 20 and 8045 per ml. Log of Species diversity recorded 0.301 to 0.903. Log of phytoplankton abundance ranged between 1.544 and 3.905 whereas Shannon-Wiener Index (Hs) was between 1.430 and 3.903 while Menhinick Index (D) was between 0.089 and 0.845. Margalef Index (d) values were from 0.551 to 2.816, Equitability was between 2.046 and 5.875 and Simpson's Dominance Index was between 0.187 and 0.669.

The key species occurring in the rivers are *Actinoptychus splendens* Ehrenberg. Other notable species recorded were *Aulacoseira granulata* var. *angustissima* Muller, *Aulacoseira granulata* Ehrenberg, (Ralfs) *Aulacoseira granulata* var. *angstissima* f. *spiralis* Muller, *Synedra ulna* (Nitzsch) Ehrenberg (diatoms), *Microcystis flos-aquae* Kirchner (blue-green algae) and *Closterium moniliferum* (Bory.) *Ehrenb* (green algae).

The wet season data of the rivers in the study area (**EPL Field Data, 2008**) indicated that a total of eleven (11) species were recorded at the downstream and upstream of river Niger, Kazai river, Gurara river, Kano river, Kaduna river, Kurara river and Challawa river (see **Appendix-4-19**). Total number of species recorded ranged from 2 to 4 species. Kano River and River Niger (4 species each) recorded the highest number of species while Challawa river, River Niger and Gurara river recorded the lowest (2 species each).

Also, River Niger recorded the highest abundance of species (120 individual per ml) while Challawa river downstream recorded the lowest (15 individuals per ml). Total phytoplankton abundance varied between 15 and 120 per ml. Log of Species diversity recorded 0.301 to 0.602. Log of phytoplankton abundance ranged between 1.000 and 2.079. Whereas Shannon-Wiener Index (Hs) was between 0.860 and 2.034 while Menhinick Index (D) was between 0.248 and 0.632. Margalef Index (d) values were from 0.551 to 1.814, Equitability was between 2.605 and 5.882 and Simpson's Dominance Index was between 0.382 and 0.739.

The key species occurring in the rivers for wet season were *Aulacoseira granulata* var. *angustissima* Muller. Other notable species recorded were *Aulacoseira granulata* var. *angustissima* Muller, *Aulacoseira granulata* Ehrenberg, (Ralfs) *Aulacoseira granulata* var. *curvata* Simon, *Diatoma elongatum* (Lyngb.) Agardh, *Cyclotella menighiniana* Kutzing, *Synedra ulna* var. *biceps* Ehrenberg *Synedra ulna* (Nitzsch) Ehrenberg (diatoms), *Oscillatoria limnosa* Agardh (blue-green algae) and *Spirogyra africana* Fritsch Cruda (green algae).

- **Zooplankton**

The downstream and upstream of surface water studied in dry season recorded a total of four (4) species; River Niger, Kazai River, Gurara River, Kano River, Kaduna River, Kurara River and Challawa River.Total number of species recorded ranged from 0 to 4. Kaduna River recorded the highest number of species while Gurara River, Kano River, Kurara and Challawa recorded no species. Kaduna river recorded the highest abundance of species (per ml) while Gurara river, Kano river and Challawa river recorded the lowest.

Total zooplankton abundance varied between 0 and 45 individuals per ml. Log of Species diversity recorded ranged from 0.0 to 0.602. Log of zooplankton abundance ranged between 0.0 and 1.176 whereas Shannon-Wiener Index (Hs) was between 0.0 and 1.563 while Menhinick Index (D) was between 0.0 and 0.596. Margalef Index (d) values were from 0.0 to 1.814, equitability was between 0.0 and 2.596 and Simpson's Dominance Index was between 0.0 and 1.000.

The key species occurring for the rivers were *Diaphnia* sp. Other species were *Bosmina sp* (**ORDER - CLADOCERA**) and *Enterpina sp*. (**ORDER - HARPACTICOIDA**). *Copepod nauplii* larva was the only juvenile stage recorded.

In wet season (**EPL Field Data, 2008**) a total of three (3) species and 1 juvenile stage were recorded at the downstream and upstream of river Niger, Kazai river, Gurara river, Kano river, Kaduna river, Kurara river and Challawa river. Total number of species recorded ranged between 0 and 4. Challawa river downstream recorded the highest number of species (4 species) while others recorded no species.

Challawa River downstream recorded the highest abundance of species (40 individuals per ml). Total zooplankton abundance varied between 0 and 40 individuals per ml. Log of Species diversity recorded 0.0 to 0.602. Log of zooplankton abundance ranged between 0.0 and 1.602. Whereas Shannon-Wiener Index (Hs) was between 0.0 and 1.508 while Menhinick Index (D) was between 0.0 and 0.632. Margalef Index (d) values were from 0.0 to 1.872, Equitability was between 0.0 and 2.505 and Simpson's Dominance Index was between 0.0 and 0.312.

The key species occurring for the rivers were *Diaphnia* sp., *other species were* Bosmina sp (**ORDER - CLADOCERA**) and *Enterpina* sp. (**ORDER - HARPACTICOIDA**). Copepod nauplii larva was the only juvenile stage recorded.

- **Benthic Macro Invertebrates**

Invertebrate are important component of aquatic ecosystem and represent a good source for many fish and birds. Benthic invertebrates consist of infauna (Organisms living in sediments) and epifauna (Organisms living on the sediment). The rivers crossed by the project was identified to have a high density of invertebrate fauna, which include species of nematodes, annelids, crustaceans, insects, mollusks (**see Table 4.19**)

Table 4.19: Benthic macro fauna present in aquatic ecosystems

Phylum	Scientific name and Common name
Annelids	*Tubifex sp, Lumbricus sp, Naris sp,* *Dero sp, Hirudinea sp, Erpobdella sp* *Hirudo sp.*
Arthropoda	*Cladocera sp, Cyclopoida sp, Ostracoda sp, Cypris sp, Copepoda sp, Diatomus sp, Gammarus sp, Decapoda sp, Grapsus sp, Centropilium sp, Enallagma sp, Cordulia sp, Gomphus sp, Orthetrum sp, Dolomedes sp*
Mollusca	*Limnaea sp, Bulinus sp, Physa sp.*
Chordata	*Rana sp, Bufo regularis, Xenopus sp*

- **Fisheries**

The habitat identified for fish and shellfish in the study area are large flowing rivers; Niger, Kaduna, Kurara, and Gurara. The species of fish common in the rivers are Tilapia sp, Clarias sp, chrysichthys sp (cat fish) and Cyprinid minnows (see Table-4.20). The locals practice fishing as evidence by selling of fish along the road, fishing activities in the rivers and smoking and marketing of fishes.

Table 4.20: Common fish species in Rivers

Order	Family	Species	Common Name
Perciformes	Cichlidae	*Oreochromis niloticus*	Tilapia
		Hemichromis bimaculatus	Jewel fish
		Sarotheodon melanotheron melanotheron	Blackchin Tilapia
Characiformes	Alestidae	*Alestes*	Bryanus nurse
Siluriformes	Mochokidae	*Synodontis batensoda*	African catfish
Perciformes	Gobiidae	*Bathygobius soporator*	Frillfin goby
Siluriformes	Claroteidae	*Chrysichthys nigrodigitatus*	Bagrid catfish
Siluriformes	Claridae	*Clarias pachynema*	-

In the study area, fishing is mostly part time. The fishermen compose mostly of workers, students and young school leavers. They fish primarily to eat, pay school fees and generate income for other needs.

Harvested fishes are usually sold to the locals. They are processed by smoking.

Plate 4.11: Fish captured at R.Niger during field study (Bryanus nurse (Alestes))

4.18.24 Vegetation

The original primary vegetation of the study area was observed to be depleted due to many decades of farming, timber and firewood exploitation, overgrazing and bush burning; the absence of electricity and unavailability of kerosene and cooking gas in some parts; made firewood the only source of cooking fuel.

Trees and shrubs favourably used for cooking are *Anogeissus leiocarpus*, *Piliostigma thonningii*, *Khaya senegalensis*, *Daniella oliveri*, *Gmelina arborea*, *Isoberlina tomentosa*, *I. doka*. Bush burning was identified to be common in the study area; Fulani herdsmen set fire to bushes during the dry season (around December) to cause fresh grass to germinate early to feed their cattle. Fire is prevalent around January, at the height of the dry season.

Most animals killed by the fire are insects with short life spans. Although the dry stems and leaves of grasses are consumed by fire, the grasses' deep roots remain unharmed. These roots, with all their starch reserves, are ready to send up new growth when the soil becomes moister. The scattered shrubs can also subsist on food reserves in their roots while they await the time to venture above the soil again. Bush fallow and rotational farming is common; lands are usually left fallow for 5 - 6 years.

Lumbering activities was identified to be common from Ajaokuta to Lokoja; trees mostly exploited are *Pterocarpus erinaceus*, *Daniella oliveri*, *Khaya senegalensis*, *Gmelina arborea* and *Tectona grandis*.

Trees are about 4 to 18 metre high, 80cm to 3 metre in diameter and about 10 to 14 metre wide apart. There is paucity of trees moving northwards; *Khaya senegalensis*, *Anogeissus leiocarpus*, *Mangifera indica*, *Parkia biglobosa*, *Azadirachta indica*, *Vitellaria paradoxa*, *Ficus species*, *Vitex doniana*, *Borassus aethiopum*, *Adansonia digitata* are the dominant trees in these regions, while *Isoberlina doka*, *I. tomentosa*, *Piliostigma thonningii*, *Sarcocephalus latifolius* and *Anonna species* are the dominant shrubs.

Plate 4.12: Vegetation of the Study Area

Wild plants were identified to be sources of livelihood for most of the communities; *Sarcocephalus latifolius*, *Anacardium occidentale*, *Anona species*, *Vitex doniana*, *Borassus aethiopum*, *Hyphaene thebaica* are sources of wild fruits. Also, *Parkia biglobosa* was also identified and their seeds are processed into a food spice called "ugba" or "daudawa". *Adansonia digitataw was also encountered; its young leaves* are used in cooking a local beloved soup called "*miyan kuka*".

Irrigation farming was identified to be common along river banks, Cucurbita maxima, *Citrullus vulgaris*, *Allium cepa*, *Colocynthis citrullus*, *Ananas comosus*, *Saccharum officinarum*, *Lycopersicum esculentum*, pepper are the major crops irrigated along the river banks, and the crops are mainly sold off. Harvested grains are stored in silo made locally from mud; the silo is about 6-7 feet high. Grains are stored in the silo between December and January and are open around June.

The plant species identified in the study area and in each sample location are listed below;

Site 1: (AAK 2) is a fallowed land by the stream Plants observed were: *Ageratum conyzoides (Goat weed), Agaricus campestris, Anacardium occidental, Cassia siamea, Cassia tora, Chromolaena odorata, Elaeis guineesis, Ficus sp., Imperata cylindrical, Parkia biglobosa, Sida acuta, Tridax procumbens, Urena lobata, Vitellaria paradoxa,*

Site 2: (AAK 4) is a fallowed farmland plants observed were: *Ageratum conyzoides, Anacardium occidentale, Cassia tora, Cynodon dactylon, Bambusa vulgaris*, *Borassus aethiopum*, *Imperata cylindrica Dryopteris filis-mas*, *Mimosa pudica, Manihot esculenta, Phyllantus amarus, Parkia biglobosa, Palisota hirsuta*, *Piliostigma thonningii*, and *Psophocarpus scandens.*

Site 3 (AAK 5) is a farmland, plants observed were: *Anacardium ocidentale,* *Andropogon gayanus, Anogeissus leiocarpus, Ageratum conyzoides, Arachis hypogaea, Bauhinia tomentosa, Borassus aethiopum, Cassia tora, Tridax procumbens, Panicum maximum, Andropogon gayanus, Sida acuta, Eleusine indica, Caesalpinia pulcherrima, Calotropis procera, Crotalaria ononoides, Chromolaena odorata,, Parkia biglobosa, Khaya senegalensis, Piliostigma thonningii, Cynodon dactylon, Setaria pallide-fusca, Solanum nigrum, Phaseolus vulgaris, solanum vulgare, Vitellaria paradoxa, Zea mays,*

Site 4 (AAK 6) Plants specimens observed were: *Anacardium ocidentalale, Ageratum conyzoides, Andropogon gayanus, Bauhinia tomentosa, Caesalpinia pulcherrima, Calotropis procera, Cassia siamea, Crotalaria ononoides, Calopogonium mucunoides, Eleusine indica, Khaya senegalensis, Ricinus communis, Panicum maximum, Sida acuta, Sarcocephalus latifolius, Oryza sativa, Setaria pallide-fusca, Sida acuta, Psophocarpus scandens, Urena lobata, Psidium guajava, Tridax procumbens,*

Site 5 (AAK 9) Plants observed were: *Acacia nilotica, Ageratum conyzoides, Andropogon gayanus,Calotropis procera, Cassia tora, Chromolaena odorata, Cynodon dactylon, Dryopteris filis-mas, Imperata cylindrica, Mimosa pudica, Nymphaea lotus, Oryza sativa, Panicum maximum, typha sp., Urena lobata, Vitellaria paradoxa.*

Site 6 (AAK 10) Plants observed were: *Ageratum conyzoides, Allium cepa, Andropogon gayanus, Borassus aethipum, Calotropis procera, Cassia tora, Chromolaena odorata, Cynodon dactylon, Dryopteris filis-mas, Imperata cylindrica, Luffa aegyptiaca, Mimosa pudica, Oryza sativa, Panicum maximum, typha sp., Urena lobata.*

Site 7 (AAK 11) is a farmland, plants observed were: *Anogeisus leiocarpus, Ageratum conyzoides, Borassus aethiopum, Bauhinia tomentosa, Calopogonium mucunoides, Costus spectabilis, Elaeis guineensis, Ficus spp. Mangifera indica, Palisota hirsute, Phyllantus amarus, Piliostigma thonningii, Psophocarpus scandens, Sarcocephalus latifolius, Setaria pallide-fusca, Sida acuta, Solanum vulgare, Tridax procumbens, Vitellaria paradoxa, Vitex doniana, Zea mays.*

Site 8 (AAK 12) is fallowed farmland plants observed were: *Anacardium Ocidentale, Ageratum conyzoides, Andropogon gayanus, Annona senegalensis, Bauhinia tomentosa, Bambusa vulgaris, Borassus aethiopum (*agobeam)*, Calopogonium mucunoides, Calotropis procera, Cassia tora, Cassia siamea, Chromoleana odorata, Elaeis guineensis, Isoberlina doka, Luffa aegyptiaca, Mimosa pudica, Parkia biglobosa, Phyllatus amarus, Sarcocephalus latifolius, Sida acuta, Palisota hirsute (Palisota), Piliostigma thonningii (kargo), Psophocarpus* *scandens, Tridax procumbens, Urena lobata, Vernonia amygdalina, Vitellaria paradoxa.*

Site 9 (AAK 13) is a farmland, plants observed were: *Borassus aethiopum, Bauhinia tomentosa, Calopogonium mucunoides, Cassia tora, Chromolaena odorata, Elaeis guineensis, Ficus asperifolia, Imperata cylindrical, Gmelina arborea (parrot's beak), Luffa aegyptiaca, Manihot esculenta, Palisota hirsute (Palisota), Phyllantus amarus, Piliostigma thonningii, Psophocarpus scandens, Sarcocephalus latifolius, Setaria pallide-fusca, Sida acuta, Solanum vulgare, Tridax procumbens, Vitellaria paradoxa, Vitex doniana, Zea mays.*

Site 10 (AAK 14) is a fallowed farmland plant observed were: *Acacia nilotica, Andropogon gayanus, Ageratum conyzoides, Annona senegalensis, Bauhinia tomentosa, Calopogonium mucunoides, Calotropis procera, Isoberlina doka, Piliostigma thonningii, Palisota hirsuta, Psophocarpus scandens, Sarcocephalus latifolius, Setaria pallide-fusca, Sida acuta, Mangifera indica, Parkia biglobosa, Setaria pallide-fusca.*

Site 11 (AAK 16) is a farmland, plants observed were: *Ageratum conyzoides, Borassus aethiopum, Bauhinia tomentosa, Calopogonium mucunoides, Costus spectabilis, Elaeis guineensis, Ficus spp. Hibiscus sabdariffa, Hyphaene thebaica, Mangifera indica, Palisota hirsute, Phyllantus amarus, Piliostigma thonningii, Psophocarpus scandens, Sarcocephalus latifolius, Setaria pallide-fusca, Sida acuta, Solanum vulgare, Tridax procumbens, Vitellaria paradoxa, Zea mays.*

Site 12 (AAK 20) The site is a farmland, plants observed were: *Abelmoschus Esculenta (Okra), Bauhinia tomentosa, Bambusa vulgaris, Cassia tora, Cucurbita maxima, Cynodon dactylon (Bahama grass), Imperata cylindrica, Hibiscus sabdariffa, Phyllantus amarus, Parkia biglobosa, Palisota hirsuta, Piliostigma thonningii, Psophocarpus scandens, Sida acuta, Setaria pallide-fusca,*

Site 13 (AAK 29) the site is a farmland, plants observed were: *Andropogon gayanus, Borassus aethiopum, Chromoleana odorata, Cynodon dactylon, Discorea sp., Hibiscus sabdariffa, Isoberlina doka, Piliostigma thonningii, sarcocephalus latifolius, Zea mays.*

Site 14 (AAK 31) is farmland plants observed were: *Adansonia digitata, Ageratum conyzoides, Arachis hypogaea, Ceiba pentandra, Ficus spp. Gmelina arborea, Calotropis procera, Abelmoschus esculenta, Hibiscus sabdariffa, Phyllanthus amarus, Sida acuta, Zea mays.*

Site 15 (AAK 35) is a farmland plants observed were: *Ageratum conyzoides, Arachis hypogaea, Bauhinia tomentosa, Borassus aethiopum, Cassia tora,* *Calotropis procera, Ceiba pentandra, Gmelina arborea, Phyllantus amarus, Piliostigma thonningii, Isoberlina doka, Oryza sativa, Solanum vulgare, Tamarindus indica, Vitellaria paradoxa, Zea mays.*

Site 16 (AAK 44) is a farmland, plants observed were: The site encompasses a fallowed land and a farmland. Plants observed were: *Adansonia digitata, Ageratum conyzoides, Andropogon gayanus, Arachis hypogaea, Bauhinia tomentosa, Calotropis procera, Caesalpinia pulcherrima, Chromolaena odorata, Cynodon dactylon, Eleusine indica, Gmelinia arborea, Khaya senegalensis, Mangifera indica, Panicum maximum, Phaseolus vulgaris, Piliostigma thonningii, Sida acuta, Setaria pallide-fusca, Solanum nigrum, Solanum vulgare, Tridax procumbens, Zea mays,*

Site 17 (AAK 56) is a farmland, plants observed were: *Andropogon gayanus, Anacardium ocidentalale, Ageratum conyzoides, Bauhinia tomentosa, Calopogonium mucunoides, Calotropis procera, Caesalpinia pulcherrima, Crotalaria ononoides, Eleusine indica, Khaya senegalensis, Oryza sativa, Sarcocephalus latifolius, Ricinus communis, Setaria pallide-fusca, Panicum maximum, Psidium guajava, Psophocarpus scandens, Sida acuta, Typha augustifolia, Urena lobata.*

Site 18 (AAK 58) is a farmland, plants observed were: *Azadirachta indica, Calotropis procera, Calopogonium mucunoides, Cynodon dactylon, Mangifera indica, Saccharum officinarum, Sida acuta, Zea mays.*

The common names of plants commonly identified in the study area is provided in Table **4.21**

Table 4.21: Economic plants identified in Study Area

Scientific names	Common names	Local names (Hausa)	Uses
Anacardium ocidentale	Cashew	Kashu	Edible fruit and nuts
Ananas comosus	Pineapple	Abarba	Edible fruit
Allium cepa	Onions	Albasa	Spice
Adansonia digitata	Baobab	Kuka	leaves use to cook soap
Andropogon gayanus	Gamba grass	Gamba	-
Annona senegalensis	Wild custard	Gwandar jeji	Edible fruit
Anogeisus leiocarpus	Chewstick tree	Marke	Firewood
Arachis hypogaea	Groundnut	gyada	food
Azadirachta indica	Neem	Dogon yaro	Medicines, oil, animal feed
*Abelmoschus esculent*us	Okra	Kubewa	soup
Balanite aegyptiaca	Desert date	Aduwa	Edible
Borassus aethiopum	Fan palm	Giginya	Edible fruit, building
Agaricus campestris	Mushroom	Naaman kaza	edible
Calotropis procera	Sodom apple	Tumfafiya, mada	-
Ceiba pentandra	Silk cotton tree	Rimi	-
Cucurbita maxima	Pumpkin	Kabewa	soup
Colocynthis citrullus	Melon	Agushi	soup
Cynodon dactylon	Dub grass	Butun shamuwa	-
Dryopteris filis-mas	Fern	Agugu	-
Elaeis guineesis	Palm-oil	Man ja	oil

Scientific names	Common names	Local names (Hausa)	Uses
Ficus spp		Baushe	firewood
Hibiscus sabdariffa	Roselle	Soborodo	Soup, drink
Hyphaene thebaica	Dum palm	Goruba	Edible, building
Isoberlina doka		Doka	firewood
Isoberlina tomentosa		Farar doka	firewood
Khaya senegalensis	Mahogany	Madaci	Building, firewood
Lycopersicum esculentum	Tomato	Tomatur	Edible fruit
Manihot esculenta	Cassava	Rogo	Edible tuber
Musa sapientum	Banana	Ayaba	Edible fruit
Newbouldia laevis		Aduruku	-
Nymphaea lotus	Water lily	Bado	-
Oryza sativa	Rice	Shikafa	food
Parkia biglobosa	Locust bean tree	Dorowa	Spice, edible fruit
Piliostigma thonningii		Kargo	firewood
Saccharum officinarum	Sugar cane	Rake	sugar
Sesamum orientale	Sesame	Riidi	food
Setaria pallide-fusca		Ta fadama	-
Striga spp.	Witch weed	Marin gona	Plant parasite
Sorghum bicolour	Guinea corn	Dawa	food
Tamarindus indica	Tamarind	Tsamiya	spice
Urena lobata		Igiyar rafi/ramaniya	sponge

Scientific names	Common names	Local names (Hausa)	Uses
Vitellaria paradoxa	Shea	Kade/kadanya	Shea butter
Vitex doniana	Black plum	Dinya	Edible fruit
Zea mays	Corn	Masara	food
Zingiber officinale	Ginger	citta	spice

- **Vegetation Health Status**

The vegetation of the study area is not affected by any diseases. Seasonal variations in vegetation are illustrated in **Plates 4.6** and **4.7.**

- **Vegetation communities of ecological conservation significance**

Vegetation communities of conservation significance are those that have unique ecological attributes and perform important ecological functions. These communities are typically rare, or restricted in distribution, and are often highly susceptible to degradation through disturbance. There are no vegetation communities of conservation significance that occur in and around the study area.

- **Flora species of ecological conservation significance**

Flora species of conservation significance include those species that are classified as 'threatened' and\or protected under Federal Government Act 11 of 1985. Many of the species that occur in and around the project area will also be of conservation significance to local Aboriginal people. Local people use parts of plants for a variety of purposes and some may also have spiritual significance.

- **'Threatened' species**

None of the plant species recorded during field surveys of the study area are declared 'threatened' species under Convention on International Trade in Endangered Species of Wild Fauna and Flora, CITES. The guinea savannah patches in close proximity to the study area have been surveyed in both the early and late dry season. No species of significance were identified during these surveys.

4.18.25 Wildlife and Wildlife Habitat

4.18.25.1 Wildlife Habitat

The types of wildlife habitat identified along the gas pipeline right-of-way and study area include; guinea and Sudan savannah vegetation, farmland land, surface water and Riparian areas (land and vegetation).

- **Guinea and Sudan Savannah Vegetation**

Guinea and Sudan Savannah Vegetation habitat consists of plant species as described above. Guinea and Sudan savannah vegetation habitat supports bird species and mammal species. The area with more Sudan savannah (without shrub cover) supports a lower diversity of bird species. The Sudan savannah vegetation has fairly sparse shrub cover and visible evidence of grazing and farming.

The loss of vegetation from farming lowered the suitability of this area for many shrub-nesting birds and other wildlife.

Species encountered in this habitat include *Egretta spp* (cattle egret), *Picus vindis* (woodpecker), *Tingonoceps occipitals* (vulture), *Lepus spp* (rabbit), *Myotis spp* (bat), *Phacochoerus aethiopicu* (warthog)

- **Farmland**

Farmland habitats in the right-of-way consist of wheat fields, farms and irrigated farms. The crops habitat provides food and cover for a variety of insects and small mammals and forage for birds that eat seeds, insects, or small mammals. Insects are abundant, insectivorous birds like *Merops apiaster* (common bee-eater) were identified. Species encountered include *Columba spp* (pigeon), *Acryllium spp* (guinea fowl), *Psittacus spp* (African grey parrot), *Blarina spp* (shrew), *Pteropus spp* (bat) and *Epixeus ebii* (squirrel).

- **Surface Water Habitat**

Surface water habitat consists of large and small bodies of open water. Surface water habitat in the right-of-way consists of stream and rivers and they are used extensively by birds for feeding, also the Fulanis feed their cattle on them.

Species encountered in surface water habitats include *Rana spp* (frogs), *Bufo regularis* (toad), *Scodra griseips* (jumping spiders), *Culex and Anopheles spp* (mosquitoes) and *Glassina spp* (tse-tse fly).

- **Riparian areas**

Riparian areas are the lands adjacent to streams, rivers, lakes and wetlands, where the vegetation and soils are strongly influenced by the presence of water. This habitat was identified in the study area. Riparian areas that are crossed by the right-of-way are located in River Niger, River Kaduna and River Gurara.

The riparian vegetation along the Rivers that is crossed by the right-of-way consists of *Elaeis guineensis* (palm trees) and *Typha latifolia* trees that line the banks of the Rivers and provide habitat for songbirds, raptors, and amphibians. Species encountered in the riparian habitat include *Alceda atthis* (common king fish), *Pandion spp* (hawk), *Parus tit* (great tit), *Archiloclus colubis* (humming birds), *Chameleo senegakleusis* (chameleon) and *Rana spp* (frogs), *Bufo regulaus* (toad).

4.18.25.2 Wildlife

- **Herpetofauna**

These animals are found both on land as well as in water, and their representatives were noticed. Few specimens were caught and released including lizards, frogs and toads. Locals attested to a healthy population of herpetofaunal species in the area.

In the sampling square quadrat, families of Amphibians and Reptiles were identified. Lizards were encountered on the project ROW grounds. Tadpoles were seen in pools of water. The specimens seen were crawling on trees, basking in the sun, feeding or hopping away. **Table 4.22** summarizes the herpetofauna encountered and attested to by locals in the area.

Table 4.22: Herpetofauna present in the study area

Habitat Type/Location	Phylum	Scientific name and Common name of Species Identified	Description of Habitat use
Fallow land and low bush (1, 4, 10, 29, 43, and 51), farmland (3, 13, 32, 35, and 48), farm and fallow land (5, 21, and 38), surface water (4, 8, 10, 15, 18, 19, 21, 26, 32, 53, and 57), mango plantation (57). But all are located in the Guinea and Sudan savannah vegetation belt of Nigeria.	Chordata	Amphibia: *Rana sp (*Frogs*), Bufo regularis (*Common African toad) Reptilia: *Gekko sp (Gekko), Lacertilia sp., Mabuya blandingii (Skink), Viper sp. Mamba sp, Naja melanoleuca (Black cobra), Leptophis, Crotalus Boa, ,* *Chameleo senegalensis (Chameleon), Varanus niloticus (Nile monitor)*	The trees and farmland serve as habitat for the Chordates and they feed and multiply, especially during the fruiting and farming season because of food abundance.

