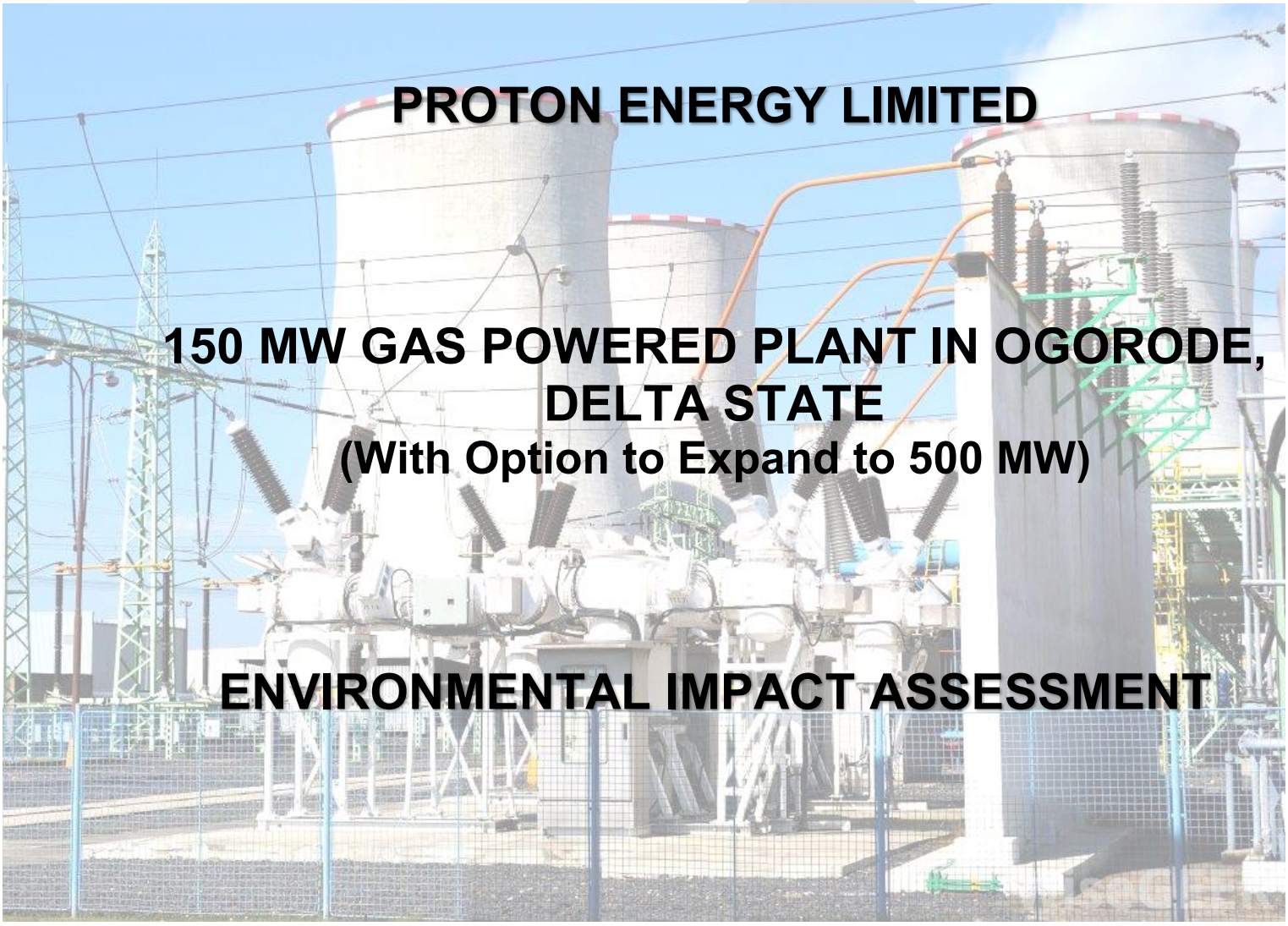

PROTON ENERGY LIMITED

150 MW GAS POWERED PLANT IN OGORODE, DELTA STATE

(With Option to Expand to 500 MW)

ENVIRONMENTAL IMPACT ASSESSMENT

FINAL REPORT **(updated) NOVEMBER, 2016**

150 MW GAS POWERED PLANT PROJECT
(With Option to Expand to 500 MW)

ENVIRONMENTAL IMPACT ASSESSMENT

FOR

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Lagos, Nigeria.

BY

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TABLE OF CONTENT

Table of Contents i of vi
List of Appendices, Figures, Plates and Tables iv of vi
List of Abbreviations and Acronyms i of iv
List of Preparers i of i
Acknowledgement i of i

EXECUTIVE SUMMARY i of xiv

CHAPTER ONE 1 of 28
INTRODUCTION 1 of 28
1.1 Background Information 1 of 28
1.2 Project Activities 1 of 28
1.3 EIA Overview 1 of 28
1.4 Project Proponent 2 of 28
1.5 Project Location 2 of 28
1.6 EIA Objectives 5 of 28
1.7 EIA Scope of Work 5 of 28
1.8 EIA Methodology 5 of 28
1.9 Legal and Administrative Framework for EIA in Nigeria 8 of 28
1.9.1 National Regulations 8 of 28
1.9.2 State Regulations 19 of 28
1.9.3 International Legal Framework 20 of 28
1.10 EIA Approval Process in Nigeria 27 of 28
1.11 Structure of Report 28 of 28

CHAPTER TWO 1 of 9
PROJECT JUSTIFICATION 1 of 9
2.1 Need for the Power Plant Project 1 of 9
2.2 Benefits of the Proposed Project 2 of 9
2.3 Envisaged Project Sustainability 2 of 9
2.4 Project Development Alternatives 4 of 9
2.4.1 Project Development Alternatives 7 of 9
2.4.2 Power Plant Alternatives 7 of 9
2.5 Site Selection 11 of 9

CHAPTER THREE 1 of 15
PROJECT DESCRIPTION 1 of 15
3.1 Project Overview 1 of 15
3.2. Project Components 1 of 15
3.3 Land Acquisition Process 2 of 15
3.4 Staffing 3 of 15
3.5 Setback Consideration 3 of 15
3.6 Project Details 4 of 15
3.6.1 PEL Technology Choices 4 of 15
3.6.2 Gas Turbines Specification 7 of 15
3.6.3 Electricity Evacuation and Transmission 8 of 15
3.6.4 Gas Supply 9 of 15
3.6.5 Ancillary Project Components 9 of 15
3.6.6 Plant Water Supply and Cooling System 10 of 15
3.6.7 Control System and Instrumentation 10 of 15
3.6.8 Compressed Air and Ventilation Systems 10 of 15
3.7 Project Design Basis 11 of 15

3.8 Project Execution Phases 11 of 15
3.8.1 Pre-Construction Phase 11 of 15
3.8.2 Construction and Installation Phase 11 of 15
3.8.3 Operation Phase 12 of 15
3.8.4 RFP Process 12 of 15
3.9 Appointment of OEM and EPC Contractor 13 of 15
3.10 Material Procurement and Fabrication 13 of 15
3.11 Security 13 of 15
3.12 Access Road to Site 13 of 15
3.13 Project Waste Streams and Emissions 13 of 15
3.14 Decommissioning and Restoration Plan 15 of 15
3.15 Project Schedule 15 of 15

CHAPTER FOUR 1 of 84
EXISTING ENVIRONMENTAL CONDITION 1 of 84
4.1 General 1 of 84
4.2 Baseline Data Acquisition Methods 1 of 84
4.2.1 Literature Research 1 of 84
4.2.2 Field Sampling 1 of 84
4.2.3 Laboratory Analysis 5 of 84
4.3 Climate and Meteorology 6 of 84
4.3.1 Wind Speed 6 of 84
4.3.2 Wind Direction 7 of 84
4.3.3 Relative Humidity 7 of 84
4.3.4 Ambient Air Temperature 8 of 84
4.3.5 Rainfall 8 of 84
4.4 Ambient Air Quality 9 of 84
4.5 Noise Level 13 of 84
4.6 Hydrology 14 of 84
4.7 Topography 14 of 84
4.8 Geology 15 of 84
4.9 Groundwater Characteristics 16 of 84
4.10 Soil Characteristics 18 of 84
4.11 Sediment Characteristics 24 of 84
4.12 Surface Water 27 of 84
4.13 Hydrobiology 30 of 84
4.14 Fish Study 38 of 84
4.15 Fauna Study 40 of 84
4.16 Vegetation Study 44 of 84
4.17 Protected Areas 49 of 84
4.18 Habitat Categorisation and Ecosystem Services 50 of 84
4.18.1 Habitat Categories and Types 54 of 84
4.18.2 Ecosystem Services 60 of 84
4.19 Socioeconomic and Health Profile 61 of 84
4.19.1 Project Stakeholder 62 of 84
4.19.2 Consultations 62 of 84
4.19.3 Demographic Conditions 66 of 84
4.19.4 Population Distribution 67 of 84
4.19.5 Socio-Cultural Resources of the Community 70 of 84
4.19.6 Quality of Life 73 of 84
4.19.7 The Economy 75 of 84
4.19.8 Health Characteristics 78 of 84
4.19.9 Infrastructural Base of Study Area 81 of 84
4.19.10 Vulnerable Groups 82 of 84
4.19.11 Perceptions, Concerns and Expectations of Residents 83 of 84

4.19.12 Project Disclosure 83 of 84

CHAPTER FIVE **1 of 29**
IMPACT ASSESSMENT **1 of 29**
5.1 General 1 of 29
5.2 Impact Assessment Methodology 1 of 29
5.3 Project Activities 2 of 29
5.4 Impact Identification 2 of 29
5.5 Impact Characterisation 5 of 29
5.6 Impact Evaluation 8 of 29
5.7 Result of Impact Assessment 11 of 29
5.8 Impacts Assessment Discussion 17 of 29
5.8.1 Beneficial Impacts 17 of 29
5.8.2 Adverse Impacts 17 of 29
5.8.3 Cumulative Impacts 29 of 29

CHAPTER SIX **1 of 12**
MITIGATION MEASURES AND RESIDUAL IMPACTS **1 of 12**
6.1 General 1 of 12
6.2 Mitigation Measures 3 of 12

CHAPTER SEVEN **1 of 29**
ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN **1 of 29**
7.1 General 1 of 29
7.2 ESMP Objectives and Guiding Principles 1 of 29
7.3 Project Management and Responsibilities 2 of 29
7.4 ESMP Safeguard Guidelines 2 of 29
7.4.1 Training and Awareness Plan 13 of 29
7.4.2 Public Participation/ Involvement Plan 13 of 29
7.4.3 Regulatory Compliance Plan 15 of 29
7.4.4 Project Design Guidelines 15 of 29
7.4.5 Project Execution Guidelines 15 of 29
7.4.6 Inspection and Maintenance Procedures 16 of 29
7.4.7 Risk Assessment and Management 17 of 29
7.4.8 Worker Safety and Health Plan 18 of 29
7.4.9 Pollution Control Guidelines 19 of 29
7.4.10 Emergency Response Plan 20 of 29
7.4.11 Communication Plan 21 of 29
7.4.12 Environmental Monitoring Plan 21 of 29
7.4.13 Waste Management Plan 24 of 29
7.4.14 Security Plan 26 of 29
7.4.15 Project Climate-Resilience 27 of 29
7.4.16 Environmental Audit and Review 28 of 29
7.4.17 Decommissioning and Abandonment 28 of 29
7.5 Cost for ESMP Implementation and Monitoring 29 of 29

CHAPTER EIGHT **1 of 2**
CONCLUSION **1 of 2**

REFERENCE **1 of 5**

LIST OF APPENDICES, FIGURES, PLATES AND TABLES

List of Appendices

Appendix 1.1: Terms of Reference
Appendix 1.2: FMEnv Public Display and Announcement Letters
Appendix 2.1: Proton Energy Limited Community Social Responsibility Policy
Appendix 3.1: Proton Energy Limited Survey Plan
Appendix 3.2: Evidence of Electricity Evacuation Approval
Appendix 3.3: Applicable Standards and Code
Appendix 4.1: Data Gathering Procedure
Appendix 4.2: Soil Physico-Chemical and Microbiology Results
Appendix 4.3: Sediment Physico-Chemical and Microbiology Results
Appendix 4.4: Surface water Physico-Chemical and Microbiology Results
Appendix 4.5: Hydrobiology Characteristics
Appendix 4.6: Evidences of Consultation
Appendix 4.7 Questionnaires Sample
Appendix 5.1: Air and Noise Modelling Report
Appendix 5.2: Climate and Disaster Risk Screening Report for Energy Project in Nigeria- Proton Delta Sunrise Project

List of Figure

Figure 1.1: Location of Sapele LGA 3 of 28
Figure 1.2: Aerial View of Project Area 4 of 28
Figure 1.3: EIA Methodology Flowchart 6 of 28
Figure 1.4: FMEnv EIA Process 28 of 28
Figure 3.1: Proposed Project Layout 2 of 15
Figure 3.2: Open Cycle Power Plant Schematics 5 of 15
Figure 3.3: Combined Cycle Power Plant Schematics 7 of 15
Figure 3.4: PEL Power Plant Project Timeline 15 of 15
Figure 4.1 Sample Stations Distribution 4 of 84
Figure 4.2: Average Wind Speed of Study Area 6 of 84
Figure 4.3: Wind Rose 7 of 84
Figure 4.4: Average Relative Humidity of Study Area 8 of 84
Figure 4.5: Minimum and Maximum Temperature of Study Area 8 of 84
Figure 4.6: Average Rainfall Data of Study Area 9 of 84
Figure 4.7: Topography Map of Project Area 15 of 84
Figure 4.8: Niger Delta Stratigraphic Column Formations 16 of 84
Figure 4.9: Soil Types from Study Area 19 of 84
Figure 4.10a: Soil Particle Size Distribution –Dry Season 20 of 84
Figure 4.10b: Soil Particle Size Distribution –Wet Season 21 of 84
Figure 4.11a: Sediment Particle Size Distribution – Dry Season 25 of 84
Figure 4.11b: Sediment Particle Size Distribution – Wet Season 26 of 84
Figure 4.12: Plankton Percentage Count and Species Richness -Dry season 31 of 84
Figure 4.13: Plankton Percentage Count and Species Richness -Wet season 32 of 84
Figure 4.14: Phytoplankton Group – Dry Season 33 of 84
Figure 4.15: Phytoplankton Group –Wet Season 33 of 84
Figure 4.16a: Zooplankton Group – Dry Season 34 of 84
Figure 4.16b: Zooplankton Group – Wet Season 34 of 84
Figure 4.17: Margalef Indices in Dry Season 35 of 84
Figure 4.18: Margalef Indices in Wet Season 35 of 84
Figure 4.19: Percentage Abundance of Macro-benthos Species -Dry Season 36 of 84
Figure 4.20: Percentage Abundance of Macro-benthos Species -Wet Season 36 of 84
Figure 4.21: Specie Indices-Dry Season 37 of 84
Figure 4.22: Specie Indices -Wet Season 38 of 84

Figure 4.23: Sapele Main Market Location 39 of 84
Figure 4.24: Vegetation Study Map 46 of 84
Figure 4.25: Proximity of Plant Location to Protected Forest Reserves 51 of 84
Figure 4.26: Biodiversity AoI Overview 53 of 84
Figure 4.27: Major Ecological Zones Around DSP Area 55 of 84
Figure 4.28: Habitat Types and Categories 58 of 84
Figure 4.29: Traditional Organisation 72 of 84
Figure 4.30: Livelihood Activities of Ogorode Residents 76 of 84
Figure 4.31: Expenditure Pattern of Households 77 of 84
Figure 5.1: Impact Assessment and Management Flowchart 1 of 29
Figure 5.2: Projected NO_x Emission Pattern 21 of 29
Figure 6.1: Matrix for Determination of Mitigation Measures 1 of 12
Figure 7.1: Company Organisational Structure 3 of 28
Figure 7.2: Effective Grievance Mechanism Components 14 of 28
Figure 7.3: PEL Waste Management Principles 24 of 28

List of Plate

Plate 3.1: Aerial View of Project Location 4 of 15
Plate 3.2: Siemens SGT 800 Gas Turbine System 6 of 15
Plate 3.3: GE GT -6F.03 Single Shaft Cross-Section 6 of 15
Plate 4.1: Fish Species Observed in Study Area 41 of 84
Plate 4.2: Mona Monkey 42 of 84
Plate 4.3: Bird Species Observed in Study Area 44 of 84
Plate 4.4: Plant Species Observed in Transect 1 47 of 84
Plate 4.5: Plant Species Observed in Transect 2 48 of 84
Plate 4.6: Plant Species Observed in Transect 3 48 of 84
Plate 4.7: Plant Species Observed in Transect 4 48 of 84
Plate 4.8: Flora Rapid Assessment 51 of 84
Plate 4.9: Fauna Rapid Assessment 51 of 84
Plate 4.10: Consultation Session 65 of 84
Plate 4.11: Nepa Staff School Entrance 72 of 84
Plate 4.12: Cement Block Houses in the Community 74 of 84
Plate 5.1: Cattles Grazing within the Project Site 23 of 29
Plate 5.2: Existing Plant Facility from Ethiope River 26 of 29

List *of Table*

Table 1.1: PEL- EIA Activities Timeline 8 of 28
Table 1.2: Equator Principles 23 of 28
Table 2.1: Electricity Generation in some Countries 1 of 9
Table 2.2: Professionals involved in Project 3 of 9
Table 2.3: Comparative Analysis of Fuel Source for Power Generation 5 of 9
Table 2.4: Emission data for Coal and Gas-fired plants 9 of 9
Table 3.1: Proposed OCGT Plant Design Specification 4 of 15
Table 3.2: General Gas Turbine Specifications 7 of 15
Table 4.1: Sampling Requirement and Co-ordinates 2 of 84
Table 4.2: Ecological Components, Analytical Methods and Test Equipment 5 of 84
Table 4.3: Average Wind Direction 7 of 84
Table 4.4: Air Parameters and Monitoring Equipment 9 of 84
Table 4.5a: Air Quality Measurement Results – Dry Season 10 of 84
Table 4.5b: Air Quality Measurement Results – Wet Season 10 of 84
Table 4.6a: Noise Levels within Study (Industrial) Area 13 of 84
Table 4.6b: Noise Levels within Study (Residential) Area 14 of 84
Table 4.7: Groundwater Physico Chemical Characteristics 17 of 84
Table 4.8a: Groundwater Microbiological Characteristics – Dry Season 18 of 84
Table 4.8b: Groundwater Microbiological Characteristics – Wet Season 18 of 84

Table 4.9: Groundwater Anaerobic Bacteria Characteristics 18 of 84
Table 4.10: Soil Physico-chemical Characteristics 19 of 84
Table 4.11: Soil Microbiological Characteristics 23 of 84
Table 4.12: Soil Anaerobic Bacteria Characteristic 24 of 84
Table 4.13: Sediment Physico-chemical Characteristics 24 of 84
Table 4.14: Sediment Microbiological Characteristics 26 of 84
Table 4.15: Sediment Anaerobic Bacteria Characteristic 27 of 84
Table 4.16: Surface Water Physico-chemical Characteristics 27 of 84
Table 4.17: Surface Water Microbiological Characteristics 30 of 84
Table 4.18: Surface Water Anaerobic Bacteria Characteristic 30 of 84
Table 4.19: Fish Composition within Ethiope River 35 of 84
Table 4.20: Mammals Reported in the Study Area 40 of 84
Table 4.21: Birds Species Reported in the Study Area 43 of 84
Table 4.22: Reptiles in the Study Area 45 of 84
Table 4.23: Amphibians Observed in the Study Area 45 of 84
Table 4.24: List of All Plant Species Observed within Study Area 49 of 84
Table 4.25: Habitat Types and Categories 56 of 84
Table 4.26: Dominant Species Photo Log 59 of 84
Table 4.27: Project Consultation Program 63 of 84
Table 4.28: Summary of Responses during Project Consultation 64 of 84
Table 4.29: Age and Sex Distribution of Respondents 66 of 84
Table 4.30: Projected Population of Sapele LGA (2013- 2017) 66 of 84
Table 4.31: Age and Sex Distribution in Sapele LGA, 2006 Census 68 of 84
Table 4.32: Education Attainment in Sapele LGA, 2010 69 of 84
Table 4.33: Marital Status of Respondents to Household Questionnaire 71 of 84
Table 4.34: Housing Attributes in Ogorode Community 74 of 84
Table 4.35: Household Monthly Income Levels in the Study Area 77 of 84
Table 4.36: Times Household Members Sought Medical Attention in a Month 79 of 84
Table 4.37: Common Disease Vectors in the Study Area 79 of 84
Table 4.38: Use of Health Services by Household Members 80 of 84
Table 4.39: Frequency in Difficulties to Satisfying Household Food Needs 81 of 84
Table 4.40: Infrastructural Framework of the Study Area 82 of 84
Table 5.1: Project Activities – Environmental Interaction Matrix 3 of 29
Table 5.2: Proton Energy Power Plant Impacts Categorisation 5 of 29
Table 5.3: Legal/ Regulatory Requirements 9 of 29
Table 5.4: Risk Criteria 9 of 29
Table 5.5: Frequency Criteria 9 of 29
Table 5.6: Importance Criteria 10 of 29
Table 5.7: Public Perception /Interest Criteria 10 of 29
Table 5.8: Potential Impact Evaluation 12 of 29
Table 5.9: OCGT Plant Design Specification 20 of 29
Table 5.10: Typical Noise Levels of Construction Equipment 22 of 29
Table 5.11: Health Effect of Major Pollutants 25 of 29
Table 6.1: Mitigation Measures Proffered for Significant Impacts 3 of 12
Table 7.1: ESMP Guidelines for the Proposed Power Plant Project 4 of 29
Table 7.2: Recommended Environmental and Social Monitoring Programme 22 of 29
Table 7.3: Waste Handling and Disposal Method 24 of 29

LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviations and Units of Measurement

°C	Degrees Centigrade
%	Percentage
µg/l	Micro Gram per Liter
µS/cm	Micro Siemens per Centimeter
cfu/ml	Colony Forming Units
dB (A)	Decibel Class A
EC	Electrical Conductivity
g/kg	Gramme per Kilogramme
Hz	Hertz
Kj	Kilojoule
km	Kilometer
kV	Kilovolt
kVA	Kilovolt Ampere
kWh	Kilowatt hour
m	Meter
m/s	Meter per Second
mg/kg	Miligramme per Kilogramme
mg/l	Miligramme per Litre
mg/m^3	Miligramme per Meter Cube
ml	Mililitre
mm	Milimeter
mmscf/d	Million Standard Cubic feet per Day
MW	Megawatts
NTU	Nephelometric Turbidity Units

General Abbreviations and Acronyms

APHA	American Public Health Association
ALARP	As Low As Reasonably Practicable
ASTM	American Society for Testing and Material
BCG	Bacillus Calmette Guérin
BEDC	Benin Electricity Distribution Company
BH	Borehole
BMI	Body Mass Index
BOD	Biological Oxygen Demand
BS	British Standard
BTU	British Thermal Unit
Ca	Calcium
CAEM	Chemical Analysis of Ecological Materials
CBD	Convention on Biological Diversity
CBO	Community Based Organisations
CBD	Convention on Biological Diversity
CBR	Crude Birth Rate
CCGT	Combined Cycle Gas Turbine
CITES	Convention on International Trade in Endangered Species
CLO	Community Liaison Officer
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
Cond	Conductivity
CO_x	Oxides of Carbon
Cr	Chromium
Cu	Copper

DELSEPA	Delta State Environmental Protection Agency
DGPS	Differential Global Positioning System
DLE	Dry Low Emission
DNA	Deoxyribonucleic Acid
DO	Dissolved Oxygen
DSG	Delta State Government
DSMENV	Delta State Federal Ministry of Environment
EA	Environmental Assessment
EAR	Environmental Audit Report
EC	Electrical Conductivity
ECN	Energy Commission of Nigeria
EGASPIN	Environmental Guideline and Standard for the Petroleum Industry in Nigeria
EHS	Environmental, Health, and Safety
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMS	Environmental Management System
ERP	Emergency Response Procedure
ESMP	Environmental and Social Management Plan
EPA	Environmental Protection Agency
EPC	Engineering, Procurement and Construction
ESA	Environmentally Sensitive Areas
ESIA	Environmental Social Impact Assessment
FA	Factories Act
FAAS	Flame Atomic Absorption Spectrophotometer
Fe	Iron
FEED	Front End Engineering Design
FEPA	Federal Environmental Protection Agency
FGD	Focus Group Discussions
FGN	Federal Government of Nigeria
FMEnv	Federal Ministry of Environment
FNL	Fugro Nigeria Limited
FTIR	Fourier Transform Infrared Radiation
GC	Gas Chromatography
GE	General Electric
GGD	General Group Discussion
GIIP	Good International Industry Practice
GIS	Geographic Information System
GPS	Global Positioning System
GSA	Gas Supply Agreement
GSM	Global System for Mobile Communications
GTG	Gas Turbine Generators
H_2S	Hydrogen Sulphide
HBV	Hepatitis B Vaccine
HHV	Higher Heating Value
HIV	Human Immunodeficiency Virus
HRSG	Heat Recovery Steam Generator
HSE	Health, Safety and Environment
HUB	Hydrocarbon Utilising Bacteria
HUF	Hydrocarbon Utilising Fungi
EC	International Electrotechnical Commission
IDI	In Depth Interviews
IFC	International Finance Corporation
IMM	Impacts Mitigation and Monitoring
IMR	Infant Mortality Rate
IPP	Independent Power Plant

IR	Infra Red
ISO	International Organisation for Standardisation
ITCZ	Inter Tropical Convergence Zone
IUCN	International Union for the Conservation of Nature
Lat	Latitude
LDAR	Leak Detection and Repair
LFN	Law of Federal Republic of Nigeria
LGA	Local Government Area
LGC	Local Government Council
Long	Longitude
LPG	Liquefied Petroleum Gas
K	Potassium
Mg	Magnesium
MIP	Maintenance and Inspection Programme
Mn	Manganese
MoU	Memorandum of Understanding
MSDS	Material Safety Data Sheets
MTN	Mobile Telecommunications Company
Na	Sodium
NAAQS	National Ambient Air Quality Standards
NBET	Nigerian Bulk Electricity Trader
NBS	National Bureau of Statistics
NCE	National Certificate of Education
Ni	Nickel
NIPP	National Integrated Power Project
NEPA	National Electric Power Authority
NERC	Nigerian Electricity Regulatory Commission
NESREA	National Environment Standards and Regulation Enforcement Agency
NIMET	Nigerian Meteorological Agency
NGO	Non-Governmental Organisation
NMR	Neonatal Mortality Rate
NO_x	Nitrogen Oxides
NPC	National Population Commission
NPE	National Policy on Environment
OCT	Over the counter drugs
OCGT	Open Cycle Gas Turbine
OEM	Original Equipment Manufacturer
O & M	Operations and Maintenance
OP	Operational Policies
OPV	Oral Polio Vaccine
PA	Project Associate
Pb	Lead
PEL	Proton Energy Limited
PF	Power Factor
PHCN	Power Holding Company of Nigeria
PM	Particulate Matter
PMT	Project Management Team
PPE	Personal Protective Equipment
PPM	Parts per Million
Proton DSP	Proton Delta Sunrise Project
PSD	Particle Size Distribution
QA/ QC	Quality Assurance/ Quality Control
QHSE	Quality Health Safety and Environment
RAM	Risk Assessment Matrix
RCP	Regulatory Compliance Plan

R&D	Research and Development
RFP	Request for Proposal
RTI	Respiratory Tract Infection
Seplat	Seplat Petroleum Development Company
SO_x	Oxides of Sulphur
SPM	Suspended Particulate Matter
SPM	Site Project Manager
SS	Soil Sample
STG	Steam Turbine Generator
STD	Sexually Transmitted Disease
SUV	Sports Utility Vehicle
SW	Surface water
TBA	Traditional Birth Attendant
TCN	Transmission Company of Nigeria
TFR	Total Fertility Rate
THC	Total Hydrocarbon Content
TOC	Total Organic Carbon
ToR	Terms of Reference
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
USD	United State Dollar
UN	United Nation
UV	Ultra violet
V	Vanadium
VS	Visible Spectrophotometer
VOC	Volatile Organic Carbon
WHO	World Health Organisation
WTW	Wissenschaftlich-Technische-Werkstätten
Zn	Zinc

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We also appreciate the support of Ogorode Community and our other stakeholders who actively participated in the EIA process.

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

INTRODUCTION

A Gas Turbine Powered Plant is proposed for construction and operation by Proton Energy Limited (PEL) in Sapele in Delta State, Nigeria, West Africa. The project ("Proton Delta Sunrise") is aimed at adding electricity supply to the National Grid, as part of the country's plan to boost power generation.

PEL intends to develop at completion a 500MW power plant in two phases. First phase would be the construction and operation of a 150 MW Open Cycle Gas Turbine (OCGT) plant. The second phase would see the addition of 350 MW, as well as a conversion to Combine Cycle Gas Turbine (CCGT) system. This document presents the Environmental Impact Assessment (EIA) study carried out for the proposed development, and emphasizes the construction and operation of 150MW at phase one. However, all environmental assessment and socio-economic impacts study was carried out in view of the intended total plant capacity of 500 MW at the completion of phase two of the project.

The proposed power project would also include:

- Installation of 1 km tie-in electricity transmission evacuation line; and
- Installation of 1.5 km gas pipeline connected to a supply system.

Other components include; gas turbine generators, gas reducing station, cooling system, water treatment plant; fire hydrants, fire pump skid, lube oil cooler, air compressors, step up transformers, electrical and an administrative building.

In line with the Nigerian Environmental Impact Assessment Act Cap E12 LFN 2004 and in fulfillment to World Bank/ International Finance Corporation (IFC) requirements, an Environmental Impact Assessment (EIA) study has been conducted and report prepared. The report contains a non-technical summary of the proposed project activities as presented herein.

Project Location

The power plant project would be located adjacent to two existing power plants (CMEC/Eurafric and NIPP) in Ogorode Community, Sapele Local Government Area. Distance between the proposed power plant and existing power plants is about 500 meters. PEL has acquired 27.4 hectares of land for the development of the power plant up to the proposed 500 MW. Of this land area, land take for the development of Phase 1 will be about 6 hectares.

Co-ordinates of the proposed project facility are; latitude 5.927177, longitude 5.641284; latitude 5.923454, longitude 5.643188; latitude 5.921454, longitude 5.638043; latitude 5.925132, longitude 5.636166 respectively.

Legal and Administrative Framework

The legal frameworks upon which this EIA project was carried out includes:

- The EIA Act Cap E12 LFN 2004;
- National Guidelines and Standards for Environmental Pollution Control in Nigeria, 1991;
- NESREA Act of 2007;
- Electricity Power Sector Reform Act, 2005;
- Energy Commission of Nigeria Regulation, 1988;
- The Nigerian Urban and Regional Planning Act No.10 of 2010;
- National Inland Waterways Authority, Act No. 13 of 1997;
- The Forestry Act CAP 51 LFN of 1994;
- The Labour Act 1990;
- The Land Use Act of 1978;
- Endangered Species Act, Cap 108 of 1990;

- Harmful Waste Act Cap H1, LFN 2004;
- Delta State Regulations;
- Equator Principles;
- World Bank's Environmental and Social Safeguard Policies; and
- Other International conventions and standards to which Nigeria is signatory to.

Benefits of the Project

The benefits of the project are as follows:

- Provide reliable and consistent power supply with aim of alleviating current power crisis;
- Income source to the government through taxes;
- Increased revenue/ derivations to Local and State Governments;
- Promotes indigenous Nigerian investor-led independent power production;
- Shifts burden of investment capital for power generation from central government to the private sector;
- Stable power supply to encourage development of agricultural-based small and medium scale enterprise;
- Promote secondary social development;
- Provide direct and indirect employment opportunities;
- Support technology development through technical assistance and training for Nigerians as part of local content;
- Reduce environmental emissions associated with privately powered generators; and
- Reduce pressure on the diesel/ petrol supply chain.

PROJECT JUSTIFICATION

The successful execution of the project would add 150 MW of electricity to the national grid supply at phase 1. This increased electricity output would translate into improved socio-economic conditions of Nigerians. The proposed project would however be sustained in terms of the following factors:

Economic and Commercial Sustainability

Electricity would be generated and sold, thereby creating steady income stream to the proponent. This would be used to operate and maintain the power plant facility as well as staff welfare and remuneration. Also, due to the expected presence of abundant gas supply in the country and existing key infrastructures such as electricity transmission and gas system, the project would be economically and commercially sustainable.

Technical Sustainability

PEL has employed and has plans to employ professionals to manage all phases of its project. Design of the plant would be carried out using latest technology, which would facilitate simple operation and maintenance system.

A number of project design planned for use by PEL includes; use of dry low- NO_x combustors and flue gas desulfurization, as well as use of higher energy-efficient systems (i.e. combined cycle gas turbine).

Social Sustainability

Through the addition of more electrical power generated capacity to the grid, the project shall ensure higher quality of life, and help create healthier and more liveable communities across the nation and for its immediate stakeholders.

Environmental Sustainability

PEL would incorporate into project design, planning, construction and operations, all mitigation measures suggested during this EIA. Also, to be implemented are environmental monitoring and management programmes as recommended in the Environmental and Social Management Plan

(ESMP). These steps and actions will ensure the environmental sustainability of the project by minimising environmental and social impacts/ risks from the project.

Project Alternatives Location Selection

PEL chose to develop this power plant using natural gas as the feedstock following a case-specific comparative analysis of different fuel sources. Wind, solar, hydroelectric, nuclear and coal where other energy sources considered. The criteria for the analysis were: environmental consideration, technical feasibility in the project area, investment cost required, social impacts, and availability of feedstock. Based on the characteristics of the project area, regulatory and technical capacity, and relatively low investment cost, natural gas was chosen as the fuel source for the power plant development.

The following criteria were considered in selecting project site:

- Available required land size;
- Suitable land characteristics/ topography;
- Proximity to river source for plant cooling and transporting materials;
- Access to gas supply and electricity transmission evacuation systems;
- Reduced project execution cost from tie-in plans; and
- Requires no destruction or demolition of unwanted structures.

PROJECT DESCRIPTION

PEL intends to construct a 500 MW gas-fired power plant which would be executed in two phases; first phase at 150MW using OCGT and expansion to 500MW using CCGT. The project development for the 150MW would be carried out in the following sequence.

- Pre-construction (engineering design and site preparation) involves:
  - clearing of 60% of acquired land for plant construction; and
  - land access creation from major road to site.
- Construction and installation involves:
  - installation of 1.5 km gas transmission pipeline to existing gas supply; and
  - connection of 1 km evacuation line to 330/120 kV sub-station.
- Operation; and
- Decommissioning at end of plant life span.

Design Basis

The design, construction and operation of the project shall be conducted to:

- Protect the safety, health and security of employees, customers and stakeholders;
- Maintain environmental integrity;
- Comply with applicable laws and regulations;
- Apply sound geo-science, engineering, technical and commercial best practices;
- Focus on flawless execution with minimum re-works;
- Meet the reasonable aspirations of the project-impacted community; and
- Achieve facility performance objectives.

Electricity Evacuation and Transmission

PEL plans to evacuate and transmit electricity generated by connecting the plant to an existing 330 kV switchyard being used by CMEC/Eurafric and NIPP operational plants, via a 1 km evacuation line.

Gas Supply

Gas would be supplied by Seplat Petroleum Development Company, through a 12” x 1.5 km diameter pipeline to the plant. Gas would be received into the proposed gas receiving station for quality check and metering before use. 40 mmscf/day of gas is required to sustain the plant.

Cooling System
Turbines will be air-cooled through an enclosed air cooling system to be delivered as part of the turbine equipment.

Waste Streams and Emissions
Summary of emissions and wastes anticipated from project activities are provided below.

Solid
Construction wastes (sand fill, food remains, refuse, organic material, packing materials etc.) and operational wastes (chemicals, office waste, pigging waste, hazardous waste etc.) are expected as part of the project process. Solid wastes shall be disposed off at appropriately licensed disposal site located in Warri Town, Delta State. The waste contractors are registered with the Delta State Waste Management, Pollution and Sanitation Authority.

Liquid Effluent
Liquid wastes expected include oily water and chemical waste from power plant operations. All effluent will be collected and sent to the disposal center for treatment and proper discharge. Sanitary waste produced will be treated in effluent treatment plant or stored in tanks and transferred to treatment center.

All wastes produced and handled by PEL or third party contractors would be managed/ monitored in line with Nigerian and World Bank requirements/ standards.

Air emissions
Air emissions from the power plant will originate from gas turbine stacks, black start diesel engine stacks and will generate NO_2, SO_2. Also, CO_2 is expected to be released up to 734,042 tonnes per annum as a result of the operation of the power station.

Noise
Sources of noise include from gas turbines during operation and from pilling works during construction. Noise would arise from personnel and vehicle movement all through the project phases.

Project Schedule
Construction activities for the 150MW are expected to commence first quarter in 2017 and commencement of operation date expected in first quarter 2019.

THE EXISTING ENVIRONMENT DESCRIPTION
Baseline information on the bio-physicochemical and socio-economic environment of the proposed project area were based on information from literature as well as findings from two season field sampling programme, laboratory analyses and detailed socio-economic and health assessment conducted as part of this EIA.

The two season surveys were carried out in the dry and wet season. The dry season survey was carried out from 2nd to 6th December, 2013 and wet from 28th to 30th July, 2014.

Social and Environmental Conditions

Aspects	Baseline Status
Climate	The project area (in Sapele, Delta State) is within the Niger Delta region of Nigeria. It is situated in the tropics and experiences a varying climate which is characterised by two distinct conditions of wet and dry seasons. The wet season occurs between April and October with a brief lull in August, while the dry season occurs between November and March. Meteorological data presented in this report is based on information from Nigerian Meteorological Agency for Warri area (closest monitoring location to Sapele – about 13km south). Data presented were obtained from 1984 to 2013
Wind Speed	Monthly mean wind speed varies from 3.4 to 4.6m/s for the period of years reviewed. Wind speed is strongest at the middle of the rainy season with a mean value of 4.4 to 4.6m/s. Nevertheless, wind speed does not vary much all year.
Wind Direction	Wind direction indicates a south westerly and westward movement for most part of the year.
Relative Humidity	Relative humidity for the area ranges from 79.4 to 88.6 %, with a mean monthly value of 83.3 %. Relative humidity trend shows a steady increase from January through to July (highest value) corresponding to time of wet season and reduction from October to December corresponding to the beginning of the dry season
Air Temperature	Minimum mean monthly temperature is 22.9 ^{0}C and occurred in January, while maximum mean monthly temperature was 33.7 ^{0}C in February
Rainfall	Rainfall within the period range between 16.9 and 532 mm, average monthly mean of 240 mm. Average total annual rainfall for the period reported is 2,874 mm
Air Quality	Ambient air quality parameters measured includes SPM, CO, SO_x, NO_x, NH_3, H_2S, VOC and C_xH_y. Equipment detection limit means parameter values were above FMEnv and WHO limits except for VOC; further air measurement prior to construction is planned. Measurements were below regulatory limits (FMEnv and WHO) for SPMexcept in eight stations in dry season and one station during wet season sampling.
Noise Level	Background noise levels measured in the study area were compared with the limits for industrial (FMEnv and WHO limits) and residential (WHO limit). Values measured were below both industrial limits. For the WHO residential limit, values were lower when compared, except for SS12 (dry season) which was slightly higher, this station was on the river bank where speed boats were observed.
Hydrology	The study area is drained mainly by the Ethiope River which has its source at Umuaja also in Delta State. The river empties into Benin River and is flanked by pristine vegetation
Topography	The project area is generally low-lying. Elevation above sea level ranges between 2 and 17 m.
Geology	Sapele in Delta State is part of the Niger Delta Structural Basin in which three major sedimentary cycles have occurred since the early Cretaceous era. These cycles are the Benin, Agbada, and Akata formations. The three formations collectively account for all soil and rock types within the state
Groundwater	Groundwater samples were obtained from three boreholes for analyses. Parameters analysed generally compared well with FMEnv and WHO limits for drinking water in both season. However, total iron level was slightly above the WHO limit in both seasons. The high level of iron is associated with the nature of Niger Delta rocks known for their high iron content. Lead and total hardness were also slightly high in the wet season
Soil	Soil samples were obtained from sixteen stations in the area for analyses. Parameters analysed from the study area were similar to those from control point and did not show concentrations of high values to cause concern in both seasons

Aspects	Baseline Status
Sediment	Sediment samples were obtained from seventeen stations in the area for analyses. Parameters analysed were similar to those from control point and did not present concentrations of high values for concern
Surface water	Surface water samples were also obtained from seventeen stations for analyses. Parameters analysed from the study area were similar to those from control point and did not show concentrations of high values for concern when compared to the FMEnv limit for supporting aquatic life.
Hydrobiology	Phytoplankton specimens were obtained from seventeen sampling stations for identification. Bacillariophyceae (diatoms) had the highest percentage abundance and distribution followed by blue green algae, the least was Euglenoid in both seasons Zooplankton specimens were obtained from same stations for identification. Arthropoda (crustaceans) had the highest abundance and distribution, followed by Rotifer, and the least were Mollusca and Nematodes Benthic specimens were also obtained from same stations. Total species abundance value of 28 and taxa of 5 belonging to two phyla were recorded. They are Annelida and Mollusca
Fish	Fish data presented are from physical identification from primary and secondary sources. Fishes identified include *Chrysicthys nigrodigitatus, Malapterurus electricus, Hemichromis fasciatus*, *Clarias macromystax, Erpetoichthys calabaricus* etc.
Wildlife	The area is rich in fauna species composition. A number of amphibians, reptiles, aves and mammals species were recorded/ observed. Some of the key fauna species include the White-throated Guenon (*Cercopithecus erythrogaster*), Tree Pangolin (*Manis tricuspis*), Otters (*Lutrinae sp*), Giant Rat (*Cricetomys gambianus*) African Grey Parrot (*Psittacus erithacus*), Grasscutter (*Thryonomys swinderianus*) African Civet (*Civettictis civetta*).
Vegetation	The project area (27 hectares) is characterized by the following vegetation types; regenerating forests, palm forest, bush fallows and secondary rainforests. The habitat types within the area is predominantly modified habitat with only about 5.37 hectares representing natural habitat (secondary rain forest). This natural habitat is outside the proposed development area. Applicable ecosystem services are provisional, supporting and regulatory. Dominant plant species include *Elaeis guinensis* (common palm tree), *Raphia hookeri* (raphia palm), *Dryopteris sp* (Fern) and *Alchornia cordifolium* (Christmas bush)

Aspects	Baseline Status
Socio-economic study	The project host community- Ogorode was visited and consulted. The community is within Sapele Local Government Area, Delta State. Information on socio-cultural resources, traditional organisation, governance, conflict management, demography including gender, quality of life, economic survey, infrastructural base, education and health survey were obtained and documented in this report. Members of the community expressed concerns about the proposed power plant project. Concerns bordered on perceived effects on their environment, infrastructure and livelihood. They also had expectations which centered on human capital and infrastructural development. They were however supportive of the project development.