- **Invertebrates**

They make up 95% of the species in the animal kingdom, they vastly outnumber the vertebrates, both in species and individuals, and they show a greater variety of forms. In the study area butterflies, moths and other insects such as beetles, ants, flies and mosquitoes mainly represented this group of animals.

Other Arthropods that were observed include centipede, scorpion etc. **Table 4.23** summarizes the invertebrates encountered and attested to by locals, during the field survey. Other classes of Arthropods includes Arachnida e.g. spider, Diplopoda e.g. millipede and Chilopoda e.g. centipede while Gastropoda e.g. snail represents the molluscs.

Table 4.23: Invertebrates in the study area

Habitat Type/Location	Phylum	Scientific name and Common name of Species Identified	Description of Habitat use
Fallow land and low bush (1, 4, 10, 29, 43, and 51), farmland (3, 13, 32, 35, and 48), farm and fallow land (5, 21, and 38), surface water (4, 8, 10, 15, 18, 19, 21, 26, 32, 53, and 57), mango plantation (57). But all are located in the Guinea and Sudan savannah vegetation belt of Nigeria.	Annelids Arthropoda Mollusca	*Oligochaeta*: *Hyperiodrilus africanus, Libyodrilus violaceus* Arachinida*: Lycosa sp., Salticus sp., Torania variata & Scodra griseips* (jumping spiders), *Loxosceles sp*. (Brown spider), *Scorpionida-Pandinus imperator, Buthus hottentous, Dermacentor variabilis* (wood tick), *Armadillidium sp*. (wood lice) Diplopoda (Millipedes): Pachybolus ligulatus, Prepodesmus sp., Oxydesmus sp., Habrodesmus sp. Insecta: Trichoptera: *Agraylea sp, Leptocella sp, Limnephilus sp. Rhodanella minos* (Collembola springtail) Coleoptera: *Canthon sp., Photinus sp., Photuris sp., Hydroporus sp., Dytiscus sp., Leptocella sp., Cybister sp, Belostoma sp., Mellodon downer* (longhorn beetles), *Anthia sp*. (ground beetle), *Adalia bipunctata* (ladybird) Diptera: *Chironomus sp*. (midge), *Culex* and *Anopheles sps*. (Mosquitoes), *Simulium sp*. (black fly), *Tipula sp., Psychoda sp., Chrysops sp., Musa domestica* (house fly), *Drosophila sp. Glossina sp.* (tse tse fly), *Tabanus sp*. Orthoptera: *Schistocerca & Locusta sp*. (Locusts), *Zonocerus variegatus, Sphedromantis lineola* (Praying mantis), *Gryllotalpa africana* (Cricket), *Conocephalus sp.* (longhorn grasshopper). Homoptera: *Tibicen sp*. (cicada), aphid Isoptera (Termites): *Reticulitermes sp, Amitermis sp, Cubitermis sp, Macrotermis sp.*	Annelids live in the soil and benthos; they feed on decaying leaves and vegetables, their juvenile feed on plankton from the water column. The trees and farmland serve as habitat for the Arthropods and Chordates respectively and they feed and multiply, especially during the fruiting and farming season because of food abundance.

Habitat Type/Location	Phylum	Scientific name and Common name of Species Identified	Description of Habitat use
		Lepidoptera (Butterflies): *Papilio sp, Limenitis sp, Danaus sp, Heliothis sp, Sphinx sp., Acrea sp., Precis sp., Neptis sp.* Hymenoptera: *Apanteles sp, Oecophylla sp*. (white/tailor ant), *Monomorium destructor* (black ant), *Apis sp* (honey bees), *Polistes sp* and *Vespa sp* (Wasps). *Limocolaria sp*. (garden snail)	

- **Avifauna (Birds)**

Birds were observed at the open savannah area in large numbers or flying in small flocks or in pairs at top-level grassland. Although mist-nets were set up in the sampling squares/plots no nocturnal bird was trapped and there was owl sound close by. A few other sluggish species were caught, examined and released. **Table 4.24** lists the birds encountered and attested to by locals during the survey.

Table 4.24: Avifauna (Birds) in the study area

Habitat Type/Location	Phylum	Scientific name and Common name of Species Identified	Description of Habitat use
Fallow land and low bush (1, 4, 10, 29, 43, and 51), farmland (3, 13, 32, 35, and 48), farm and fallow land (5, 21, and 38), surface water (4, 8, 10, 15, 18, 19, 21, 26, 32, 53, and 57), mango plantation (57). But all are located in the Guinea and Sudan savannah vegetation belt of Nigeria.	Chordata	**Aves**: *Egretta sp (Cattle egret), Picus viridis* (Woodpecker),*Trigonoceps occipitalis (Vulture), Ciccaba woodfordi (Owl), Columba sp* (Pigeon), *Falco pelegrinus* (Falcon), *Pandion sp* (Hawk), *Acryllium sp (Guinea fowl), Euplectes sp* (Weaver bird), *Psittacus sp* (African grey parrot), *Alcedo atthis* (Common kingfisher), *Merops apiaster* (Common bee-eater), *Hirundo rustica* (Swallow), *Parus tit* (Great tit), *Archilochus colubris* (Hummingbird), *Tringa hypoleucos* (Sandpiper)	The trees and farmland serve as habitat for the Chordates (aves) and they feed and multiply, especially during the fruiting and farming season because of food abundance. They use the trees for homing.

- **Mammals**

Fourteen (14) mammalian Families represented by sixteen (16) species were identified and attested to by local hunters in the area during the survey (see Table 4.25). Their tracks were observed especially early in the mornings. Antelope, cat and rabbit tracks were seen on and across trails.

Table 4.25: Mammals present in the study area

Habitat Type/Location	Phylum	Scientific name and Common name of Species Identified	Description of Habitat use
Fallow land and low bush (1, 4, 10, 29, 43, and 51), farmland (3, 13, 32, 35, and 48), farm and fallow land (5, 21, and 38), surface water (4, 8, 10, 15, 18, 19, 21, 26, 32, 53, and 57), mango plantation (57). But all are located in the Guinea and Sudan savannah vegetation belt of Nigeria.	Chordata	Mammalia*: Lepus sp* (Hare/Rabbit), *Blarina sp* (Shrew), *Myotis sp*(Bats), *Rattus rattus* (Rat), *Pteropus sp* (Bat), *Canis mesomelas* (Jackal), *Sus sp* (Warthog), *Thryonomys swinderianus* (Grass cutter), *Cervus sp* (Deer), Antelope, *Syncerus sp* (Bush cow), *Epixerus ebii* (Squirrel), *Atherurus africanus* (Porcupines), *Felis libya* (Wild cat), *Civettictis civetta* (African civet cat), *Cercopithecus sp* (monkey) *Crocuta crocuta* (Spotted hyena), *Equus sp* (Donkey).	The trees and farmland serve as habitat for the Chordates and they feed and multiply, especially during the fruiting and farming season because of food abundance.

4.19 Human and Economic development

4.19.1 Land use/Tenure

The major use of land in the study area include agriculture, vegetation, rivers/streams, settlements and provision of social needs such as railway line, gas pipeline, transmission lines and road (see Table 4.26).

Vacant land (vegetation) has the largest land use category in the study area followed by agriculture. The majority of people rely on the land for subsistence. Land is used for crop cultivation and grazing of livestock.

All the communities are engaged in farming, the Fulanis also use them in small amounts of animal husbandry.

Table 4.26: Percentage Estimate of Land Use by Category in the Study Area

Land use Category	Percentage %
Farmland	33
Vegetation/vacant land	40
Settlement/commercial activity	10
Surface water	5
Roads	7
Transmission lines	3
Railway line	2

The Land Use Act of 1978 vests all land in the state through the office of the governor. Land is held in trust and administered for the use and common benefit of all Nigerians according to the provisions of the Act.

By this, the states have replaced the traditional institutions and community land owners in their roles as keepers of communal land. The control and management of land in the study area is the responsibility of the State Governors and Local Government Authorities.

Plate 4.13: Existing Pipeline ROW

4.19.2 Waste Management

In the study area, comprehensive approach to solid waste management was identified especially is the Urban Areas. In the rural areas where the quantity of waste generated is small, waste disposal is by dumping, burying and burning.

The urban centers have waste management authorities that ensure proper disposal of waste generated are accomplished by accredited waste management contractors; who collect wastes and dispose them at designated approved disposal site.

4.19.3 Traffic Condition

Movement in the study area is by road. The study area has paved and unpaved roads. Paved roads are to the urban areas and unpaved roads to the villages. The major paved roads with high traffic identified in the study area are; Ajaokuta road, Okene-Lokoja road, Lokoja Abuja road, Izom-Niger road, Sarkin Pawa road and Kaduna-Zaria-Kano road. Vehicular traffic on these roads includes heavy vehicle, light vehicle and motor bikes.

The traffic on the major roads is much higher than traffic on the road leading to communities. It was noted that vehicular speed on the major roads is approximately 50-120km/h while that of the communities' roads is 35-45km/h and traffic congestion and jam do not occur. (See **Appendix 4-22**)

4.19.4 Infrastructure Services

Most of the rural communities depend on other villages/communities to enjoy some infrastructures. Some of the infrastructures in the study area are described as follows;

4.19.4.1 Road

Access to the study area is by road (Ajaokuta – Okene, Lokoja – Abuja, Izom –Suleja – Sarkin Pawa, Sarkin Pawa – Kaduna, Kaduna – Kano).The study area has paved and unpaved roads. Paved roads are to the urban areas and unpaved roads to the villages. Government maintains the road in the urban areas. In the villages, passenger's movement is provided by buses and commercial motor- cyclist (popularly known as Okada).

4.19.4.2 Utilities

Access to reliable sources of energy is a major concern for the urban centers and villages in the study area. Some villages do not have electricity supply those that have stated that they receive epileptic electricity supply.

Almost all the communities in the study area have electricity supply from PHCN, except in Katchi Tsoho, Kaida Sabo, Kassanki, Kazai Kadara, Kijimin Gobirawa and Ungwan Samaila. Also generator sets are used as an alternative source of power supply in communities in the study area due to the incessant power supply from PHCN. The sources of fuel supply in the study area are Kerosene, Petrol, Diesel, Firewood and Charcoal.

Most of the people in the rural communities close/along the study area get their water supplies from locally constructed wells, streams, rivers and rainwater during the rainy season.

In the villages there are no refuse or sewerage system; domestic wastes are disposed by burning, burying and dumping.

Surface drains are provided by the rivers and stream in the villages and drainage channels in the urban areas.

GSM communication is the common telecommunication in both the urban and villages, although few villages don't have coverage. Celtal, Glabacom, MTN have network coverage in the area. Only the urban areas have land phones.

4.19.4.3 Schools

Majority of the rural communities in the study area do not have either primary or secondary schools. Some of them have primary but no secondary schools. Communities that don't have schools walk about 2km to 4km to the neighbouring village/communities where schools are located. Table 4.27 shows the communities that have Primary, Secondary/Tertiary institutions and those that have none of these institutions.

Table 4.27: Primary, Secondary/Tertiary institutions in affected communities

Community	Primary/Secondary Schools.
Ajaokuta	LEA Primary School, Ajaokuta, Govt. Sec. School, Ajaokuta
Iloshi	Iloshi Primary School, UBE Primary School, Iloshi Govt. Secondary School.
Zango Daji	LEA Primary School, Adavi, Success Primary School, Command Primary School, Chari Magumeri Barracks, Zango Daji.
Koton Karfe	Govt. Secondary School, Girls Secondary School, Rahma Private Secondary Secondary, Amazing Grace Private Secondary School, Central Primary School, UBE Primary School, J.S.S Koton Karfe, St. Pius School.
Abaji	Govt. Day Secondary School, Abaji and other Govt. and Private Schools.
Agyana	UBE Primary School, LEA Primary School, Agyana.
Dangara	UBE Primary School, LEA Primary School Dangara.
Dafa	UBE Secondary School, Dafa Primary, Four Square Church Secondary School, Dafa.
Gwagwalada	They have both Govt. and Private Schools including the University of Abuja.
Kassanki	UBE Primary School
Katchi Tsoho	LEA Dobi, UBE, Dobi, Govt. Secondary School, Dobi
Kaida Sabo	Kaida Sabo Primary School.
Izom	Govt. Science College, Junior Day Secondary School, Central Primary School, Kpau Primary School and other private Primary and Secondary Schools.
Lambata	Govt. Secondary School, LEA Primary and Other Private Nursery and Primary Schools.
Bonu	Bonu Primary School.
Kaffin Koro	Govt. Girls Day Secondary School, Junior Secondary School, Baptist Secondary School, Nakowa Nursery School, Wazobia Primary School.
Kaazai Kadara	None
Sarkin Pawa	Central Primary School, Dangunu Central School, Kutchi Central School, Zazaga Central School, Dandaudu,

Community	Primary/Secondary Schools.
	Central School, Fuka Central Private Schools.
Gwagwada	LEA Primary School, Govt. Secondary School, UNICEF Nursery School and other Private Nursery/Primary Schools.
Ligari	LEA Primary School, Ligari
Mando	LEA Primary School, Junior Secondary, Nigerian Air Force Nursery, Primary and Secondary, Nigerian Defense Academy Nursery, Primary and Secondary School, National Institute for Water Resources, Ahmadu Bellow University School of Animal Husbandry, Nigerian Defense Academy.
Kigimin Gobirawa	None
Jaji	Govt. Secondary School, Child Friendly School, LEA Primary Hayin Gada, LEA Primary Gadan Madaki, Command Staff Secondary School, New Barrack Primary School, Armed Forces Command and Staff College Jaji, Infantry Center Aid School and other Private Schools.
Zango Aya/Lamban Zango	LEA Primary School
Pangurza Gari	LEA Primary School
Likoro	LEA Primary School, UBE Ungwa Mathuta Likoro, Govt. Day Secondary School.
Ungwan Samaila Kutakure	None
Rahaman Wali	LEA Primary School, Junior Secondary School.
Gimi Gari	
Rumin Mamuda	LEA Primary School and other Private Primary Schools.
Kunkumi Rumi	LEA Primary School.
Zakau	LEA Primary School.
Gangarida Ikara	LEA Primary School.
Nasarawan Kofa Gwarmai	None
Tashan Alhaji	None

Community	Primary/Secondary Schools.
Kunan Dandogari	LEA Primary School, Govt. Day Secondary School.
Chiromawa	Govt. Arabic Primary School, Govt. Day Secondary School.
Karfi	Lea Primary School.
Tamburawa	LEA Primary School, Govt. Day Secondary School.

4.19.4.4 Industries

Various industries were found in some of the communities' in the study area. In Ajaokuta, there are industries such as The Ajaokuta Steel Rolling Company, ZHAKEM Engineering Company, PHCN Sub Station, and Geregu Independent Power Plant Station etc. in Kaduna; we have the PHCN sub Power Station etc.

4.19.4.5 Recreation

There are limited numbers of hotels and guest houses in the study area. The hotels and guest houses are in the urban areas. Gurara Waterfall was identified as the major tourist attraction in the project area.

Plate 4.14: Gurara Waterfall

4.19.4.6 Public Health and Medical Services

Primary health care facilities were identified in some of the communities in the study area. Communities that do not have health care facility, depends on the nearby community or travel to the nearest town/city to make use of the available ones there. Even amongst those that have the facility, some are not well equipped while some are too small to accommodate the large number of patients using the facility.

The availability of primary health care facilities in communities of the study area is shown in the **Table 4.28**.

Table 4.28: Primary health care facilities in communities of the study area

Community	Primary Health Care Centers.
Ajaokuta	Both govt. and private health centre
Iloshi	Govt. dispensary and primary health centre
Zango Daji	Govt. hospital
Koton Karfe	Both govt. and private health centre
Sensenyi	None
Abaji	Both govt. and private hospital
Agyana	Govt. health centre
Dangara	Govt. and private hospital
Dafa	None
Gwagwalada	Govt., private health centre and Specialist hospital.
Kassanki	None
Katchi Tsoho	None
Kaida Sabo	None
Izom	Both govt. and private health centre
Lambata	Both govt. and private health centre
Bonu	None
Kaffin Koro	Both govt. and private health centre
Kaazai Kadara	None
Sarkin Pawa	Both govt. and private health centre
Gwagwada	Govt. health centre present
Ligari	Govt. health centre present
Mando	Both govt. and private health centre
Kigimin Gobirawa	None
Jaji	Both govt. and private health centre
Zango Aya/Lamban Zango	None
Zaria	Both govt. and private health centre and the University Teaching Hospital are present
Pangurza Gari	None
Likoro	Both govt. and private health centre present.
Ungwan Samaila Kutakure	None
Rahaman Wali	Private health centre present
Gimi Gari	None
Rumin Mamuda	None
Kunkumi Rumi	None

Community	Primary Health Care Centers.
Zakau	None
Gangarida Ikara	Govt. health centre present
Nasarawan Kofa Gwarmai	Govt. health centre present
Tashan Alhaji	Govt. health centre present
Kunan Dandogari	Govt. health centre present
Chiromawa	Govt. health centre present
Karfi	Govt. health centre present
Tamburawa	Govt. health centre present

4.20 Quality of Life Values

4.20.1 Public Health

In the study area public health was studied under the following; housing conditions; water quality; sanitary facilities and waste management.

4.20.2 Air Quality

The air quality parameters in the study area showed good air quality but issues that can be a source of air pollution. Vehicular use in the rural communities and urban areas was identified as source of air pollution. In the communities, waste disposal in some areas is by burning and it adds to bush burning generally practiced by communities.

Indoor air quality issues was identified; homes in rural areas of the study area use wood stoves, and fireplaces, and kerosene for cooking, resulting in potentially higher levels of indoor pollution.

4.20.3 Water Quality

In the study area communities were identified to depend on surface and ground water sources for most of their drinking, cooking, bathing, washing, and irrigation needs. The surface water quality in the study area showed presence of E. coli.

4.20.4 Housing Condition

Poor overcrowded housing exposes people to health risk by facilitating the spread of infection diseases such as acute respiratory track infection. In the study area, urban areas have housing pattern that is linear and nucleated while in the rural communities houses are dispersed and small. Unsanitary means of excreta disposal are closely associated with diarrhoeal. The toilet facilities in the study area include pit latrines, open area, bush and soak-way (in urban areas).

4.20.5 Solid Wastes

In the rural communities there are limited solid waste services or none at all, leaving homeowners to haul waste to a dumpsite or dump on their own or another person's property, bury or burn it. These conditions can generate vectors and nuisance and also provide breeding ground for mosquitoes and flies, which favours the spread of malaria.

4.20.6 Aesthetics Value

Aesthetics is the visual quality of an area characterized by one or more visual elements such as an open space, scenic view, or architecture. Aesthetically significant features in the study area include bushes, existing NNPC product pipeline ROW, surface water, settlements, railway line and roads. The visual setting of the study area is primarily vegetation and farm areas. Surrounding land uses in the study area include primarily agriculture. The project would be located predominantely in existing NNPC corridors for gas and petroleum product rights-of-way.

4.21 Socio-Economic Baseline Description

Information collected during the socio-economic survey in the affected communities and literatures were used to describe the socioeconomic conditions of the study area.

4.21.1 Community Background

A total of 41 communities were identified as being located within (or partly encroaching into) a 2km corridor of the project ROW. Five (5) communities falls within Kogi State, 8 in Abuja, 7 in Niger State, 17 in Kaduna State and 6 in Kano State. The communities in in Kogi State include Ajaokuta, Iloshi, Zango Daji, Koton Karfe and Sensenyi.

Abuja include the following; Abaji, Agyana, Dangara, Dafa, Gwagwalada, Kassanki, Katchi Tsoho, and Kaida Sabo.

Niger State include the following; Izom, Lambata, Bonu, Kaffin Koro, Kazaai Kadara and Sarkin Pawa.

Kaduna include the following; Gwagwada, Ligari, Mando, Kigimin Gobirawa, Jaji, Zango Aya / Laban Zango, Zaria, Pangurza Gari, Likoro, Ungwan Samaila Kutakure, Rahaman Wali, Gimi Gari, Rumi Mamuda, Kunkumi Rumi, Zakau, Gangarida Ikara (Sabongida).

Kano State include the following; Nasarawan Kofa (Gwarmai), Tashan Alhaji, Kunan Dandogari, Chiromawa, Karfi and Tamburawa.

Most of the communities are rural in nature while few have urban setting. The rural communities can be accessed through the major roads leading to the urban areas but most rural communities' roads are unpaved and some can only be accessed in the dry season (Kassanki).

The communities generally have the following ethnic origins; Igalas, Igbirra, Bassange, Igbirra, Koto, Ganagana, Bassa Komo, Gbagi, Nupe, Koro, Kadara, Bajju, Kataf, Ikulu, Mangu, Idoma etc.

The specific ethnic group of each identified community and the respective Local Government Area is shown in **Table 4.29**. In the study area urban settelement include Ajaokuta, Koton Karfi, Abaji, Dangara, Gwagwalada, Mando, Jaji, Zaria, Izom, Lambata, Kafin Koro, Sarkin Pawa, Konan Dandogari, Chiromawa, Karfi and Tambarawa.

Table 4.29: Ethnic groupings of affected community

COMMUNITIES	TRIBES	LOCAL GOVERNMENT	STATE
Ajaokuta	Igala	Ajaokuta	Kogi
Iloshi	Igala/Igbira	Ajaokuta	Kogi
Zango Daji	Igbirra	Adavi	Kogi
Koton Karfe	Egburra koto	Koton Karfe	Kogi
Sensenyi	Egburra koto	Koton Karfe	Kogi
Abaji	Egburra koto	Abaji Area Council	FCT
Agyana	Nupe Ganagana	Abaji Area Council	FCT
Dangara	Gwari, Nupe, Ganagana	Kwali Area Council	FCT
Dafa	Gwari, Nupe	Kwali Area Council	FCT
Gwagwalada	Bassa Komo	Gwagwalada A/C	FCT
Kassanki	Bassa	Gwagwalada A/C	FCT
Katchi Tsoho	Gwari	Gwagwalada A/C	FCT
Kaida Sabo	Gwari, Nupe	Gwagwalada A/C	FCT
Izom	Gwari	Gurara	Niger
Lambata	Gwari	Gurara	Niger
Bonu	Gwari	Gurara	Niger
Kaffin Koro	Koro	Paikoro	Niger
Kaazai Kadara	Kadara	Munya	Niger

COMMUNITIES	TRIBES	LOCAL GOVERNMENT	STATE
Sarkin Pawa	Gwari	Munya	Niger
Gwagwada	Gwari	Chikun	Kaduna
Ligari	Gwari	Chikun	Kaduna
Mando	Hausa/Gwari	Igabi	Kaduna
Kigimin Gobirawa	Hausa	Igabi	Kaduna
Jaji	Fulani	Igabi	Kaduna
Zango Aya/Lamban Zango	Hausa	Igabi	Kaduna
Zaria	Hausa	Igabi	Kaduna
Pangurza Gari	Hausa	Igabi	Kaduna
Likoro	Hausa	Kudan	Kaduna
Ungwan Samaila Kutakure	Hausa	Markafi	Kaduna
Rahaman Wali	Hausa	Markarfi	Kaduna
Gimi Gari	Hausa	Markafi	Kaduna
Rumin Mamuda	Hausa	Ikara	Kaduna
Kunkumi Rumi	Hausa	Ikara	Kaduna
Zakau	Hausa	Ikara	Kaduna
Gangarida Ikara	Hausa	Ikara	Kaduna
Nasarawan Kofa Gwarmai	Hausa	Bebeji	Kano
Tashan Alhaji	Hausa	Kiru	Kano
Kunan Dandogari	Hausa	Kiru	Kano

COMMUNITIES	TRIBES	LOCAL GOVERNMENT	STATE
Chiromawa	Hausa	Garin Mallam	Kano
Karfi	Hausa	Kura	Kano
Tamburawa	Hausa	Dawakin Kudu	Kano

4.21.2 Cultural and Social Settings

4.21.2.1 Traditional and Administrative Structure

The traditional administrative structure of the communities in the study area is such that the village Head/Magajis oversees the smaller villages while the ward Heads/Mai ungwa oversees more villages headed by the village Heads/Magajis (see **Table 4.30**).

The District Heads/Dakachi oversees other groups of villages that are headed by the Ward Heads.

As identified in Kogi, Abuja, Niger, Kaduna and Kano, the 'Traditional Cities/Towns have the Emirs/Ohimege as their traditional/administrative Heads which are assisted by the Council of Chiefs.

The community heads have ascriptive council of chiefs which assist them in the day to day running of the affairs of the communities both administratively, socially, economically etc.

The highest traditional rulers in the various communities in the study area are addressed with different names/title. In Ajaokuta, the highest traditional ruler is called 'The Onu', in Koton Karfe, He Is called 'The Ohimege', in Abaji, He is called 'The Ona', in Dangara, He is called 'The Mai Wako', in Gwagwalada, He is called 'The Aguma', In Niger State He Is known as 'The Emir', in some parts of Kaduna (from Gwagwada to Ligari) He is known as 'Sir Gbagi', from Mando up to Kano, He is also known as 'Emir'.

4.21.2.2 Groups and Association

The major associations that are involved in the administration and development of the communities in the study area are listed in **Table 4.31**.

Table 4.30: The traditional administrative structure of the communities in the study area

State	Community Head	Highest Traditional Ruler
Kogi State		
Ajaokuta	Alh. Kassim Ibrahim	HRH. Alh. Dr. Aliu Obaje. The Atta of Igala.
Iloshi	Pa Jimoh. O. Alaja.	HRH. Alh. Dr. Ado Ibrahim. The Ohinoyi of Igbira land.
Zango Daji	Elder Bayo John	HRH. Alh. Abu Ali. The Etsu Bassange.
Koton Karfe	HRH. Alh. (Dr) Shuaibu Mammam Lafia	HRH. Dr. Shuaibu Mamman Lafia. The Ohimege of Koton Karfe.
Sensenyi	Alh. Shuaibu Dauda.	
Paki	HRH Ibrahim Eneye Ananyuwa	HRH Ibrahim Eneye Ananyuwa
Abuja –FCT		
Abaji	HRH. Alh. Adamu Yunusa	HRH. Alh. Adamu Yunusa. The Ona of Abaji.
Agyana	Alh Salihu Usman	
Dangara	Alh. Ibrahim Dan Usman	HRH. Alh. Ibrahim Dan Usman.
Dafa	Alh. Abdulahi Kajiya	HRH. Alh. Audu Sha'aban. Azazu. The Etsu of Kwali.
Gwagwalada	HRH. Alh. Muhammed Magaji	HRH. Alh. Muhammed Magaji. The Aguma of Gwagwalada.
Kassanki	Majuwa Alabura	
Katchi Tsoho	Magaji Sarki	
Kaida Sabo	Mallam Yakubu Magaji	
Niger State		
Izom	Alh. Ibrahim A. Salihu	HRH. Alh. Dr. Bahago. The Emir of Minna.
Lambata	Alh. Haruna Shuaibu	
Bonu	Tanko Maikasuwa	
Kaffin Koro	Alh. Abubarka D. Mamman	
Kazaai Kadara	Yakubu Kazaai	
Sarkin Pawa	Alh. Umar S. Muhammed	
Kaduna State		
Gwagwada	Yusuf Gambo	HRH. Dr. Danjuma Barde. Sir Gbagi 1.
Ligari	Mr Sunday M. Barde	
Mando	Alh. Sani Musa Umar	HRH. Alh. Dr. Shehu Idris. The Emir of Zazzau.
Kigimin Gobirawa	Alh. Ahmadu Dan' Aka	

State	Community Head	Highest Traditional Ruler
Jaji	Alh. AbudulRasheed Sani	
Zango Aya/Laban zango	Ibrahim Abubakar	
Dutsen Abba	Alh. Falalu Umar	
Zaria	HRH. Alh. (Dr) Shehu Idris	
Pangurza Gari	Muhammed Lawal Musa	
Likoro	Alh. Waziri Likoro	
Ungwan Samaila Kutakure	Samaila Abdul	
Rahaman Wali	Ibrahim Dabo	
Gimi Gari	Dalhatu Muhammed	
Rumin Mamuda	Mai' Ungwa Ali	
Kunkumi Rumi	Abdulahi Chiroma	
Zakau	Mamuda Musa	
Gangarida Ikara	Yahaya Lawal	
Kano State		
Nasarawan Koba (Gwamai)	Alh. Garba Idris	Alh. Dr. Ado Bayero. The Emir of Kano.
Tashan Alhaji	Alh. Musa Munkhailu	
Konan Dogari	Alh. Musa Idris	
Chiromawa	Alh. Kabiru Yusha'u	
Karfi	Alh. Magaji Shehu	
Tamburawa	Alh. Auwalu Umaru	

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Table 4.31: Communities' Associations in the study area

Communities	Major Association
Ajaokuta	Igala Traditional Association ; Igbira Traditional Association
Iloshi	Central Fan Club Comm. Development;Adogo/Umaneve Club of Nigeria;Monkuta Youth Association;Avapa Traditional Youth Association;Muche Youth Association
Zango Daji	Igala Traditional Association ; Igbira Traditional Association ; Bassange Traditional Association
Koton Karfe	Koton Karfe Cooperative Association;Koton Karfe Timber Association;Koton Karfe Tailoring Association;Koton Karfe Youth Association;Koton Karfe Market Association Koton Karfe Women Association
Sensenyi	Ibura Koto Traditional Association
Abaji	Abaji Traditional Development Association;Abaji Market Development Association Abaji Youth Development Association
Agyana	Agyana Youth Development Association
Dangara	-
Dafa	Young Producers Farmers Association;Gatherer Women Association;Old Age Association;Cattle Rearers Association;Fishermen Association;Hunters Association Market Women Association
Gwagwalada	Gwagwalada Development Association;Gwagwalada Youth Association
Kassanki	Kassanki Christian Association;Kassanki Muslim Association
Katchi Tsoho	-
Kaida Sabo	Kaida Youth Association;Kaida Farmers Association;Kaida Students Association Kaida Women Association;Kaida Market Association
Izom	Izom Farmers Association;Izom Mechanic Association;Izom Mothers Club
Lambata	Lambata Farmers Association
Bonu	Bonu Ataza Association ; Bonu Sumari Association
Kaffin Koro	Kaffin Koro Development Association;Kaffin Koro Youth Association;Koro Development Association;Bajju Development Association;Yoruba Development Association Igbo Development Association;Hausa Development Association
Kazaai Kadara	
Sarkin Pawa	Gbagi Development Association;Sarkin Pawa Youth Dev. Association;Sarkin Pawa Market Women Association
Gwagwada	Gwagwada Farmers Club

Communities	Major Association
Ligari	Ligari Farmers Association Ligari Women Association
Mando	Mando Youth Association
Kigimin Gobirawa	Sakotawa/Zanfarawa Association;Kabawa Development Association
Jaji	Jaji Youth Association;Jaji Drivers Association;Jaji Cotton Farmers Association Jaji Farmers Association;Jaji Miyati Allah Cattle Association
Zango Aya/Laban zango	Farmers Association
Zaria	Farmers Development Association; Zaria Youth Forum Miyati, Allah Cattle Breeders Association Zaria.
Pangurza Gari	
Likoro	Likoro Development Association;Likoro Forum;Likoro Youth Association Likoro Farmers Association
Ungwan Samaila Kutakure	Cooperative Society;Fadama Farmers Association
Rahaman Wali	Parent Teachers Association;Rahaman Health Association;Farmers Association Rahaman Wali Youth Dev. Association
Gimi Gari	Gimi Youth Development Association;Gimi Farmers Association;Fadama 1 Gimi Association;Ungwam Karfe Association
Rumin Mamuda	Rumi Development Association
Kunkumi Rumi	Kunkumi Rumi Dev. Area Association;Kunkumi Rumi Association
Zakau	
Gangarida Ikara	Gangarida Youth AssociationGangarida Forum; Gangarida Comm. Dev. Association
Nasarawan Koba (Gwamai)	Gwamai Development Association;Gwamai Youth Association
Tashan Alhaji	Tashan Alhaji Youth Dev. Association
Konan Dogari	Konan Dogari Youth Dev. Association;Konan Dogari Farmers Association
Chiromawa	CHIDA Development Association;Chiromawa Youth Association;Chiromawa Farmers Association;Water Users Association
Karfi	Karfi Development Association;Karfi Youth Association
Tamburawa	Tamburawa Development Association;Tamburawa Youth Association

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4.21.3 Local Government Council (LGA)

The Local Government Council handles the modern administrative system with the Local Government Chairman as the Head, while the Councilors are representatives of the wards/areas under the Local Government Council. The communities have their own councilor who represents their interests in various matters affecting the LGC. The communities' distances from their respective LGA headquarters is shown in **Table 4.33**.

Table 4.32: Affected communities' location distances to their respective LGA

Communities	Distance From The Nearest Local Govt.	Local Government.
Ajaokuta	25km	Ajaokuta L.G
Iloshi	60km	Ajaokuta L.G
Zango Daji	35km	Adavi L.G
Koton Karfe	Within the Council H/Q	Koton Karfe L.G
Sensenyi	3km	Koton Kafe
Abaji	1km	Abaji Area Council
Agyana	8km	Abaji Area Council
Dangara	10km	Abaji Area Council
Dafa	15km	Kwali Area Council
Gwagwalada	Within The Area Council	Gwagwalada Area Council
Kassanki	20km	Gwagwalada A.C
Katchi Tsoho	50km	Gwagwalada A.C
Kaida Sabo	20km	Gwagwalada A.C
Izom	2km	Gurara Local Govt.
Lambata	Within the local Govt.	Gurara Local Govt.
Bonu	10km	Gurara Local Govt.
Kaffin Koro	60km	Paikoro Local Govt
Kazaai Kadara	25km	Munya Local Govt.
Sarkin Pawa	Within the Local Govt.	Munya Local Govt.
Gwagwada	20km	Chikun Local Govt.
Ligari	50km	Chikun Local Govt.
Mando	80km	Igabi Local Govt.
Kigimin Gobirawa	20km	Igabi Local Govt.
Jaji	24km	Igabi Local Govt.
Zango Aya/Laban zango	15km	Igabi local Govt.
Zaria	Within the Local Govt.	Zaria Local Govt.
Pangurza Gari	16km	Igabi Local Govt.
Likoro	7km	Kudan Local Govt.
Ungwan Samaila Kutakure	8km	Makarfi Local Govt.
Rahaman Wali	7km	Makarfi Local Govt.
Gimi Gari	5km	Makarfi Local Govt.
Rumin Mamuda	30km	Ikara Local Govt.
Kunkumi Rumi	45km	Ikara Local Govt.
Zakau	30km	Ikara Local Govt.

Communities	Distance From The Nearest Local Govt.	Local Government.
Gangarida Ikara	2km	Ikara Local Govt.
Nasarawan Koba (Gwamai)	5km	Bebeji Local Govt.
Tashan Alhaji	3km	Kiru Local Govt.
Konan Dogari	4km	Kiru Local Govt.
Chiromawa	4km	Garun Mallam L.G
Karfi	7km	Kura Local Govt.
Tamburawa	2km	Dawakin Kudu

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4.21.4 Security

The rural communities have vigilante` groups that help in security while the urban areas use police. Also, the communities that are close to urban centers use both vigilante and police to handle civil and administration of law and order in the communities.

4.21.5 Archaeology, Culture and Religion

4.21.5.1 Archaeology/Historical Site

There are archaeological sites in some of the communities visited some of which are shown in **Table 4.33.**

Table 4.33: Archaeological sites in some of the communities

Communities	Archaeology/Historical Site
Koton Karfe	They have an ancient historical site that is located within the community.
Gwagwalada	They have a reservoir at Dukpa (the Dukpana reservoir), which serves as their source of water for domestic purpose to the people of Dukpa. It's an ancient reservoir used by their forefathers.
Izom	There is the 'Moclean' reservoir located close to the community.
Lambata	There is the Gurara water falls and the Dam located about 1km from the main road and about 2km away from the settlement
Sarkin Pawa	There is a Dam called Tsoho Dam situated closed to the community
Gwagwada	Bushishin forest is situated very close to the community
Ligari	They have two sacred forests called 'Kurmin Ligari and Kurmin Kuroda'
Mando	Mando ancient walls which used to be the site of their former settlement situated in Afaka village far from the Project area. Also, there is the burial site of the Christians behind the PHCN station which is very close to the site of the KEPCO Power station
Jaji	There is an ancient wall situated behind the district head's house about 200m away from the NNPC Pipe Line
Pangurzan Gari	There is an ancient burial site situated close to the community
Zaria	There is an ancient wall (built during the time of the late Queen Amina of Zaria) housing the ancient Zaria city situated far away from the Pipelines Right Of way
Likoro	There is an ancient wall situated close to the settlement called 'Gidan Madura

4.21.5.2 Culture

The cultural and social setting of the communities along the study area is typically that of the Northern setting. The settings identified is such that in each of the villages visited from Ajaokuta in Kogi State to Tamburawa in Kano State, the people cohabit in a compound setting such that there can be as many as five to ten members of an extended family living together in the same compound.

The cohabitation in the villages is in such a way that both the **Igala, Bassange, Igbira, Ibura, Koto, Gwari, Kadara, Nupe, Ganagana, Bassa, Bassa Komo, Hausa-Fulanis, Yorubas, Igbos** and other ethnic tribes live together in the same community. Generally, the cultural setting is Patriarchal in nature.

4.21.5.3 Dressing Pattern

The people are seen to be dressed in native attire; the men are dressed in ‘Malumalum, Kaftans, Trousers, Caps and Palm Slippers, while the Traditional Title Holders wear Turbans as a mark of Title ship. The women are dressed in wrappers with headgears and also with a veil to cover sensitive parts of their body. This pattern of dressing is both for formal and informal occasion.

Also in some of the urban centers, the white collar workers are seen to be dressed corporately in the western way; in Shirts, Trousers, Suites, and Skirts (for ladies), most especially from Monday to Friday. The youths are seen dressed in Casual Wears such as Jeans, T-Shirts, Skirts (for the ladies) and Caps.

4.21.5.4 Festival and Taboo

The communities in the study area that celebrate traditional festivals include Iloshi, Dafa, Kassanki, Kaida Sabo, Bonu and Sarkin Pawa. The festivals and repective taboo including period of celebration is shown in Table 4.36.

Table 4.34: Festivals and Respective Taboo in Communities

Community	Festival	Date	Taboo
Iloshi	Isimisi festival (New Yam Festival), Ekuechi and Ebe festival.	January of every Year.	The taboo during the Ekuechi and Ebe Festival in Iloshi is that women are not allowed to participate but male visitors/strangers are allowed to participate if they want to.
Dafa	Agunu festival. It's a kind of festival that allows men to show brevity in the face of danger. The men take their bath with hot water.	The Festival is celebrated in October/November.	The taboo during the Agunu in Festival in Dafa is that men are no allowed to sleep with women; visitors/strangers too do not see or participate in the festival.
Kassanki	The community celebrates Jiba festival and Timiji festival. It is a festival of the right of passage into adulthood'.	They celebrate these Festivals in June/July.	There are no taboos during this Festival
Kaida Sabo	The community celebrates Maiwa traditional festival (New Yam Festival).	The Festival is celebrated in the month of August.	There are no taboos during this Festival
Bonu	They celebrate Bonu festival, Patauchi Festival (New Yam Festival)	January of every Year.	There are no taboos during this Festival
Sarkin Pawa	They celebrate Vingo Jessi Festival (New Yam Festival).	The Festival is celebrated in December.	There are no taboos during this Festival
Ligari	They celebrate the Ajibasul and Bayi Festival.	The Festival is celebrated in December.	The taboo during the Ajibasul Festival in Ligari is that women and visitors are not allowed to take part in the traditional Festival but during the Bayi Festival, everyybody can participate

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4.21.5.5 Marriage and Family Institutions

Marriage as a legal union between a man and a woman is an old institution ordained by God. It is both regarded as sacred by the two religions i.e. Christianity and Islam. The three types of marriage institution in the study area are: Christian/Church marriage, Islamic Wedding and Court marriage. Out of the three, Islamic marriage is the predominant.

- Church Wedding Ceremony

This type of marriage ceremony is consummated in the church especially if the bride or both couples are Christians. Normally, the bride's family church is chosen in order to honor the parents of the bride. The presiding bishop, priest/reverend, and the overseer conduct the service depending on the denomination the brides' family worships. Wedding rings are exchanged after the bride's father has handed the bride over to the officiating minister at the altar and the blessings are pronounced on the couple.

The couples together with some selected persons from each of their family are asked to go to the church registry for the signing of the marriage register after which the marriage certificate is giving to the couple. The wedding reception and other ceremony follow after the church service. The church allows the couple to be to go to the marriage registry of any local government of their choice to register their intention to be joined together as man and wife before the church wedding is conducted.

- Islamic Wedding Ceremony

This is commonly referred to as 'NIKKAI' and it is presided over by the Imam as the officiating minister who will perform the marriage rite and bless the couple. Other activities necessary as part of the wedding programme are carried out.

- Court Wedding

This is believed to be so important than all the other types of marriage because it is more recognized by the government and also by the constitution of the Federal Republic of Nigeria. The couple appears before the marriage registrar who declares them legally married after they have successfully sworn an oath and exchanged rings. A marriage certificate will then be issued to them. Although, Mando has no court of law, the ceremony is carried out at the nearby customary court in Kaduna.

4.21.5.6 Burials

The burial type practiced in the area includes Muslim, Christain and Animist. In the animist, the family of the deacesed arranges for the burial as they deem fit.

In Muslim burial the deceased is laid to rest on the day the individual passes and if it happened during late hours, he or she buried the next day. Whether the relatives are present or not, the rite must go on. The Imams preside over burials.

While in the Christian burial it is presided over by the clergymen. The burial ceremony can take place anytime, as long as the family of the deceases is ready. The corpse is taken to the church the deceased attends in his/her lifetime for prayers.

4.21.5.7 Religion

Christianity and Islam have keen followership in communities. Some of the communities are dichotomized in religion with majority being either Christians or Muslims while in the urban centers, mixture of the two religions and a negligible number of animists.

Communities like Koton Karfe, Abaji, Agyana, Dangara, Kaida Sabo, Kassanki, Gwagwalada, Izom, Lambata, Bonu, Kaffin Koro, Kigimin Gobirawa, Jaji, Pangurza Gari, Zaria, Laban Zango/Zango Aya, Likoro, Rahaman Wali, Gimi Gari, Kunkumi Rumi, Zakau, Gangarida, Nasarawa Kofa (Gwarmai), Tashan Alhaji, Kunan Dongari, Chiromawa, Karfi, Tamburawa, are predominantly Muslims with small percentage of indigenous and migrant Christians cohabiting together while communities like Iloshi, Zangon Daji, Ajaokuta, Katchi Tsoho, Dafa, Kazaai Kadara, Ungwan Samaila, Rumi Mamuda, Gwagada, Ligari, Mando are mostly Christians, with a small percentage of indigenous and migrant Muslims cohabiting together. In all these communities, there are negligible numbers of Animist.

4.21.6 Shrine

Some of the communities in the study area where shrines are found are listed in **Table 4.35**

Table 4.35: Shrines in some affected communities

Communities	Name of Shrine
Ajaokuta	Okuta Itabe Shrine
Iloshi	Isimisi Shrine
Zango Daji	Okonbia Igba Shrine
Dafa	Agunu Shrine
Kassanki	Jiba Tomoji Shrine
Bonu	Kpagoda Shrine
Kaffin Koro	Kutagba, Yelekas, Nenati Shrine
Sarkin Pawa	Mubba, Tsoho Shrine
Gwagwada	Kunaba shrine

In some of the communities visited, it was discovered that Animists cohabits side by side with the Christians and Muslims. These traditional worshippers have traditional shrines where they worship their 'gods'.

Plate 4.15: Okuta Itabe Shrine

Table 4.36: Percentage distribution of religion in study area

State	% Christains/Muslems/Animist
Kogi	
Ajaokuta	60% Christians/39% Muslims/1% Animists
Iloshi	70% Christians/39% Muslims/1% Animists
Zango Daji	80% Christians/19% Muslims/1% Animists
Koton Karfe	90% Muslims/8% Christians/2% Animists
Sensenyi	80% Muslims/20% Christians
Abuja (FCT)	
Abaji	60% Muslims/30% Christians/10%Others
Agyana	90% Muslims/10% Christians
Dangara	80% Muslims/20% Christians
Dafa	60% Muslims/38% Christians/2% Animists
Gwagwalada	70% Muslims/30% Christians
Kassanki	60% Muslims/30% Christians/10% Animists
Katchi Tsoho	20%Muslims/70% Christians/10% Animists
Kaida Sabo	60%Muslims/30% Christians/10% Animists
Niger	
Izom	60% Muslims/30% Christians/10% Animists
Lambata	60%Muslims/35% Christians/5%Animists
Bonu	60% Muslims/35% Christians/5% Animists
Kaffin Koro	60%Muslims/35%Christians/5% Animist
Kazaai Kadara	10%Muslims/90% Christians
Sarkin Pawa	30%Muslims/60%Christiana/ 10% Animist
Kaduna	
Gwagwada	40%Muslims/59%Christians/1% Animist.
Ligari	29%Muslims/70%Christians/1%Animist
Mando	60%Christians/40%Muslims
Kigimin Gobirawa	100% Muslims
Jaji	60% Muslims/39% Christians/1% Animists
Zango Aya/Laban zango	70% Muslims/30% Christians
Zaria	60% Muslims/40% Christians
Pangurza Gari	100% Muslims
Likoro	70% Muslims/30% Christians
Ungwan Samaila Kutakure	100% Christians
Rahaman Wali	100% Muslims

State	% Christains/Muslems/Animist
Gimi Gari	100% Muslims
Rumin Mamuda	70% Christians/30% Muslims
Kunkumi Rumi	70% Muslims/30% Christians
Zakau	70% Muslims/29% Christians/1% Animists
Gangarida Ikara	100% Muslims
Kano	
Nasarawan Koba (Gwamai)	100% Muslims
Tashan Alhaji	80% Muslims/20% Christians
Konan Dogari	80% Muslims/20% Christians
Chiromawa	90% Muslims/10% Christians
Karfi	100% Muslims
Tamburawa	100% Muslims

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4.22 Community Health

The diseases commonly experienced by the people of the community are primarily malaria; measles, typhoid and diarrhea (see **Table 4.37**).

Malaria and typhoid were the common diseases identified in the study area

Water supply for drinking and domestic activities is by borehole, the quality of the borehole water did not indicate contamination and the coliform content is zero. Large population of the people has access to the borehole water.

Table 4.37 provides the level of occurrence of diseases identified in the study area.

Table 4.37: Level of occurrence of diseases identified in the study area

Name of disease	Level of Diseases Occurrence				
	None	Rare	Few	Common	Very common
Tuberculosis		*			
HIV/AIDS			*		
Respiratory track diseases: Asthma and Bronchitis			*		
Digestive disease		*			
Heart disease		*			
High Blood Pressure			*		
Headache					*
Bone joint disease and deformity			*		
Nervous disease			*		
Drug sensitivity		*			
Diarrhoeal				*	
Malaria					*
Typhoid				*	
Measles		*			
Menigitis		*			

The prevalence and distribution of vector population in the study area was identified. The term vector is used to denote a carrier of disease causing organisms. Nuisance organisms also are addressed with the understanding that they are not generally considered disease carriers but do present nuisance effect to human and domestic animal populations.Vectors identified include houseflies and mosquitoes.

The small sized bees of the order *Hymenoptera* were identified to be endemic to the study area. They have very small membranous, narrow wings coupled distally, subordinate hind wings, mouthparts for lapping up liquids, ovipositor modified into stinger. They are social and their lava is legless and maggot like. As many as 60,000 to 70,000 individuals of this insect may live in a single hive. In no way are they implicated in the transmission of diseases they only constitute nuisance.

Birds, as potential carriers of the HN5-Virus are common in the area. Domestic rearing of poultry was identified in study area. There have been no reported cases of the virus in birds and humans in the study area.

Mosquitoes in the study area are potential nuisance to human and animal -secondary infections and allergic reactions resulting from the bite of any mosquito species exacerbate their nuisance effect.

4.23 Demography

Demographic estimates and characteristics are very vital in this kind of study because it gives insight to various activities that affect the daily lives of the people of the study area. These include age distribution, settlement pattern, occupation, employment level etc.

However, demography will shed more light on whether the proposed project will have a direct impact on the people considering its proximity to them.

4.24 Population/Households

The sampling shows that in the rural communities each household comprise of at least 9 individuals.

The communities have low population where majority falls within the dependent age bracket of under15 and above 65. In the rural communities the active members have gone to the cities in search of greener pastures. The estimated population of communities in the study area is shown in **Table 4.38**.

4.24.1 Age Distribution

Majority of the population of these settlements falls within the Dependent age bracket of below 15 and above 65years in the rural communities while people in the most active population were found in the urban settlement in the study area.

The population distribution in the villages includes;

The children: - This category is the most populated and contains people of between a day and 15 (fifteen) years of age. They make up about 35% of the total population of the villages in the project areas and can be found in their immediate vicinity when not in their schools, since they are considered to still need firm parental guidance.

The Youths: - They make up about 20% of the total population of the villages in the project areas and of the ages of between 15 and 39. They are in small number because most of them have moved to nearest cities and towns.

The Middle Aged: - Their estimate is about 20% of the communities studied. Their age range is between 40 to 64 years. They are in small number because most of them have moved to nearest cities and towns

The Elders: - They still make up about 25% of the total population depicting that they have the tendency to live long. They make up a very respectable class, and the chiefs are mostly in this category and they ratify decisions brought before them by individuals or groups of people.

Table 4.38: Estimated populations of communities in the study area

	Community	Population	No. Of Housing Units	Settlement Pattern
1	Ajaokuta	39000	Above 1000	Nucleated/Clustered/Dispersed
2	Iloshi	1022	100+	Clustered/Dispersed
3	Zango Daji	5719	1000	Nucleated/Linear
4	Koton Karfe	8296	500+	Clustered/Dispersed
5	Sensenyi	421	100	Linear/Dispersed
6	Abaji	4186	1000	Nucleated/Linear/Clustered
7	Agyana	5054	1000	Linear/Clustered
8	Dangara	19383	1000	Linear/Clustered
9	Dafa	10207	1000	Linear/Clustered
10	Gwagwalada	65378	1000	Nucleated/Linear/Clustered
11	Kassanki	83	100	Linear/Dispersed
12	Katchi Tsoho	75	200	Linear/Dispersed
13	Kaida Sabo	215	100+	Dispersed
14	Izom	840	400+	Nucleated/Clustered/Dispersed
15	Lambata	3480	600+	Nucleated/Clustered/Dispersed
16	Bonu	341	100	Clustered
17	Kaffin Koro	12626	500+	Nucleated/Clustered
18	Kaazai Kadara	601		Clustered/Dispersed
19	Sarkin Pawa	3174	800+	Clustered/Dispersed
20	Gwagwada	1128	400+	Clustered/Dispersed
21	Ligari	518	150	Clustered/Dispersed
22	Mando	17017	1000	Nucleated/Linear/Clustered
23	Kigimin Gobirawa		30	Nucleated/Dispersed
24	Jaji	15168	1000	Nucleated/Linear/Dispersed
25	Zango Aya/Lamban Zango	1178	400	Clustered/Dispersed
26	Zaria	29195	1000	Nucleated/Linear/Dispersed
27	Pangurza Gari	533	100+	Nucleated/Dispersed
28	Likoro	1516	500+	Nucleated/Dispersed
29	Ungwan Samaila Kutakure		20	Dispersed
30	Rahaman Wali		200	Clustered/Dispersed
31	Gimi Gari		100+	Clustered/Dispersed
32	Rumin Mamuda		100	Clustered/Dispersed
33	Kunkumi Rumi		800	Nucleated/Dispersed
34	Zakau	721	30	Clustered/Dispersed

	Community	Population	No. Of Housing Units	Settlement Pattern
35	Gangarida Ikara	1083	100	Clustered/Dispersed
36	Nasarawan Kofa Gwarmai	3282	500+	Nucleated/Dispersed
37	Tashan Alhaji	1243	400	Nucleated/Dispersed
38	Kunan Dandogari		1000	Nucleated/Linear/Dispersed
39	Chiromawa	1245	400	Nucleated/Dispersed
40	Karfi	8525	750+	Nucleated/Dispersed
41	Tamburawa	8907	800+	Nucleated/Dispersed

The 1991 population census of the communities by the National population Commission is given in the table **Table 4.39** below

Table 4.39: 1991 National Population Commission Data of the Project Area

	Locality	Males	Females	Both Sexes	1996 Projection	2006 Projection
1	Ajaokuta	19664	15543	32207	39634	54488
2	Iloshi	426	482	908	1022	1250
3	Zango Daji	2483	2597	5080	5719	6997
4	Koton Karfe	3638	3731	7369	8296	10150
5	Sensenyi	157	217	374	421	515
6	Abaji	1761	1911	3672	4186	5214
7	Agyana	2087	2347	4434	5054	6294
8	Dangara	8618	8386	17004	19383	24141
9	Dafa	4844	4110	8954	10207	12713
10	Gwagwalada	27636	29718	57345	65378	81426
11	Kassanki	30	44	72	83	101
12	Katchi Tsoho	38	31	69	75	87
13	Kaida Sabo	92	94	186	215	273
14	Izom	411	317	728	840	1064
15	Lambata	1551	1464	3015	3480	4410
16	Bonu	144	151	295	341	433
17	Kaffin Koro	5400	5539	10939	12626	16000
18	Kaazai Kadara	244	277	521	601	761
19	Sarkin Pawa	1385	1365	2750	3174	4022
20	Gwagwada	515	450	965	1128	1454

	Locality	Males	Females	Both Sexes	1996 Projection	2006 Projection
21	Ligari	225	218	443	518	668
22	Mando	7882	6678	14560	17017	21931
23	Kigimin Gobirawa	245	237	482	563	644
24	Jaji	7152	5826	12978	15168	19548
25	Zango Aya/Lamban Zango	526	482	1008	1178	1518
26	Zaria	13687	11292	24979	29195	37627
27	Pangurza Gari	221	235	456	533	687
28	Likoro	662	635	1297	1516	1954
29	Ungwan Samaila Kutakure	276	256	532	622	802
30	Rahaman Wali	462	429	891	1041	1341
31	Gimi Gari	142	146	288	337	435
32	Rumin Mamuda	591	624	1215	1420	1830
33	Kunkumi Rumi	607	540	1147	1341	1729
34	Zakau	311	306	617	721	929
35	Gangarida Ikara	477	450	927	1083	1395
36	Nasarawan Kofa Gwarmai	1534	1611	3145	3282	4878
37	Tashan Alhaji	690	360	1050	1243	1629
38	Kunan Dandogari	1284	1454	2738	3240	4244
39	Chiromawa	545	507	1052	1245	1631
40	Karfi	3550	3653	7203	8525	11169
41	Tamburawa	3891	3635	7526	8907	11669

Source: 1991 National Population Commission Data

4.24.2 Housing Pattern

There are some adobe houses in the rural communities of the study area. Most of these houses are unique because of the way they were built with fences made of clay built around these houses as walls for security purposes. Also, found in the study area are the modern types of houses with corrugated iron roofing sheets and walls built around most of them also for security purposes. The housing pattern identified in the study area is a combination of both the linear, nucleated, clustered, dispersed/scattered settlement pattern depending on the area where they are found (see Table 4.35).