IMPACT ASSESSMENT AND MITIGATION

The potential and associated impacts of the proposed PEL Power Plant project have been identified and evaluated using standard procedures such as source reference materials, project environment baseline data, FMEnv EIA sectoral guidelines for power transmission line projects, ISO 14001 guidelines, World Bank /IFC environmental assessment sourcebook/guidelines, etc.

The flowchart (**Figure E.1**) overleaf shows the impact assessment, mitigation and monitoring management process and interaction between project activity and environmental baseline.

As part of the process of identifying environmental and social impacts of the project, series of stakeholders' consultations were conducted during the ESIA study period. Three stakeholder consultations took place during the ESIA preparation, this comprises:

- Kick-off consultation which took place as part of FNL's first site visit and project scoping exercise. Members of the Ogorode community and Sapele Local Government were met during this session.
- Socio-economic engagement sessions: this was a major stakeholders' consultation session spanning three (3) days where in-depth interviews, focus group discussions were held with Ogorode women and youth groups, and community elders.
- A public stakeholders' forum which involved environmental and socio-economic experts, community members and staff of the Ministry of Environment at the Federal and State level.

Mitigation measures which would eliminate or reduce to as low as reasonably practicable, the identified negative impacts as well as enhance the beneficial impacts have been proffered in the EIA study.

Environmental and Social Management Plan (ESMP) which outlines the mitigation, monitoring and institutional measures that will be taken during the project implementation and operation to avoid identified environmental impacts have been established for the project.

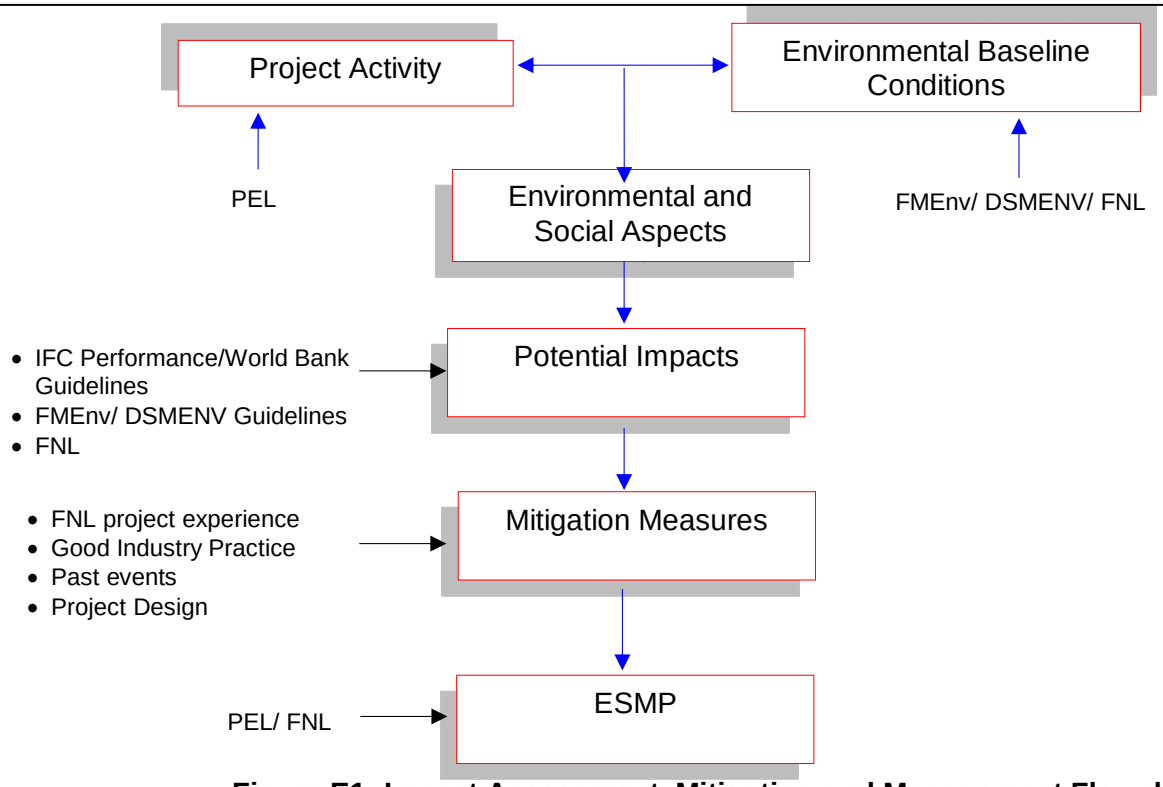

Figure E1: Impact Assessment, Mitigation and Management Flowchart

Highlights of beneficial and adverse impacts as well as appropriate mitigation measures proffered are presented in **Table E.1** below. Also included is the residual ranking of the impacts after mitigation.

Table E.1: Mitigation Measures Proffered for Significant Impacts

Project Activities / Environmental Aspects	Potential and Associated Impacts	Ranking Before Mitigation	Mitigation / Enhancement Measures	Residual Ranking
Pre-Construction Phase				
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Employment opportunities arising from recruitment of workers	Beneficial	PEL shall: • Ensure early stakeholders' engagement sessions are held, and all agreed issues properly documented and signed • Make transparent communication on hiring policies amongst local communities	Beneficial
	Conflicts/ community agitations over employment issues (quotas and methods)	Major	PEL shall: • Ensure early stakeholders' engagement sessions are held, and all agreed issues properly documented and signed • Due consultation of relevant groups within host community at all phases of the project • Ensure that its workers are briefed on community engagements and security. • Explore ways of encouraging goodwill and friendly relationship between its workers'/ service contractors and members of the community • Establish and publicise grievance procedure	Minor
	Loss of vegetation cover which is basically modified habitat consisting of bush fallows, and palm forest.	Medium	PEL shall: • Limit vegetation clearing and site preparatory activities to footpring earmarked for Phase 1 and Phase 2 activities; • Employ the services of biodiversity specialists to advise procedures to dispersing and transfer of mobile and non-mobile fauna species during land clearing • Prepare a biodiversity action plan to document monitoring and performance improvement measures to biodiversity resoures throughout project lifespan	Minor
	Influx of people (migrant workers, sub-contractors and suppliers) and increased pressure on existing social infrastructure Increase in social vices (like theft, prostitution) resulting from increased number of people in the area	Major	PEL shall: • In the future, construct infrastructural facilities in the area to ease pressure on the existing amenities/ infrastructure • Encourage personnel to participate in community development affairs • Ensure that workers are educated on health issues	Minor
	Risks of armed robbery attack and hostage taking leading to injury/ death of personnel	Medium	PEL shall: • Ensure a detailed security plan is developed and communicated to personnel • Make sure there is open communication with security operative in the area • Support local law enforcement agencies to combat crime	Minor

Table E.1: Mitigation Measures Proffered for Significant Impacts- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Ranking Before Mitigation	Mitigation / Enhancement Measures	Residual Ranking
Construction and Installation Phase				
• Plant foundation works • Piling, trenching, etc. • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Employment of local labour and skills acquisition for workers taking advantage of new opportunities	Beneficial	To enhance this beneficial impact, PEL shall • Retain some of the skilled and unskilled locals to encourage them in acquiring basic skill for self-sustenance • Encourage local contractors through the award of contracts as appropriate and per their competence levels	Beneficial
	Workplace accidents leading to injury or fatalities from burns, cuts, bruises, trips, falls from objects at height	Major	PEL shall: • Ensure that HSE briefings are conducted prior to work commencement • Ensure personnel wear adequate PPE • Design work area to meet industrial standards recognizing all ergonomic factors • Encourage employees to maintain good house keeping	Minor
	Potential collapse of power plant structures because of unsuitable geotechnical conditions	Major	PEL shall: • Carry out a comprehensive geotechnical study of the project site before construction works • Ensure geotechnical report provide all strength values and settlement potential required for adequate foundation design • Make use of experts with experience in plant design and construction	Negligible
	Hazards from construction of base camp, gas pipeline and electric evacuation lines	Major	PEL shall: • Ensure personnel wear appropriate PPE (eye goggles, nose masks etc.) • Make use of competent and well trained personnel for construction works	Minor
	Risk of electrocution and burns during welding	Major	PEL shall: • Ensure strict adherence to standard work operations including the use of PPE (nose masks, hand gloves, etc.) are maintained as stated in the company's HSE policy • Ensure all electrical and welding equipment are maintained at optimal working conditions • Make sure first aid facility are in place at construction site	Minor

Table E.1: Mitigation Measures Proffered for Significant Impacts- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Operational Phase				
• Testing and commissioning • Power generation • Power plant maintenance and servicing	Generation and addition of electricity supply to the national grid Increased business opportunities and quality of life (small, medium, large scale) due to enhanced power delivery Reduced demand on petrol and diesel used for household power generation	Beneficial	To enhance this beneficial impact, PEL shall • Ensure project is actualised and sustained as planned • Make sure power plant is maintained by professionals to allow for its continued existence • Encourage business growth and SME as appropriate in host community • Discourage locals from sabotage through direct education, newspaper publications, etc. • Proactively assist with the acquisition of new transformers in the host community to boost electricity supply in the area (if possible)	Beneficial
	Greenhouse gas emissions from natural gas used as feedstock	Major	PEL shall: • Ensure possible fugitive gas leakage are avoided • Carry out periodic maintenance test to determine possible leakages in the gas pipeline	Minor
	Air pollution from release of NO_x, CO_x, SO_x, from gas powered generating plants	Major	PEL shall: • Make use of dry low- NO_x combustors and natural gas with zero sulfur content • Make use of higher energy-efficient systems • Maintain plant system at optimal operating conditions	Minor
	Workplace accidents/ incidents (cuts, trip, falls etc.) leading to injury/ death of personnel during operations; potential explosion/ fire.	Major	PEL shall: • Ensure that HSE briefings are conducted prior to work commencement • Ensure personnel wear adequate PPE while working in the plant • Design work area to meet industrial standards recognizing all ergonomic factors • Encourage employees to maintain good housekeeping within work site always	Minor
	Potential explosion/ fire accident	Major	PEL shall: • Develop and emergency preparedness and response plan • Staff training and awareness on emergency procedures	Minor

Table E.1: Mitigation Measures Proffered for Significant Impacts- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Decommission Phase				
	Availability of land for alternative uses	Beneficial	To enhance this impact, PEL shall: • Develop a detailed Decommissioning /Abandonment Plan ensure alignment of all stakeholders (state, local, community) • Clean all excavations to acceptable limits and have then backfilled • Remove all wall fences and structures as advised by the abandonment team • Clean contaminated soils to acceptable limit	Beneficial
• Mobilisation of personnel and equipment • Power plant decommissioning • Abandonment/ restoration	Loss of employment, business opportunities and decreased economic activity	Medium	PEL shall ensure: • As part of training and awareness programmes, local workers are adequately trained with skills to sustain livelihood. • That host communities are informed prior to decommissioning	Minor
	Reduced power generation to national grid and low power supply	Medium	PEL shall ensure: • Plans are made for another plant to continue generating electricity	Minor
	Risk of accident and injury to workers during demolition of structures	Major	PEL shall: • Ensure that HSE briefings are conducted prior to demolition activities • Ensure personnel wear adequate PPE while carrying out demolition • Encourage employees to maintain good housekeeping within work site • Make sure trees or shrubs are re-grown on project site to restore its original form	Minor
	Increased dust and vehicular emissions from decommissioning activities	Medium	PEL shall: • Ensure demolition activities are conducted after sprinkling of water to prevent dust build up • Ensure personnel wear adequate PPE (i.e. dust mask) while carrying out demolition • Maintain all its vehicles at optimal working conditions	Negligible

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

To ensure that mitigation measures developed for all significant impacts of the proposed project are implemented and maintained throughout the project duration, an ESMP has been developed. The ESMP outlines management strategies for managing hazards from project associated and potential impacts on the environment.

Elements of this plan will be incorporated into a comprehensive project ESMP that will be used to deliver the project's health, safety and environmental (HSE) regulatory compliance objectives and other related regulatory and management commitments. The ESMP presented in **Chapter Seven** of this document are captioned as follows:

- Training and Awareness Plan
- Public Participation/ Involvement
- Regulatory Compliance Plan;
- Project Execution Guidelines
- Inspection and Maintenance Plan;
- Risk Assessment and Management Plan;
- Worker Safety and Health Plan;
- Pollution Control Guidelines;
- Emergency Response Plan;
- Communication Plan;
- Environmental Monitoring Plan;
- Waste Management Plan;
- Security Plan;
- Environmental Audit Review; and
- Decommissioning and Abandonment Plan

The ESMP is a dynamic working tool and its scope may be reviewed periodically to effect changes in regulatory regimes, guidelines and standards as well as PEL's corporate HSE policies. It shall be made a green document throughout the project duration to ensure that lesson learnt, new environment findings and sustainable technology are incorporated to guarantee continuous mitigating measures to reduce the project potential impacts.

Cost for ESMP Implementation and Monitoring

Funding of the Impacts Mitigation and Monitoring (IMM) will be borne by PEL, upon issuance of a pre-approval letter by FMEnv which will include the cost of IMM and other conditions that will be fulfilled prior to the issuance of the approval. The current regulatory cost by the FMEnv for impacts monitoring operation is about five hundred thousand naira only (₦500,000). However, PEL has highlighted and provided estimates in Chaper 7 of this report, the monitoring costs for exercises which will be conducted on an ongoing basis.

CONCLUSION

The Environmental Impact Assessment of the proposed Proton Energy Limited 500 MW Gas Powered Plant project has been carried out and findings on the first phase of 150MW is documented herein. While the document emphasizes technology option and specification for a 150MW plant, social and environmental conditions measurements were carried out with full proposed capacity of 500MW in view. The study was carried out to satisfy stakeholders that proactive environmental actions have been incorporated into project design/ plan.

The study was conducted in line with statutory requirements for environmental management with regards to power plant projects in Nigeria as well as in compliance to World Bank/ International Finance Corporation (IFC) requirements.

Consultation with the immediate project host community (Ogorode), regulatory authorities and other stakeholders have been carried out and shall continue throughout the project lifecycle. Stakeholders were supportive of the project, nevertheless expressed their fears, concerns and expectations.

Existing environmental baseline conditions as well as sensitive components of the study area were established through field data gathering/ sampling and complemented with information from literature/ desktop research for the area. The established baseline data will serve as future reference.

The EIA identified several positive (beneficial) impacts associated with the proposed development. Impacts to the national economy and local employment in terms of electricity generation and job creation. Some other positive impacts are; community infrastructural development by PEL, training (health and safety) of personnel, use of natural gas (otherwise flared) as plant feedstock, income generation for government, etc.

The study further identifies potential and associated adverse impacts from the project execution and mentions practical, and cost effective mitigation measures for these impacts. An Environmental and Social Management Plan (ESMP) has also been developed to assure environmental sustainability and management commitment throughout the duration of the project.

The ESMP contains environmental monitoring programme that would be used to monitor future changes to the ecological and social environment from project activities. As a result, PEL would ensure that air pollutants, noise and groundwater are monitored in line with FMEnv and World Bank/ IFC standards/ requirements.

CHAPTER ONE

INTRODUCTION

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1.1 Background Information

This document presents the Environmental Impact Assessment (EIA) for the proposed Proton Energy Limited (PEL) 150 megawatts (MW) Gas Fired Independent Power Plant Project in Sapele, Delta State, Nigeria, West Africa. The project aims at generating electricity, for addition to the national grid supply.

The EIA study has been carried out under the terms of the Nigerian Environmental Impact Assessment Act Cap E12 LFN 2004 and in fulfillment of World Bank/ International Finance Corporation (IFC) requirements for financing project of this magnitude.

Nigeria currently generates about 4,000 MW of electricity. Given a population estimated at over 160 million people, power generated is grossly inadequate (USTDA, 2014). Nigeria requires a minimum 40,000 MW electricity, hence the importance of this type of project.

1.2 Project Activities

The project also referred to as "Proton Delta Sunrise Project" (Proton DSP) would be developed in phases; the first phase who be actualisation of 150 MW Open Cycle Gas Turbine (OCGT). It would however be expanded to 500MW using a Combined Cycle Gas Turbine.

Key project components of the 150MW Open Cycle Gas Turbine include;

- Installation of 1 km electricity transmission evacuation line to tie into existing switchyard connected to 330/120 kV substation in Sapele; and
- Construction of 1.5 km gas pipeline to connect to Seplat Petroleum Development Company pipeline network. About 40 mmscf/day of gas would be required by the plant at full operation.

Other facilities to be installed would include; gas turbine generators, gas reducing station, cooling system, fire hydrants, fire pump skid, pipe-rack system, lube oil cooler, air compressors, step up transformers, electrical and administrative building.

1.3 EIA Overview

Execution of this project through construction, installation and operation would affect the bio-physical and socio-economic/ health conditions of the area, and as such requires careful planning, implementation and management. This has necessitated the conduct of an Environmental Impact Assessment (EIA). The study is carried out in line with best environmental management practices and to demonstrate PEL's commitment to sustainable development.

The EIA also aims at achieving an acceptable level of compliance with applicable international standards such as the World Bank Operational Performance Standards and IFC Environmental, Health and Safety Guidelines. Compliance would provide assurance that environmental and social risks are comprehensively understood by PEL and that system and processes are in place to manage potential risks to an acceptable level. The EIA is also necessary to acquire permits required to operate the power plant.

Fugro Nigeria Limited (FNL), a Geotechnical, Survey, Geophysics and Geo-informatics, Environmental Consulting and Laboratory Testing Services Company certified to ISO 9001: 2008, ISO 14001:2004 and OHSAS 18001 management systems was commissioned to carry out this EIA on behalf of PEL.

1.4 Project Proponent

PEL is a company incorporated under the laws of the Federal Republic of Nigeria in 2011. The company was established by business and finance professionals comprising Nigerian and USA based partners as an independent power plant developer to:

- Engage in the management of electricity power projects and electricity power consortia;
- Act as managers of electricity power pools; and
- Operate in energy value chain optimization and gas processing/ distribution.

PEL has been an active participant in the Nigerian Power Sector over the years. PEL was involved in the recent Nigeria power privatisation program. The company plans to develop three (3) Independent Power Plants in Nigeria, with a total installed capacity of 1,500 MW over the next five years, contributing positively towards national 'transformation agenda' goal of generating 20,000 MW by 2020. The power plant proposed in Sapele is one of its projects, and is focused on gas power generation.