4.24.3 Transportation/Road Network

The means of transportation available in the study area is road. The roads in the urban areas are well developed while the link roads to villages are not paved and remian impassable during rainy season. The means of transportation available in the study area include intercity buses, and motorcycles popularly known as 'okada' and foot (especially in the rural communities) are used as means of movement in the study area.

4.24.4 Employment

There is generally a high level of unemployment in the study area. In the rural areas, mostly everybody is self employed taking part in farming activities; the women are engaged in gathering and selling of fire wood, petty trading etc. In the urban areas, there are people that engage in various occupations ranging from the white collar jobs mixed with farming in some cases.

All communities surveyed have members who would be available for temporary work. Also members of most community were identified to have skills that will be useful for the project construction, eg engineers, drivers and welders.

4.24.5 Occupation

Top on the list of the occupation of most of the people in the study area is farming i.e. agriculture. Other occupations include; trading, carpentry/furniture making, intercity car/bus operators, motorcycle operators popularly known as 'okada' riders, teachers, civil servants, artisans, fishermen, canteen operators/food sellers, mobile phone operators etc.

Although some people especially those in the white collar jobs, privately owned/small scale business sector and the civil servants who do not fully participate in farming as their major occupation practice farming either as a hobby because of the large expanse of land available or as a means of subsistence.

Other skills identified in communities in the study area such as Ajaokuta, Koton Karfe, Abaji, Gwagwalada, Dangara, Izom, Lambata, Sarkin Pawa, Mando, Jaji, Chiromawa and Tamburawa which can be useful during the project execution include; engineers, technicians, auto mechanics, masons, drivers, security men, heavy vehicle drivers and tree cutters.

Other communities in the study area that don't have such skills could be trained in order to afford them the opportunity to be gainfully employed during the Project Execution.

Plate 4.16: Wood sellers

4.24.6 Income

The income level of the people in the study area varies from one community to another and also from one State to another. For example, the average monthly income in Dafa, Abuja is about ₦30000, in Jaji, Kaduna State, the average monthly income is about ₦ 50000, in Mando it varies between ₦ 10000 to ₦ 80000 per month.

Income in the study area is generated mostly from the sales of agricultural products ranging from the roots and tuber crops, grains and cereal products, vegetables and fruits and animal husbandry.

The highest income generated from the agricultural sector is mostly during the harvesting period usually around September to January and lower around April to July.

Other sources of income are generated from the white collar jobs sector, the privately owned/small scale business sectors and of course the government worker ranges from ₦20000 - ₦ 80000. Some of the people in this sector who take farming either as a means of subsistence or as a hobby also generate little income from sales of their agricultural products.

4.24.7 Educational Status

Getting quality education and maintaining a good educational status is strongly viewed as a necessity for all. The literacy level in most of the rural communities in the study area is very low compared to those in the urban areas.

Majority in the rural areas could not converse in both written and spoken English language; it's only in the urban areas in the study area that majority can converse in both written and spoken English language even with their elders having high proficiency for both written and spoken English language.

In the rural communities, their highest educational status is either Primary or Secondary except for some of their children who are graduates of higher institutions but not living with their parents in the village, while in the urban areas, virtually all households have either University or Polytechnic graduates some of whom are no longer living in the community but have gone away in search of greener pastures since their town/communities do not have the facilities or jobs available/suitable for them.

4.24.8 Quality of life

The quality of life of the people in the study area (especially in those of the rural areas) is low. This can be explained in terms of the non-existing basic social infrastructures absent in these communities.

Top on the list of these facilities is their road network. These rural communities serve as the food producing areas and the road network they need to move their agricultural produce out to the developed areas are seasonal and in some cases, they are not accessible. Also, majority of them don't have access to good, portable drinking water, schools, primary health care facility, electricity etc.

Plate 4.17: Community settlement in the study area

4.25 Natural Resources

The natural resources found in some of the communities along/close to the Project area can be classified into mineral resources, agricultural resources and the economic trees.

4.25.1 Mineral Resources

The major natural resource found in the Project area is at Ajaokuta where there is iron ore tapped for the existing steel rolling mill. Other natural resources that can be found along the Project area include granite, sharp sand etc.

4.25.2 Agricultural Resources

Agricultural resources identified include sugar cane, lettuce, onions, pumpkin, Beni seed and etc. the animal resources such as cattles, sheeps, goats, swine and guinea fowls.

4.25.3 Economic Trees

The economic trees include mango trees, cashew tree, locust bean trees (dorowa), mahogany trees (madaci), neem trees (dogon yaro) and Gmelina trees.

4.26 Consultation

Widescale consultation was carried out with major stakeholders to the proposed gas pipeline. Stakeholder consultation is the process of involving those individuals or groups that are likely to be either directly or indirectly affected by any part of a proposed project development. Those individuals or groups likely to be directly affected, such as native communities and their representative organizations are referred to as primary stakeholders, while those likely to be indirectly affected, such as environment ministries, government departments and national non-government organizations (NGOs) are referred to as secondary stakeholders.

4.26.1.1 Objectives of Stakeholder Consultation

The general objectives of stakeholder consultation is to ensure that the concerns, fears and suggestions expressed by the communities, feed back into shaping project design.

The specific objectives of stakeholder consultation amongst others include:

- to provide information related to proposed project activities;
- to facilitate and maintain dialogue;
- to seek participation of all interested parties;
- to explain NNPC’s commitment to providing ‘net benefit’ to the project area
- to indentify community expectations

- to create solutions for addressing these concerns and integrating them into project design, operations, and management;
- to enhance the project by learning from and incorporating the expertise of individuals, professionals, communities and organizations

4.26.1.2 Community Consultation (Primary Stakeholder)

Baseline socio-economic information of the project area was collected in consultation with members of the communities whose land, farming activities etc will be affected within 2km corridor of the project route and it covers both existing conditions and their attitude towards the project.

The various meetings with community heads were held between 14th and 22nd of December 2009. The consultation within this period include; focal discussions, interviews and meetings; the meetings were held with the communities before dry season field data gathering.

The meeting enabled the people to familiarize themselves with the details of the project and form opinion about its (Project) perceived benefits and negative impacts.

The communities consulted and their GPS locations are provided in **Table 4.40.**

Table 4.40: GPS locations of affected communities

COMMUNITY	N	E
Ajaokuta	827356	242543
Iloshi	829649	222698
Zango Daji	864746	238353
Koton Karfe	898064	255865
Sensenyi	901028	255911
Abaji	941690	266121
Dangara	948350	270694
Dafa	969925	274225
Gwagwalada	993078	175830
Kassanki	991339	272948
Katchi Tsoho	994109	272363
Kaida Sabo	999212	274070
Izom	1022532	280745
Lambata	1027940	279989
Bonu	1053010	287384
Kaffin Koro	1053010	287384
Kaazai Kadara	1078431	292163

COMMUNITY	N	E
Sarkin Pawa	1108353	292718
Gwagwada	1133762	313027
Ligari	1153104	320130
Mando	1171106	322417
Kigimin Gobirawa	1185527	344022
Jaji	1196648	344073
Zango Aya/Lamban Zango	1209254	348935
Zaria	1225287	358243
Pangurza Gari	1208977	349808
Likoro	1237705	368972
Ungwan Samaila Kutakure	1246885	381389
Rahaman Wali	1248905	381396
Gimi Gari	1252072	384044
Rumin Mamuda	1255989	394452
Kunkumi Rumi	1256129	394129
Zakau	1259423	399983
Nasarawan Kofa Gwarmai	1275438	419115
Tashan Alhaji	1260673	402219
Kunan Dandogari	1279363	427016
Chiromawa	1287463	435888
Karfi	1306949	444746
Tamburawa	1312268	447785

In each community consulted, receptions were cordial and discussions and deliberations were interpreted in the local language by a member of the consultant's team or community member as the case may be. In every consultation, the views, concern and fears of the communities towards the project were collected. The major activities to be carried out at the project location, such as works (site preparation etc) were explained to the community.

- In each meeting different topics were discussed and they include the following: -
- Desirability or otherwise of the project
- The essence of EIA and consultation process
- Socio-economic impacts particularly on lifestyle, quality of life and the people's perception of the project

- Capacity of the project
- Project benefits.

AIES representative informed the community representatives that;

- The project development was likely to impact positively and /or negatively on the community, hence the need for the consultant and community to meet and discuss and for the community to express fears and concerns.
- The consultant had been commissioned to carryout an environmental impact assessment study of the proposed activities in line with regulatory requirement.
- The natural biophysical and socio-economic environment of the project area shall be study to assess the project environmental impacts.
- It was necessary for the community to be informed before hand before baseline studies and for them to give definite approval.

Issues and concern raised by Communities Consulted

- They expected NNPC to give employment to their youths.
- They want NNPC to compensate them for their land that shall be taken, crop that might be destroyed and rivers/streams that might be affected during construction. They expect basic social infrastructure such as borehole to be provided
- Avoiding interference with their lifestyle, cultural values and beliefs.
- Expect NNPC to help equip the community clinics and schools
- As much as possible, NNPC should operate with the minimum disruption of the means of their livelihood by adopting measures that will miKanote any adverse impact on the environment.

The signed attendance list and minutes /proceedings of the meetings as well as concerns expressed by the communities are presented in **Appendix-4-20** and picture in **Plate 4.16**.

4.26.2 Public Consultation (Primary and Secondary Stakeholders)

Public consultation in the form of public forum was carried as part of the EIA process. It was organized as a distinct integrated component of the stakeholder EIA consultation process.

The major objective of the EIA public forum includes:

- To provide information about the project to all stakeholders
- To identify stakeholders concerns and issues and address those concerns
- To seek participation of all interested parties

- To enhance the project by learning from and incorporating the ideas of primary and secondary stakeholder

4.26.2.1 The secondary stakeholders invited for the public forum include:

- Ajaokuta Local Government Area. — Kogi State
- Adavi Local Government Area — Kogi State
- Koton Karfi Local Government Area — Kogi State
- Abaji Area Council. — FCT. Abuja
- Kwali Area Council. — FCT. Abuja
- Gwagwalada Area Council. — FCT. Abuja
- Gurara Local Government. — Niger State
- Paikoro Local Government. — Niger State
- Munya Local Government. — Niger State
- Chikun Local Government. — Kaduna State
- Igabi Local Government. — Kaduna State
- Kudan Local Government. — Kaduna State
- Markarfi Local Government. — Kaduna State
- Ikara Local Government. — Kaduna State
- Bebeji Local Government. — Kano State
- Kiru Local Government. — Kano State
- Garin Mallam Local Government. — Kano State
- Kura Local Government. — Kano State
- Dawakin Kudu Local Government. — Kano State

Others are

- Kogi State Ministry of Environment
- Kogi State Environmental Protection Agency
- Abuja Environmental Protection Board
- Niger Ministry of Environment
- Kaduna State Environmental Protection Agency
- Kano Ministry of Environment
- Nigerian Environmental Society (NES)

The primary stakeholders invited include all the communities as listed in **Table 4.29**.

Community schools were chosen as public forum venues as a strategy to meet with the affected communities. In each state easy accessibility and location informed the choice of community school.

Public holidays and religious worship days were considered in the choice of dates for the public forum.

In Kano State, the public forum was held at Govt. Arabic Secondary School, beside Unity Bank, Chiromawa, Kano State on Saturday, January 30, 2010 between 10am and 2pm.

Kaduna State Public Forum was held at Child Friendly School, Jaji, and Kaduna State on Thursday, January 28, 2010 between10am and 2pm.

In Niger State, the public forum was held at Central Primary School, Izom Niger State, on Wednesday, January 27, 2010 and between 10am and 2pm.

In Abuja, the public forum was held at Pilot Science Primary School, Gwagwalada, Abuja, Tuesday, on January 26, 2008 and between10am and 2pm.

Kogi State Public Forum was held at Council Chamber, Ohimege's Palace Koton Karfe on Monday, January 25, 2010 and between 10am and 2pm.

In each State and venue the forum started with the arrival and introduction of guest.

The forum opening remarks were made by the representative of Federal Ministry of Petroleum Resources. The representatives in their opening remarks highlighted the need and benefits of the project to the project area and seek the corporation of community members in the successful implementation of the project.

The project environmental profile was presented and described by the representative of AIES. During the presentation the AIES representative explained that the forum was a two – way flow of information and dialogue between NNPC and all stakeholders, especially aimed at developing ideas that can help shape project design and resolve conflict at an early stage.

The presentation also explained the potential impact of the project and how the concerns raised in the forum will be included and addressed in the EIA Environmental Management Plan (EMP). It also provided the participants information relating to EIA methodology and process, benefit to NNPC and stakeholders.

Presentations and forum deliberations were translated to local language; this is to ensure that every participant was carried along.The total number of parcicipants in the Public Forum is 249 (Kaduna 68, Niger 59, Kogi 53, Abuja 17 and Kano 52). The forum attendance list and minutes are provided in Appendix-**4-21** and picture in plate **4.16 -21**.

4.26.2.2 Issues Raised by Stakeholder during Public Forum

- Stakeholders were ppsitive about the project and expect that it will bring about a lot of benefits like employment during the construction period and steady power supply.

- The communities wanted to learn more about the project including more benefits. Participants were keen to know the economic gain and the mitigation measures that will be provided against adverse impact and expresessed the need for the pipeline to be well buried to avoid vandalism.

- The stakeholders supported the project implementation and generally commended NNPC for the idea.

- They expect artisans and labourers to be employed from their communities during project construction.

- They want affected farmers to be compensated and it should be the same in all affected communities from Ajaokuta to Kano.
- The community heads want to be carried along during compensation to avoid conflict
- They want compensation to be paid to people that uses streams that will be affected by the project in the form of provision of borehole water.

- They demanded for adequate compensation not necessarily in monetary terms but infrastructures.

- The stakeholders want employment of unskilled labour from communities where the pipeline is crossing and that their young men and women are trained and employed.
- The stakeholders wanted to know whether the gas is poisonous especially when inhaled;
- They asked how project impact on air (especially bad odour) shall be mitigated.
- They want the community members to be involved in the security of the pipeline to reduce vandalism.

- They suggested that every comment made in the public forum should be incorporated in the scheme of project planning and the list of skills available in the community be made and training provided where needed.

- The stakeholders in general welcome the forum and see it as a consultation process that will reduce crisis.

4.26.3 NNPC Response to issues raised by Host communities

In response to the above, NNPC during the Panel review exercise reiterated its commitments to the wellbeing of the host communities. They recognized the communities as major stakeholders in this projects, NNPC promised that in line with its Corporate Social Responsibilities, it will adopt strategies that would be sustainable.

Its plans to provide a proactive guideline in ensuring that Environmental, Cultural, Social and Economic issues that bother on the welfare of host Communities are adequately addressed during the execution of the pipeline project.

To achieve this, efforts will be geared towards infrastructure development, community assistance, or human capacity building with strict compliance with the Nigerian content initiative of the Federal Government.This strategy main thrust would be geared towards engagement, empowerment andsustainable development of the Community.

NNPC will maintain correct and proper relations with all arms of Government, related Agencies, Local Government Authorities and recognized pressure groups in the project environment through the Global Memorandum of Understanding (GMU).

CHAPTER FIVE

5.0 ASSOCIATED AND POTENTIAL ENVIRONMENTAL IMPACTS

5.1 General

This chapter evaluates the associated and potential environmental impacts of the proposed project. Matrix method was used to identify the environmental impacts anticipated during the project construction and operation. The different methods employed in this report are discussed below:

5.2 Scoping

Scoping is an activity aimed at identifying those components of the environment which may be impacted by the project and which may be of concern to the stakeholders and regulators. Scoping seeks to identify those aspects of the proposed project which could have significant impact on the environment. The scoping process tackles such questions as:

- What will be the effects of embarking on the project?
- What will be the extent, magnitude and duration of the impacts?
- Which of these impacts will be important within local and national contexts?
- What are the measures to be taken to mitigate, reduce or avoid the negative impact or measure to enhance positive impacts?

- The project activities likely to impact on the environment were identified as:

- Route Survey
- Bush clearing
- Excavation
- Pipeline laying / Construction
- Ancillary facilities
- Testing, operation and maintenance
- Abandonment

5.3 Impact Assessment Methodology

The first stage in the impact assessment procedure involves the collation and use of various source references to develop and establish:

- Checklist of associated and potential impacts
- Checklist of legal and other requirements
- Record of consequences, severity, probability and frequency of occurrence of various environmental impacts.

The key sources of reference were:

- FMENV Sectoral Guideline for Oil and Gas industry project (1995)
- DPR Environmental Guidelines and Standards for Petroleum Industry in Nigeria (1999)
- World Bank Environmental Impact Assessment Source Book (1991)
- ISO 14000 Environmental Management System
- Environmental and socio-economic baseline status of project area.

The impacts identified in the first stage of the assessment procedure were subsequently evaluated in the second stage based on clearly defined criteria – legal requirements, risk, frequency, importance and public perception; in order to determine their significance. The criteria and weighting scale used for the evaluation are described below:

2. Legal/Regulatory Requirement (L)

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

3. Risk (R)

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

4. Frequency (F)

1 = Low frequency
3= Intermediate frequency
5= High frequency

5. Importance (I)

1 = Low Importance
3= Intermediate Importance
5= High Importance

6. Public Interest/Perception (P)

1 = Low interest/perception
3= Intermediate interest/perception

5= High interest/perception

The Health, Safety and Environmental risks associated with each impact were assessed using the Risk Assessment Matrix (**Figure 5.1**) and information from other sources.

Consequence					Increasing Probability				
					A	B	C	D	E
Severity	people	Asset	Environment	Reputation	Never heard of incident in E&P industry	Incident has occurred in E&P industry	Incident has Occurred in FMPR, NNPC	Happens several times	Happens several times per year in the project area
0	No injury	None	None	None					
1	Slight injury	Slight	Slight	Slight		Low			
2	Minor injury	Minor	Minor	Limited		Risk			
3	Major injury	Localized	Localized	Considerable			Medium		
4	Single fatality	Major	Major	National			Risk		High
5	Multiple fatality	Extensive	Massive	International					Risk

Figure 5.1: Risk Assessment Matrix for Environmental Consequences

Table 5.1: Severity Rating for Risk Matrix

Severity	Potential Impact	Definition
0	Zero effect	No environmental damage. No change in environment. No financial consequences
1	Slight effect	Local environmental damage within the fence and within the systems. Negligible financial consequences
2	Minor effect	Contamination, damage sufficiently large enough to affect the environment. Exceeds. No permanent effect on the environment.
3	Localized effect	Limited loss of discharge of known toxicity. Repeatedly exceeding statutory or prescribed criteria. Affects neighborhood
4	Major effects	Severe environmental damage. FMPR required to take extensive measures to restore the contaminated environment to its original state. Exceed statutory or prescribed criteria highly
5	Massive effect	Persistent severe environmental damage. Severe nuisance extending over a very large area. A major economic loss to FMPR and large scale environmental degradation. Continuously exceeding Exceed statutory or prescribed criteria highly.

Table 5.2a: Detailed likely impact Associated with Pre-construction

Project Phase	Activity	Environmental Aspects	Associated and Potential Impacts
Pre-construction activities	Land Acquisition	Clearing and staking for the ROW	Loss of economic land and economic crops Increase in soil erosion Deforestation Oil spills and leakages
	Provision of social Amenities	Creation of more link roads	Deforestation and land take
Site Preparation Pipeline ROW	ROW Survey	Mobilization of men and equipments Establishment of base camp Recruitment of local labour	Removal of vegetation/ Wildlife emigration Destruction of economic trees Loss of wildlife habitat and disruption that may lead to decrease reproduction. Exposure to wild animals like snakes, pythons etc
	Soil study/investigation		Limited soil strata inversion during leveling of soil
	Bush clearing		Vegetation loss / increased soil erosion , emigration of wildlife and dust generation during clearing Short term loss of wildlife

Table 5.2b: Detailed likely impact Associated with Construction

Project Phase	Activity	Environmental Aspects	Associated and Potential Impacts
Construction	Land acquisition for contractor's lay down area	Mobilization of men, materials and equipments Establishment of base camps Recruitment of local labour Influx of workers into the host communities Bush clearing Transportation of equipment	Deforestation and land take Communal agitations and land ownership crisis
	Site Preparations		Destruction of economic trees Loss of wildlife and wildlife habitat due to increased access for hunting and poaching Increased soil erosion and offsite sedimentation Water pollution by construction spoils Acquisition of land for ROW, compressor stations etc Solid waste from camps Oil spills and leakages Increase in turbidity of nearby water bodies Degradation of water quality due to disposal of solid waste and liquid waste from camps, sites, offices, workshops etc Alteration to stream/river flow Alteration of in-

Project Phase	Activity	Environmental Aspects	Associated and Potential Impacts
			sedimentation Stream crossing will impair water quality Fugitive emission-dust emission from earth moving equipment Emission of SO2, CO, NOx from earth moving equipment Temporal annoyance and stress due to increased noise level at nearby residence Damage to road way Traffic congestions Pressure on existing infrastructures –health centers, schools, churches, mosque, recreational centers Improved employment potentials Impact on culture and cultural diversity of the communities/villages Third party agitations over employment issues.

Project Phase	Activity	Environmental Aspects	Associated and Potential Impacts
	Excavation/Trenching		Noise and gaseous emission from heavy equipment and machineries Impairment of water quality due to increased turbidity Interference with other traditional water uses – bathing drinking, fishing Exposure of rive banks to erosion Disturbance of planktons and benthic, fishery communities. Changes in land use due to establishment of base camps Conflicts between the host communities during labour recruitments. Increased income and economic activities Accidents and injuries Undue pressure on existing social amenities Increased social vices – drug,/alcohol abuse, rape, stealing prostitution, armed robbery etc Labour crisis – agitation

Project Phase	Activity	Environmental Aspects	Associated and Potential Impacts
			over employment by host communities.
	Fabrication and non-destructive testing		Generation of high intensity noise from pipe welding operations Accidents and injuries Exposure to radioactive emissions Increased opportunities for local contractors
	Pipe laying and tie-in		Loss of vegetation Air emission of fugitive gases by heavy equipment Disturbance of aquatic lives in river crossing areas Impairment of water qualities Emission of fugitive gases from heavy duty machines Increased demand on limited social amenities Simulation of local economy and market Socio-cultural conflicts between workers and host communities Introduction of sexually transmitted disease into the

Project Phase	Activity	Environmental Aspects	Associated and Potential Impacts
			communities Increase in government revenue Development of industrial sectors leading to greater employment
	Pipeline river crossings	Oguro River Segment	Disruption in the fishing activities and sand mining Water quality impairment Alteration to river flow Increased turbidity Disturbance to benthic organisms
		Osara River Segment	Pollution of drinking water due to resuspension of bottom sediments. Disruption in the fishing activities and sand minning Water quality impairement Alteration to river flow Increased turbidity

Project Phase	Activity	Environmental Aspects	Associated and Potential Impacts
			Disturbance to benthic organisms
		Niger River Segment	Change in beneficial use Disruption in the fishing activities and sand mining Water quality impairment Alteration to river flow Increased turbidity Disturbance to benthic organisms Disposal of wastes – sewages, domestic wastes etc resulting soil Damage to river banks and vegetation
		Gurara River Segment	Alteration in-stream sedimentation Re-suspension of bottom sediments leading to alterations in the Physicochemistry. Adverse impact on aquatic organisms Impact on the drinking quality of the river by the local populace

Project Phase	Activity	Environmental Aspects	Associated and Potential Impacts
		Kaiza River Segment	Changes in drainage and hydrological patterns Degradation of water quality Dredging will impact on the benthic organisms
		Kaduna River Segment	Degradation of water quality resulting from siltation and sedimentation Decreased fisheries diversity and abundance due to change in water quality
		Tiga River Segment	Alteration in-stream sedimentation Re-suspension of bottom sediments leading to alterations in the Physicochemistry. Adverse impact on aquatic organisms Impact on the drinking quality of the river by the local populace
		Other minor rivers and streams	Dry during the dry season. While some has low flow during the rainy season. Flooding hazards during rainy season

Project Phase	Activity	Environmental Aspects	Associated and Potential Impacts
	Road crossings	Ajaokuta-Okene Kaduna-Zaria Zaria – Kano Major road to, state, towns and communities	Accidents and traffic delays Damage to road segments at crossing points Damage to buried utility cables
	Railway crossings	Before Kaduna River Zaria area Towards Kano	Possibility of collision ,accidents and traffic delays Damage to rail segments at crossing points Damage to buried utility cables
	Existing Pipeline	Intersection at 23 sections	Damage to PPMC lines Risk of spills Fire explosion and hazards Erosion at points of intersection
	Transmission Line	Intersection at 5 sections PHCN transmission lines to the North	Damage to PHCN cables Disruption to electrical supplies leading to black-outs Danger of electrocution
	Construction of Accessory facilities – Terminal Gas stations etc 3	Mobilization of men, materials and equipments Establishment of base camps Recruitment of local labour	Loss of economic land and economic crops Increase in soil erosion Deforestation

Project Phase	Activity	Environmental Aspects	Associated and Potential Impacts
			Removal of vegetation/ Wildlife emigration Short term loss of wildlife habitat Loss of wildlife habitat
	Operation of machines and vehicles	Air quality	Changes in air quality due to gases from exhaust Soil pollution and loss of easthetics associated with fueling and lubricant leaks Increase in ambient noise Fugitive emission: dust form earth moving equipment Point Sources: emission SO_2, CO, NO_X and other greenhouses gases from fuel consumptions
	Waste disposal	Disposal of routine wastes during construction	Soil and water contamination from improper disposal Loss of aesthetics Risk of injuries from improper handling of industrial wastes.
	Construction risks	Workers	Work place accidents during construction Risk of collision of equipments

Project Phase	Activity	Environmental Aspects	Associated and Potential Impacts
			Incidence of spills and gas leaks Noise pollution and health risks from construction equipments. Blasting accidents
	Back filling and restoration		Disruption of habitat from rodents Road accidents and traffic delays due to movement of heavy equipments and materials on the local road Temporal obstruction of road or road diversion
	Pressure testing using water from the local rivers		Disruption of other uses of water Disturbance of planktons and benthic communities Waste produced may include hazardous waste Noise and electromagnetic may affect human, birds and other wildlife

Table 5.2c: Detailed likely impact Associated with Operation and maintenance

Project Phase	Activity	Environmental Aspects	Associated and Potential Impacts
Pipeline operation and	Pigging	Soil and water	Water and soil pollution from disposal of pigging waste

Project Phase	Activity	Environmental Aspects	Associated and Potential Impacts
maintenance			Changes in air quality may occur due to release of misty gaseous products leading to odour and aesthetic devaluation. Increased incident of water borne diseases if wastes are dump into streams or rivers used for drinking by the host communities. Contamination of soil, sediment, surface and groundwater from machinery maintenance operation Destruction of economic trees Loss of wildlife and wildlife habitat in events of fire outbreak
	Gas transportation	Soil and water	Fire and explosion hazards Condensates may contaminate soil and water bodies
	Gas Leaks	Leakages from faulty valves or due to system failure	Temporal changes in air quality from release of gaseous products Contamination of soil and water bodies
	Maintenance	Soil, water and organism	Disturbance of aquatic and terrestrial organisms during sediment and soil movement during routine pipeline maintenance.