PEL has in place, a technical department for the project. This department would handle all tasks and functions relating to technical operation, business development and setup of power plants. Funding is in partnership with Private Equity firm, international and local banks including the World Bank. Boasting a strong team, the Consortium has added a group of advisors with extensive experience in working on similar projects in Nigeria and Sub-Saharan Africa to co-ordinate the development and installation of the Proton DSP Power Plant efficiently.

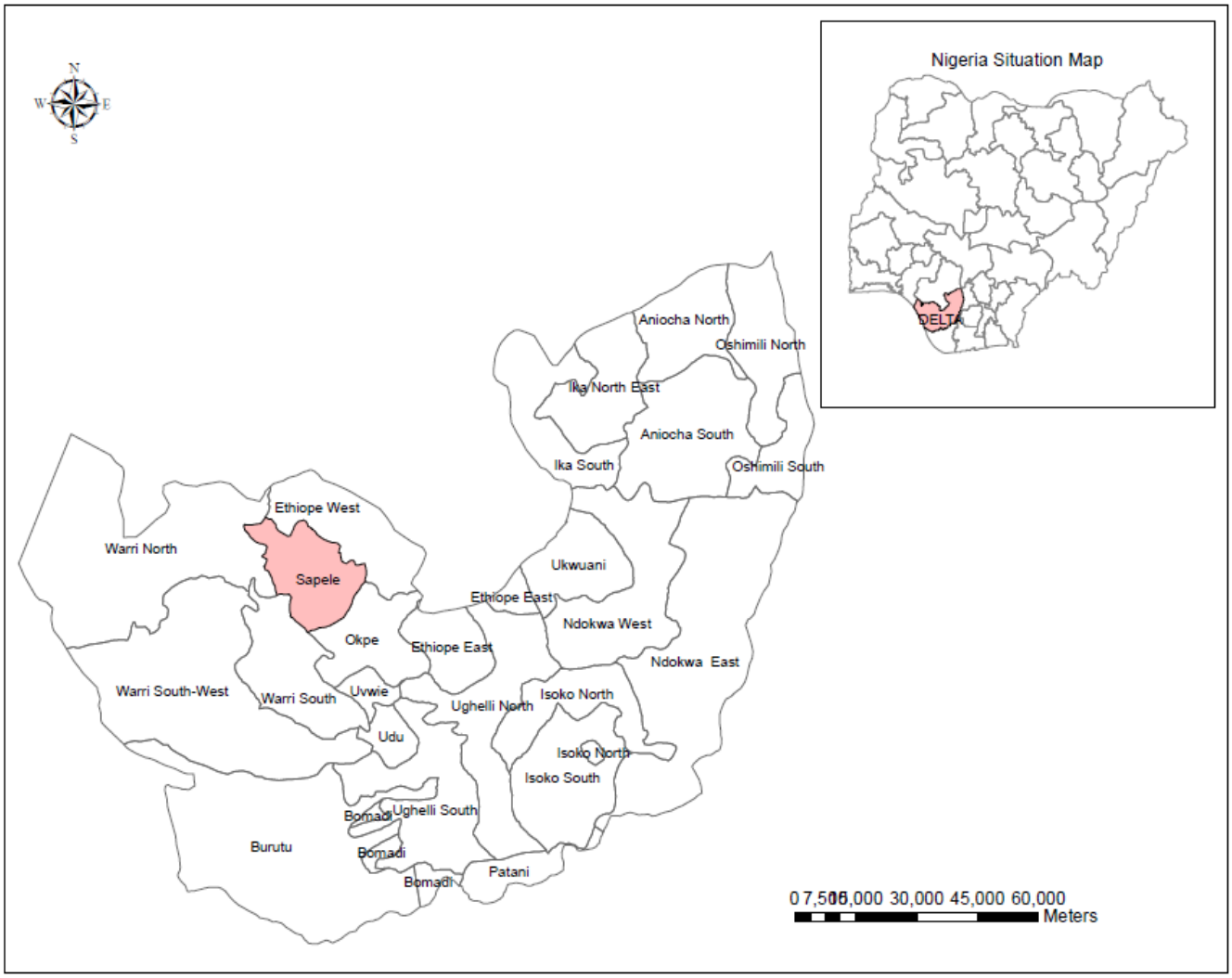
Key International Partnership

PEL is a partner in President Obama's "Power Africa Initiative", leveraging partnerships towards improving access to power in Sub-Saharan Africa. Power Africa is a United States-led initiative to increase the number of people with access to power, aiming to add more than 30,000 MW of cleaner, more efficient electricity generation capacity as well as increase electricity access by adding 60 million new home and business connections. Nigeria with an electricity access of less than 40% is one of the six focal countries for the initiative. PEL is one of the few private sector partners of the initiative.

1.5 Project Location

The proposed power plant site is to be located within Ogorode Community, in Sapele Local Government Area (LGA) of Delta State, Nigeria. Administrative Map showing the LGA is presented in **Figure 1.1**. The plant is to be situated on 27.4 hectares, fully owned by PEL with title.

The project would be located adjacent to two existing power plants; the National Integrated Power Project (NIPP) Plant and CMEC/Eurafric Energy Limited Plant (formerly known as Power Holding Company of Nigeria Plant [PHCN]). Distance between the proposed power plant and existing power plants is about 500 meters. Proximity to these functioning plants would be an advantage in terms of connecting and sharing electricity evacuation line as well as gas pipeline.



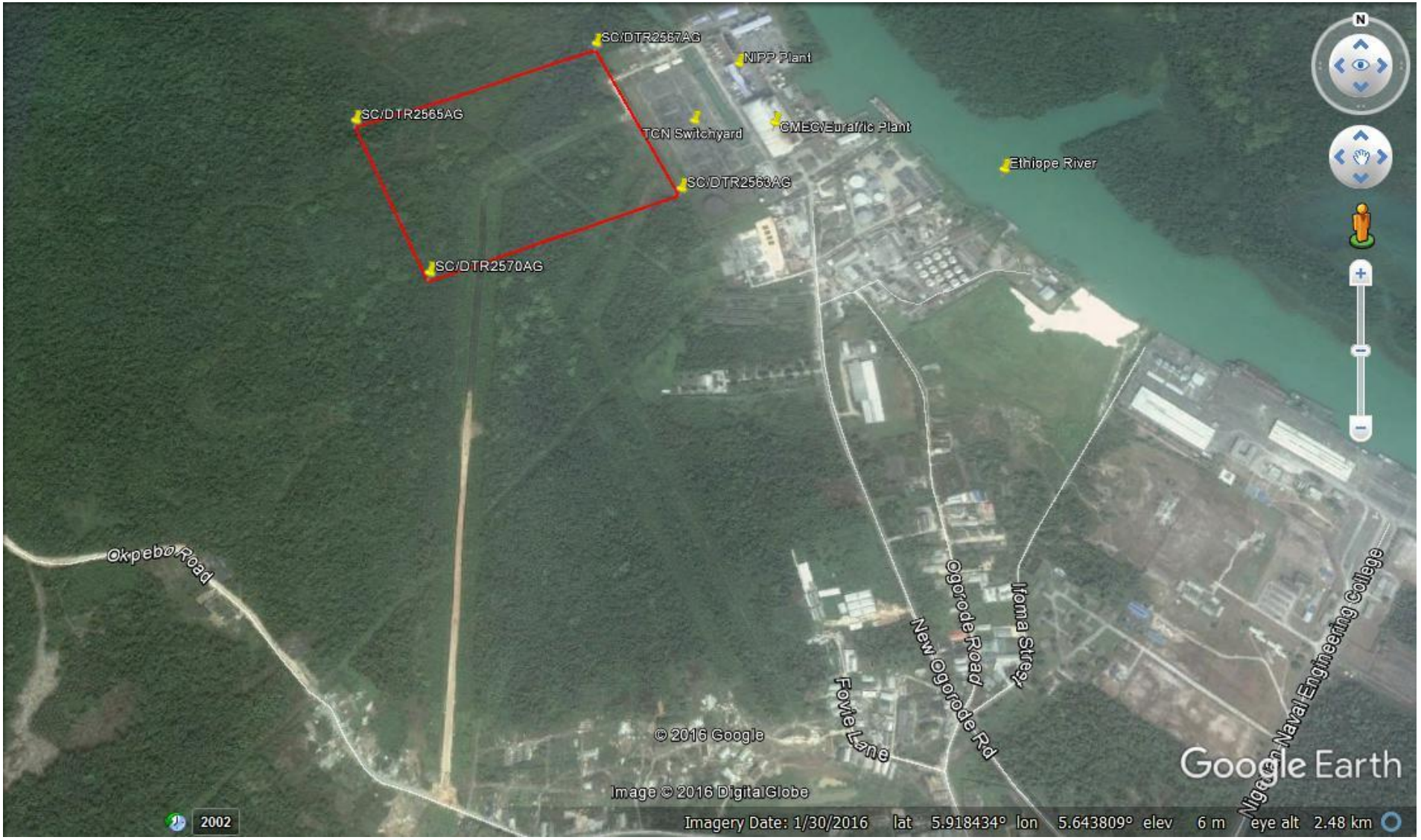
Source: FNL, 2014

Figure 1.1: Location of Sapele LGA

The project site can be accessed from Warri Town (13km, south) and from Benin City (45km, north). The area can also be accessed through Ethiope River by boat. Map showing aerial view of the site and surrounding features are shown in **Figure 1.2** overleaf. Geographical co-ordinates of the site are lat 5.926598, long 5.640701; lat 5.925116, long 5.635697; lat 5.920295, long 5.638190; lat 5.922407, long 5.643111 respectively.

On the north-eastern boundary to the site are NIPP Plant, CMEC/Eurafric Energy Limited Plant, Ethiope River, sections of Oghara Town, expanse of rainforest and pockets of mangrove vegetation. To the south-eastern area are facilities such as Regadas Nigeria Bitumen Company, Nigeria Gas Company and the Nigerian Naval Base Camp, south is Ogorode community, and to the west is section of rainforest vegetation.

Sapele LGA has its headquarters in Sapele Town, a cosmopolitan town and an important sea port for trade in timber related products. It is one of the oil producing areas of the state, and the people speak Okpe, Urhobo and Itsekiri dialect.



Source: Google Earth Map, 2016

Figure 1.2: Aerial View of Project Area

1.6 EIA Objectives

In line with statutory requirements for environmental protection in Nigeria, the proposed EIA study has been carried out to:

- Satisfy Federal, State and Local Governments as well as stakeholders, that proactive environmental actions shall be incorporated in PEL project design, installation, construction and operation phases of the project;
- Provide all necessary answers to stakeholders, assessors, host community, regulators, financiers, pressure groups and other interested parties;
- Ensure all environmental components (baseline) from the project site are established and documented;
- Identify all environmental aspects of the proposed project that may interact positively or negatively with the environment;
- Make appropriate recommendations to prevent, reduce or control identified potential and associated impacts;
- Develop Environmental Social Management Plan (ESMP) and procedures for effective and proactive environmental management of the environment throughout the project life cycle;
- Include a proposed institutional structure to govern the implementation of the ESMP; and
- Provide all necessary data/ evidence that will form basis for the preparation of the Environmental Impact Statement (EIS) of the project.

1.7 EIA Scope of Work

The scope of study includes:

- Project screening and site visit;
- Preparation of Terms of Reference (ToR) in accordance with regulatory guidelines;
- Review of national and international environmental regulations guiding the project;
- Consultations with regulators and other relevant stakeholders concerned with the proposed project;
- Extensive and comprehensive literature review specific to the project site to obtain background information on the environmental characteristics of the area;
- A two-season field data gathering exercise and survey of the area in order to establish environmental baseline information specific to the study area;
- Impact identification, prediction, interpretation and evaluation from project activities;
- Development of an effective mitigation/ ameliorative measures and monitoring programmes for significant impacts;
- Development of comprehensive Environmental and Social Management Plan covering the project life cycle; and
- EIA reporting following Federal Ministry of Environment (FMEnv) guidelines and procedures as well as public disclosure.

1.8 EIA Methodology

The Environmental Impact Assessment study was carried out in line with the FMEnv EIA procedure. **Figure 1.3** is a methodology flowchart of the EIA process. The study involved combination of multidisciplinary studies (science, engineering, law and social sciences). Information on the project area, project design as well as past project experience were used for impact identification and evaluation as well as to establish mitigation and enhancement measures.

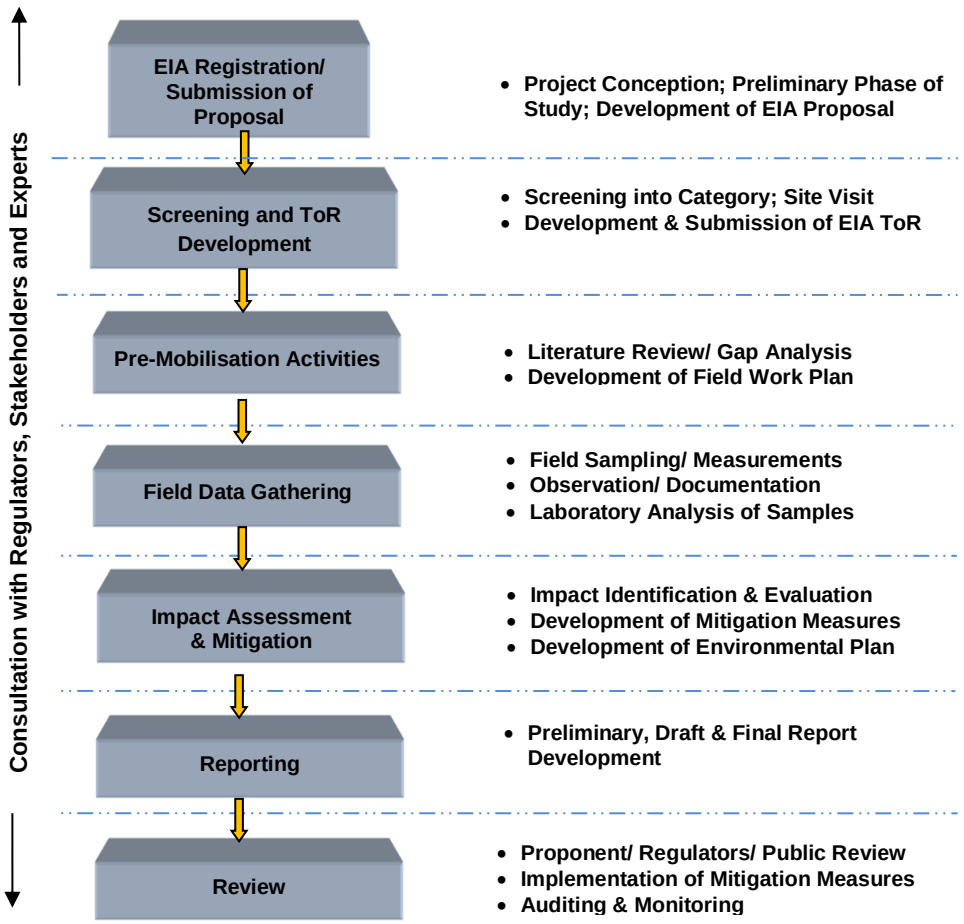


Figure 1.3: EIA Methodology Flowchart

EIA Registration and Screening

An EIA registration form for the project was filled and forwarded to the FMEnv on the 30th of September, 2013 by PEL. Subsequently, a screening process was conducted by FMEnv and the EIA placed in Category One (1), equivalent to Category A for World Bank.

Site Visit and EIA Terms of References

The EIA terms of reference (ToR) was defined and prepared in line with the EIA Procedural Guidelines (FEPA, 1995). It was submitted to the FMEnv for approval after site visit carried out on the 5th November, 2013. The approved ToR (**Appendix 1.1**) outlined the general scope of the EIA study and requirements for data collection.

Field Data Gathering

The EIA study provides a description of the existing environmental and socio-economic conditions as basis against which the impacts of the proposed project can be assessed. The main objective of the baseline description is to identify environmental and socio-economic resources and conditions in areas potentially affected by the project (such as air quality, groundwater, surface water, fauna and flora etc.) and other key receptors.

Data gathering also involved desktop studies of climatic conditions as well as obtaining information from journals on the project area. Project engineering studies were also obtained for quantitative information on environmental elements.

Field data gathering campaign was carried out in two seasons (dry and wet) to acquire information on the baseline condition of the area. Field survey was conducted within FMEnv guidelines and standards. Field survey was carried out in the presence of FMEnv representatives for dry season (between 2nd and 6th December, 2013) and wet season (from 28th to 30th July, 2014). Sampling requirements investigated include air quality and noise, surface water, soil, sediment, groundwater as well as socio-economic and health profile of host community.

Data Analysis and Interpretation

Samples collected from the field visit were transferred to FNL laboratory located at 91, Odani Street, Elelenwo, Port Harcourt, Rivers State for analyses. Results obtained were interpreted and used to describe the existing baseline of the study area as documented in **Chapter Four** of this report.

Impact Assessment and Mitigation

The potential/ associated adverse and beneficial impacts of the proposed power plant project on the existing environment were identified at this stage of the EIA. The EIA Procedural Guidelines and the World Bank Environmental Assessment Source Book among other references were used in the identification process. Evaluation of the identified impacts were carried out and compared using specific criterion such as legal/ regulatory requirements, magnitude of impact, risk posed by impact, public perception and importance of affected environmental component. Results of identification and evaluation are presented in **Chapter Five** of this report.

Mitigation measures designed to prevent, reduce or control the adverse impacts of the environmental aspects of the proposed project to as low as reasonably practicable were considered and documented in **Chapter Six** of this report.

Environmental Management

An Environmental and Social Management Plan (ESMP) was developed, which would be an environmental management tool to ensure that all mitigation measures are implemented and adhered to during the duration of the power plant operation. The EMP also enables a rapid rescue/ response if an unforeseen environmental impact occurs. It is found in **Chapter Seven.**

Reporting and Disclosure

The overall findings of the study were documented as contained in this report. A draft report was first issued, and inputs made by client. The report was then forwarded to the FMEnv for the 21-day mandatory public disclosure and an expert review session organised by FMEnv to review the report. Letter of display and announcement for public review is contained in **Appendix 1.2**. The FMEnv decision to grant or deny the certification for the EIA would be based on the outcome of the review process. Based on expert comments, a final version of the report was issued.

In line with World Bank requirements for stakeholder consultation, the draft EIA report is published to the World Bank's InfoShop upon approval by the federal government of Nigeria after consultation with stakeholders through a public forum/seminar and subsequent integration of stakeholders' comments and disclosure in-country.

Consultation Process

Consultation is a tool used to assess stakeholders' concerns and expectations of pertinent issues on environmental, social and health concern for integration into the impact prediction, assessment, evaluation and mitigation. Consultation involved information dissemination and interactions/ dialogues with various stakeholders concerned in the proposed project including professionals/ experts in relevant fields

relating to the power project. Consultation was carried out all through the study i.e. during screening, reconnaissance (site) visit, field survey/ data collection, public disclosure, expert review meetings. Consultation shall continue even through construction and operational phases of the project. The overall schedule for the EIA study is provided in **Table 1.1** below.

Table 1.1: PEL- EIA Activities Timeline

Activity	Timing
EIA Registration	30th September, 2013
Site Visit	5th November, 2013
ToR Approval	13th November, 2013
Field Survey-dry/ Consultation	2nd to 6th December, 2013
Field Survey –wet season	28th to 30th July, 2014
EIA Draft Report -Completed	13th November, 2014
Draft Report Submitted to FMEnv	19th November, 2014
21 Days Public Disclosure	15th December, 2014 to 14th January, 2015
FMEnv Interim Approval	22nd January, 2015
Expert Review Meeting	14th to 16th May, 2015
Received Expert Comments	16th June, 2015
EIA Final Report –Completed and Submitted to FMEnv	12th August, 2015

1.9 Legal and Administrative Framework for EIA in Nigeria

In Nigeria, existing statutes on environmental protection contains specific provisions designed to prohibit or control environmental pollution/ degradation and to prescribe sanctions to be enforced against persons or companies who infringe on these provisions. The legal, regulatory and administrative framework upon which the EIA of the proposed PEL Gas Powered Plant project was carried out includes:

- Various national and state statutes, regulations, standards on environmental protection in Nigeria; and
- Applicable international agreements, guidelines and conventions to which Nigeria is signatory.

Specific policies, acts and guidelines enforced by FMEnv and relevant to this project are presented in the following sub-sections:

1.9.1 National Regulations

The Federal Ministry of Environment

The defunct Federal Environmental Protection Agency (FEPA) was created by Decree No. 58 of 1988 as a parastatal of the Federal Ministry of Works and Housing.