Table 5.2d: Detailed likely impact Associated with Decommissioning/Abandonement

Project Phase	Activity	Environmental Aspects	Associated and Potential Impacts
Decommissioning/Abandonment	Pipeline removal and cleaning / abandonment Removal of above ground structure		Waste /scrap materials from decommissioned equipments. Disturbance of normalized aquatic and terrestrial habitats Impacts on amenities Temporal disruptions on community □ctiveties and on the future use of the land Exposure of the environment to pipeline related contaminants. Potential impact on the surface and ground water Potential soil contamination Visual amenity/ loss of aesthetics

5.4 Impact Identification and Categorization

Based on the scoping matrix, the environmental baseline data was collected on which the impacts due to the project were superimposed to assess the beneficial and deleterious impacts due to the project construction and operation.

To assess the project impact, the project's potential impacts were screened and categorized.

The criteria used in the screening of various identified potential environmental impact is given in **Table 5.3**

Table 5.3: Criteria for screening project activities

Type	Positive/ Beneficial (+) or negative/adverse (-)
Severity	Extent of damage to the environment, whether; Minor/Very low/Insignificant, Moderate, High/Major/Very significant
Rating	I-Very low. II-Low impacts III -Moderate impact, IV-High impact. IV-Very high impact
Prevalence	Likely extent of the impact
Duration /Frequency	How long the impact last; Long term (> 12 month), Short term (< 12month or Intermittent)
Importance	Economic; social and cultural values attached to the undisturbed project environment.

Severity is further classified as shown in **Table 5.4** below:

Table 5.4: Criteria for screening project activities- Environment Interaction

Severity of impact	Description/quantification
1.Impact on Sensitive Aquatic Habitats	
Very High (Major)	Very severe long-term adverse effects: more than 20% of the habitat area destroyed or damaged.
High	Major long term adverse effects: 1-2% of the habitat are destroyed or damage
Moderate	Moderate term adverse effects: 0.25-1% of the habitat area destroyed or damage.
Low	Minor adverse effects: 0.02-0.25% of the habitat area destroyed or damage.

Severity of impact	Description/quantification
Very Low	Negligible term adverse effects: 0.001-0.02% of the habitat are destroyed or damage
2.Impacts on Water Quality	
Very High	Water quality parameters change significantly by several orders of magnitude; toxic trace metals or hydrocarbons exceed FMEnv and DPR level: changes persist for months or longer
High	Water quality parameters change significantly by one or two orders of magnitude; toxic trace metals or hydrocarbons exceed DPR and FMEnv safe level: changes persist for months or longer
Moderate	Statistically significant changes in water quality parameter, which persist for several weeks.
Low	Some measures of water quality deviate significantly from ambient measures but are quickly (within 1-2 days) restored to normal Areas extent likely up to a total of 7.05 square kilometer
Very Low	Normal measures of water quality such as dissolved oxygen content, salinity, temperature, trace metal concentration and hydrocarbon levels show no statically significant changes from ambient condition.
3. Impacts on the Air Quality and Noise Regime	
Very High	Significantly increase levels of criteria pollutants such that non-attainment areas will be degraded further or attainment and prevention of significant deterioration (PSD) are significantly degraded significant effects on public health and welfare are expected.
High	Source increase levels of criteria pollutants such that non-attainment areas are likely to be degraded less than significantly, or attainment and PSD area are likely to degrade. Likely to pose hazards to public health and welfare.
Moderate	Source increase levels of criteria pollutants such that non-attainment areas are likely to experience minor degradation and PSD area are likely to degrade significantly. Unlikely to pose hazards to public health and welfare.
Low	Source increase levels of criteria pollutants such that non-attainment areas are unlikely to be degraded further and attainment and PSD area are likely to undergo only very small increase in levels of criteria pollutants. Very unlikely to pose hazards to public health and welfare.
Very Low	Source increase levels of criteria pollutants such that non-attainment areas are unlikely to be degraded further and attainment and PSD area are likely to undergo negligible increase in levels of criteria pollutants. Does not pose hazards to public health and welfare.
4. Impacts on Endangered and Threatened Species	

Severity of impact	Description/quantification
Very High	A pollution declines in the affected area resulting in a change in the distribution and /or abundance (greater than 5%) of the species in the local area and /or the planning area. The expected duration of the effects within the local area and or/the planning area is two or three generations or 10 years or more
High	Pollution declines in the affected area resulting in a localized relatively isolated change in the distribution and /or abundance (greater than 5%) of the species in the local area and /or the planning area. The expected duration of the effects within the local area and or/the planning area is two or three generations or 6-7 years.
Moderate	A pollution declines in the affected area resulting in a change in the distribution and /or abundance (greater than or equal to 1%) of the species in the local area and /or the planning area in one generation 3-5years.
Low	A pollution declines in the affected area resulting in a changes in the distribution and /or abundance (greater than 5%) of the species in the local area and /or the planning area. The expected duration of the effects within the local area and or/the planning area is two or three generations or 1-3 years
Very Low	No discernible later effects, but individuals experience sub-lethal effects which cause reduced biogenic activity or reduced metabolic functions. Organisms would recover to pre-impact conditions within one generation of 1-3 years.
5. Impacts on Cultural /Archeological Resources.	
Very High	An interaction between cultural resources and an archaeological site and an impact producing factor occurs and results in the loss of cultural /archeological information.
Moderate	An interaction between a cultural and an archaeological site and an impact producing factor occurs and results in the loss of cultural /archeological data that are not significant.
Low	An interaction between a cultural resources and an archaeological site and an impact producing factor occurs, but impacts are temporary and reversible
Very low	Little damaging interaction between an impact producing factor and cultural resource/archaeological site occurs.
6. Impacts on Local Employment, Income and Population	
Very High	10% or greater annual growth in employment, payroll, population.
High	7-9% annual growth in employment, payroll, population
Moderate	4-6% annual growth in employment, payroll, population
Low	2-3% annual growth in employment, payroll, population

Severity of impact	Description/quantification
Very Low	1% annual growth in employment, payroll, population
7. Impacts on Community Infrastructure	
Very High	Potentially major long-term effects on community services and facilities indicated by a 10 % or more average annual growth rate in the population of the potentially affected area.
High	Potentially major long-term effects on community services and facilities indicated by a 3-9.9 % average annual growth rate in the population of the potentially affected area.
Moderate	Potentially major long-term effects on community services and facilities indicated by a 1.5-2.9 % average annual growth rate in the population of the potentially affected area.
Low	Minor effect on community services and facilities indicated by a 0.5-1.4% average annual growth rate in the population of the potentially affected area.
Very Low	Negligible to minor effect on community services and facilities indicated by a 0.5% average annual growth rate in the population of the potentially affected area.
8. Impacts on State and Local Land Use/Management.	
Very High	Project activities/facilities cannot be designed, located, constructed and operated in any manner that would not result in a significant conflict with land use polices and implementing provisions, land use plans and development regulations. Federal mediation procedures necessary
High	Project activities/facilities cannot be designed, located ,constructed and operated in any manner that would entirely avoid or mitigate major impacts on land use polices and implementing provisions, land use plans and development regulations. Federal mediation procedures necessary
Moderate	Project activities/facilities can be designed, located, constructed and operated in a generally compatible but less than ideal manner, i.e. moderate incompatibilities and potential impacts with respect to one or more land use polices and implementing provision, land use plans and development regulations would be likely. Many additional mitigation measures and/or project changes would be necessary to resolve conflict and gain approval
Low	Project activities/facilities can be designed, located, constructed and operated in a manner that is compatible, but not without some potential minor impacts to one or more land use polices and implementing provision, land use plans and development regulations. A few additional mitigation measures and/or project changes would be necessary to resolve conflict and gain approval

Severity of impact	Description/quantification
Very Low	Project activities/facilities can be designed, located, constructed and operated in a generally compatible but less than ideal manner, i.e., moderate incompatibilities and potential impacts with respect to one or more land use polices and implementing provision, land use plans and development regulations would be likely. Very few additional mitigation measures and/or project changes would be necessary for approval
9. Impacts on Wildlife /Forestry	
Very High	A spices, population, community or assemblage of wild life will be harmed as a result of habitat area destroyed or disturbed, to the extent that recovery of that particular entity may not occur.
High	A significant interference with ecological relationship. This usually involves the mortality or alteration of a noticeable segment of the population, community or assemblage.
Moderate	A short-term interference with ecological relationship. Although some species may sustain substantial losses, other species will sustain low losses, and the ecological mix will not be altered.
Low	A few species may sustain low losses, but any interference with ecological relationship will not be evident.
Very Low	Loss of a few individual but no interference with ecological relationship.
10. Impacts on Agricultural Development	
Very High	Project activities cannot be designed, located, constructed and operated in a any manner that would not result in unavoidable effect, for the duration and after completion of the project, on agricultural development; production on lands within the vicinity of the project site
High	Project activities/facilities cannot be designed, located, constructed and operated in a any manner that would entirely avoid or mitigate major affects for the duration and after completion of the project, on agricultural development; production on lands within the vicinity of proposed project
Moderate	Project activities/facilities can be designed, located, constructed and operated in a generally compatible but less than ideal manner, i.e. moderate incompatibilities and potential impacts with respect to one or more effects to one or more agricultural development /production plans and use.
Low	Project activities/facilities can be designed, located, constructed and operated in a manner that is compatible, but not without some potential minor effects to one or more agricultural development /production plans and use.
Very Low	Project activities/facilities can be designed, located, constructed and operated with negligible to minor incompatibilities or potential impacts to agricultural development /production plans.
11. Economic Impact	

Severity of impact	Description/quantification
Very High	Widespread modification of considered severity in economic conditions and commercial activities, lasting beyond two years duration.
High	Widespread modification /more than 50 percent of those individuals affecting /affected by socio-economic condition or engaging in commercial activities in the project area of lesser severity and duration.
Moderate	Local modification of considerable severity in less than 10 percent of those individuals affecting /affected by socio-economic conditions or engaging in the commercial activities in the project area, lasting from a few months to two years.
Low	Localized relatively isolated changes in economic conditions or commercial activities lasting only a few days to a few months, with no observable residual/effects.
Very Low	Little (negligible) or no change in economic conditions or commercial activities (e.g. fishing, hunting/any effects are barely measurable above background conditions, much less significant than periodic stress by on-going socio-economic /commercial activities, measurable effects very temporary (a few days or less)

5.5 Potential Impact Evaluation

This section describes the logical and systematic method used to specify the impacts associated with each phases of the project (site preparation and construction phase, operational phase and decommissioning phase) and the activities undertaken. The issues identified during the screening and scoring activities were subjected to detailed investigation with the aim of taken into account all of their important environmental and social project impacts and interactions, making sure that indirect and cumulative effects, which may be potentially significant are not omitted.

The method used to identify, qualify and evaluate the potential impacts of the proposed project was the interaction matrix method. Here, the interactions between the various project actions and environmental component where identified.

5.5.1 Interaction Matrix Method

A simplified version of Leopold interaction matrix, which is an open cell matrix for scoring project interactions with environment, is suitable for determining significance of impact. This pioneering approach to impact assessment was developed by Luna Leopold and others at the United States Geological Survey (Leopold, *et, al,* 1971).

The use of matrix although abstract and subjective is important for decision-making as it highlights and scales the impacts of each project activity against a fixed environmental component highlights most likely to be affected. An aggregate score for each project activity or environmental component and its weighted percentage highlights the environmental impacts.

In a Leopold matrix and its variants, the columns of the matrix corresponds to project activities while the rows represents environmental components

5.5.2 Scoring

Different activities will be undertaken during the construction–operation and demolition phases of the proposed project. Each of these activities will have implications to the immediate environment. The scale of impact will vary according to the activity being undertaken and this is illustrated in **Table 5.5**.

The scoring in each cell of the matrix has been scaled in the range of 0 to 5, where 0 represents an activity of no environmental significance (no impact/interaction). A score of 1 represents impact of very low significance (insignificant); score of 2 represents impact of low significance, score of 3 represents impact of environmental significance; score of 4 represents impact of high significance and score of 5 represents impact of very high significance. Positive (+) sign denotes beneficial potential impact while negative sign indicates adverse potential impact (see **Table 5.5**).

Table 5.5: Guide on score rating for Project interactions with the environment.

Rating	**Effects**
+ Added in front of a number	Positive
- Added in front of a number	Negative
O/ Blank	No impact /interactions
1points	A minor effect in magnitude and duration (very low)
2 points	A moderate short term effect (low)
3points	A moderate long term effect (moderate)
4 points	A major short term effect (high)
5 points	A major long term effect (very high)

Based on the 0-5 scale and due to the fact that impacts of each of these activities have been considered against fourteen fixed and vulnerable environmental parameters, a maximum score of 70 in each row represents the highest level of environmental impact per activity. Therefore, an aggregate score of 0-20 will represent an activity of no environmental significance.

Aggregate score of 21-40 represent activities whose environmental impacts are of very low significant. Aggregate 41-50 represent activities whose environmental impacts are of low significant. These are impacts that will manifest themselves during the project cycle and must not be overlooked in decision making and also having mitigation as part of project design.

This is one category of environmental impacts, which will require mitigation measures. Where practicable, some of these activities will be carried out in a manner that will minimize their impacts on the environment. Careful planning is one way of mitigating these impacts.

Aggregate score of 51-70 represents activities whose environmental impacts are highly significant in relation to fixed environmental attributes. In the proposed project interventions, highly sensitive activities cannot be ignored because their impacts could be detrimental to the project or general environment.

The matrices and graph that follow have been used in determining the environmental impact of activities and sensitivity of environmental attributes and individual activities. Analyses of the matrices and the graph are good starting point in identifying impacts and proposing appropriate mitigation measures.

5.5.3 Potential Impact Analysis

Column totals in **Table 5.6** shows the level of significance of each activity on the environment.
The project enumerates twenty activities during site preparation and construction, operation and decommissioning stages of the project.

The majority of the project impacts will be associated with the construction phase. Potential construction impacts will be mitigated through the implementation of good construction practice, adherence to management plans, and through the application of localized measures to protect specific or sensitive receptors.

The operation of the pipeline will result in low significant localized impacts. The likelihood of any event occurring and the risk of significant impacts resulting are low.

The positive socioeconomic impact is in relation to possible employment opportunities, and possible expenditure on local goods and services by construction workers.

Both the construction and operation of the pipeline will bring short and long term benefits to the communities. These are particularly relevant in relation to employment, provision of goods and services and community investment which will provide longer term benefits to many communities thereby helping to off-set any short term negative impacts.

Table 5.6: Level of Impact Significance of each Project Activity on the Environment

	Phase of Project																				
	Site Preparation and construction phases														Operation Phase					Decommissioning Phase	
Project Activities / Environmental Component	Contract Award	Land Survey	Heavy Machinery use	Clearing of Land of all Vegetation	Solid Waste disposal of spoils/drainage	Excavation & Filling/Grading	Access Road Construction	Pipe	Camp and other building activities	Assemblage & welding of pipe	Laying of underground pipe	Generators use	Testing of pipe	Demobilization	Transportation of gas	Emergency	Solid waste management	Pipe Maintenance activities	Use of ROW	Demolition /removal of surface structure	Totals
1. Air Quality	0	0	-1	-1	-1	-1	-2	-1	-1	-1	-1	-2	-1	-1	-1	-1	-1	-1	-1	-2	**-21**
2. Noise /vibration	0	0	-1	-1	-1	-2	-1	-2	-1	-2	-1	-2	-1	-1	-1	-1	-1	-1	-1	-2	**-23**
3. Flora and fauna	0	0	-2	-2	-2	-2	-1	-1	-1	-1	-1	-1	-1	-0	-1	-1	-1	-1	-1	-2	**-24**
4. Wildlife and Habitat	0	0	-2	-2	-2	-2	-1	-1	-1	-1	-1	-1	-1	-0	-1	-1	-1	-1	-1	-2	**-24**
5. Soil	0	-1	-2	-2	-2	-2	-2	-2	-2	-1	-2	-1	-1	-2	-2	-2	-2	-2	-2	-2	**-28**
6.Water resources	0	-1	-2	-2	-2	-2	-1	-1	-1	-1	-2	-1	-1	-2	-2	-2	-2	-2	-2	-1	**-24**
7. Groundwater Quality	0	0	-2	-2	-1	-2	-1	-1	-1	-1	-1	-1	-2	-1	-1	-1	-1	-1	-1	-2	**-21**
8. Aquatic flora and fauna	0	0	-2	-2	-2	-2	-1	-1	-1	-1	-1	-1	-2	-1	-1	-1	-1	-1	-1	-2	**-23**
9. Land use and visuals	0	0	-1	-2	-1	-2	-2	-1	-2	-1	-2	-1	-1	-1	-1	-1	-1	-1	-1	-2	**-24**
10. Traffic	0	0	-1	-1	-1	-2	-1	2	-1	-4	-1	-1	-1	-1	-1	-1	-1	-1	-1	-2	**-22**
11.Ocuptional and health issues	0	0	-1	-1	-1	-2	-2	-2	-2	-2	-2	-1	-1	-2	-1	-1	-1	-1	-1	-2	**-27**
12.Waste Management	0	0	-1	-2	-2	-2	-2	-1	-2	-1	-1	-1	-1	-2	-1	-1	-1	-1	-1	-2	**-26**
13. Infrastructure Demand	0	0	-1	-1	-1	-1	-1	-2	-2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-2	**-21**
14. Socio economic	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+2	+2	+3	+2	+4	+2	+3	+2	+2	-2	**-50**
Total	0	1	16	-17	-16	-18	-14	-15	-15	-12	-16	-13	-12	-13	-9	-11	-12	-11	-11	-27	

Key: + = Positive impact - = Negative impact	Major long term effect (high) = 5 points Major short term effect (Moderately) = 4 points Moderate long term effect (Low) = 3 points	Moderate short term effect (Very) = 2 points Minor effect (Low) = 1 point No impact = 0

Aggregate scores indicate the sensitivity of each fixed parameter. These scores are interpreted and illustrated in Figure 5.1, giving a score of 50 as environmental sensitivity divide.

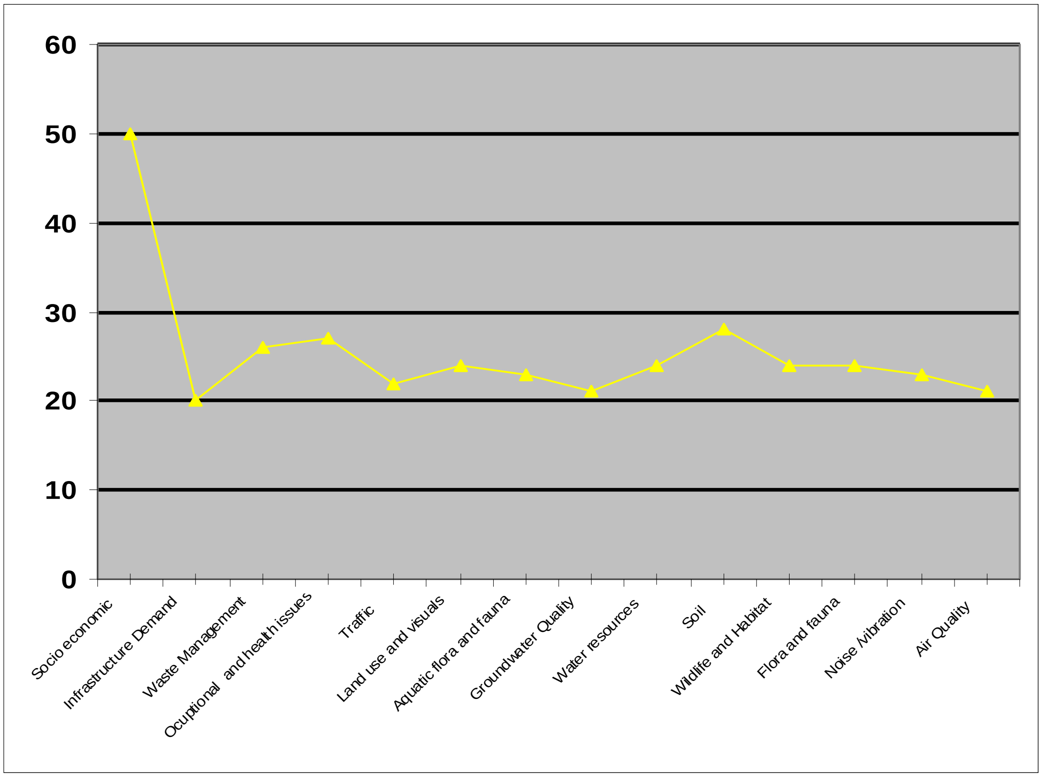

Figure 5.2: Environmental sensitivity

Parameters scoring above the divide (score of 70) are highly sensitive, while those scoring below the divide are less sensitive. The degree of sensitivity depends on the distance from the divide. In the case of the project, socio-economic score highly in terms of its sensitivity to the project; the projects' positive impact to the environment is sensitive. The factors include employment and income generation Air quality, soil and noise score low, which is why they are some distance away from the divide and have moderate sensitivity to the project actions. Other parameters scored low.

5.6 Potential Impact Prediction and Description

5.6.1 Project Construction Impact

5.6.1.1 Air Emission Impact

The sources of air emission identification were based on three categories of point, area and line sources:

- A point source is a single source of emission with an identified location, such as an industry;
- An area source is when the sources of emission are many with widely distributed point sources having relatively comparable significance and
- A line source is when the sources of emission from a number of fixed or moving facilities have relatively comparable significance, such as road.

The construction phase dust emission sources include pre-mobilization activities such as off-site material, equipment and supply procurement, pipe delivery and construction activities of vegetation clearing, in addition to excavation and reclamation activities and on-site roads (paved and unpaved).

Gaseous emissions will be from vehicles that will be used during pre-mobilization and construction activities and it will be mainly SO_2, CO and NO_2, in addition to stand by power generator that will be used in construction camps.

Air emission will be distributed in the study area; hence SO_2, CO and NO_2 were modeled for point sources (generator usage in construction camps), area sources (excavation activities) and line source; truck and vehicle movement on roads in urban and rural areas.

For the purpose of modeling gaseous emission from generator usage in construction camps, the capacity of generator was taken to be 25KW with stack height of 15m and CO, SO_2 and NO_2 emission rates of 2.326g/s, 3.424g/s and 1.0418g/s respectively. The air modeling for concentration of CO, NO_2 and SO_2 was a distance of 1000m.

The **DISPER 4.0** Air pollution dispersion modeling software was used to model air emission from the project construction activities.

The model result (see Appendix-5-1) shows that the maximum level of NO_2, SO_2, CO from point of activity up to 100m showed zero and the baseline data generally showed zero concentration. The project construction activities will slightly affect air quality parameters levels in the study area.

Also, air pollution modeling results of NO_2, SO_2 and CO in settlement areas that is less than 100m in the study area showed air emission from trucks and light vehicles and generator usage will have negligible effect on NO_2, SO_2 and CO levels.

As predicted by the model, air emission will not dispersed over a larger area; areas dispersed will be limited, thus the residential areas will not be affected. The impact of air emission will be of low significant.

5.6.1.2 Noise Impact

During construction phase of the project, noise will be generated from truck movement of construction equipment, excavation activities, construction machines, generator usage and welding activities.

CUSTIC 2.0 noise pollution modeling software was used to model noise impact of the project construction activities. For the modeling purpose, a flat terrain was considered and environmental attenuation factors were excluded so as to formulate the worst case scenario. The maximum distance of 200m from the point of noise generation location was taken for the purpose of the modeling. The sensitive receptors (settlement) are located at a distance of 100m to 200m from the project ROW (**source of noise**).

The model result shows that noise levels decreases rapidly from the estimated source noise (maximum of 77.03dB (A) for heavy truck); the noise levels from construction activity in worst case scenario decreased to 43.75 dB (A) at 100m (see **Appendix-5-2**). The existing noise level of the study area varies between 31.5 dB (A) to 76.8dB (A) with the settlement areas indicating highest levels. Thus, the noise emission impact of the project construction activities will be very low significant.

Also, noise that will be generated as a result of vehicle movement on community roads was modeled. For the purpose of modeling, it was estimated that the number of project vehicle that will ply the road per hour is 10 and at maximum speed of 50km/h. The predicted noise level of vehicle from a rural approach road is 48 dB (A). The sensitive receptors along the roads are at 50m to the road; from the road the noise level will reduce to 27.40 d B (A) at 14.21m (see Appendix-5-3). The noise from project vehicular traffic will be of very low significant.

The modeling for impacts of noise from DG set usage in construction camps; the worst case scenario for noise pollution when the generator set is working was chosen. The noise level modeling at 50m is shown in Appendix-5-4. At the source point the noise level is estimated to be 83.9 dB (A) and it reduces to 59.34 dB (A) at 21m. If the camp is located within the community the use of generator will slightly affect the noise level of the community especially in the night period.

5.6.1.3 Impact on Vegetation

In areas where the pipeline will not follow existing NNPC ROW, vegetation will be cleared. Also, in areas where the pipeline follows the existing ROW, vegetation will be cleared outside the ROW for storage and other construction activities. In guinea savannah area of the project area, shrubs and trees will be cleared while in the Sudan savannah area the tree and shrubs clearing will be very limited because of their dispersed nature. The clearing of vegetative cover for the ROW will expose the soils to potential erosion. Vegetation clearing will be limited to construction corridor (30m wide) and in areas where the corridor is exceeded reclamation will be carried out after construction.

Vegetation clearing will be performed within the surveyed ROW. The clearing of vegetation will result to soil exposure that can lead to erosion runoff into the nearby surface waters.

No areas protected for biotic conservation value are located on, or in the vicinity of the study area. The project ROW will create unavoidable impacts on the terrestrial ecosystem because of the destruction of grassland, and tree-shrub communities at the ROW. The project construction impact on vegetation will be of significant considering that large area of land will be cleared along the ROW and contractors' equipment lay down and project site access roads.

5.6.1.4 Wildlife and Wildlife Habitat Impact

The project right-of-way will cross irrigated cropland and secondary guinea and Sudan savannah vegetation. Also, it will also cross Riparian habitat.

Also, the construction activities will result in the loss of habitat for ground-dwelling animals within the trenched area. Native soil removed during construction will be returned to the trench and the area re-graded and re-vegetated with native grasses and shrubs.

Noise and visual disturbance during construction activities will also affect wildlife species but the impact will be low as the disturbed areas will be limited and temporary.

Habitat loss from clearing trees within the right-of-way will be limited; trees provide structure for nesting and perching for birds including migratory birds. Vegetation clearing during nesting season can result in direct mortality of nestlings, while clearing trees in the non breeding season can result in habitat loss but avoid potential mortality.

Habitat loss from clearing riparian vegetation in the study area and along the rivers may affect herbivorous annelids, anthropods and molluscs. Additionally, removal of this vegetation could alter the hydrology and microclimates of the associated water bodies, thereby affecting habitats that potentially support amphibians.

Habitat loss from clearing guinea savannah vegetation will not affect the food chain in ecosystem because it will be limited.

Also, vegetation clearing during nesting seasons could result in the direct loss of grasshopper sparrows, grass cutters and other organisms that depend on the vegetation for feeding and brooding.

Ground disturbance from heavy equipment operation, road grading, and ROW preparation will affect burrowing animals such as ground squirrels, rats and snakes.

The project impact on wildlife habitat will be of low significant.

5.6.1.5 Soil Impact

During project construction soil excavation will be carried out and erosion may occur due to soil disturbance; fill areas tends to be more susceptible to erosion than excavated areas.