In 1992, the Agency's authority was strengthened through Decree 59 of 1992 by which the defunct FEPA was transferred to the Presidency. FEPA's goals were to improve and maintain the quality of the Nation's environment, manage its resources and physical characteristics, prepare ecological Master Plan to guide the use of coastal areas rift with diverse and often conflicting economic and social activities.

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

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

National Policy on the Environment

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

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

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

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

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

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

National Guidelines and Standards for Environmental Pollution Control

This guideline and standard was initiated in March 1991 sequel to the promulgation of the National Environmental Policy in 1989. This document is a basic instrument for monitoring and controlling industrial and urban pollution. The guidelines and standards relates to six (6) areas of concern, thus:

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

- Management of solid and hazardous wastes, and
- Pollution abatement in industries.

National Environmental Protection Regulations

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

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

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

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

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

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

The Environmental Impact Assessment Act

The EIA Act Cap E12 LFN 2004 requires that for all new major public and private projects in Nigeria, where the extent, nature or location of a proposed project or activity is such that it is likely to significantly affect the environment, its EIA is undertaken in accordance with the provision of the Act. The EIA Act sets out to:

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

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

Nigerian Content Act

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

- Nigerians are given first consideration in the award of oil blocks, oil field licenses, oil lifting license and shipping service as well as projects for which contracts are to be awarded in the industry;
- there is exclusive consideration for Nigerian indigenous services to the oil and gas industry subject to the fulfilment of specified conditions;
- every multinational oil company operating in Nigeria is to domicile a minimum of 10% of its annual profit in Nigerian banks;
- Nigerian insurance companies are to do all aspect of insurance in the oil and gas sector except where local capacity has been exhausted;
- one percent of every contract awarded in Nigeria's oil and gas sector to be set aside for capacity building;
- at least 50% of the asset of any company seeking to execute oil and gas contract in Nigeria must be domicile in Nigeria, among others.

The Factories Act, 1990

The Factories Act 1990 (FA) is the primary law regulating the health, safety and welfare of workers in the country's factories. The law holds management and staff personally responsible for violations of the provisions in the Act.

With respect to safety, there are general provisions as to the securing, fixing, usage, maintenance and storage of prime movers, transmission machinery, other machinery, unfenced machinery, dangerous liquids, automated machines, hoists and lifts, chains, ropes and lifting tackle, cranes and other lifting machines, steam boilers, steam receivers and containers, and air receivers. There are, in addition to these, standards set for the training and supervision of inexperienced workers, safe access to any work place, first aid boxes, prevention of fire, and safety arrangements in case of fire.

The law requires that all accidents and industrial diseases be notified to the nearest inspector of factories and be investigated. The Act also prohibits the owner or occupier of a factory from making any deductions from the wages of any employee in respect of anything to be done or provided in pursuance of the FA.

NESREA Requirements

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

NESREA Act

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

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

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

Section 27: prohibits, without lawful authority, the discharge of hazardous substances into the environment. This offence is punishable under this section, with a fine not exceeding, ₦1,000,000 (One Million Naira) and an imprisonment term of 5 years. In the case of a company, there is an additional fine of ₦50,000, for every day the offence persists. Other sections include:

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

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

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

National Gas Policy

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

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

The aims of the policies shall be achieved by:

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

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

- encouraging the oil-producing companies to gather and utilize associated gas in order to eliminate flaring;
- imposing appropriate and effective penalties to discourage gas flaring;

- encouraging the establishment of the necessary infrastructure for the effective gathering, transmission and distribution of gas nationwide;
- formulating suitable urban and regional planning regulations needed for the effective distribution of natural gas to, and its utilization by, domestic and industrial consumers;
- providing necessary incentives to indigenous and foreign entrepreneurs to facilitate their participation in the gas industry;
- providing incentives to encourage industrial and domestic consumers to use gas or to convert to gas;
- providing incentives to encourage the introduction and use of LPG appliances in areas not accessible to natural gas to encourage the consumer preference for gas;
- establishing suitable infrastructure for the export of natural gas;
- expanding and promoting gas related R & D outfits in the country; and
- ensuring that the price of natural gas is cost-effective, while giving due attention to the effect on local consumption.

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

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

Electricity Power Sector Reform Act
The Nigeria Electric Power Sector over the years witnessed a slow and steady decline leading to a near complete failure of the system. The Government therefore, as a matter of dire necessity embarked on an Electric Power Sector Reform Program, which led to the establishment of the Nigerian Electricity Regulatory Commission (NERC) in 2005 and the Sector Reform Act.

This Act provides for the formation of initial and successor companies for the transfer of assets and liability of the National Electric Power Authority (NEPA), development of a competitive electricity market, establishment, functions and powers of the Nigerian Electricity Regulatory Commission (NERC), licenses and tariffs, acquisitions of land and access rights, consumer protection and licensee performance standards, completion and market power, the power consumer assistance fund, etc. for the regulation and control of electrical installations, and the generation, supply and use of electrical energy in Nigeria. Sections/parts of the Electricity Act relevant to the IPP project are:

Part III: Establishment of the Nigerian Electricity Regulatory Commission; objects and functions of the commission are as follows:

- to create, promote and preserve efficient industry and market structures and to ensure the optimal utilisation of resources for the provision of electricity services;
- to maximise access to electricity services, by promoting and facilitating consumer connections to distribution systems in both rural and urban areas;
- to ensure that an adequate supply of electricity is available to consumers;
- to ensure that the prices charged by licensees are fair to consumers and are sufficient to allow the licensees to finance their activities and to allow for reasonable earnings for efficient operations;

- to ensure the safety, security, reliability and quality of service in the production and delivery of electricity to consumers;
- to ensure that regulation is fair and balanced for licensees, consumers, investors and other stakeholders;
- to present quarterly reports to the President and National Assembly on its activities;
- promote competition and private sector participation, when and where feasible;
- establish or approve appropriate operating codes and safety, security, reliability and quality standards;
- establish appropriate consumer rights and obligations regarding the provision and use of electricity services;
- license and regulate persons engaged in the generation, transmission, system
- operation, distribution and trading of electricity; approve amendments to the market rules;
- monitor the operation of the electricity market; and
- undertake such other activities which are necessary or convenient for the better carrying out of or giving effect to the objects of the commission.

Part IV: Licensing requirement (for generation, transmission, system operation, distribution and trading), tariffs, fines and penalties;

Part V: Acquisition of land and access rights. Regulation 77 of this part stipulates a special provision for companies that require land for purposes of generation, transmission and distribution of electricity and notice to construct or extend any railway, road or any works for telecommunications is also provided for in regulation 79 of this part;

Part VI: Regulation 80 of this part stipulates that the commission shall develop, in consultation with the licensee the following materials for the protection of the consumer:

- customer services standards;
- customer complaint handling standards and procedures;
- codes of practice for the provision of assistance to special needs customers, such as the blind or disabled, the elderly or severely ill;
- procedures for dealing with, and assisting where necessary, customers who have difficulty in paying bills;
- procedures for applying for electricity service;
- procedures for disconnecting non-paying customers or for those breaches of other terms and conditions of an applicable tariff or contract;
- the information to be provided to consumers and the manner of its dissemination; and
- standards for compensation to consumers who do not enjoy regular power supply.

Part VII: Regulations pertaining to competition and market power; and

Part VIII: Regulations pertaining to establishment of the power consumers' assistance fund. Regulations 93 to 95 of the same Act stipulate conviction for false declarations, penalties for contravention and appointment of inspectors for undertakings and safety operations

Recently, the reform has led to the corporatisation and unbundling of the state-owned monopoly, now known as the Power Holding Company of Nigeria (PHCN). The unbundling has led to the establishment of 18 successor companies from PHCN comprising of six generation companies, one transmission company and 11

distribution companies. The sector has also been deregulated leading to private sector participation in the generation sector and the operation of Independent Power Plants in the country today. The establishment of the Nigerian Electricity Regulatory Commission (NERC) is also in line with the Reform Programme.

Energy Commission of Nigeria

The Energy Commission of Nigeria (ECN) was established in 1988 with the statutory mandate for strategic planning and coordination of national policies in the field of energy. It was established in line with the declaration of the Heads of the Economic Community of West African States in 1982 for the establishment of an Agency in each member state charged with the responsibility of coordinating and supervising all energy functions and activities. The functions of the ECN include, but are not limited to, the following:

- serve as a centre for gathering and dissemination of information relating to national policy in the field of energy;
- inquire into and advise the Government of the Federation or the State on adequate funding of the energy sector including research and development, production and distribution;
- monitor the performance of the Energy sector in the execution of government policies on energy; and
- serve as a centre for providing solutions to inter-related technical problems that may arise in the implementation of any policy relating to the field of energy.

The ECN is headed by a Director General, who also serves as its Chief Executive.

The Nigerian Urban and Regional Planning

The Nigerian Urban and Regional Planning Act 1992 was established to:

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

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

Planning Authority Approval

- it is mandatory for a developer to submit a development plan which would be approved by the Development Control Department (department under the commission);
- it is mandatory for a developer (whether private or government) to apply for development permit by using specified forms and providing information such as plans, design drawings and other information as may be prescribed by regulation made pursuant to this section.
- no development shall commence by any Government or its agencies without obtaining an approval from the relevant Development Control Department.
- plan required to be made under this Act shall be prepared by registered Architect of Town Planner or Engineer and shall be in accordance with the provisions of this Act.

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

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

(b) above applies to the proposed power plant development.

Validity of Development Permit:
A development permit granted to a developer shall:

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

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

National Building Code
The national building code is aimed at setting standards on building pre-design, designs, construction and post-construction stages with a view to ensuring quality, safety and proficiency in the building industry.

The provisions of this code shall, subject to its adoption by the states, apply to and control all matters concerning the design and specification, costing, construction, alteration, addition to, moving, demolition, location, repair and use of any building or structure, for existing or proposed building works within the Federal Republic of Nigeria. The standards specified in this code shall constitute the minimum requirement from which other regulations may be derived.

National Inland Waterways Authority
This Act was established in 1997 as Act No. 13 of 1997, with responsibility, among other things, to improve and develop inland waterways for Navigation. The objectives of the Authority are to:

- improve and develop inland waterways for navigation;
- provide an alternative mode of transportation for the evacuation of economic goods and persons; and
- execute the objectives of the national transport policy as they concern inland waterways.

The general functions of the Authority are to:

- provide regulations for inland navigation;
- ensure the development of infrastructural facilities for a national inland water ways network connecting the creeks and the rivers with the economic centers using the river-ports as nodal points for inter-model exchange;
- ensure the development of indigenous technical and managerial skill to meet the challenges of modern inland waterways transportation;
- undertake capital and maintenance dredging;
- undertake hydrological and hydrographic surveys;
- design ferry routes;
- survey, remove, and receive derelicts, wrecks and other obstructions from in- land waterways;
- operate ferry services within the inland waterways system;
- undertake installation and maintenance of lights, buoys and all navigational aids along water channels and banks;
- issue and control licenses for inland navigation, piers, jetties, dockyards;
- examine and survey inland water crafts and shipyard operators;
- grant permit and licenses for sand dredging, pipeline construction, dredging of slots and crossing of waterways by utility lines, water intake, rock blasting and removal;
- grant licenses to private inland waterway operators;
- approve designs and construction of inland river crafts;
- approve and control all;
- jetties, dockyards, piers within the inland waterways;
- advertising within the right-of-way of the waterways;
- reclaim land within the right-of-way;
- undertake the construction, administration and maintenance of inland river ports and jetties;
- provide hydraulic structures for river and dams, bed and bank stabilisation, barrages, groynes;
- collect river tolls;
- undertake the production, publication and broadcasting of navigational publications, bulletins and notices, hydrological year books, river charts and river maps;
- carry out consultancy and contractual services;
- represent the Government of Nigeria at national and international commissions that deal with navigation and inland water transportation;
- subject to the provisions of the Environmental Impact Assessment Act, carry out environmental impact assessment of navigation and other dredging activities within the inland water and its right-of-ways;
- undertake erection and maintenance of gauges, kilometer boards, horizontal and vertical control marks;
- advise government on all border matters that relate to the inland waters;
- undertake acquisition, leasing and hiring of properties;
- run cruise boats;
- carry out boat repairs, boat construction and dockyard services; and
- clear water hyacinth and other aquatic weeds.

Water Resources

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

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

- **Section 18** makes offenders liable, under this Act, to be punished with a fine not exceeding ₦2000 or an imprisonment term of six months. He would also pay an additional fine of ₦100 for everyday the offence continues.

The Forestry Act
The principal legislation in force for the regulation of the forest sector is the Forestry Act 1958. The Forestry Act CAP 51 LFN of 1994 prohibits any activity that may lead to the destruction of or cause injury to any forest produces, forest growth or forest property. The project area does not fall within any protected or reserved forest.

EIA Sectoral Guidelines for Oil and Gas Industry Projects
This EIA Sectoral Guidelines for the Oil and Gas Industries, 1995 are presented in five sub-sectors, namely, Oil Exploration & Production Onshore, Oil and Gas Production & Exploration Offshore, Oil and Gas Pipeline, Petroleum Refining, and Petrochemicals. The document stipulates guidelines for conducting EIA for this specific industry type.

The Labour Act
The Labour Act (1990) (LA) is the primary law protecting the employment rights of individual workers. The LA covers protection of: wages; contracts; employment terms and conditions; and recruitment. It also classifies workers and special worker types. Union membership is governed by the Trade Union Amendment Act (1995). A 1999 constitution includes stipulation of "equal pay for equal work without discrimination on account of sex, or any other ground whatsoever".

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

Land Use Act
The Land Use Act of 1978 states that "it is public interest that the rights of all Nigerians to use and enjoy land in Nigeria and the natural fruits thereof in sufficient quality to enable them to provide for the sustenance of themselves and their families be assured, protected and preserved".

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

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

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

- **Section 6:** provides for a punishment of life imprisonment for offenders as well as the forfeiture of land or anything used to commit the offence.
- **Section 7:** makes provision for the punishment accordingly, of any conniving, consenting or negligent officer where the offence is committed by a company.

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

Criminal Code

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

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

1.9.2 State Regulations

Delta State Ministry of Environment

The monitoring and implementation of all environmental assessments including EIA in the state is a function of the Delta State Ministry of Environment. The ministry was established in 2001 and functions of the ministry are:

- advise the Governor on Environmental policies and priorities and on scientific and technological activities affecting the environment;
- prepare and update a State Environmental Action plan to improve the quality of the environment;
- implement the state Environmental Action plan;
- monitor the state of the environment and prepare an Annual State of the Environmental Report for the State and transmit same to the Secretariat of the National Council on Environment in December of each year;
- be responsible for general environmental matters in the state including the negative effects of soil degradation due to flooding and erosion, mineral and oil exploitation and exploration, deforestation, physical planning including Amusement Parks, Gardens and beautification programmes, sewerage matters, water quality and water pollution control;
- be responsible for monitoring compliance with waste management standards;
- co-operate with Local Government Councils, statutory bodies and research agencies on matters and facilities relating to environmental protection particularly in the management of wastes;
- establish and implement the numerous strategies of the National Policy on the Environment towards achieving sustainable development;
- mobilize the inhabitants of all areas in the state for the effective observation of environmental rules and guidelines for the promotion of healthy and safe environment;
- supervises the Delta State Environmental Protection Agency
- implement applicable existing Edicts on activities related to the environment;
- monitor the implementation of the Environmental Impact Assessment (EIA) and the Environmental Audit Report (EAR) guidelines and procedures on all development policies and projects within the state.

Delta State Waste Management Law

This law was established for the purpose of evolving and maintaining a system of effective waste collection, management and disposal in the state and matters connected therewith. The law came into force on the 6th of July 2004.

Delta State Ecology Law

The Delta State Ecology Law, 2006 provides for the management of the environment within Delta State and for matters incidental thereto". The purpose of the law "is to

provide a law for the management of ecological components in the environment as it affects Delta State".

The law provides for the Governor to designate lands (in Delta State) as Environmentally Sensitive Areas (ESA) and Special Protection Areas (SPA).Section 6 of the law states that it is unlawful for a person or corporate body to enter upon land designated as ESA or SPA for purposes of mining, dredging and construction of roads, rail, buildings, pipelines or other structures or dig, cut, cultivate, navigate, clear, strip or take produce unless such act is authorised by a permit issued by the appropriate authority or the person doing same is authorised to do so. Section 18(1) of this law makes provision for EIA study in Delta State.

Delta State Forestry Law

The principal legislation in force for the regulation of the forest sector is the Forestry Act 1958. The Forestry Law CAP prohibits any activity that may lead to the destruction of or cause injury to any forest produces, forest growth or forest property.

The Delta State Forestry Law CAP 59 (1976) (previously known as Bendel State Forestry Law CAP 59 (1976), provides classification for forest types.

1.9.3 International Legal Framework

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

World Bank Performance Standards

The International Finance Corporation (IFC) Performance Standards, which define clients' responsibilities for managing their environmental and social risks have been adopted by the World Bank as the Performance Standards (WB Performance Standards) for Private Sector Activities. These Performance Standards are applicable to projects designed, owned, constructed and/or operated by a Private Entity[1] for which the Bank's support is needed.

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

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

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

[1] Private Entity refers to a proponent who is privately or publicly owned whose day-to-day management is not controlled by the government; in this case Proton Energy Limited. The IFC refers to 'private entity' as 'client'

- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
- Performance Standard 7: Indigenous People
- Performance Standard 8: Cultural Heritage

Over the course of the project, some performance standards will be triggered and must be managed in a manner consistent and compliant with the World Bank's Guidelines.

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

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

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

Performance Standard 2: Labor and Working Conditions

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

The objectives of this performance standard are to: (i) promote the fair treatment, non-discrimination and equal opportunity of workers, (ii) establish, maintain and improve the worker-management relationship, (iii) promote compliance with national employment and labour laws, (iv) protect workers, including vulnerable categories of workers such as children, migrant workers, workers engaged by third parties, and workers in the client's supply chain, (v) promote safe and healthy working conditions, and the health of workers, and (vi) avoid the use of forced labor.

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

Performance Standard 3: Resource Efficiency and Pollution Prevention

This standard recognizes that increased economic activity and urbanization often generate increased levels of pollution to air, water and land, and consume finite resources in a manner that may threaten people and environment at the local, regional and global levels. In the light of more efficient and effective resource use and pollution prevention technologies, this performance standard takes a project-level approach to

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

Performance Standard 4: Community Health, Safety, and Security
The objective of this performance standard is to scope and avoid adverse impacts on the health and safety of the project area during the lifecycle of the project from both direct and indirect project activities. It is also to ensure that property and personnel are safeguarded in a manner that avoids or minimizes risks to the local community especially to vulnerable groups.
Following an expansive scoping process and stakeholder engagement, PEL has documented environmental and social risks and impacts affecting the community. Mitigation measures where these impacts can not be avoided have been proferred in the report. Further to this, actions required to meet the requirements of this Performance Standard are managed by PEL's ESMP and ESMS.

Performance Standard 5: Land Acquisition and Involuntary Resettlement
This performance standard recognizes that project-related land acquisition and land use change can have adverse impacts on persons and communities that use this land. Among the objectives of this standard are: (i) to avoid, and when avoidance is not possible, minimize displacement by exploring alternative project designs, (ii) to avoid forced eviction, (iii) to improve, or restore, the livelihoods and standards of living of displaced persons, where applicable (iv) To anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land acquisition or restrictions on land use.

Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
This Performance Standard addresses how the private entity can sustainably manage and mitigate impacts on biodiversity and ecosystem services throughout the project's lifecycle. The objectives of this performance standard are: (i) to protect and conserve biodiversity, (ii) maintain the benefits from ecosystem services, (iii) promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.
Scoping during assessment of environmental and social conditions for the PEL project identified modified habitats which will experience direct and indirect impacts because of the development. Threats to biodiversity and ecosystem services have been mapped in this report and mitigation measures proffered. Implementing measures that ensure resource efficiency and proper utilization of land area to ensure minimal distortion to biodiversity are methods proffered to minimize impacts.

Performance Standard 7: Indigenous Peoples
This standard recognizes that indigenous peoples have identities that are distinct from mainstream groups in national societies, and are often among the most marginalized and vulnerable segments of the population. This performance standard among other things aims to ensure that the development process fosters full respect for the human

rights, dignity, aspirations, culture, and natural resource-based livelihoods of indigenous peoples.

Performance Standard 8: Cultural Heritage
This recognizes the importance of cultural heritage for current and future generations. The requirements for this performance standard on a project's use of cultural heritage are based in part on standards set by the Convention on Biological Diversity. The aim of this performance standard is to protect cultural heritage from the adverse impacts of project activities and support its preservation, and to promote the equitable sharing of benefits from the use of cultural heritage.