Also, soil excavation will generate spoils which if not managed will affect the soil quality of the area and also move as sediment run-off to nearby surface water. Top soil removed during earthmoving and grading associated with ROW preparation will be used within the ROW.

Construction activities will generate spillage and leakages of lubricant and fuels, which can contaminate the soil if not managed.

Hydrostatic test water can cause erosion when discriminately discharged on land surface, also it may evaporate or infiltrate into soil contaminating it when it contains oil etc. The project hydrostatic testing will be sectionalized; thereby limiting the amount of water discharged. The project construction impact on soil will be of low significant.

5.6.1.6 Water Resources Impact

7. Surface Water Quality

During project construction the impact of surface water quality will be in the form of changes in slope runoff dynamics, accelerated erosion, pollution and littering of water bodies, increased turbidity and changes in flow regime of watercourses and the formation of bottom sediments.

The crossing of the project pipeline in surface water will result in increased turbidity, which is caused by offsite sedimentation. However, given that the river beds have a width of approximately range of 10-20meters at crossing locations, and that the volume and flow of river waters, during the dry and rainy seasons respectively (**see Table 4.11**); the river crossing will cause low localized significant impacts such as some disturbance to the bottom communities, but limited in aerial extent. During peak of rainy season there is possibility of surface runoff portions of fines and clays generated during excavation and oil and lubricants spills during ROW preparation to be carried to the nearby stream and rivers.

Also, during ROW preparation especially in the dry season, construction equipment can raise enough dust particles that can increase the settleable solids or suspended solids of the rivers especially in areas where the rivers and stream are close to project ROW.

Water used for hydrostatic testing of the pipeline may be obtained from surface water resources. The project hydrostatic testing will be sectionalized; thereby limiting water usage and discharge. Hydrostatic test water will be tested to ensure free oil etc with the view of not contaminating drainage or stream where it might find itself when released. The project construction impact on surface water will be of low significant.

8. Groundwater Quality

Project ROW preparation will incrementally reduce on-site groundwater recharge by creating an additional amount of impervious surface on the ROW. This loss will not have meaningful consequences on recharge or groundwater availability in the study area.

Groundwater will not be encountered during excavation; this is attributed to the depth of groundwater location in the study area. It is expected that the construction activities will not disturb groundwater. In the event that the water table is encountered, water will be pumped out of the excavation onto the ground and returned to the alluvium via seepage through the soil.

In the case of a spill or release of chemicals or hydrocarbons during construction, existing best management practices and procedures associated with spill response and materials handling will be employed to minimize subsurface impacts.

There will be sewage output from construction camps and it will be handled by septic systems. Septic tank sizes will be based on anticipated loads from maximum staffing.

The poor permeability and slow percolation of the soil of the study area will limit the effectiveness of groundwater contamination.

Project construction impacts on groundwater will be of very low significant.

5.6.1.7 Aquatic flora and fauna

During pipeline crossing, the riverbanks and beds will be disturbed, which may cause organisms to avoid the immediate area and some benthic organisms may be killed; adult fish and mobile juveniles will swim away from the disturbed area and use other parts of the river. Juvenile fish unable to swim away from the area of construction may perish if they are in the path of the outfall trench. The construction activities also will increase the amount of suspended solids in the river waters. If sediment does become suspended in the water, there is the potential for sands and mud to smother juvenile fish or the fish eggs of species that breed and lay in the river. Any effects on fish are dependant on the amount of sediment loading that occurs and where these finally fall out of suspension. Impacts to the aquatic flora and fauna will be limited to the areas near the pipeline crossing.

The construction impacts on the river water quality and on the aquatic communities will be of low significance and of short duration.

5.6.1.8 Land Use and Visuals

The pipeline will mainly follow existing NNPC petroleum product and gas pipeline. Area where new permanent ROW will be acquired for the pipeline there will be loss of vegetation and farm land. The project ROW avoided settlements and structures. Agricultural uses (farmland) will be allowed to continue as before at new ROW.

There will be short-term obstruction or temporary disruption to local and major roads in the study area during construction. Major highways will be bored. There would be no long-term impacts to transportation.

Also, the crossing of rivers and streams will disturb their beneficial use (drinking, fishing, and swimming) during construction phase but it will be short-term.

The impact of the proposed project to the land use of the area is considered to be of low significant.

5.6.1.9 Traffic

The crossing of major roads will result in a temporary increase in traffic flow with potential impacts on major road users in the study area.

Also, the greatest transportation requirement during construction is the delivery of the steel pipe lengths to the working width. Pipes will be transported by heavy goods vehicles (HGVs) to the pipe storage areas. Village road will be used to access the ROW.

In addition, there will be HGV movements to deliver materials to the working width and car and minibus traffic associated with personnel during the construction period.

Construction traffic will have localized temporary impacts on road users, through potential congestion and delays. Access will normally be maintained while the pipe is being installed under public roads; project construction impacts on traffic condition will be of low significant

5.6.1.10 Occupational Health and Safety

Occupational hazards associated with the construction of the Project are typical of medium-scale construction work. Health and safety concerns during construction can generate hazards from transportation of equipment and materials to and within the project ROW, handling and storage of materials onsite, use of other heavy equipment, welding, excavations and trenching, electrical and other energized work, spill, and other emergencies.

There will be provision of a high standard health and safety management on site and construction of the gas pipeline will be in accordance with good industry practice. The occupational health and safety risks associated with construction of the gas pipeline will be minimized and the impact of low significant.

5.6.1.11 Impact on Waste Management

It is expected that the following waste types will be generated; excavated materials that will be used for backfilling of trenches, chemical waste (lubricants); sewage from the on-site construction workforce; and general refuse. The quantities of waste materials that will arise from the construction phase are not expected to be unduly high; however practical mitigation measures will be taken to avoid, minimise and recycle wastes and to reduce environmental impacts.

5.6.1.12 Impact on Infrastructure Demand

During project construction, heavy equipment that will transport project equipment will pass through the major and village roads in the study area. This may cause the wear and tear of the roads. The road access to the project ROW is expected to be rehabilitated to enable the passage of heavy and light vehicle to the project ROW. The passage of the heavy equipment will not be continuous but within a short period. The wearing of the road as a result of project equipment movement to ROW will be of low significant.

Temporary electricity will be supplied from existing distribution system for construction; field fabrication, welding process and lightening and construction camp residences. The power supply will be supplemented with diesel generator.

The use of electricity will be temporary and will not have a significant impact on electricity supply in the study area.

5.6.1.13 Socio-economic Impact

9. Demography

The maximum number of workers on-site will be high during peak period of construction period. Workers will be mobilized from nearby communities and camps facilities will be built to accommodate the workforce. The camp will attract business activities such as sell of food, bush meat and water within the camps and project ROW by women and children.

The demand for consumer goods and foodstuff within the study area will increase, which will result from project camp workers. The demand of food stuff will increase business activities of especially women. Prices of goods are expected to increase within the project location, which will in addition empower the locals that engage in trading in the study area.

The increase in population of study area where camp will be located will cause increase in the use of infrastructure; road, electricity, health centers etc. The infrastructure demand and usage associated with the project construction will be limited and not expected to cause social conflict. Project construction impacts on demography of the study areas will be positive and moderate significant

10. Employment

Project construction impacts on employment in the study area will be positive and moderate significantly.

The project construction is expected to stimulate the local economy through direct employment as well as the purchase of goods and services. The communities in the study area affected by the project will benefit from the project; subordinate economic activities, which result from increase employment opportunities, will be reinforced.

Employment associated with the construction phase is expected to last one to four years. Employment will vary depending on the construction activity being performed; clearing of bush /vegetation will be carried out by the use of heavy machines that will need operators. In all, a significant number of unemployed youths and men will be engage to perform various jobs during this phase of the project. The large construction labour force (construction labourers) required for the project during construction will recruited locally. This will create a number of employment opportunities. The trading activities of women in the area will increase.

11. Culture

The project ROW avoided settlements and archaeological and historical sites in the study area. Construction activities will not affect archaeological sites.

Changes in cultural values such as shared customs, traditional value systems (e.g. language, dressing mode, religious beliefs and rituals) is not going to be impacted upon significantly by the project. However, there would be a language barrier between the unskilled workforce to be engaged during the construction phase and the contractors.

12. Income

The gas pipeline will cross some agricultural lands, disrupting farming activities in areas where new ROW will be acquired. The major occupation and source of income of people in the study area is farming. Farmland is the second land use category in the study area, so there is major opportunity cost in terms of loss of agricultural production. Compensation of economic tress and crops is expected to be paid to affected people. The construction phase generally is expected to have a significant positive impact on the average income of the locals. The positive impact will be as a result of the injection of money into the local economy by staff and contractors, through their purchase of foodstuff and consumer goods from the local traders.

13. Occupation

The common occupation of people of the area will not be altered; logging, hunting, fishing, farming and civil service. The locals that will be engaged in construction work activities will learn new skill and occupation. The project is will have a moderate positive impact on occupation of the communities in the study area.

14. Public health

The project construction will add to existing ambient or background concentration of dust. In addition exhaust emission of trucks and construction equipment will not increase airborne levels of NO_2, CO and SO_2

The site preparation and construction activities will cause degradation of water quality of rivers and stream, which also supply drinking water to the area. This may adversely impact public health if contaminants are present in sufficient concentration and duration.

The migration of workers and locals to the project site location will have the following health impact; there will be high incidence of defecation in and around the forest area, which will contribute to high incidence of water-born-diseases, and also there may be an increase in sexually transmitted diseases due to interaction between the immigrant workers and local business women, which would have far reaching health implication.

5.7 Project Operational Impact

5.7.1 Air Quality Impact

During operation, natural gas will be transported along the pipeline from Ajaokuta to Kano, the scraper receiver and launcher stations and terminal stations located along the pipeline will ensure the transmission of gas in a safe manner. During operation and maintenance activities of the pipeline, gaseous emissions can result from purging and venting procedures and gas leakage as a result of pipeline rupture or damage.

Also, dust can be generated from vehicular movement during maintenance activities and pipeline rupture; when dirt is blown or appearing thrown into the air.

The characteristics of natural gas include the following;

- Natural gas is the cleanest burning fossil fuel.
- It moves silently, safely and efficiently
- Natural gas is not a poisonous or a toxic gas.
- Natural gas is colorless and odourless in its natural state.
- Natural gas will not ignite on its own. In order to burn, gas requires both a precise amount of oxygen and an ignition source.
- Natural gas is lighter than air and will rise and diffuses rapidly.

When odourised the smell of natural gas emission will be offensive. The nearest settlement to the project ROW is not less than 100m. Since natural gas is lighter than air and diffuses rapidly, the odour impact from leakage will be of very low significance to settlement that is at 100m to point of leakage. The impact of project operation on air quality will be of very low significant.

5.7.2 Noise Impact

Vehicle movement along the project ROW during maintenance activity may generate noise emissions. Also during maintenance noise will be generated from above ground maintenance, gas venting from pressurized equipment and above ground equipment, at line valves and scraper stations. Noise emissions are not expected to be high and activity will be short term. The noise impact on residential areas and wildlife will be of very low significant.

5.7.3 Surface Water Impact

During emergencies, rupture or damage, gas leakage can occur in water. Given the poor solubility in water, methane will not have a significant impact on the chemical composition of water in the event of a pipeline rupture. The operation impact on surface water will be of very low significance.

5.7.4 Aquatic Impact

The impact of a pipeline accident (seepages and ruptures) on aquatic species is insignificant. Hardly any categories of biota will experience ill effects from gas in the water; in some cases, for example macrozoobenthos, biomass may actually increase.

5.7.5 Soil and Ground Stability

Operation and maintenance activities may increase the vulnerability of the pipeline corridor and surrounding land to erosion. The use of heavy vehicles and use of vehicles where soil is not stable might lead to erosion. During maintenance slashing, lopping or removal of vegetation is required to access the project ROW; the action may expose the bare earth to increased or accelerated rates of erosion. The operation impact on soil will be of low significance.

5.7.6 Vegetation Impact

Vegetation cover protects against erosion and contributes to production in agricultural areas. Weeds are any plant growth that invades areas of native vegetation. Vegetation along the project ROW will be permanently lost and there is potential for the ROW to harbour weed species. Weed growth usually affects the health of natural vegetation, productivity of agriculture etc. If weed that might come up along the ROW is not controlled it will impact negatively on the adjacent vegetation and farmland. Also, during gas leakage as result of pipeline rupture, the surrounding vegetation will start dying off if not attended to. The project operation impact on vegetation is of very low significant impact.

5.7.7 Waste Management

During pipeline easement, sediment load and spillage of lubricant can be generated. Rain water runoff can carry the sediments and spills of products or chemicals to nearby surface water. Waste management impact during gas pipeline operation is of low significant.

5.7.8 Land Use

During pipeline operation the ROW will be accessed on a regular basis. Access may be by foot, vehicle, or boat. In some cases access routes to a pipeline corridor may be provided which may be rare. This activity might change the land use of the area.

Aboveground facilities (valves) will exist for the life of the project. The majority of these facilities will be located in rural areas. Pipelines will be located underground and therefore, will pass without the view of roadside residences. The project operation impact on land use will be of very low significant impact.

5.7.9 Impact on Visuals

The project will be constructed in an area already characterized by the presence of pipeline and in some areas it will be adjacent to a major interstate highway (Kano-Kaduna) that sustains heavy truck traffic. The existing ROW are in some areas noticeably visible from the main highway and do not constitute a major aesthetic problem.

5.7.10 Socio-economic Impact

This phase of the project will continue throughout the projected 50 years lifespan of the project. The operational phase is expected to be a relatively stable period compared to the social changes that will occur during the construction phase. For one, it will require fewer workers.

15. Population

Changes in population of the study area during the operational phase will be minimal. The project staff during operation will be at the terminal station hence there will relatively slow or no business activity when compared to the construction phase.

16. Employment

Operations employment associated with the proposed project is expected to be low and would be associated with pipeline maintenance, management activities, emergency responses and security. There will be a major beneficial impact on employment. The professionals in the study area will be employed. Also, the local communities will be involved in the security of the pipeline.

17. Impact on Economic Development of the Study Area

There is poor power supply in the study area, insufficient or no gas supply for domestic and industrial purposes. These have restricted the economic development and the raising of the standard of living of the people in the area. The project will improve the supply of gas in the area which will in turn lead to steady power supply and industrial development. The project will cause new investment in power station construction in the area.

18. Public Health

Movement of operation and maintenance vehicles, equipment and personnel may spread disease along the pipeline corridor but it will have very low significant impact.

5.8 Project Decommissioning/Abandonment Phase

The lifetime of the transmission system is estimated at 50 years. However, in the event of the project termination/abandonment, the aboveground structures will be removed, while subsurface structures are abandoned in place

Upon abandonment of the pipeline, in part or in whole, the ROWs associated with the abandoned facilities will be returned to the landowners.

A demolition of the above structure facilities will generated minimal environmental impacts.

5.8.1 Disposal of Demolition Waste

Poor management of wastes can lead to visual and aesthetic problems, as well as health and ecosystem impacts from possible contamination of land and water.

5.8.2 Soil and Land Use

The impact of removal of above ground facilities can lead to soil erosion, distortion of soil quality and profile and contamination. This is a result of fuel leakage, spills, and improper disposal of waste during decommissioning operation. The impact will be short term. Also, the decommissioning activities will not affect the land use of the area.

5.8.3 Air Quality

The decommission activity will result in dust generation from excavation and gaseous emission from trucks and vehicle. In the event of demolition, particulate matter is expected to increase, but only temporarily. The impact will be localized, short term and of very low insignificance.

5.8.4 Noise Level

The decommissioning activities will increase the noise level of the study area and it will result from truck movement, bulldozer and decommissioning equipment. The noise impact will be localized and short termed.

5.8.5 Occupational Health

Occupational accident like cut and fall from height will result from dismantling of above ground equipment.

5.8.6 Socio-Economic

The decommissioning/abandonment of the project will result to a significant increase in unemployment and decrease in related business activity in the area. It will also, lead to shortage in the supply of electric power in the nation. The land of the people will be returned.

5.9 Residual impacts

5.9.1 Air Quality

During construction phase dust generated especially in dry season will be deposited in the immediate vicinity of the construction work site. Given the extent of spatial and temporal distribution of emissions to the atmosphere, no significant residual impacts will be associated with construction activities.

5.9.2 Noise

Noise associated with pipeline construction will be short term and will not be hard at settlement areas. But in construction camps, noise will be heard but it will be minimal. Therefore there will be residual noise impacts at camp site.

5.9.3 Soils

The handling and storage of soils, and soils re-instatement, will minimize erosion and therefore no significant residual impacts are expected.

5.9.4 Ecology

The pipeline route will not cross ecologically sensitive areas, so there would not be any residual impact.

5.9.5 Landscape

The visual impact of pipeline construction activities will be short term for most stationary receptors. The ROW will be appropriately reclaimed after construction; hence residual impact will be of very low significance.

5.9.6 Socio-economic residual impacts

The project identified positive residual socio-economic impacts for both the construction and operation of the pipeline include:

- There will be additional cash injected into communities cause by increased trading
- The employment of locals for construction will enhance local experience and employability
- There will be economic benefit of indirect employment opportunities
- The people in the study area will have enhanced capacity to tender for contracts
- There will be construction of new roads / improvements to roads
- There will be new cultures and international attitudes

The main residual negative social impacts associated with the construction and operation of the project include;

5.9.6.1 Employment expectations

The communities have high employment expectation on the project; they expect that the numbers of jobs that will be created, and the duration of the employment, are larger and longer than they will actually be.

5.9.6.2 Accidents involving community members

There may be accidents involving community members, but it is expected to be rare given the strong emphasis that will be attached to health and safety issues.

5.9.6.3 Local infrastructure, services and natural resources

Damage to roads from construction traffic was key concerns for local communities.

The project will build some new roads and improve some existing roads which will have a beneficial impact for local communities. Residual community resentment may be generated if the high standards that follow the initial upgrades are not maintained.

5.9.6.4 Community relations

Despite the positive attitude towards the project during consultation, it is possible that tensions between communities and the pipeline project will arise during construction especially opportunities for employment.

5.9.6.5 Cumulative Impacts

At the route level the project's main interaction is clearly with the NNPC oil and gas pipeline with which it will share a common ROW. The main route level cumulative impacts are outlined below.

5.9.6.6 Land take and subsequent habitat loss

The construction of new corridor will be required for the pipelines in some areas. But generally the pipeline will follow existing NNPC ROW. Land taken for storage during construction will be returned to the owners. There is a significant positive cumulative impact of the two pipelines sharing a common corridor.

5.9.6.7 Reinstatement of the ROW

The co-existence of the two projects in the same corridor may lead to proper reinstatement of the existing pipeline where there is degradation.

5.9.6.8 Economic Benefits and Livelihoods

The cumulative socio-economic impacts resulting from the project and any other industrial development projects will, if well managed, provide an overall increase in wealth and livelihoods for the national population. The main national level benefit is increased government revenues from transit of gas and from taxes and improved power supply. Increased government revenues will contribute to an increased standard of living for the national population.

The combined effect of the new and existing pipeline projects will be to double the inflow of cash into the local economies along the pipeline corridor, through doubling:

- Number of opportunities for employment for unskilled and semi-skilled labour
- Opportunities for the provision of goods and services
- The knock-on effect of having salaried workers living in the local villages.
-

5.10 Hazard and Risk Assessment

5.10.1 Risk Overview

The transportation of gas via transmission pipelines is safer than transportation via other modes, but a significant failure can result in loss of life, personal injury, property damage, and environmental damage

Throughout the ROW the pipeline will generally be continuous but with spurlines at Abuja and Kaduna Terminal Stations. Valves will be located at strategic points, which are designed to close automatically in the events of pressure drop, limiting the inventory available for release in the event of a leak or rupture.

The pipeline will be buried. The depth will be variable but the minimum depth will not be less than 1m. The largest land use adjacent to the project ROW is vegetation followed by farmlands and settlements. The closest settlements and farmland to the project pipeline is separated by approximately 100m and 10m respectively. The project ROW will generally follow NNPC existing petroleum product and gas pipeline.

5.10.2 Hazard Identification

5.10.2.1 Pre-construction and site preparation

Premium and regular unleaded petrol and diesel would be stored on site and used for re-fuelling equipment during construction. Petrol is classified as dangerous goods. Diesel is a combustible liquid.

The most common ailments identified in the project area include malaria and typhoid. It is therefore possible that site staff can be exposed to the ailments. It is expected that at this stage of the project, there will be influx of people into the area and there may be introduction of sexually transmitted diseases (STDs) and HIV.

5.10.2.2 Operation and Maintenance

The primary hazard identified during operation is the potential release of gas from high pressure pipeline, which when ignited can potentially lead to the following scenarios:

- Fire ball
- Flash fire and
- Vapour cloud explosion
-

5.10.3 Risk Analysis

For immediate or early ignition, a fire ball will be the most likely result, whereas delayed ignitions will typically result in a flash fire or a vapour cloud explosion.

Vapour cloud explosion represents the most significant hazard, with the capacity to result in damage and injury well beyond the extent of the released plume. Depending on the proximity of persons that will be exposed to events, the impact ranges from minor injury to adverse conditions and fatality.

The following were identified to be factors that can cause hazard in the study area;

- Accelerated corrosion that can cause pipeline failure and rupture
- External fire that can cause pipeline failure and rupture
- Deliberate attack on pipeline causing pipe rupture
- Impact from unauthorized digging, drilling and piling within the pipeline ROW
- Impact from dropped load causing pipe failure

The probability factor that can cause pipeline rupture in the study area was evaluated based on expert opinion and information on existing pipeline. Probability likelihood scoring was based on estimation and scoring criteria shown in **Table 5.6**

Table 5.7: Guide on score rating for probability of risks

Rating/Likelihood	Effects/significance
0	No impact /insignificant
1	Very low
2	Low
3	Moderate
4	High
5	Very high

Attack on pipeline by vandal for economic reason has the highest probability. In the study area vandals rupture NNPC petroleum pipeline with the intention of scooping petroleum for sale.

Table 5.8 detailed the probability for the root causes of rupture that can lead to fire hazard.

Table 5.8: Risk assessment result

Root Cause	Likelihood	Estimation/reason for likelihood
Gas escapes promoting cloud	1	It was assumed that a cloud will always be formed when there is delay ignition
Accelerated corrosion due to electrical current	0	It was assumed to be zero based on the expected effectiveness of control
External fire when there is rupture: Vehicle Building Vegetation	0 0 1	Based on location of pipeline Based on location of building Based on the fact that in the study area local set fire on vegetation during dry season for grazing purposes
Attack on pipe for economic reasons	2	Assumed to be two based on the existing information pipeline attacks in the area
Attack on pipe for sabotage	0	Assumed to be zero based on the existing information pipeline attacks in the area
Heavy load crushing pipe	0	Based on depth of burying pipe
Unauthorized digging impact with sufficient force/equipment, angle to locate pipe	0	Based on restriction to usage of project ROW and site security
Pipe sufficiently exposed	1	Based on exposure of existing pipe by erosion
Operator unable to handle work cause error	0	Based on KC experience

CHAPTER SIX

6.0 IMPACTS AND PROPOSED MITIGATION MEASURES

6.1 General

One crucial objective of EIA is to ensure that suitable mitigation measures for reducing identified associated and potential impacts of the proposed project to a level as low as practically possible are developed, established and maintained throughout the entire project life cycle.

The chapter provides the proposed mitigating measures to control impacts and to ensure compliance with relevant standards, how effective this mitigation is expected to be and consequences of failure.

Detailed mitigation measures have been proffered to ensure that the adverse environmental impact was kept to an absolute minimum.

6.2 Procedures for Developing the Mitigation Measures

The mitigation measures have been determined by associated risk to health, safety and environment. The likelihood that an impact will occur and the severity of its consequence were used as criteria in proposing the mitigation.

Summary of the proposed mitigation measure for the identified environmental impact of NNPC proposed Ajaokuta-Abuja-Kaduna-Kano Gas Pipeline (Phase I) Project is provided in **Table 6.1** below

Table 6.1: Summary of the Mitigation Measures of Identified Significant Impact.

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
Clearing and staking for the ROW	Land take and Loss of economic land and economic crops	High Negative	NNPC will Conduct regular consultation with host communities and other stakeholders Pay adequate and proper compensation to all project affected persons Set up a committee of village heads, district heads and Relevant Government bodies to monitor land takes and signing of all necessary MOU Ensure that the compensation gets to the true and identified project affected persons	GID Unit, NNPC	To ensure that all avenues for communal crisis and agitations are handled at the onset of the project. Reduce land take and ensure that NNPC do not acquire more land than is needed for the project	Agreements with communities Records of meeting Evidence of payment where compensation is paid	Preconstruction and construction period
Construction - Site Preparation Pipeline ROW	loss of vegetation including medicinal plants	Medium Negative	NNPC will Encourage re-growth of native plants, medicinal plants and shrubs along the right-of-way, where appropriate (i.e. –not in farmland used for cropping).	GID Unit, NNPC	To preserve existing flora and fauna To ensure that there is adequate compensation and revegetation of all species plants especially the medicinal plants	The physical presence or efforts on ground to revegetate and conserve the habitat	Preconstruction and construction period

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
			Enforce restriction on poaching on wildlife, encroachments on use of vegetation for trees, waste disposal etc Rehabilitate cleared areas that are outside the survey site with local vegetation species Monitor and manage regeneration of disturbed areas; native vegetation re-growth (plants, shrubs & trees) Take action on complaints from communities in respect to crop losses along the ROW. Adequate means of conserving economic, medicinal and sacred biodiversity should be provided				
Construction - Site Preparation Pipeline ROW	Loss of wildlife and wildlife habitat/loss of vegetation including	Medium Negative	NNPC will : Establish a game reserve in Kogi and Kaduna States respectively, to preserve wildlife species	GID Unit, NNPC	To preserve existing flora and fauna To ensure that there is adequate compensation and revegetation of all species	The physical presence or efforts on ground to establish the game reserves.	Preconstruction and construction period

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
	medicinal plants				plants especially the medicinal plants		
Construction - Site Preparation Pipeline ROW	Exposure to wild animals like snakes, pythons etc and insects like bees	Low Negative	Provide proper personal protective equipment Create awareness for workers and hoist communities on the possibility of exposure to these animals Provision of first aid facilities on-site Emergency response should be in place Orthodox anti-venom and services of local snake charmers should be provided on-site	GID Unit, NNPC	Protect workers and other members of the public from harm, accidents and injuries	Statistics of harm or injuries from wild animals e.g. snake bites Site inspection report Minutes of tool box meetings	Preconstruction and construction period
Land acquisition for contractor's lay down area	Communal agitations and land ownership crisis	Medium Negative	NNPC will conduct regular consultation with host communities and other stakeholders Adequate and proper compensation of all project affected persons Set up a committee of village heads, district heads	GID Unit, NNPC	To ensure that all avenues for communal crisis and agitations are handled at the onset of the project. Reduce land take and ensure that NNPC do not acquire more land than is needed for the project	Agreements with communities Records of meeting Evidence of payment where compensation is paid	Preconstruction and construction period

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
			and Relevant Government bodies to monitor land takes and signing of all necessary MOU Ensure that the compensation gets to the true and identified project affected persons				
Construction - Site Preparation Pipeline ROW	Land use		NNPC will: - inform communities of likely land use disturbance as a direct result of activities. - act on complaints from communities in relation to land use modification or infrastructure damage - ensure that any disrupted irrigation system is reinstated at least equal to original condition upon completion of construction work. - that soil spoil (over burden) will not be kept near agriculture land.	GID Unit, NNPC	To avoid significant disturbance to land use or damage to infrastructure.	Agreements with communities Records of meeting Evidence of payment where compensation is paid	Pre-mobilization Construction/ Decommissioning

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
Construction Excavation/Trenching	Increased Erosion and off-site sedimentation/ turbidity/degradation of water qualities due to waste from camps	Medium Negative	Ensure that measures are taken to control erosion. This should include construction of embankments and proper channeling of run-offs. Ensure that soil is rehabilitated and reclaimed in an appropriate manner. Ensure that loose material are compacted Ensure that Storm water drainage are provided Ensure that there is control of test water discharge to reduce erosion Ensure that potable water is supplied to affected communities	GID Unit, NNPC	To conserve the original state of the soil and water bodies	Surface and ground water will be monitored in line with regulatory requirements	Pre-mobilization/ Construction/ Decommissioning
Construction Excavation/Trenching	Fugitive emission-dust emission from earth moving equipment Emission of SO2, CO, NOx from earth moving equipment	Low Negative	NNPC will ensure: - That uncontrolled gas emissions are reported and actioned in a timely manner. - the reduction of dust generation by ensuring the management of vehicle operations along the	GID Unit, NNPC	To ensure that there is no air pollution from the construction activities by minimizing the potential for emissions that heightens public concern.	Air quality should be monitored and proper records kept for inspection	Pre-mobilization/ Construction/ Decommissioning

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
			right-of-way is minimized by frequent water spraying of ROW and exposed earth surfaces of vehicle covers; - that vehicle and equipment are well maintained and operators are trained in fuel efficiency and anti-idling; - that vehicles transporting materials are covered with tarpaulins - speed reduction to 10 kilometers per hour (kph) - Periodic emission check for equipment/machinery is carried out.				
Construction - Site Preparation Pipeline ROW	Influx of large number of workers may lead to social conflict, theft and spread of Sexually Transmitted Diseases (STDs) like HIV	low Negative	NNPC will Use appropriate technology that can be sourced locally Recruit as many local firms/contractors as possible to execute their projects Use of community labour as in-kind contributions	GID Unit, NNPC	To minimize the spread of STDs including HIV	Health status of the workers	

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
			Sensitize community leaders on the cause and prevention of spread of STDs Carry-out proper screening of both regular and casual workers before engagement Establish health centers to cater for the needs of the host communities				
Construction Excavation/Trenching	Temporal annoyance and stress due to increased noise level at nearby residence	Low Negative	impose restriction on working hours - use equipment with lower noise generation levels - ensure that workers wear ear protection devices and helmet - take action on noise related complaints from Affected persons or third parties	GID Unit, NNPC	To minimize noise due to Construction activities.	Air quality should be monitored and proper records kept for inspection	Pre-mobilization/ Construction/ Decommissioning
Construction Excavation/Trenching/pipe laying	Traffic Congestion / Road crossing	High Negative	Schedule construction work on road crossing to night time and low traffic periods	GID Unit, NNPC	To reduce traffic congestions		Pre-mobilization/ Construction/ Decommissioning
Construction	Fishing/threat to	High	Introduction of rational fish	GID Unit, NNPC	To reduce aquatic life/threat		Pre-mobilization/

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
Excavation/Trenching/pipe laying	food security	Negative	production through aquaculture in the area Construction of fish farms Establishment of production ponds and cage-based hatchery for the production of fries for restocking. Ensure that known fish breeding areas are avoided Ensure proper habitat restoration program Restore and stabilize all stream and river banks to minimize disturbance of riparian and river bank areas		to food security and occurrence of malnutrition		Construction/ Decommissioning
Construction Excavation/Trenching/pipe laying	Water Resources	Medium Negative	Promote and maintain water drainage patterns. - ensure the construction of sediment fencing, drainage channels & trench barriers where appropriate - the discharge of wastewater is through a filtering medium - test and treat wastewater that have pollution potential before discharge	GID Unit, NNPC	To prevent pollution of watercourses		Construction/ Decommissioning

Project Activity	**Impact**	**Impact Rating**	**Mitigation measures**	**Responsibility**	**Objective**	**Parameter to monitor**	**Timing**
Construction Excavation/Trenching/pipe laying	Waste management	Medium Negative	All wastes are removed from the ROW and, in order, reused, recycled or appropriately disposed - locals are allowed to collect tree trunks as fire wood - Secured waste storage sites are established in defined areas away from watercourse and natural drainage part.	GID Unit, NNPC	To manage all construction wastes in an appropriate manner		
Construction Excavation/Trenching/pipe laying	Increase risk of injury	Medium Negative	NNPC will ensure that: -workers comply with safety codes and procedures to prevent occupational injuries and illness - there will be safety training. -Restrict public movement on sites -Road signs are Installed and maintained -Passage route for farmers	GID Unit, NNPC	To avoid significant risk of accident		Pre-mobilization Construction/ Decommissioning

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
			e.g Fulani herdmen are provided				
Construction Excavation/Trenching/ pipe laying	Population influx during implementation/ construction (which may lead to social conflict, theft, diseases)	Medium Negative	NNPC will ensure: - Use of appropriate technology that can be sourced locally -Recruit local firms/contractors as much as possible -Use of community labour as in-kind contributions Provide police posts	GID Unit, NNPC/Nigeria Police	To reduce incidence of violent crimes		Pre-mobilization Construction/ Decommissioning
Construction Excavation/Trenching/ pipe laying	Transportation of goods, materials and personnel will lead to generation of vehicular traffic, noise, dust and Vehicular emissions		NNPC will: - impose restriction on working hours. - regulate vehicle speed -conduct periodic maintenance of vehicles - regulate vehicle speed. - ensure proper covering for materials (like tarpaulin cover) carry out periodic emission check for vehicles.	GID Unit, NNPC	To minimize noise due to transport activities and reduce dust generation that may heightens public concern.		Pre-mobilization Construction/ Decommissioning

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
			-ensure use of good fuel for vehicles				
Construction Excavation/fabrication, Trenching/pipe laying and testing	**Camp site** Generation of waste Vehicular emission Risk of accident and Exposure to radioactive emission		NNPC will: - provide proper sanitary facilities. -provide septic tanks for collection of domestic sewage - ensure treatment of domestic sewage - that all wastes are removed and, in order, reused, recycled or appropriately disposed	GID Unit, NNPC	To manage all wastes in an appropriate manner	Waste log and disposal records	Pre-mobilization Construction/ Decommissioning
			NNPC will: - carry out periodic emission check for vehicles.	GID Unit, NNPC	To minimize the potential air emission that heightens public concern.	Air quality monitoring	

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
			- ensure use of good fuel for vehicles				
			NNPC will ensure that -vehicles associated with pre-mobilization and construction activities are restricted to main routes; - heavy vehicle movement will be in the night Adequate PPE will be provided	GID Unit, NNPC	To minimize accidents and exposure to radioactive emissions during the construction	Emission monitoring in as required by regulatory authority	
	Pipeline river crossings at Oguro, Osara, Niger, Gurara, Kaiza,Kaduna, Tiga, and other minor streams This will cause changes in the drainage pattern, alteration in stream sedimentation and impact on water quality	High	NNPC will ensure that : - water crossings are maintained in a stable condition - stability of the pipeline corridor, and in particular the condition of watercourse banks, is properly maintained - Erosion control measures such as silt fences and drains are appropriately maintained - HDD method are used in all river crossings.	GID Unit, NNPC	To minimize effect on water quality and destruction of aquatic life	Water quality	Construction/ Decommissioning

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
			- Crossing of the seasonal streams is through open cut, and only during dry season when the stream is dry. -Restoration works is undertaken as soon as possible and will include removal of temporary structures, reshaping the stream to its original configuration and gradient, and removal of construction material and debris. - Any disturbed stream banks susceptible to erosion are re-stabilized immediately following construction through a combination of re-vegetation and erosion control. -Stream banks must be re-stabilized by stabilizing the waterline with rock or other heavy "non-erodible" material and then by slope the upper bank, seed and install erosion control				

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
			matting.				
	Road /Railway, Existing pipeline and PCHN Crossings		NNPC will ensure: - that road crossings are maintained in a stable condition - stability of the pipeline corridor, and in particular the condition of roads and railways is properly restored - that erosion control measures such as silt fences and drains are built - Boring method will be used in all road and railway crossings Ensure that precautions are taken against damage to PHCN equipment and electrocution.		To minimize accident and traffic delays and destruction of third party infrastructures - PHCN		Construction/ Decommissioning
Backfilling and restoration	Disruption of habitat of rodents etc	Low	NNPC will ensure Backfilling is done as soon as possible before rodents and other earth burrowing animals inhabits the area That proper road diversion signs are put in place.	GID Unit, NNPC	To minimize destruction of wildlife habitat and reduce road accidents	Water quality	Construction/ Decommissioning
	Road accidents and traffic delays						

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
			That traffic warden are positioned at every road crossings				
Pressure testing	Disturb other uses of the water Disturbance of plankton and benthic communities	Low	NNPC will provide boreholes as alternative source of drinking water to host communities Conduct public enlightenment campaign before any pressure testing Test all wastewater from pressure testing operations to ensure that the parameters fell with the regulatory standard before disposal.	GID Unit, NNPC	To minimize destruction of water resources	Water quality	Construction/ Decommissioning
Operation and maintenance /Pigging	Water, sediment and soil pollution	Medium	NNPC will ensure that Pipelines are made of steel and corrosion coating is properly done Concrete coating will be done for sections in water or marshy areas Pigging will be carried out on schedule and pigging waste properly disposed of.	GID Unit, NNPC	To minimize pollution of land and water resources	Soil and water testing	Operation and maintenance /Pigging

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
	Air emission	Low	NNPC will that ensure that: - odourization of the gas is undertaken in a manner to minimize the risk of accidental release of the odorant - the release of gas from the pipeline is minimized during venting Vehicles are equipped with emission controls, as applicable, and operated within regulatory requirements; -Vehicles are not subjected to long-term idling; -Appropriate earth moving practices must be exercised; and, Construction activities are limited during high wind events.	GID Unit, NNPC	To minimize air emission due to operation and maintenance activities.	Air quality monitoring	Operation and maintenance /Pigging
	Noise	Low	NNPC will ensure that;	GID Unit, NNPC	To minimize noise emission	Noise level	Operation and

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
			- local residents are informed of potential noise from maintenance or project activities prior to the commencement of those activities -where appropriate noise monitoring are conducted		due to operation and maintenance activities		maintenance /Pigging
	Land use	Low	NNPC will - manage vegetation re-growth along the right-of-way, so as not to restrict access or to incur damage to the pipeline infrastructure. - avoid the disturbance of native vegetation restricted to right-of-way.	GID Unit, NNPC	To enable unobstructed access for right-of-way inspection; routine operation, maintenance and emergency access	-	Operation and maintenance /Pigging
Operation and maintenance /Pigging	Surface water	Low	NNPC will: - that water crossings are maintained in a stable condition - stability of the pipeline corridor, and in particular the condition of watercourse banks,	GID Unit, NNPC	To minimize surface water pollution due to operation and maintenance activities	Water quality	Operation and maintenance /Pigging

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
			- that erosion control measures such as silt fences and drains are appropriately maintained				
	Soil and Erosion	Low	NNPC will ensure: - that erosion control structures are routinely checked -that vehicle access are restricted to stable ground where practicable - maintenance operations are carried out in a manner that will not expose the bare earth to increased or accelerated rates of erosion	GID Unit, NNPC	To conserve the original state of the soil.	-	Operation and maintenance /Pigging
Operation and maintenance /Pigging	Flora and Fauna	High Negative	NNPC will ensure; - that care is taken not to disturb any areas of native vegetation outside the access tracks or pipeline corridor -that environmental weeds and pathogens along the right-of-way are managed in a	GID Unit, NNPC	To preserve existing habitats	Species diversity	Operation and maintenance /Pigging

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
			manner consistent with adjoining land				
	Public Safety		NNPC will: - put adequate measures in place to protect public and third party safety during operations and maintenance activities. - that there is no occupational health, safety and welfare incident or accidents involving third parties, third party health and safety during operations and maintenance activities. - minimize the risk of fire during routine operations - document evidence of public safety management and pipeline awareness, in the course of pipeline operations	GID Unit, NNPC	To minimize risks to public and third party health and safety.	HSE statistics	Operation and maintenance /Pigging
Decommissioning/ Abandonment	Disturbance of normalized aquatic and terrestrial habitat	Low negative	NNPC will Ensure that all excavated trenches are properly covered.	GID Unit, NNPC	To minimize risks to public and third party health and safety.	-	Decommissioning/ Abandonment

Project Activity	Impact	Impact Rating	Mitigation measures	Responsibility	Objective	Parameter to monitor	Timing
	Disruption of community activities	Low negative	NNPC will Ensure that all operations interfere as little as possible with the activities of the host communities. Schedule all activities to reduce overall impact on traffic, and other use of water Conduct regular consultation	GID Unit, NNPC	To minimize communal crisis and agitation	-	Decommissioning/ Abandonment
	Opportunity for Employment	High positive	NNPC will Make use of indigenous contractors qualified for the job Enforce a procedure for employment of indigenous labour	GID Unit, NNPC	To minimize communal crisis and agitation		Decommissioning/ Abandonment

CHAPTER SEVEN

7.0 ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

The Nigerian National Petroleum Corporation (NNPC) is committed to management of the environment in the project areas by ensuring that this EIA complies with the EIA Act and other statutory regulations.

An applicable, relevant and appropriate Environmental Management Plan (EMP) has been developed in accordance with ISO 14001 (Environmental management System Specification) to mitigate and minimize the environmental impacts identified in Chapter five. The EMP incorporates measures that include protection, mitigation, and enhancement measures.

A separate monitoring plan has been developed to assess the effectiveness of the management plan. The EMP will ensure that all mitigation (as provided in Chapter six) is implemented effectively. Monitoring will be undertaken to evaluate the success or failure of the environmental management plan.

The management plan has been developed to ensure that the impacts identified are minimized to the maximum extent possible. The wildlife and vegetation impacts are not exactly mitigated by the provisions of the management plan. However, there is a relative abundance of similar vegetation and wildlife in project areas. It is expected that wildlife will return to the area after reclamation and vegetation re-generation.

7.1 EMP OBJECTIVES

An effective EMP is designed to achieve the following;

19. Ensure the progressive reduction of the potential impact of project on the environment;
20. Ensure that all mitigation measures prescribed in the EIA document for eliminating or minimising the projects impacts are fully implemented;
21. Provide part of the basis and standards needed for overall planning, monitoring, auditing and review of environmental performance throughout the project life cycle.

The above objectives will be achieved by taking the following measures:

- Ensuring that all stipulated legislations on the protection of the environment is adequately complied with;
- Ensuring that environmental concerns are adequately incorporated into the developmental and operational phase of the project;

- Justifying existing environmental activities to enhance efficiency and effectiveness;
- Ensuring that only environmentally approved procedures should be employed during the execution of the project.

7.2 Mitigation Measures

The effective mitigation of each potential impact identified has been listed in chapter six, **Table 6.1**. Regulatory bodies such as DPR, FMENV and Affected State Environmental Protection Board and Agencies will monitor the implementation of the mitigation measures.

7.3 Proposed Environmental Management Plan

NNPC understands that communities are major stakeholders in any developmental projects. NNPC will therefore adopt strategies that would be sustainable. It plans to provide a proactive guideline in ensuring that Environmental, Cultural, Social and Economic issues that bother on the welfare of host Communities are adequately addressed in its area of operation.

To achieve this, efforts will be geared towards infrastructure development, community assistance, or human capacity building withstrict compliance with the Nigerian content initiative of the Federal Government.Thisstrategy main thrust would be geared towards engagement, empowerment andsustainable development of the Community. NNPC shall maintain correct and proper relations with all arms of Government,related Agencies, Local Government Authorities and recognize pressure groups inthe project environment through the Global Memorandum of Understanding (GMU)

NNPC is committed to the implementation of the EMP enumerated below;

7.3.1 Air Pollution Control and Management

7.3.1.1 Construction Phase Plan

Air emission from construction site can pose health risk to workers and sensitive receptors along the project ROW, if not properly managed. It is the responsibility of the NNPC to ensure that the selected construction contractor provide appropriate safety training, information equipment, signage, security and emergency response plans on the ROW.

Dust reduction

- On disturbed surface areas, water will be applied to at least 80% of all inactive accessible disturbed surface areas on a daily basis when there is evidence of wind driven fugitive dust;
- There will be wetting of ROW and spoils periodically;

- Unpaved roads used for movement of pipes, heavy machinery etc will be sprinkled with water and speed of vehicles restricted to 15kmph;
- Wheel washing machine will be installed at a proper location to prevent spoils of paved roads;
- Limitation on maximum volume of loading soil will bind on every truck;
- Incoming loads will be covered to avoid loss of material in transport, especially if material is transported off-site.

Air emission

- Equipment and vehicles will be regularly maintained;
- Vehicle driver will be warned against idling;
- Smooth Flow of Traffic – Sudden acceleration or de-acceleration of vehicles produces more pollution than a vehicle maintaining a constant speed. Smooth flow of traffic will ensure lesser emission from vehicles;
- The use of good fuel for vehicles will be ensured.

7.3.1.2 Operation and Maintenance Phase Plan

To reduce fugitive and vented emission during pipeline operation the following measures will be applied by selected construction contractor:

- Purging and flaring procedures will be used to manage the environmental risks associated with air emissions when these activities take place on the pipeline ROW;
- The release of gas from the pipeline will be minimized for economic, environmental and greenhouse gas emission reasons;
- Periodic leakage detection surveys will be conducted to detect gas leaks;
- Gas vents will be located at appropriate distances from residential areas and infrastructure;
- Adjacent residents and local authorities will be advised of pending major venting operations prior to undertaking the activity;
- Odourization of the gas will be undertaken in a manner to minimize the risk of accidental release of the odorant.

7.3.2 Noise Control and Management Plan

7.3.2.1 Construction Phase Plan

The implementation of the following plan will result in the reduction of noise emission:

- Hearing protection – Earplugs will be provided to those working very close to noise generating machinery;
- Noise reduction – Unnecessary noise generating activity such as honking will be avoided as necessary. Noise emission will be abated by using low noise level equipment where appropriate;
- Local resident will receive prior notification of particularly noisy activities. Vehicles will be used responsibly; machines will not be left idling for long period if they are not in use;
- Heavy equipment use will include a basic operational plan that considers the location of households and time of equipment use.

7.3.2.2 Operational Phase Plan

- Local residents will be informed of potential noise from maintenance or project activities prior to the commencement of those activities;
- Where appropriate noise monitoring will be conducted and;
- Appropriate strategies for dealing with noise complaints will be implemented. In particular, all complaints including noise will be investigated and remedial action will be undertaken as required.

7.3.3 Surface Water and Wastewater Quality

7.3.3.1 Construction Phase Plan

To prevent degradation and maintain the quality of surface water crossed by the project, adequate control measures have been proposed to check surface runoff. The following management measures will be implemented to protect the water quality during the construction phase:

- The construction camps will be provided with sanitary latrines so that surrounding surface water is not polluted;
- Sediment fencing, drainage channels and trench barriers will be installed where appropriate;
- There will be no storage of hazardous materials within 30m of a watercourse;
- The hydrostatic water discharge will be tested to assure that oil content is low and if oil content is high, an oil separation will be used on the discharge flow;
- The hydrostatic water will be discharged through drainage channel to eventually get to river or stream;

- All generated waste oil resulting from the machineries will be collected in sealed drums and sent for reuse;
- Any wash off from oil/grease handling area will be drained through impervious drains. Oil and grease traps will be constructed and water is allowed to leave site only after passing through them;
- Spoil material dump points will be located at least 100meters away from water flowing course;
- Sedimentation will be controlled by frequent removal of spoil material from water body;
- Containment measures (ditches, impermeable membrane, covers) will be provided to minimize runoff from contaminated soil piles.

7.3.3.2 Operational Phase Plan

- As a priority, water crossings will be maintained in a stable condition;
- Stability of the pipeline corridor, and in particular the condition of watercourse banks, will be inspected;
- Erosion control measures such as silt fences and drains will be appropriately maintained;
- Appropriate remedial action will be undertaken if erosion and sedimentation occurs;
- Regular pipeline surveillance and monitoring for any problems due to altered drainage patterns of some water flows along the route of the pipeline and;
- Conduct any repairs promptly to minimize wash away and erosion at watercourses.

7.3.4 Soil and Erosion

7.3.4.1 Construction Phase Plan

The soil management measures will include;

- There will be erosion control measures along the ROW at points of steep inclination – siltation fences, rip rap and diversion channels.
- All steep cuts will be flattened, benched, protected if necessary.
- There will be adequate reclamation along the ROW to avoid erosion
- Discharge of hydrostatic water will be controlled to reduce soil erosion
- Soil storage areas will be protected from vehicle movement

- The subsoil beneath the vehicle running track will be broken up prior to reinstatement
- There will be appropriate use of load bearing materials in areas of particularly soft ground
- Topsoil and subsoil will be stored separately to maintain seed bank viability and soil structure.

7.3.4.2 Operational Phase Plan

Operation and maintenance activities may increase the vulnerability of the pipeline corridor and surrounding land to erosion. The potential environmental issues and the strategic measures for management of these issues are described below.

- When slashing, lopping or removal of vegetation is required for easement maintenance, operations will be carried out in a manner that will not expose the bare earth to increased or accelerated rates of erosion;
- Adequately trained staff in the repair of problems with soil erosion and sediment release will be employed;
- Erosion control structures will be routinely checked to ensure they are in good order and continue to be effective and if deficient are restored as soon as practicable;
- Where erosion is occurring due to inadequate vegetation cover on the pipeline corridor, consideration will be given to promoting additional growth in consultation with stakeholders;
- Where erosion is occurring due to inadequate water control on the pipeline corridors, consideration will be given to establishing new erosion control structures in consultation with stakeholders;
- Vehicle access will be restricted to stable ground where practicable;
- Additional care will be taken near waterways and drainage lines.

7.3.5 Land use

7.3.5.1 Construction Phase Plan

- Top soil will be kept separately from other excavated layers in order to return it as it was before excavation;
- Soil spoil (over burden) will not be kept near agriculture land;
- Workers and contractors will be prohibited from cutting any tree or destroying plants outside the boundaries of the ROW;

- Where possible flow will be maintained in active drainage or irrigation system through use of measures such as pumping and channel diversion;
- Any disrupted irrigation system will be reinstated at least equal to original condition upon completion of construction work;
- Periodic soil pollution survey will be conducted to check the soil condition.

7.3.5.2 Operational Phase Plan

Earthworks may be required during maintenance activities for construction of additional facilities and inspection of the buried pipeline within the corridor.

- Hazard netting will be placed around excavations to prevent entrapment of animals;
- Where practicable, all relevant residents, landowners and third parties will be notified in advance of any disruptive activities and;
- Consultation with landowners will be maintained and documented.

7.3.6 Flora and Fauna

7.3.6.1 Construction Phase Plan

- Any kind of activities outside the construction corridor will be prohibited;
- Any removal of the topsoil outside the construction corridor will be prohibited;
- The returning of topsoil within the construction corridor as before construction and maintaining its original composition (without mixing with the lower parts of soil) will be ensured;
- Prohibit animals hunting among staff;
- Trans-locate any nest found;
- Prohibit workers from capturing or hunting birds;
- Collect the domestic solid waste in closed bags and ensuring proper disposal at government approved site;
- Prohibit workers from cutting wood from trees and shrubs for any purpose;
- Rehabilitate the construction corridor by removing any leftovers after the construction activity;
- Ensure that dumping site is not located in areas with vegetation.

7.3.6.2 Operational Phase Plan

Vegetation cover protects the soil against erosion and contributes to production in agricultural areas. Weeds are any plant growth that invades areas of native vegetation. Pipeline corridors have the potential to harbour weed species.

Weed growth usually affects the health of natural vegetation, productivity of agriculture etc.

Control measures include:

- Re-growth trees that are within three meters of the trench centre line will be removed at seedling or sapling stages to ensure tree roots do not create a safety risk to the pipeline;
- The access track will be kept navigable by adequately controlling vegetation growth;
- Care will be taken not to disturb any areas of native vegetation outside the access tracks or pipeline corridor access track;
- Vegetation re-generation success will be monitored ; further restoration works may be required in areas where vegetation establishment has been less than acceptable;
- Pipeline route will be regularly inspected and monitored for weed control;
- Some field personnel will be trained in weed identification and techniques for the irradiation;
- Maintenance personnel will be aware of weed control techniques and their activities are monitored by trained operators and
- All weeds within the pipeline ROW will be removed as far as reasonably practicable.

7.3.7 Groundwater Contamination

7.3.7.1 Construction Phase Plan

To avoid risks of groundwater pollution, during the construction phase the following were proffered:

- Domestic wastewater will be collected in a sealed containers located in the employees camp sites. The wastewater will then be tested and hauled to the nearest government approved site;
- All generated waste oil resulting from the machineries during the construction phase, will be collected in sealed drums and sent for reuse;

- Hazardous materials will only be stored within designated storage areas and using appropriate procedures like bounding, impermeable surfaces, limited access and labeling;
- Contaminated soil will be separated from uncontaminated material.

7.3.8 Traffic Congestion, Accidents and Stress on roads, rivers and Infrastructure

7.3.8.1 Construction Phase Plan

- Peak traffic hours will be avoided when transporting pipes, other facilities and heavy machinery and project speed will be strictly enforced;
- Qualified drivers will be used and they will follow traffic regulations and they will be trained on safety and environmental awareness;
- There will be use of well maintained appropriate trucks having a gross weight within the axial permissible load;
- Vehicles will be maintained to minimize emissions and fuel consumption;
- Construction traffic will be restricted to approved access roads and the ROW;
- Warning signs will be placed at road crossing and other appropriate locations as required;
- There will be community safety awareness and communities will be discouraged from use of the ROW as road;
- Interruption of traffic flow on major roads will be avoided by conducting underground excavation and installation of the gas pipeline;
- The crossing of secondary roads will be done by direct cutting; it will be done at the lowest traffic flow and there will be establishment of traffic detours;
- Communities will be consulted prior to any temporary road closure;
- Where possible, existing river flow interruption will be maintained by use of measures like trenchless crossing, pumping and channel diversion;
- Temporary traffic control will be established where necessary at road crossings and junctions;
- A local community safety awareness programme will be implemented;
- Speed of vehicles will be restricted to be reduced at residential areas; drivers will be cautioned to reduce speed at residential areas.

7.3.8.2 Operational Phase Plan

During pipeline operation the corridor is accessed on a regular basis. Access may be by foot, vehicle, and boat. Providing and using access routes to a pipeline corridor may have an impact on the environment.

- The ROW will only to be used as an access for activities essential to ensuring continued safe pipeline operation and protection of the local environment, and not as a general thoroughfare;
- Access to the pipeline will be via existing farm tracks and roads only – no new tracks will be created to access the ROW;
- Public access along the ROW will not be permitted;
- The width of the ROW will be kept to the minimum practical width to enable safe vehicle movement;
- In sensitive environments, vehicle access will be restricted as appropriate and foot access only permitted.

7.3.9 Solid Waste Management

7.3.9.1 Construction Plan

- Secured waste storage sites will be established in defined areas away from watercourse and natural drainage part.
- There will be a prohibition on uncontrolled burning or burial of waste.
- Retaining walls and vegetation re-generation will be adopted for disposal sites to minimize erosion and safety risks.
- Small quantities of domestic refuse from construction camps will be collected and disposed in government approved sites.
- Wastes will be segregated into organic waste (food waste), inorganic (glass bottles, cans, plastic bottles), construction waste (scrap timber, scrap metal, etc), combustible waste (paper, cartons, wood chips, etc) and hazardous waste (used oil, oil filters, oil rags, used batteries, etc).