Equator Principles[2]
The Equator Principles is a risk management framework, adopted by financial institutions, for determining, assessing and managing environmental and social risk in projects and is primarily intended to provide a minimum standard for due diligence to support responsible risk decision-making. The Equator Principles are presented in **Table 1.2**.

Table 1.2: Equator Principles

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

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

- **Category A**- Projects with potentially significant adverse social or environmental impacts that are diverse, irreversible or unprecedented;
- **Category B-** Projects with potentially limited adverse social and environmental impacts that are few, generally site-specific, largely reversible and readily addressed through mitigation measures; and
- **Category C**- Projects with minimal or no social or environmental impacts.

World Bank's Environmental and Social Safeguard Policies
The World Bank's environmental and social safeguard policies are a cornerstone of its support to sustainable poverty reduction. The key objective of these policies is to prevent and mitigate undue harm to people and their environment in the development process. These are achieved through:

- supporting the integration of environmental and social aspects of projects into the decision-making process;

[2] The Equator Principles are based on the IFC's Performance Standards. They have been included here to scope in any Equator Principle Financial Institution that could be involved in project financing.

- providing mechanism for addressing environmental and social issues in program and project design, implementation and operation;
- identifying and managing impacts and risks;
- providing framework for consultation and disclosure; and
- supporting development effectiveness – increase results on the ground both short and long term.

The World Bank Safeguard policies are mechanisms for integration of environmental and social issues into decision-making. For private sector-involved development where the World Bank's support is needed, the World Bank Group Performance Standards discussed above are the applicable standards and reference. However, the the World Bank Safeguard policies are meant to:

- provide a set of specialised tools to support development processes;
- support participatory approaches and transparency; and
- apply to all investments financed by the World Bank.

The World Bank stresses the need for a full and engaging disclosure process of the ESIA which involves all stakeholders.

Disclosure

A number of public forums have so far been organised by PEL to disclose proposed project to stakeholders. This is to ensure active participation of stakeholders and as a feedback mechanism. Activities concerned with the project, impacts associated, benefits of the project as well as proposed mitigation for the project formed the basis of such forums. Public forum organised include:

- 21-day draft EIA report public display at centers in Sapele and Asaba (both in Delta State) as well centers in Abuja (the Capital of Nigeria); and
- Stakeholders and expert review workshop in Warri, Delta State, Nigeria.

Stakeholder that participated include: regulators (FMEnv and DSMENV), representatives of Minister of Environment, Commissioner of Environment, Delta State, Sapele LGA Chairman, host community (Ogorode), Benin Electricity Distribution Company (BEDC), NIPP and investors. Details of public disclosure for the EIA are presented in **Chapter Four** of this report.

World Bank Group EHS Guidelines

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

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

When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are

appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

The General EHS Guideline (*April, 2007*) is organized to provide environmental, occupational health and safety, community health and safety, constructuion and decommissioning guidelines for new and existing facilities. The General EHS Guidelines are designed to be used together with relevant Industry Sector EHS Guidelines to provide guidance on EHS issues in specific industry sectors.

Applicable industry-specific EHS guidelines to the PEL Power Plant project are presented as follows:

- *EHS Guideline on Thermal Power Plants (December, 2008)*
  This guideline includes information relevant to combustion processes fuelled by gaseous, liquid and solid fossil fuels and biomass and designed to deliver electrical or mechanical power, steam, heat, or any combination of these, regardless of the fuel type (except for solid waste which is covered under a separate Guideline for Waste Management Facilities), with a total rated heat input capacity above 50 Megawatt thermal input (MWth) on Higher Heating Value (HHV) basis. It applies to boilers, reciprocating engines, and combustion turbines in new and existing facilities.

- EHS Guidelines for Electric Power Transmission and Distribution (*April, 2007*)

United Nations Guiding Principles on the Human Environment

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

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

Principle Two

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

Principle Four

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

Principle Six

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

The Rio Declaration on Environment and Development

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

Principle Ten

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

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

Principle Thirteen

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

Principle Seventeen

Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

World Heritage Convention

The World Heritage Convention (1978) seeks to set aside areas of cultural and natural heritage, the latter defined as areas with outstanding universal value from the aesthetic, scientific and conservation points of view.

Other Relevant International Conventions

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

Biodiversity

- Environment of the West and Central African Regions, 1981;
- Convention on the Protection of the World Cultural and Natural Heritage, 1972;
- United Nations Framework Convention on Climate Change (Kyoto Protocol), 1997;
- Montreal Protocol on Substances that Deplete the Ozone Layer, 1987;
- Convention on International Trade in Endangered Species (CITES), 1973;
- Bonn Convention on the Conservation of Migratory Species of Wild Animals, 1979;
- United Nations Convention on Biological Diversity (CBD) adopted at the Earth Summit in Rio de Janeiro, 1992;

- The Copenhagen Accord reached by Heads of State, Heads of Government, Ministers and other heads of delegation at the United Nations Climate Change Conference 2009 in Copenhagen, Denmark.

1.10 EIA Approval Process in Nigeria

The Federal Ministry of Environment (FMEnv) is statutorily responsible for the processing and approval of EIA reports. The EIA Act stipulates that no major project shall be undertaken without prior consideration, at early stages, of their environmental effects. Appropriate mitigation measures for potential significant impacts shall be stated before the commencement of the project. The steps leading to formal approval for EIA projects are usually as follows:

- Project Conceptualisation;
- EIA Registration and ToR Submission;
- Site Verification Visit;
- EIA Scoping;
- Conduct baseline and environmental impact studies;
- Proponent's informs host communities about the extent and processes of the project;
- Proponent submits required copies of the EIA report to FMEnv for assessment;
- FMEnv publicly displays the EIA report in designated areas to enable any interested members of the public to read and comment upon;
- FMEnv places advertisement in some National Dailies to inform the public about the display of EIA report;
- FMEnv appoints an independent review panel, comprising academicians and professionals to review the EIA report;
- FMEnv distribute the EIA report to the review panel members;
- FMEnv convenes a public hearing including site visit after the display of the EIA reports, backed by state wide radio announcement;
- Proponent gives a presentation to the public panel at the review session giving details about the project and its environmental management, followed by a questions and answers session;
- The review panel members, and representatives present their comments on the presentation and the EIA report;
- Proponent responds to all comments and takes note of the public and panel member's observations for incorporation in to the final EIA report;
- Upon fulfillment of the environmental requirements, recommendation for provisional approval will be made by the review panel members; and
- FMEnv will communicate the granting of a provisional approval to proponent and requests the incorporation of the panel's comments into the final EIA report before a final approval of the EIA report. After that the permit is granted.

The steps mentioned above are presented in the diagram (**Figure 1.4**) overleaf.

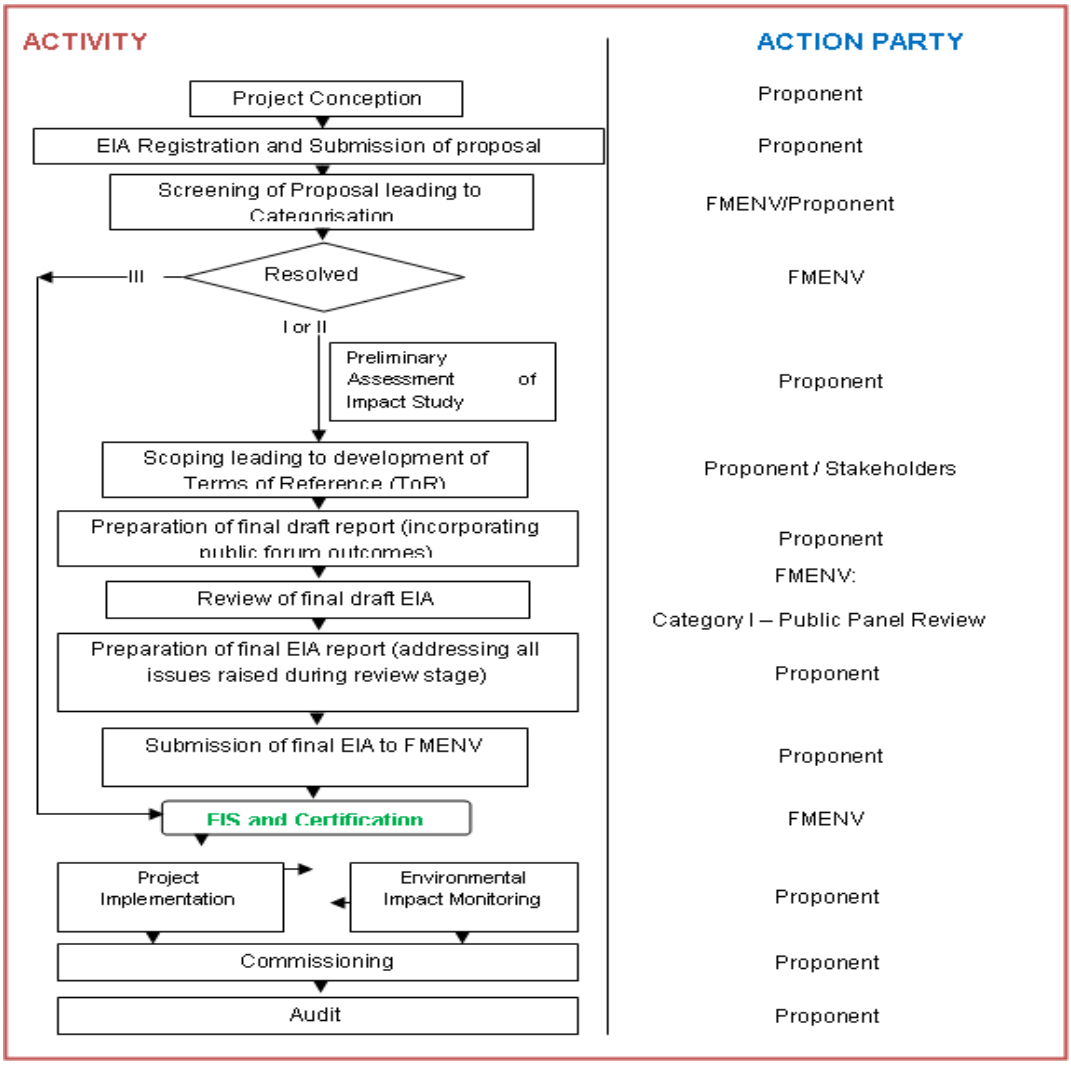


Figure 1.4: FMEnv EIA Process

1.11 Structure of Report

The EIA report is presented in eight chapters as follows:

- **Chapter one:** is an introduction of the proposed project with background information on the proponent, project key design, project location, objectives, work scope, methodology and a review of the legal and administrative framework/ policies applicable to the project;
- **Chapter two:** discusses the project justification, benefits, sustainability, project options considered as well as site selection criteria;
- **Chapter three:** presents the project description which includes technical details of the proposed power plant project, waste streams and project timeline;
- **Chapter four:** describes the existing environmental condition (geographical and ecological) of the study areas as well as socio-economic and health conditions;
- **Chapter five:** identifies and evaluates the impacts from the project, which includes significant impacts;
- **Chapter six:** contains mitigation measures proffered for identified impacts;
- **Chapter seven:** presents the Environmental Social Management Plan (ESMP) to be adopted throughout the project life cycle;
- **Chapter eight** is the report conclusion. List of references and appendices are also included.

Other sections of the report are; table of content, list of EIA preparers, list of abbreviations and acronyms, acknowledgment and executive summary.

CHAPTER TWO

PROJECT JUSTIFICATION

CHAPTER TWO

PROJECT JUSTIFICATION

2.1 Need for the Power Plant Project

The absence of reliable electricity supply and constant blackout causes severe economic stagnation and damage. The cost of alternative power source is at least four times the cost of a reliable power supply. In addition to this direct cost, is the negative impact on people in terms of stress, pollution and continuous maintenance. The modern world is dependent on access to information, which in turn is only possible with a reliable and constant source of electricity.

Availability of affordable electricity has the potential to tackle both the symptoms and causes of poverty. Electricity enables hospitals to function more efficiently and people to cook without exposure to wood-smoke pollution. It reduces CO_2 emissions by removing the need for highly polluting petrol/diesel generators. Most importantly, it removes the greatest obstacle to doing business and enables manufacturing and other industries to compete internationally. In Nigeria, about 40 % of the production cost of manufacturers goes into provision of electricity, compared to 5-10 % in other similar economies (Imoh and Matthew 2011).

Without investment and reform in the power sector, the Nigerian government estimates that annual loss in economic growth is as high as US$ 130 billion or 50 % of Nigeria's 2012 GDP. Provision of adequate grid electricity will transform Nigeria's economic prospects and provide more jobs to millions of Nigerians (Osueke and Ezeh, 2011).

Nigeria has an installed capacity of 10,396 MW and available capacity of 6,056 MW (Osueke and Ezeh, 2011). Many of the existing generating plants, however, are non-functional due to inadequate maintenance, non-availability of gas or breakdown of critical equipment which are no longer available for generation without major rehabilitative work. At the end of January 2014, actual power generation capacity in Nigeria stood at 4,000 MW compared to over 40,000 MW generated by South Africa with less population (USTDA, 2014).

As presented in **Table 2.1** below, Nigeria's electricity generation is much lower than other major countries in Africa with smaller populations. Given a population estimated at over 160 million people, this is grossly inadequate.

Table 2.1: Electricity Generation in some Countries

Country	Population (in Million)	Electricity Generated (MW)
Nigeria	160	4,000
South Africa	52	47,000
Egypt	60	20,000

Source: USTDA, 2014

Annual public sector investment averaging US$2 billion has only led to a limited increase in supply, so the Government of Nigeria took the logical decision to privatise the bulk of its power sector assets as one of the key steps in delivering improved service to Nigerians.

As a result of the power sector reform act and unbundling of Power Holding Company of Nigeria (PHCN) private sector participation such as PEL has been enabled. It is anticipated that the private owners of power companies spread across the country will act quickly to enhance the electricity generation/ supply and improve human resource capacity for effective management of infrastructure within the sector. A new wholesale market in electricity commenced in January 2014, which will lead to more efficient utilisation of power generation.

Nigeria has abundant natural gas reserve (the ninth largest in the world). As a result, PEL intend to utilise the gas fuel for powering its plant. The gas would be sourced from Seplat Petroleum Development Company (Seplat).

PEL is in final phase of contracting Siemens AG or General Electric as its technical partner to ensure the successful construction, operation and management of the power plant. PEL would set up a Project Management Team of indigenous engineers to supervise the execution of the proposed power plant project. The power plant shall evacuate generated power to the National Grid.

The provision of steady and reliable power supply would better the socio-economic conditions of the people. Therefore, the proposed power project is needed to support the development initiatives of the Nigerian Government.

2.2 Benefits of the Proposed Project

The most significant accrued benefit from the proposed power plant project is the expected improvement in power generation and supply. The nation's economy is industrial and agricultural-based; the proposed project is intended to stimulate growth that would provide employment opportunities and further development in these sectors. Generally, the project is expected to yield the following benefits:

- Provide reliable power supply to assist in reducing current generation deficit in the country with the aim of alleviating the current power crisis;
- Source of income to the government through royalties and tax generation;
- Increased revenue/ derivations to Local and State Governments as well as other mandated agencies/ commissions;
- Promote indigenous Nigerian investor-led independent power production;
- Shift the burden of investment capital for power generation from the central government to the private sector;
- Provide stable power supply to encourage development of agricultural-based small and medium scale enterprises thereby reducing poverty and rural-urban migration;
- Promote secondary social development and services such as healthcare service delivery, manufacturing etc.;
- Provide direct and indirect employment opportunities;
- Support technology development through technical assistance and training for Nigerians as part of overall strategy of institutionalising local content in Nigeria's Energy Sector;
- Reduce environmental emissions associated with privately powered generators; and
- Reduce pressure on the diesel/ petrol supply chain.

2.3 Envisaged Project Sustainability

Economic and Commercial Sustainability

The proposed power plant is expected to make electricity available to industrial and domestic users. Hence, customers would be able to purchase electricity, and in turn allow cash flow to PEL for the continued operation and maintenance of the facility, as well as payment of staff remuneration.

Other factors that ensure the project is economically and commercially sustained throughout its designed life span are as follows.

- Availability of natural gas to be supplied by Seplat with existing gas network within the state; and
- The proximity of the proposed power plant to existing CMEC/Eurafric and NIPP power infrastructures for tie-in purposes.

The project actualisation is expected to engage some unemployed Nigerians. It is envisioned that at the peak of construction, about 400 to 500 workers will be employed for the project. Around 80 percent of the workers will be hired from the host community (Ogorode). The EPC contractor will be responsible for the selection and management of all sub-contractors.

Financing

The total project cost for phase 1 construction of the "Delta Sunrise Proton" power plant is approximately US$ 270 million. Phase 1 will be completed in a period of approximately 21 months and will deliver 150 MW to the grid. Further expansion of the plant is expected to take it to its projected 500MW capacity.

The financing for phase 1 will be provided by a mix of debt and equity in the ratio 72.5/ 27.5. Development equity would be largely provided by the project sponsors (i.e. Proton Consortium) and sufficient to take the project to financial close. Project debt will be sourced from a combination of domestic and foreign financial institutions including commercial banks and development finance institutions. Equity investors are being finalised and include well known private equity players and equipment suppliers.

Technical Sustainability

Design of the power plant facility would be carried out using latest technology, which would facilitate simple operation and maintenance system. Also, the proposed project would be technically sustained in view of adherence to international and nationally accepted engineering practices to be adopted at all stages of the development.

Technology to be employed by PEL includes use of dry low- NO_x combustors and flue gas desulfurisation as well as use of higher energy-efficient systems (i.e. combined cycle gas turbine).

PEL has employed and is considering the services of experienced professionals conversant with the various phases of the project within and outside Nigeria. These professionals and their areas of responsibilities are presented in **Table 2.2**.

Table 2.2: Professionals involved in Project

S/No	Organizations
1	Seplat
2	Fieldstone
3	Norton Rose Fulbright
4	Fugro Nigeria Limited
5	PwC
6	Transmission Company of Nigeria
7	Paul Usoro & Co.
8	JN Energy Services
9	CraterLake Group
10	Pedabo
11	Group Five
12	China Machinery Engineering Corporation
13	Siemens AG
14	General Electric

Social Sustainability

Stakeholder consultation process has been implemented throughout the EIA process to assist in ensuring that all stakeholders can provide input into the project planning process. This would go a long way in ensuring better relationship with stakeholders throughout the lifecycle of the project. Details of conducted stakeholder engagement sessions for the power project are included in **Chapter Four, Section 4.18.1**.

PEL is committed to ensure that a portion of the revenues earned by the Proton DSP IPP is spent on programmes that will benefit the local community. These programmes are likely to comprise projects aimed at improving the health, education and infrastructures of the inhabitants of the community. The specific form and extent of these programmes will ultimately be guided by the company's Community Social Responsibility Policy (which will have input from all stakeholders including the Company's employees). This would in the long term assure the continuous operation of the facility. See **Appendix 2.1** for the detailed PEL Community Social Responsibility Policy.

Environmental Sustainability

The project will be environmentally sustained by incorporating into project design, mitigation measures or controls suggested during this EIA (see **Chapter Six**). Also by implementing the environmental monitoring and management programmes as recommended in the ESMP (**Chapter Seven**). Implementing these actions would also ensure that the project meets and/or exceeds the requirements of the Nigerian FMEnv and World Bank/ IFC regarding minimising the environmental and social impacts.

The use of natural gas as feedstock for the plant will help address the problem of gas flaring and pollution associated with oil and gas production in Nigeria. Natural gas has less detrimental effect on the environment than fossil fuels (e.g. coal, diesel, petrol or heavy fuel oil) and emits low levels of greenhouse gases, as well as associated air pollutants.

The project alongside similar power projects would eventually lead to reduce footprint of air pollutant emissions from individual and corporate owned power generators. It will also reduce/ eliminate noise generation associated with these generators.

The power plant would be designed to allow for a conversion to a combined cycle power plant. Conversion to combined cycle will increase energy output by approximately 50 percent with no increase in fuel consumption or carbon emissions. Furthermore, the envisioned cooling technology option considered for the combined cycle power station is air based (to minimize water consumption).

2.4 Project Development Alternatives

The proposed project alternatives as outlined below were considered based on engineering judgment, environmental concerns, adaptability, cost-effectiveness and ease of operation and maintenance of the project throughout its design life.