7.3.9.2 Operation Plan

During maintenance workers will not be allowed to litter garbage in the ROW

7.3.10 Socioeconomic Impact Management

The main issues related to socio-economic conditions include; employment, employees training and benefits; business prosperity; compensations; agricultural lands, infrastructure and services, workers and community relations**,** aesthetic value, gas leakage and fire risk, bush fire and vandalism and security. The following management measures will be put in place to address the Socio-economic impact.

7.3.10.1 Employment

There will be employment of people from affected communities in accordance with Nigerian local content and qualified local contractors / suppliers will be considered.

Also, appropriate training (where necessary) will be provided to local people in order to qualify them to get the new job opportunities.

7.3.10.2 Business prosperity

To enhance the positive impact on local businesses located along the pipeline route during construction phase and operation phase, workers will get supplies, food, beverages from local stores. Also there will be renting of apartments, where possible, to replace constructing camps in some areas.

7.3.10.3 Compensation

The displacement of the farmers along the project ROW will result to significant social and economic impacts for the affected households since a source of food and income will be lost. To avoid conflict and ensure smooth compensation of persons whose crops will be affected by the project ROW, the following will be implemented:

- NNPC will get involved and compensate the people in line with Federal Government guidelines on crops and economic trees.
- Promote hiring of local manpower.
- An estate surveyor will be employed by NNPC to enumerate economic trees and crops that will be affected by the project ROW for adequate compensations of the owners.
- NNPC will promote renting of apartments in community rather than creation of temporary settlement during construction
- A compensation committee in each affected states of Kogi, Abuja, Minna, Kaduna and Kano will be established. The committees in each affected state will comprise of Estate surveyor, Environmental consultant/NNPC, affected communities' heads, LGAs, State Ministry of Environment/Environmental Protection Agency, DPR and FMENV. This committee will ensure that the right people are compensated and also monitor the estate surveyor to ensure proper enumeration.
- Compensation will be paid with picture identity

7.3.10.4 Agricultural lands

The gas pipeline will cross some agricultural lands. Although the impact is limited to the ROW, however, the following management plan will be implemented:

- To collect topsoil and keep it separated from other excavated layers in order to return it as it was before excavation;
- Not to place the overburden near the agricultural land;
- Prohibit workers and contractors from cutting any tree or destroying the plants outside the boundaries of the acquired lands (ROW).

7.3.10.5 Infrastructure and services

- Road used by the project will be maintained during construction and any damage to roads caused by the project will be rectified.
- All roads will be restored to a condition at least as good as that existing before the project.
- There will be appropriate signals or signs on all roads which would be constructed and utilized during operation period for access to the project
- Irrigation channels will be restored to at least their pre-existing condition after construction

7.3.10.6 Community relations

- All workers will receive cultural sensitivity and health awareness training where appropriate
- Code of conduct for workers will be established to facilitate relationships with communities during construction phase.
- A community liaison team in each state will be established to facilitate relationships with communities during construction phase; the team will include affected communities' representatives, NNPC's and Environmental Consultant's representatives.

7.3.10.7 Aesthetic Value

Debris resulting from construction will be disposed to areas or dump sites specified by local government. Also, at the end of construction lands along the ROW will be rehabilitated

7.3.10.8 Gas leakage and Fire Risk

To reduce the incidence of gas emission and fire risk the following management measures were proffered:

- Sectionalizing valves will be installed along the 48// pipeline to minimize the quantity of gas release in case of leak / accident, these valves will allow NNPC to isolate the pipe from any section where problems are encountered.
- The distance between the valves and the edge of settlement areas will be around 500 m. Where the pipeline will pass through highly populated areas, thicker wall and concrete slabs located 0.5 m above the pipeline will be used if necessary.
- There will be monitoring and control procedures such as patrolling and involvement of local communities. Venting will be under strict control.
- At branches, the pipe will be protected using concrete slabs at 0.5 m above the pipe.
- Remote control valves will be installed strategically to shut down parts of the system by remote control using when there is major leakage
- Shut down valves will be provided to isolate the branch from the main pipeline.
- Above ground state-of-the-art telemetry devices which feed vital round-the-clock data about the performance and condition of equipment to NNPC will be installed.
- Pipeline internal gauges (PIG) will be sent through the pipes regularly to check for any defaults
- The communities' members will report to NNPC if the following are identified along the ROW:
    - ✓ Vegetation over or near the pipeline, appears to be dead or dying for no apparent reason.
    - ✓ Water bubbling at a stream, river, or any wet area.
    - ✓ Dirt being blown or appearing thrown into the air.
    - ✓ Fire or explosion near or involving the pipeline.
    - ✓ Exposed pipeline, which may have been caused by a natural disaster, such as a flood.
    - ✓ A hissing, whistling or roaring sound along the pipeline right-of-way.
    - ✓ A "rotten egg" odor; natural gas is usually colorless and odorless. It may have a petroleum smell at times unless odorized.

7.3.10.9 Bush fire

Generally, the risk of bushfire as a result of pipeline operation and maintenance is considered low. The following management plan has been proffered:

- Pipeline operations and maintenance will be conducted in accordance with the requirements of the local regulatory and local fire authority
- All equipment will comply with relevant fire safety standards
- Where flammable or combustible chemicals are required to be stored on-site, appropriate containers will be used and fire-fighting equipment will be available. Incompatible chemicals will not be stored together
- Firebreaks will be installed and maintained at facilities as appropriate
- Staff will be trained in basic fire fighting techniques
- Clear vegetation for above ground facilities and the areas around above ground facilities to minimize the risk of bushfire
- Use diesel fuelled vehicles generally to eliminate the risk of hot catalytic converters coming into contact with vegetation and igniting a fire.

7.3.10.10 Vandalism and Security

The pipeline is naturally secured because it is buried below ground, however there is need to take additional steps to secure the pipeline and also enhance the security of the surrounding communities. The measures proffered include:

- The security structure (use of community members) of the existing pipeline will be used for the pipeline (see Appendix-7-1).
- There will be engagement of more community members (in form of youth associations) where the pipeline traverses to ensure surveillance of the pipeline
- The pipeline community security members will be paid promptly
- The communities’ security will have watchful eye by regularly walking the route and report any unauthorized activity, deliberate or otherwise
- Excavation within 3m either side of the pipeline ROW will not be allowed
- There will be enlightenment campaigns among the communities that pipeline traverses to alert the people that the pipeline carries gas which cannot be fetched like petroleum products and that there is no economic gain that will result from vandalism. Also, the people will be made to know the fire danger associated with gas pipeline vandalism and leakage

7.4 Institutional Arrangement for EMP

NNPC will ensure that the project is integrated harmoniously into the host environment and that the project operation will provide an opportunity to play active part in the development of the area.

NNPC will establish an environmental and social monitoring unit (ESMU) that will ensure implementation of the environmental management plan during construction and operational phases of the project.

The unit will be led by project manager and consisting of staff members of NNPC, Environmental Consultant, contractor and communities' representatives.

The unit will be responsible for ensuring that the overall environmental targets are achieved and that the environmental responsibilities and obligation of the EMP is satisfied during project construction and operation.

Also, the unit will coordinate the day-to-day monitoring of regulatory bodies.

There will be 2-way communications to initiate the flow of environmental information among members of the ESMU. The communication will be mainly achieved through site meeting, environmental briefing, site inspection, etc and environmental awareness promotion activities.

The communities' representative will act as liaisons between the unit and all affected communities; they will carry all affected communities along on the implementation of the project.

The environmental Consultant will monitor the implementation of the Environmental management and monitoring plan; regular visit of work areas, collect monitoring data on noise, air, water quality, socioeconomics, discharge of wastewater and solid wastes and provide periodic reports to the Unit for the regulatory bodies. During construction phase the report will be prepared quarterly and operation phase according to agreed schedule. Annual reports presenting monitoring results and analysis will be prepared during construction. The management structure of the ESMU is shown in **Figure 7.1**

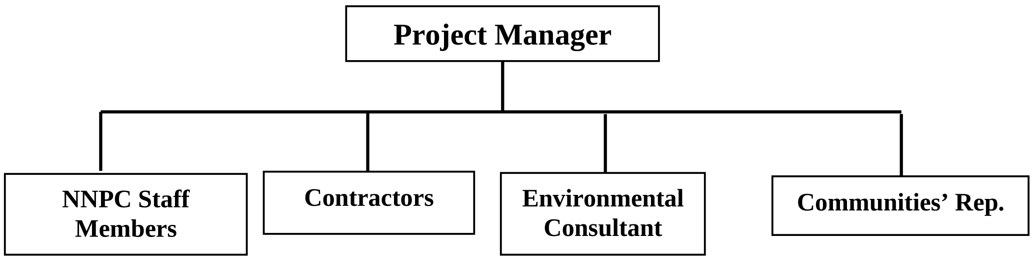

Figure 7.1 Environmental Management Unit Structure

7.5 Environmental Monitoring

The environmental Monitoring plan will serve as an integral part of the construction and operational activities and is expected to generate the requisite information dissemination. The plan will play a pivot role in ensuring that the trends for specific parameters are traced and also will provide information on compliance with legislation norms, set guidelines or desirable operational limits; and form basis for corrective and modification of activities if necessary.

The main objective of the monitoring plan includes the following:

- Ensuring that legal standards for the environmental parameters are not exceeded
- Checking that mitigation measures are implemented
- Providing early warning of environmental damage so that actions may be taken, if possible, to prevent or reduce the seriousness of the unwanted impact

NNPC will ensure that the eventual construction contractor monitors its wastewater discharges in line with FMENV and DPR mandatory requirement on wastewater(s) discharges. The monitoring plan of the project is given in **Table 7.1**

The Environmental Monitoring Plan of the project is summarized in **Table 7.1**;

Table 7.1: Details of Environmental Monitoring Plan

Monitoring Scope	Parameter	Location	Timing		Responsibility
			Construction	Operation	
Air Quality	TSP, NO_2, SO_2, CO	Settlement areas	Monthly	Bi-annual	ESMU, FMENV, DPR and Affected State regulatory agency/board
Noise Level	Noise	Settlement areas	Monthly	Bi-annual	ESMU, FMENV, DPR and Affected State regulatory agency/board
Surface water	TSS COD, BOD, Turbidity, DO, pH, Oil, etc	Rivers and streams crossed by project ROW	Monthly	Annual	ESMU, FMENV, DPR and Affected State regulatory agency/board
Wastewater	TSS COD, BOD, Turbidity, DO, pH, Oil, etc	Surface runoff, hydrostatic water	Monthly	Bi-annual	ESMU, FMENV, DPR and Affected State regulatory agency/board
Soil and Erosion	Top soil management, gradient slope	Along Project ROW	Monthly	Annual	ESMU, FMENV, DPR and Affected State regulatory agency/board
Land use	Agricultural lands	Along Project ROW	Monthly	Bi-annual	ESMU, FMENV, DPR and Affected State regulatory agency/board
Flora/fauna	Land clearing, Plant and animal species	Along Project ROW	Monthly	Annual	ESMU, FMENV, DPR and Affected State regulatory agency/board
Groundwater	Groundwater quality	Along Project ROW	Monthly	Bi-annual	ESMU, FMENV, DPR and Affected State regulatory agency/board
Traffic and safety	Signs, fire risk, public safety records	Roads crossed by project ROW	Monthly	Bi-annual	ESMU, FMENV, DPR and Affected State regulatory agency/board

Monitoring Scope	Parameter	Location	Timing		Responsibility
Infrastructural use	Road and river use	Along Project ROW	Quarterly	Bi-annual	ESMU, FMENV, DPR and Affected State regulatory agency/board
Solid waste	Waste segregation	Along Project ROW	Monthly	Bi-annual	ESMU, FMENV, DPR and Affected State regulatory agency/board
Socioeconomics	Increased local revenue and increased income of locals and Increased employment	Project affected communities	Middle and end of land acquisition	Year 5 and 10 of project operation	ESMU, FMENV, DPR and Affected State regulatory agency/board
	Compensation	Affected persons	Middle and end of land acquisition	Year 5 and 10 of project operation	ESMU, FMENV, DPR and Affected State regulatory agency/board

FMENV= Federal Ministry of Environment, ESMU= Environmental and Social Management Unit,
DPR= Department of Petroleum Resources.

7.5.1 Environmental Audit

In line with the FMENV and DPR requirements, the project will be environmentally audited every three years, this is to check the prediction of the environmental assessment and assess the general performance of the project to ensure that environmental standards are maintained and environmental management and monitoring plan are followed. Environmental audit acts as an internal control process that ensures that environmental protection and management procedures are enforced.

The environmental audit will be conducted by an environmental consultant.

The audit objectives are to examine the line management system and procedures, facility operations and monitoring practices and date. It will cover the following:

- Verification of prediction in the EIA
- Verification of implementation of mitigating recommendations
- Review incident reporting and remedy schemes
- Identification of current and potential environmental problems
- Recommend necessary improvements to management operation practices
- Thorough documentation, feedback and implementation procedures

7.6 Staff Development and Training

Environmental awareness training for operations staff is an integral part of a comprehensive environmental management policy. Environmental training and awareness will be conducted for staff of NNPC.

Environmental issues are a line responsibility for which all staff at all level is accountable.

General information on environmental protection and specialized training courses for dealing with environmental aspects of operations will be offered to staff and contractors to enhance environmental awareness and expertise.

7.7 Contingency Planning

In the design of the gas pipeline construction and operations, relevant standards, codes, specifications, operations and maintenance philosophies, HSE and community issues have been addressed. Despite all these measures, accidents may occur due to equipment failure, negligence, sabotage, and nature catastrophes. Measures will be put in place to handle the situation, the essential elements of the measures (contingency plan) include early warning, activation of plan, evacuation procedure and emergency response contacts, reporting requirements, pollution responses procedure, a structure consisting of personnel, equipment and supplies to implement the plan, and notification system to activate the plan, provision of first aid facilities and training of first aid officers.

7.8 Occupational/Safety Plan

7.8.1 Emergency Response Procedures

The specific objective of the procedures includes the following:-

- Protection of the health and safety of employees, client and the general public.
- Ensure compliance with applicable environmental, health, and safety laws, regulation and guidelines.

7.8.2 Emergency Response

NNPC will develop a comprehensive emergency response procedure that will contain an emergency plan; gas leak detection and a spill discharge response procedure.

In developing an emergency response procedure NNPC will consider the following:

- Comprehensive risk analysis and management planning that will identify risks or emergency events; an established, effective management control, warning and communications system; the plan will be able to address the following:
- Emergency reporting procedure that will highlight the lines of communicating the emergency to the appropriate personnel and support entities like hospitals, fire department, and other governmental agencies.
- Fire response action that will include fire notification, fire brigade procedures and description and location of fire control equipment.
- Evacuation procedures that will include personnel responsibilities during evacuation, identification of evacuation routes and designation of meeting areas. First aid equipment and medications including accident.
- Training of staff on gas leak prevention and response.
- Regular inspections of gas pipeline and storage areas,.

7.8.3 Environmental and Safety Awareness

The staff to be employed for construction and operation of the project will be trained or have adequate knowledge of the potential work hazard. There will be periodic environmental and safety training of staff.

Other media of awareness creation will include the following:

- Organized periodical health and safety workshop
- Pre-employment safety training
- Safety signs and warning pasted at strategic position.
- Caricatures demonstrating safe acts and practices

The communities' members will be aware that they are not to do the following when gas leakage is noticed;

- Use an open flame or bring anything into the area that could cause the gas leak to ignite (phones, lighters, etc.).
- Go near the area. Keep other untrained individuals away from the emergency site.
- Attempt to shut off any valves or extinguish any fires.
- Touch any equipment in the area of a natural gas leak.
- Turn off the ignition or attempt to move it.
- They will leave the area immediately and warn others to stay away.

7.8.4 Safety Plan/Procedure

Accident prevention no matter how minor is a major responsibility of the management. The creation of a safe work environment and development of a safety-minded efficient operation are the economic, legal and moral obligation of NNPC. Enforcement of the safety rules, procedures and codes is also the responsibility of the NNPC.

The safety procedure that will be provided will cover the following;

7.8.4.1 Management Leadership

The safety programme will have the support of the management and an integral part of the project policy.

7.8.4.2 Responsibility Assignment

Responsibility to provide guidance and direction in the enforcement of compliance of staff with safety codes of NNPC will be assigned to a staff (safety officer).

7.8.4.3 Work Condition

Periodic inspection will be conducted with detail records being kept to determine top priority hazardous conditions that will be removed.

7.8.4.4 Training Programme

A Safety training programme that will ensure regular training of the workforce to keep abreast their awareness and efficiency will be organized.

In confirmation with the objectives of safety programme the following training programmes will be implemented:

a) Basic first aid programmes (all employees).

b) Advanced first aid programmes (selected employees).

c) Accident investigation & reporting seminars (supervisory personnel & safety officer.)

The basic first aid programme will be extended to all employees and would be geared to ensure that in the event of an accident or injury, someone with first aid knowledge will always be present to render initial assistance until further medical attention can be made available. Qualified personnel will run seminars to impart the necessary theoretical as well as practical skills required. These courses will be scheduled depending on the employee strength and attrition.

The advanced first aid programme will constitute an upgrading course from the basic first aid programme in which selected employees including supervisors and the Safety officer will be exposed to advanced first aid knowledge and techniques which will enable them to participate in the recognition and the initial management of serious injuries and illnesses e.g. Fractures, Spinal Injuries, Malaria, Typhoid fever etc.

7.8.4.5 Accident Record System

There will be accident record system, to eliminate guesswork relative to accident experience, cost and other specific data.

7.8.4.6 Medical and First Aid System

An equipped first-aid center will be installed for accidents or injuries that require minor treatment and also for major injuries that require a first-aid treatment before a hospital treatment.

There will be records for all first-aid injuries, to determine the frequency and severity rates of injuries.

Serious injuries will be referred to a retainership hospital and medical institution. The medical institution and hospital will be preferably close to the plant and contact will be maintained by radio/ radiophone at all times. In the event of an industrial accident the following protocol will be followed:

a) A basic first aider will be summoned if not already present at scene of accident.
b) The basic first aider will render first aid care.
c) The basic first aider will summon an advanced first aider who will administer further care if necessary and evaluate the necessity for removal to the first aid centre.
d) The advanced first aider will summon the vehicle specifically identified for this purpose and supervise the removal of the injured to the first aid station.

The staff's immediate supervisor will be informed. He will:

1. Make contact with the identified hospital and inform them of the time of arrival of the injured employee.
2. Complete the accident form and forward same along with the injured to the hospital inform the Safety officer who will record the accident in the Industrial accident register.

A vehicle will be available at all times to respond to accidents. That vehicle will be four wheel drives and will have the following equipment:

1. Oxygen cylinder and gas masks resuscitation equipment.
2. A bed and accommodation for a first aid attendant to sit alongside the injured.
3. A flashing light attached to warn other road users.
4. Communication equipment

7.8.4.7 Personnel Safety

Staff will be concern and responsible over his/her safety by complying with HSE policy.

Industrial accident prevention and management will be effected via HSE safety policy/programme. This will commence during the construction phase and last through the operating phase until the cessation of operations. The programme will include the following:

i. Hazard identification and control.

ii. Monitoring and reporting of occupational accidents.
iii. Training or education of employees in industrial first aid.
iv. Industrial Accident Procedure.
v. Fire Safety & Preparation.
vi. Hazard Identification and Control

Table 7.2 provides the potential hazards in different phases of the operations of the project and the preventative and remedial activities necessary for their elimination and control. In addressing these hazards, the first priority will be their elimination via modification in the design of equipment or process. If this is not possible or feasible and the hazard cannot be eliminated, then the employees will be provided with the necessary safety protective gear to prevent any injuries during the work process. Hazard identification and reporting will constitute an ongoing activity in which the employees' participation will be considered an integral part of his work functions. The environmental officer/safety officer will have the following obligation:

- Inspect all machines and equipment for the existence of potential hazards and ensure that they are in working order.
- Inform the worker of any hazards present and remove those if possible.
- Instruct the employee in the correct safe work procedure to prevent any injuries and ensure that those instructions are followed
- Provide the necessary safety protective gear when required.

Table 7.2: Potential Hazards during Construction/Operational Phases

Phase	Potential Hazard	Protective and Preventive Safety measures
Clearing of site and construction of: Vegetation Removal of top soil and overlying vegetation Assemble of pipes	Lacerations from use of sharp tools	Use of safety shoes and gloves
Transportation and installation of pipes	Fugitive dust blown into eyes Inhalation of fugitive dust High noise levels from working of heavy duty vehicles	Use of clear goggles Use of dust/mist respirators Use of ear plugs
Operation/Maintenance operations	Skin irritation from exposure to leakage. Welding	Use of bam or creams and detergents on hands Use of eye goggles

7.8.5 Public Safety

Line markers will be used to indicate the approximate location of pipeline along the ROW.

The markers will display the material transported in the line, the name of the pipeline operator, and the telephone number where the operator can be reached in the event of an emergency.

The greatest risk to underground natural gas pipelines is accidental damage during excavation. Even minor damage such as a gouge, scrape, dent, or crease to a pipeline or its coating may cause a leak or failure. To protect pipelines, the excavators will contact NNPC in the immediate area.

7.8.6 House Keeping Procedure

The Personal Protective Equipment that will be used will be of standard quality and include; helmet, nose mask for gas pipeline workers, safety boot, earmuff and coverall.

The first-aid system at the site will be functional

The staff will be educated (gas pipeline workers) on the material types and potential hazards of the pipeline. The staff will be educated on how to handle potential hazards and safety procedures of the pipeline.

Waste (solid) collection and disposal will be carried out by an approved management contractor.

7.8.7 Record Keeping Procedure

The record keeping procedure of the project operation will include the following;

- Information on relevant environmental regulations and requirements; the information must include National Environmental Laws, National Guideline for Environmental Audit and Environmental Management System in Nigeria, FMENV Guideline and Standard for Environmental Pollution Control in Nigeria (1991), International Standards (WHO standard for potable water etc) National Environmental Protection Regulation (FMENV 1991) and DPR guidelines and standards.

- Complaints from neighbours on how the project will negatively or positively affect the life of its people vis-à-vis pollution incidence and socio-economics.

- Data on staff education/training that must include: Type of training, category and number of staff that attended, venue of training, trainer, date, courses outline.

- Records on the type of inspection and maintenance carried out and it will include the following:
    - Daily inspection report; facilities inspected.
    - Outcome of the inspection, dates and number of inspection carried out, number of maintenance work carried out, number and type of staff involved, facility, type of waste generated, and method of disposal.
    - Incidence reports will include pollution incidence, accident and type. Type of pollution (air emission, effluent discharge etc), common (epidemic) diseases.
    - Pertinent contractor and supplier information: Record that will cover the following must be kept.
    - Chemical procurement; name of material, manufacturers name, flash point (closed or opened), auto ignition temperature, explosive range, shelf live, and other hazardous properties.

7.9 Decommissioning Plan

7.9.1 Introduction

As the pipeline wears out (as a result of wear and tear) to non/low gas supply levels, the project is no longer viable. This often marks the end of the pipeline's useful lifetime and heralds the requirement to abandon /or decommission the project. The project is designed, built and maintained to operate efficiently for about 50 years after which, it will be decommissioned in conformity with a plan that meet local and international regulatory requirement and standards.

A general approach will be to commence detailed planning of decommissioning activities from the project initial stage in line with EGASPIN Part VIIIG (A1.0) provisions. This would ensure a safe, environmental friendly and efficient decommissioning programme.

A plan will be developed that will establish:

- Facilities to be decommissioned or recovered
- Environmental aspect of the decommissioning activity
- Methods for facility re-use, recycling, disposal or removal
- Proper consultation with all stakeholders (communities, other land users and regulators)
- Efforts to integrate negative environmental impacts and appropriately rehabilitate site
- Programmes for restoring the environment in accordance with national and international best practices and regulatory requirement.
- Scope of work to assess possible residual impacts of the gas pipeline in the environment.

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-operation study of the impacts of the project on the environment will be conducted to determine appropriate restoration and remedial measures. At this stage, only preliminary plans exist for decommissioning activities.

In general, however, decommissioning activities will be conducted in compliances with applicable regulations and guidelines or any other regulations that are in force at the time of decommissioning. The plan will also include regulations and a risk and cost analysis of various options.

The plan will consider all facilities associated with the project.

7.9.2 Stakeholders Consultation

The project-decommissioning plan will include consultation with various stakeholders including employees from various departments, communities, regulators and experts. The decommissioning team will include competent personnel from NNPC as well as the regulatory authorities.

7.9.3 Wind – Down Operations

As the project approaches the end of its economic viability, plans will be put in place to wind down operations.

These will include a review and rationalization of operations and personnel and a possible gradual shut down of some facilities. The decommissioning will be planned for a significant period before the cessation of the project. This will allow for a carefully planned redeployment and, where necessary, disengagement of personnel as appropriate.

An adequate Compensation will be provided and remove those if possible to the disengaged personnel to take care of themselves before getting their hands on new jobs.

7.9.4 Decommissioning of Above Structure Facilities

At the end of the pipeline utilitization, all equipment will be decommissioned. The Environmental plan will be implemented to assure safety of personnel and the public during decommissioning as well as minimize negative environmental impacts.

Particular attention will be paid to the following:

- Protection from noise
- Waste handling
- Spent oil management
- Air pollution.

All structures will be dismantled and removed from the site. Disturbed areas (vegetation) will be identified and restored using native plant species.

7.9.5 Re-Use/Recycling of Equipment

All facility components that can be used or re-cycled will be identified and quantified. Re-useable facilities will either be sold or converted to other uses.

7.9.6 Reporting

As required by regulations, a post decommissioning reports will be prepared and submitted to FMENV and DPR and local regulatory authorities.. The reports will provide the following details

- Overview of decommissioned facilities
- Details of methods used for decommissioning
- Nature of decommissioning (partial or whole)
- Records of consultation meetings
- Details of recyclable /re-useable material/ facility components
- Decontaminated facilities
- Decommissioning schedules
- State of surrounding environment
- Waste management plan
- Plans for restoration, where necessary.

CHAPTER EIGHT

8.0 CONCLUSIONS

The Environmental Impact Assessment study was carried out with strict adherence to the guidelines and regulation of the Federal Ministry of Environment and Department of Petroleum Resources (DPR). The study has identified the environmental issues/impacts associated with project activities on the immediate environment. And, in order to minimize these impacts appropriate mitigation has been proffered

On the socio-economic impacts, potentially, the project will provide social and economic opportunities capable of enhancing the economic growth of the host communities in particular and the country in general.

Generally the project construction and operation phase indicated very low and low significant impact.

The assessment showed that the majority of the impacts will be associated with the construction phase. Potential construction impacts will be mitigated through the implementation of good construction practice, adherence to management plans, and through the application of localized measures to protect specific or sensitive receptors.

The operation of the pipeline will result in minimal localized impacts and measures have been provided to ensure safe pipeline operation.

Consultation indicates that most communities are generally positive towards the project. Their perception is that any disruption will be temporary and offset by potential economic benefits both to their community and to the nation.

Two positive aspects were particularly prominent during consultation, firstly in relation to possible employment opportunities, and secondly in relation to possible expenditure on local goods and services by construction workers.

It is generally anticipated that both the construction and operation of the pipeline will bring short and long term benefits to the communities. These are particularly relevant in relation to employment, provision of goods and services and community investment which will provide long-term benefits to many communities thereby helping to off-set any short-term negative impacts.

Mitigation measures have been proffered to reduce the adverse effects that might arise from project activities. Communities shall be carried along during project implementation.

Thus, the project is adjudged to be environmentally friendly as supported by this EIA report. Consequently the project should be undertaken by the Nigerian National Petroleum Corporation (NNPC).

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