2.4.1 Project Development Alternatives

Option 1: Do Nothing

Currently, electricity supply to the national grid has been very low and unreliable. The "Do Nothing" option implies that the status quo would be maintained. Adopting this option would ensure that frequent outages and slowed economic development continues. If the power plant is not developed, the direct benefits to the availability and stability of electricity will not be realized as the current electricity supply is unreliable and insufficient. Other direct and indirect benefits as earlier listed will not be actualized.

Option 2: Upgrade Existing PHCN Plant Facility

The ex-PHCN facility was put up for sale by the Government, but during the bidding process, PEL lost. Consequently, the plant was sold to another company (CMEC/EURAFRIC). This option was therefore not considered as PEL intends to develop a new plant facility close by.

Option 3: Develop New 150MW Plant

This was the option selected, majorly due to the potential advantage and immense benefit the project would provide to the country once operation commences. The benefits have been discussed earlier.

2.4.2 Power Plant Alternatives

For a project of this scale it is important to ensure the most efficient and effective use of available environmental, financial and human resources. The table below presents a comparative analysis of technical feasibility, environment impacts, investment cost, social impacts of various alternative energy sources.

Table 2.3: Comparative Analysis of Fuel Source for Power Generation

Criteria	Wind	Solar	Hydroelectric power	Nuclear	Coal	Natural Gas
Environmental Consideration	- Zero direct emissions involved - Land take for 150 MW will be in excess of 150 ha @ 1ha±0.7/MW[3], hence total land acquired for project will be insufficient and further acquisition will see larger area than needed for gas plant acquired. - Aestethic and potential noise disturbances due to rotor blade movement	- Land take for solar plant about 1ha/MW is in excess of land acquired by Proton for power generation. - Zero emissions from generation	- Adverse impact on land use and land use change due to large hydropower dam construction. - Distortion of aquatic habitat due damming - Zero direct emission although considerable loss to ecosystem services.	- High considerations for nuclear plant safety. - Large amounts of nuclear radioactive waste to be discharged	- Coal produces SO_x, NO_x, particulate matters, wastes and ash. - Effluents and waste require advanced capture and sequestration; more land required for ash disposal.	- Less polluting than a coal plant. - Low land take required. PEL 150 MW power plant has a direct land take of 3.7 ha. This implies less distortion to flora and fauna habitat. - Development of gas power plants reduces flared gas
Technical Feasibility	- Average wind speed of 4.4m/s[4] during windiest period not enough for optimum generation[5]. - Intermittency of generation due to availability of sufficient wind speeds. Costly and unreliable	- Capacity factor of about 26% - Variable generation from solar and need to regulate output before dispatching to grid makes solar best suited for peak demand whereas natural gas is	- Reservoir capacity recoverable from the Ethiope river, topography make the project site area unsuitable for hydroelectric power generation	- There is currently no active nuclear program for safe exploitation of this resource for electricity in Nigeria	- Low regulatory capacity for coal power	- Lower lead time - High indigenous capacity for regulation and operation of gas power plant

[3] http://www.nrel.gov/docs/fy09osti/45834.pdf
[4] From wind speed measurement presented in Chapter 4
[5] Utility-scale wind projects require a minimum of 6.3m/s at 50metres above http://sustec.appstate.edu/sites/sustec.appstate.edu/files/WindEnergyFactSheetWNCREIFeb07.pdf

Criteria	Wind	Solar	Hydroelectric power	Nuclear	Coal	Natural Gas
	energy storage methods.	suitable as base load generator needed to meet Nigeria electricity supply. - Unproven energy storage technology for large scale generation as proposed.				
Investment Cost	Capital intensive (although zero fuel cost and low variable O&M cost). Estimates in excess of $1.2million/MW[6]	Average installed price of $4.7million/MW	High capital cost required estimated at about $2million/MW[7]	High insurance and operating cost of operating nuclear plant asides high overnight cost estimate of $5.5million/MW. Very low variable O&M cost due to long half-life of fuel.	Higher investment cost in Nigeria due to poor value chain for coal, estimated at $3.2 million/MW[8] $5.3million/MW[9]. Plant capital cost could increase by 4-9% for secondary NO_x reduction	Lower capital cost than nuclear, coal, and renewables considering project site peculiarities and conditions.
Social Impacts	Higher cost of electricity to be passed to consumers through feed-in tariffs.	Higher cost of electricity to be passed to consumers through feed-in tariffs.	- Large scale displacement of persons as a result of construction and development will arise. - There will be adverse impact on the socio-economic status of affected communities due to construction and displacement e.g. impact to fishermen and farmers	Need to create safety setbacks result in displacement of persons living within proximity to site.		- Low lead time means impact of electricity generation on socio-economic status will be quickly felt.
Feedstock	Zero cost for wind, although	Availability of sufficient solar	Available water	No radioactive feedstock	Annual production of	Abundant natural gas

[6] Estimate based on European Wind Turbine Installations
[7] Figure based on estimates for capital costs for a hydropower dam in Africa made by the International Renewable Energy Agency for large hydropower dams; smaller hydropower dams have higher estimates.
[8] Figure based on US Energy Information Administration estimate for overnight cost for 2012 of a Single Unit Advanced Pulverized Coal plant without Carbon Capture and Storage (CCS)
[9] Figure based on US Energy Information Administration estimate for overnight cost for 2012 of a Single Unit Advanced Pulverized Coal plant with Carbon Capture and Storage (CCS)

Criteria	Wind	Solar	Hydroelectric power	Nuclear	Coal	Natural Gas
	availability of sufficient wind speed makes project site unfeasible for adapting technology.	energy resource is a key consideration. Sunlight hours in the region ranges between 8-12hours at different intensity and shading.	resources for damming which will however be impacted by season water levels.	currently being exploited in Nigeria. Hence this is not a viable option	coal on the decline since the 1990s of less than 100,000 tonnes	reserves of 187Tcf with aggressive gas master plan for utilization of gas.

Option 1: Wind Plant

Wind power is the conversion of wind energy into useful form of energy, such as electricity, using wind turbines. The wind power plants make use of available wind to push against the turbine blades, spinning the copper wires inside the generator to create an electric current. In 2008, wind power produced about 1.5% of worldwide electricity (World Wind Energy Association Report 2008 - February 2009). It is a renewable source of energy but is usually non-dispatchable, i.e., for economic operation, all of the available output must be taken when it is available. It is also intermittent (i.e. varies) due to weather condition, location, and season.

The environmental and health benefits of wind power include: widespread, inexhaustible cheap resource that could be developed; low emissions (reduces smog and eliminates a major source of acid rain and total emissions of carbon dioxide - a greenhouse gas) ensuring cleaner and healthier air, especially for people with respiratory disabilities. The drawback to the application of wind power which has made this option not considered by PEL are:

- Intermittency of adequate wind speeds for base load generation
- Large land area required to generate same amount of power; and
- their height makes them obtrusively visible across large areas, disrupting the appearance of the landscape and aesthetically unappealing.

Option 2: Solar Plant

It is a system for harnessing sunlight for generation of electricity. There are two main types, namely solar thermal and solar photovoltaic (SPV) panels.

The solar thermal method involves parabolically shaped mirrors arranged to concentrate sunlight on long steel pipes filled with circulating oil, heating it at 750 °F. The heated oil passes through giant radiators (heat exchanger) that extract the heat and boil water into steam. The steam then turns turbine and dynamo thereby producing electricity that can be evacuated through the grid. Solar thermal systems have however only been developed at commercial scale in few locations.

Photovoltaic panels (made of semiconductors such as silicon) on the other hand convert sunlight directly into electricity. Solar thermal requires large acres of land (greater land-take) and long transmission lines to bring the power to where it is needed. However, both solar energy sources fade when it is cloudy and disappear at night. The average daily sunshine hours in Delta State is about 12 hours only. The solar power plant was not considered for implementation because of the land take required, and the early development stage of storage technology for SPV-generated energy.

Option 3: Hydroelectric Plant

Hydroelectric plant uses gravitational force of falling (or flowing) water to spin the turbine blades which generates electricity. It is the most widely used form of renewable energy. Once

a hydroelectric complex is constructed, the project produces no direct waste, and has a considerably lower output level of the greenhouse gas carbon dioxide (CO_2) than fossil fuel powered energy plants.

Approximately 20% of the world's electricity (and about 88% of electricity from renewable sources) come from hydroelectric plants (WVIC, 2012). The cost of operating a hydroelectric plant is nearly immune to increases in the cost of fossil fuels such as oil, natural gas or coal, and no imports are needed. The hydroelectric plants also tend to have longer economic lives than fuel-fired power plants. On the other hand, hydroelectric dam failures create large scale environmental and socio-economic destruction. Often, good design and construction are not an adequate guarantee of dam safety. Dams for hydroelectric plants lead to siltation which damages both the aquatic ecosystem and reduces life span of the plant.

The dams developed across the rivers can disturb aquatic life and lead to their large-scale destruction. There is a chance that fish and other water animals may enter the penstock and ultimately the power generation turbines where they will be killed. Dams can also disturb the mating seasons and mating habitats of water animals.

To build dam a huge amount of land is needed for installing facilities such as power generation unit, transformers and connecting systems. This requires forests to be cleared disrupting many local and natural ecosystems. Also, considering that dams take up such a large area, it is often necessary for humans to relocate. As such, the rigors of relocation do not often favour the affected communities which could lead to large scale opposition, revolts and civil unrest.

Option 4: Nuclear Power Plant

Nuclear generators use nuclear fission to turn water into steam. This drives steam turbine, which spins a generator to produce electricity which is then evacuated through a grid. The energy yield is very high and with very low carbon foot print. The nuclear power technology is well developed with track record of producing electricity with few safety incidents. It is also suitable for power production in areas with poor natural and renewable resources. The major concerns are nuclear plant safety, nuclear weapons proliferation (uranium enrichment which can produce higher concentrations of U^{235} suitable for nuclear weapons), and nuclear waste. It also produces large amounts of highly radioactive nuclear waste that must be stored/ isolated from the biosphere for very long time. Insurance cost and overall cost of operating nuclear power stations are very high.

Nuclear accidents or mishap can spread radiation producing particles over a wide area. This radiation harms body cells which can make humans sick or even cause death. Illness can appear and strike people years after they were exposed to nuclear radiation and genetic problems can occur too (i.e. mutation). There have been cases of burns, cancer, radiation poisoning etc.

Option 5: Coal Power Plant

Coal power plant burns coal to generate steam which turns turbine engine to generate electricity which is then distributed through a grid. This is a viable option considering vast coal deposit in Nigeria and the technology of coal power plant is well developed. Energy supply from coal power plant is independent of weather conditions. It also has secondary advantage of providing jobs and revenue for existing industries and communities (coal mining and coal transport). However, the carbon foot print is large with environmental concerns (particulate and gaseous pollutants emissions and contribution to global climate change through greenhouse gas emissions). Coal mining is often very destructive to the landscape and to coal miners.

Large land area is required for ash disposal. Deploying Carbon Capture and Storage (CCS) technology increases cost of generation and electricity with its attendant environmental and soil formation issues. The table below shows the emissions for an advanced pulverized coal plant, an advanced pulverized coal with carbon capture and storage plant, a conventional

natural gas combined cycle plant, and a conventional combustion turbine plant for NO_x, SO_x, and CO_2.

Table 2.4: Emission data for Coal and Gas-fired plants

	APC (lb/MMbtu)	APC/CCS (lb/MMbtu)	Conventional NGCC (lb/MMbtu)	Conventional CT (lb/MMBtu)
NO_x	0.06	0.06	0.0075	0.03
SO_2	0.1	0.02	0.001	0.001
CO_2	206	20.6	117	117

Source: U.S. Energy Information Administration, 2013

Option 6: Natural Gas Plant

The natural gas-fired system was the preferred option selected by PEL. Natural gas plant was chosen because of abundance of feedstock (gas) in Nigeria as well as relative expertise technology available in Nigeria by operators and regulator alike.

Also, because of the efficiency of natural-gas fired plant (about 35 percent for simple-cycle and 54 percent for combined cycle).

2.5 Site Selection

Alternative sites were considered within Delta State during the design phase of the project. Areas considered were Warri, Ughelli and Asaba. However, the preferred location (i.e. Sapele) was selected by considering the site which offers the least disruption to both human and natural environment; the following criteria was also condisered:

Land Size

The intended project land size is about 27.4 hectares, this is sufficient to reduce footprint from further land acquisition. The land selected is enough to accommodate the proposed plant facilities and structures up to 500 MW. Consideration was given to proper land coverage ratios, installation heights, future expansion and site development.
Of this land area, direct land take for the development of phase 1 will be about 6 hectares.

Physical Characteristics

The site's physical characteristics were also considered. The soil conditions, slope, topography and other site-specific factors were considered.

Proximity to River Source

The proposed power plant facility is to be located close to Ethiope River. This could be leveraged as source of water during construction or for transportation of materials.

Access to Gas Supply and Transmission Evacuation Systems

Access to gas supply and evacuation systems was a key site selection criteria considered by PEL. The acquired land is near gas transmission pipeline. PEL intends to construct and connect a 1.5 km gas pipeline to this supply network.
Electricity evacuation would be via a 1 km transmission line connected to already existing switchyard used by nearby existing power plants (CMEC/Eurafric and NIPP).

Reduced Project Cost

The cost for project execution would be reduced as common facilities are optimally being shared as mentioned above.

Structural Demolition

The proposed project site does not require the removal of any existing structures, such as parking lot, platform, buildings etc. The area is green field devoid of pre-existing infrastructure; hence demolition of any structure would not be required for this project.

CHAPTER THREE

PROJECT DESCRIPTION

CHAPTER THREE

PROJECT DESCRIPTION

3.1. Project Overview

Proton Energy Limited (PEL) intends to construct a 500 MW Power Plant which would be developed in two phases. First phase construction of 150 MW Open Cycle Gas Turbine (OCGT) Power Plant at full operation. Then a second phase addition of 350 MW capacity plant and conversion to Combined Cycle Gas Turbine (CCGT).

This document concentrates on the development of phase 1 by emphasizing on technology option and specifications for the 150 MW. However, environmental baseline as well as socio-economic survey was carried out taking into consideration full proposed capacity of 500 MW in view. Impact mitigation measures and monitoring systems where required have also been prepared to cover the eventual development up to 500MW.

The proposed project is required to boost power supply in the country by addition of electricity to the national grid. The plant would be located within Ogorode community, Sapele, Delta State, Nigeria. Project footprint is 27.4 hectares. See **Appendix 3.1** for survey plan of the site.

The following are key elements of the project activities:

- a first stage construction of 150 MW OCGT power plant;
- second stage conversion to 500 MW CCGT system;
- gas transmission pipeline (1.5 km) connecting to existing gas supply pipeline; and
- a 1 km evacuation line connecting switchyard to 330/120 kV substation in Sapele.

The proposed power plant development would also be achieved via the following sequence:

- pre-construction (engineering design and site preparation);
- construction and installation;
- operation; and
- decommissioning.

3.2. Project Components

The power plant components are as follows:

- gas reducing station;
- gas turbine;
- diesel tanks;
- fire water tanks;
- fire pump skid;
- fire mains;
- fire hydrants;
- lube oil cooler;
- pipe-rack system;
- air compressors;
- electrical and administration buildings;
- step up transformers; and
- gate etc.

Project layout showing locations of plant components are presented in **Figure 3.1** (attached).

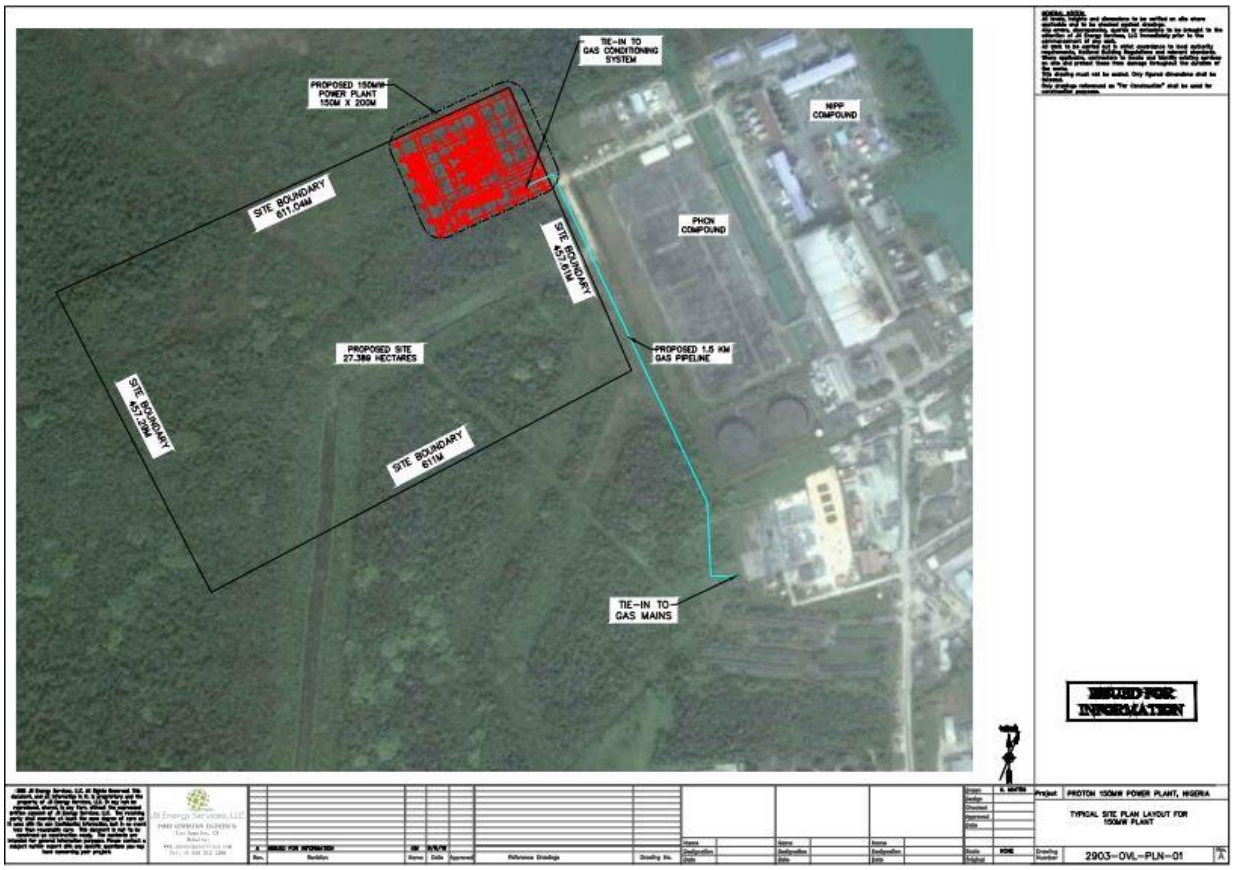
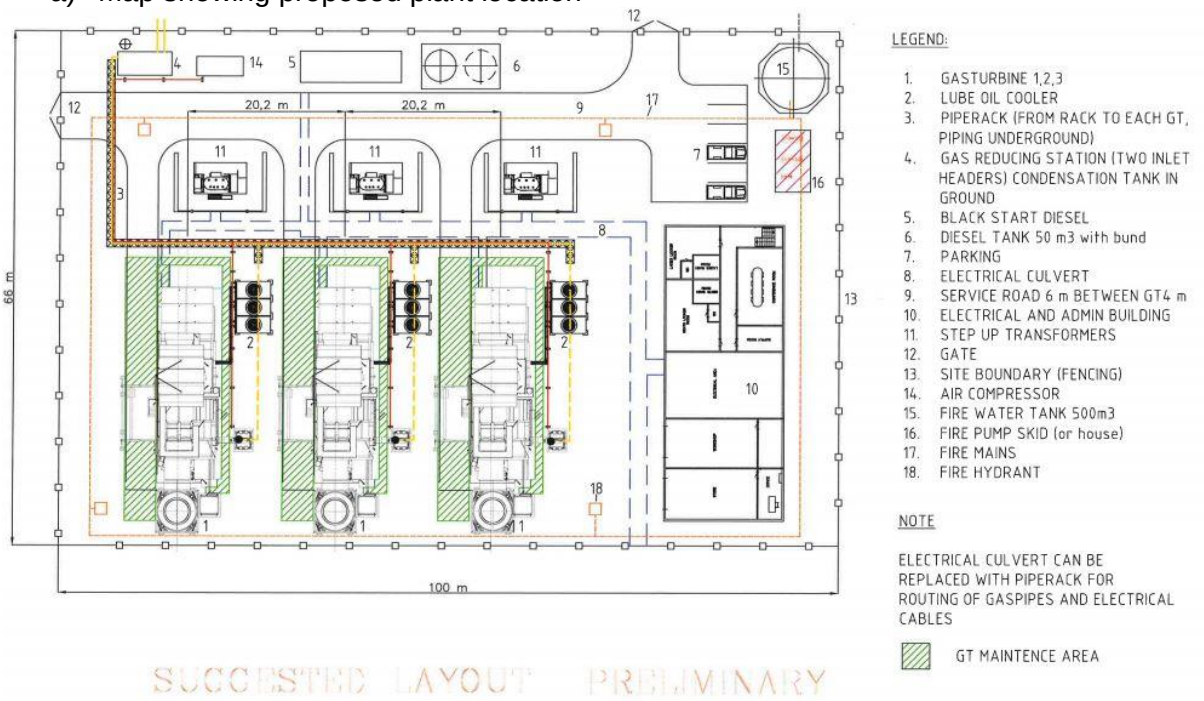


Figure 3.1: Proposed Plant Layout

a) Map showing proposed plant location



b) Proposed Turbine Position

3.3 Land Acquisition Process

The proposed project site land is made up of two adjoining plots – one 13.4 hectares and the other 14.003 hectares. Both plots combine to make the total land area of 27.4 hectares. The 13.4 ha was leased to Proton Energy Limited for a period of 99 years and governed by a deed of lease dated March 2013, while the 14.003 ha was assigned to Proton Energy Limited

through a deed of assignment. Prior to acquisition of the land, various family meetings were held wherein the head and principal members of both families were given authority to bind and execute the agreements on behalf of the families in respect of the land. Land was surveyed and registered with the Delta State Ministry of Lands, Surveys and Urban Development in October, 2013.

The State Governor's consent has been sought and obtained for the assigned piece, while the issuance of a Certificate of Occupancy is expected for the 13.4 ha.

It should be noted that there would be no relocation of people, as the area is chiefly undisturbed rainforest vegetation and a few sections of secondary re-growth. No further compensation was required beyond the fee paid for the transfer of rights and ownership of the land. Prior to change of ownership, no form of economic activity took place on the land.

During land acquisition, community members were fully engaged and there were no issues during the entire process.

3.4 Staffing

There will be between 400 and 500 workers at each interval during construction phase, and a base camp will be created on site to cater for the accommodation and welfare needs of construction workers. About 80% of these workers will be sourced locally (within host community) and may already have personal accommodation in place. In this instance, PEL will provide adequate means of transportation to and fro the site during this period.

PEL intends to employ initially about sixty (60) direct personnel during operation phase. PEL will seek ultimately to 'multi-skill' its personnel such that a significant number of operators will be skilled craftsman and vice-versa. This will allow greater flexibility of staff so that minor problems can be addressed on shift thus maximising availability and allow best use of staff during planned outages of plant. This will allow staff to be better rewarded, giving them greater job satisfaction and serve to build a highly motivated team that strives to maximise output of the plant. The EPC contractor would work together with PEL Management to ensure deserving Nigerians are employed.

3.5 Setback Consideration

There are currently no regulations regarding the location of gas fired electric generation plants in Nigeria with regards to setback consideration. In siting power plants however, buffer zones are usually considered, to limit access to the facility from trespassers and unwanted visitors.

Around the globe, there has been recognition for the need of separating facilities from residential/community areas. It is PEL intention to construct the power plant away from residential area, as was achieved with the existing power plants in the area.

The proposed power plant would be located away from residential areas and directly beside the existing power plants facilities. The plant would be sited about 1.5 km away from the community. A buffer or green zone would be set at 200m radius of the site (except for areas where the existing facilities are). **Plate 3.1** shows the location of the proposed power plant in relation to residential areas within Ogorode Community.

Source: PEL, 2014

Plate 3.1: Aerial View of Project Location

The plate above shows that setback for the project has been considered and residential areas are not in close proximity to the facility. The first major cluster of residential area, as indicated to the far north-west of the plant site is about 1.5 km away.

3.6 Project Details

The Proton "Delta Sunrise Project" (Proton DSP) would be the construction, installation and operation of a 150 MW power plant.

The preferred plant design specification for the OCGT power plant is presented below. Design parameters have been further used for air concentration modeling see **Chapter Five, Section 5.8.2**.

Table 3.1: Proposed OCGT Plant Design Specification

Components	Specification
No. of turbine units	3*
Stack height (in m)	18
Stack internal diameter (in m) at the exit	3.2
Stack area (sqm)	8
Flue gas temperature (^{O}C) at the exit	544
Flue gas velocity (m/s) at exit	20
SO_2 (ppm)	0.73
NO_X (ppm)	15

* number of turbine units to be confirmed after EPC selection process
Source: PEL, 2014

3.6.1 PEL Technology Choices

Phase 1

PEL shall see the development of 150 MW gas-fired plant at phase 1 using the OCGT technology.

Technology Justification

This technology is the most popular for gas-fired power plants globally and is the benchmark technology upon which the Nigerian Electricity Regulatory Commission (NERC) based its tariff calculation for gas-fired plants. It is also the most economically viable electricity generation method for Nigeria considering prevailing technical know-how and competition for scarce funds. OCGT is also the cheapest power generation method in terms of capacity cost.

Furthermore, there are numerous suppliers of the technology across the world, with project construction varying from 20 months – 3 years.

Process

A compressor takes in air from the atmosphere and compresses it through a number of compressor stages. Fuel is pumped into a combustion chamber and mixed with the compressed air. The fuel/air mixture is then ignited to form hot, high velocity gas. This gas is passed through turbine blades that turn the shaft that is attached to the rotor of the generator. The rotor turns inside the stator and electricity is generated. This electricity is then distributed via high voltage network to where it is needed. Schematic of this process is shown in **Figure 3.2**.

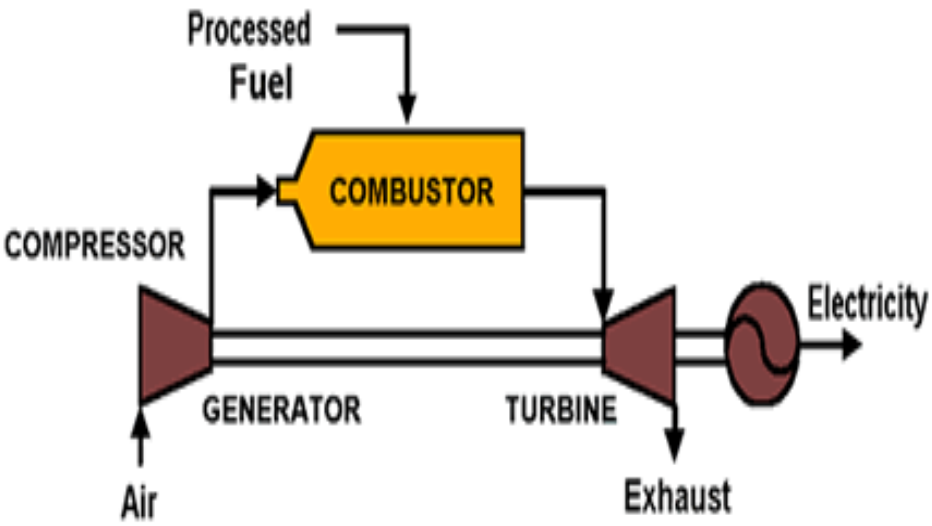


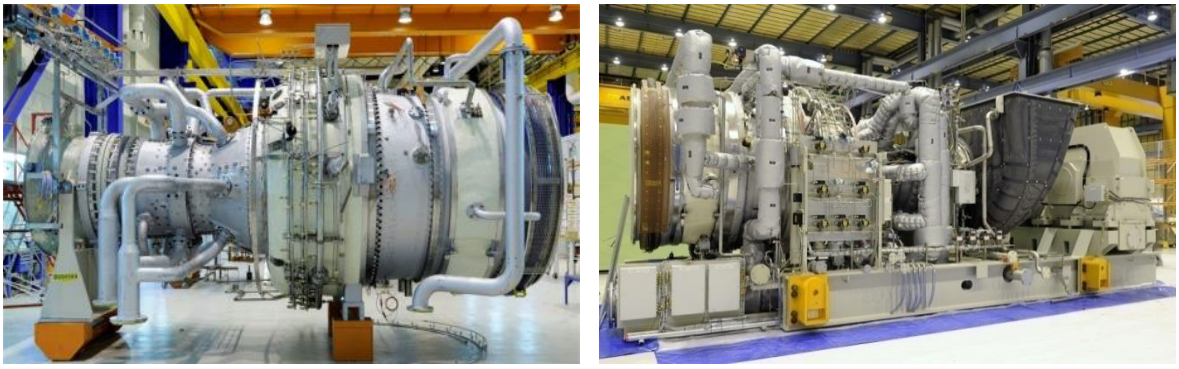
Figure 3.2: Open Cycle Power Plant Schematics

PEL following due process and best international practice, advertised for suitable Original Equipment Manufacturer (OEM) and Engineering, Procurement and Construction (EPC) contractors to develop the initial 150 MW based on its preliminary Front End Engineering Design (FEED). Two companies have been shortlisted as OEM contractors; Siemens AG, and General Electric (GE) Nigeria. Award of contract to successful company would be concluded in July, 2016.

This currently suggests two equipment options (listed in no order) for the development of the 150MW gas fired power plant.

Option 1: Three (3) Siemens SGT-800 (**Plate 3.2**) class industrial gas turbines, each rated at 47±5MW for a total of 150MW

This turbine affords very competitive economy for independent power producers, has high efficiency and outstanding cogeneration capability. It also has true dual-fuel Dry Low Emission (DLE) combustion to minimize NO_x emissions and ensure that the turbine complies with both global and local emission regulations. This option combines flexible maintenance, high availability and modular overhaul thereby allowing on-site maintenance. Its high power-to-footprint ratio implies lower construction costs and less environmental distortions in terms of land clearing and land use change. Exhaust temperatures of 544^{0}C are indicative of its high suitability for combined cycle operations, with low NO_x emissions of ≤15ppmV.



Source: http://www.siemens.com/energy

Plate 3.2: Siemens SGT 800 Gas Turbine System

Option 2: Two (2) GE GT -6F.03 50 Hertz Combustion Gas Turbines @ 75 MW per turbine for a total of 150 MW

GE machines currently power about 25% of electricity plants globally. As with the Option 1, the GE 6Frame operates on a Dry-Low NO_x combustion technology, and has capability to operate at up to 0.95 power factor with a wide flexibility range to suit operating environment, and by offering fast and reliable start-up capabilities they assure on minimal downtime lags.

Source: http://www.ge.com

Plate 3.3: GE GT -6F.03 Single Shaft Cross-Section

The 6F gas turbine utilizes same advanced technology developed for 7F gas turbine. The configuration is a single shaft, bolted rotor with the generator connected to the gas turbine through a speed reduction gear at the compressor or "cold" end. This feature provides for an axial exhaust to optimize the plant arrangement for combined cycle or waste heat recovery applications.

Phase 2 -Expansion to 500 MW

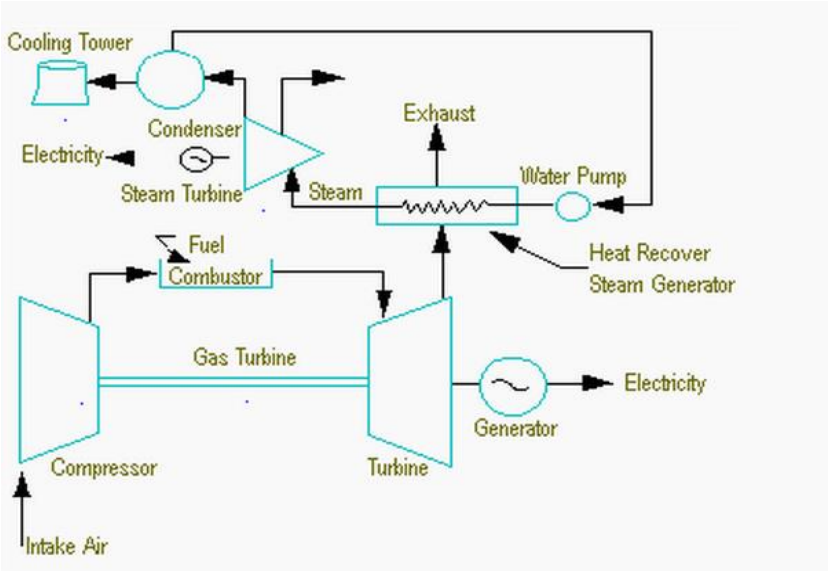
Expansion to total installed capacity of 500 MW at Phase 2 would be through utilizing the combined-cycle technology leading to additional capacity of circa 350 MW. The configuration of both turbines considered at Phase 1 allow for scalability to the combined-cycle through advanced heat recovery made more efficient through the axial exhaust arrangement. Typically, a heat recovery steam generator (HRSG) would be installed at the exhaust, utilizing exhaust temperatures to condense water into steam to drive steam generators.

Phase 2 equipment would similarly be either:

- Two (2) Siemens SST-700 series with a combined output of circa 350MW @175MW per turbine; or
- Two (2) GE 106FA/206FA Combined Cycle plant.

CCGT Principle

The basic principle of the CCGT is simple: burning gas in a gas turbine produces not only power – which can be converted to electric power by a coupled generator – but also hot exhaust gases. Routing these gases through a water-cooled heat exchanger produces steam, which can be turned into electric power with a coupled steam turbine and generator (**Figure 3.3**).



Source: EEP, 2012

Figure 3.3: Combined Cycle Power Plant Schematics

Combined cycle power plant produces high power outputs at high efficiencies (up to 55%) and with low emissions. Open cycle power plants generate about 33% electricity only, and 67% as waste. About 68% electricity is generated using the combined cycle power plant system (EEP, 2012).

3.6.2 Gas Turbines Specification

The gas turbine specifications for the two options being considered are presented below in **Table 3.2.**

Table 3.2: General Gas Turbine Specifications

Components	Siemens SGT 800	GE GT 6F.03 50 Hertz
Power generation	47 MW	75MW
Frequency	50 or 60 Hz	50 or 60 Hz
Electrical efficiency	37.5%	36%
Heat rate	9,597 kJ/kWh (9,096 Btu/kWh)	9,991 kJ/kWh (9,470 Btu/kWh)
Turbine speed	6,608 rpm	-
Compressor pressure ratio	19.9:1	16.0
Exhaust gas flow	131.5 kg/s (289.9 lb/s)	-
Exhaust temperature	544° C (1,011° F)	601° C (1,113° F)
Exhaust energy	-	498 MMkJ/hr (472 MMBtu/hr)
NO_x emissions	with DLE corrected to 15 % O_2 dry	15 (@ 15% O_2 ppm)[2]
CO emission (ppm)[2]	-	9
GT ramp rate (MW/minute)	-	7
Startup Time (Hot, minutes)	-	29

Sources: https://powergen.gepower.com/plan-build/products/gas-turbines/6b-03-gas-turbine/product-spec.html
http://www.energy.siemens.com/nl/en/fossil-power-generation/gas-turbines/sgt-800.htm#content=Features

Key features of SGT 800 Gas Turbine

- Simple and robust dual-fuel DLE technology;
- Available for both 50 Hz and 60 Hz applications;
- Reduced project risk due to proven plant concepts and experienced organisation;
- High electrical efficiency with low deterioration;
- Optimisation of power train and balance of plant for excellent efficiency;

- Complies with -IEC/EN 6034-1 standard;
- Low emissions per generated MWh due to high efficiency/ high fuel utilization;
- Cold-end drive enabling straight and simple fit with HRSG;
- Stable load-rejection capability with < 5 % over-speed;
- Low gas-supply pressure required; and
- Optimised plant layout combining high maintainability with small footprint.

Key Features of GE GT 6F.03 50 Hertz

- Available for both 50 Hz and 60 Hz applications;
- Fast start capability and full power output within 10 minutes;
- Excellent reliability and availability from aero derivative design;
- High simple-cycle, base-load efficiency;
- Excellent hot day and part-load performance;
- Load following and cycling capabilities;
- Excellent part-load performance;
- No maintenance penalties for cycling; and
- Water injection NO_x emission control.

<u>Maintenance of Turbine</u>
Both gas turbines can be maintained as follows.

- Establish on-site service concept to eliminate need for special workshop maintenance;
- Compact, modular layout enabling easy on-site maintenance;
- Removable burners for quick and easy inspection;
- Vertically split compressor casing;
- Staff training in operation and maintenance;
- Provide 24/7 support; and
- Remote diagnostics available.

3.6.3 Electricity Evacuation and Transmission

PEL conducted a power evacuation study for its proposed power plant and was approved by the Transmission Company of Nigeria (TCN) up to 500 MW nominal capacity. The Power System Planning Research and Development division conducted additional evacuation studies to establish optimum grid connection and specifically investigate critical 330/132kV installation for effective power evacuation. Based on the evacuation study, PEL would evacuate generated electricity to a sub-station in Sapele by connecting to existing 330kV switchyard beside its facility via a 1 km evacuation line.

The existing switchyard is currently being used by CMEC/Eurafric and NIPP power plants and has the capability of evacuating 2,800 MW of electricity, but at present only 150MW is being evacuated. PEL therefore intends to make use of the switchyard, and has gotten approval from TCN (see evidence attached in **Appendix 3.2**)

In the future, for robust support and efficient metering, PEL will construct its own switchyard close to the existing switchyard.

3.6.4 Gas Supply

The source of fuel for the power plant is natural gas. The gas will be supplied by Seplat Petroleum Development Company (also in Sapele Town). 40mmscf/day of gas is required by the plant. Seplat is in the process of laying pipelines to make available gas from its expanded assets.

The gas would be supplied through a 12" x 1.5km diameter pipeline to existing pipe network and booster station feeding the existing CMEC/Eurafric and/or NIPP plants. The 1.5km gas pipeline would be buried underground. Gas would be received into the proposed Plant Gas Receiving Station for quality check and metering.

3.6.5 Ancillary Project Components

Project components based on design are indicated below. It should be noted that component details may differ slightly.

OCGT Associated Machinery

Auxiliary compartments, including fin fan coolers, and inlet air filter bag houses for gas turbines.

Water Treatment Plant

A water treatment plant and storage tank with capacity of 12 m^3/h and 800 m^3 respectively, is planned for installation at the site. This will meet the maximum daily water requirement of the plant which is estimated at 40m^3 (40,000 litres) over the lifetime of the Project, and meet water storage needs. Water would be obtained from four (4) bore holes to be drilled after proper study to ensure optimum locations and sustainable exploitation. For efficiency, the boreholes will be drilled with expectations of meeting water needs sustainably at Phase 1 and Phase 2.

The water will be taken into a tank where the first stage of treatment will take place through aeration and sedimentation. Treated water will be transported to required plant sections through a dedicated piping network. The tanks will be constructed to allow for easy isolation during routine maintenance.

Treated water will be required for washing of gas turbine compressor, for general service water to the plant and potable water connected to administrative buildings which will meet WHO/Nigerian water quality standards.

Gas Receiving Station

There would be a gas receiving station which would have an emergency shutdown system with a Slam Shut Valve Station. It will also have a metering station, scrubbers, filters, gas heaters, and pressure reducing device.

Black Start System

Auxiliaries and gas turbine starting motors may not be available whenever they are power outage or failures. As a result, PEL plans to install three 3.0 MVA diesel units to provide an estimated 9.0 MVA. These units will also be available to assist in the emergency shutdown required in the event of a total grid system collapse.

Approximately 50 m^3 of diesel will be stored onsite for black starts. This volume is equivalent to approximately 24 h of operation. Diesel will be stored in a 50 m^3 tank with a surrounding bund wall which will have a capacity of at least 60 m^3. The diesel will be piped from the storage tank to the black start units. Diesel is hazardous and inflammable and should be handled effectively.

Fire Protection System
PEL will use suppression systems that will include combinations of dry chemicals and/or wet agents to suppress fire during outbreaks. The means of detection would be through heat sensors, wiring, or manual detection (depending on system selection).

Two (2) fire service water storage tanks will be provided in case of emergency. Gas turbine enclosures will be fitted with self-contained fire detection and protection systems based on a carbon dioxide fire suppressant system (or equivalent).

Waste Treatment
PEL intends to install a waste (effluent) water treatment plant for managing produced waste/ effluent. However, this is still being considered. The other option would be to store effluent waste in storage tanks and evacuate to approved disposal center for treatment when filled.

Lube Oil System
The purpose of the lube oil system is to deliver clean, cool, lubricating oil to the engines at the proper pressure and temperature. This is accomplished by a series of pumps, coolers, tanks, and filters. Lube oil is circulated to the engine and back in a continuous loop, via a lube oil circulating tank that serves as a central receiver.

Workshop/ Store
A workshop and storage area will be constructed close to the administrative building and away from the plant area. The workshop will contain the following:

- work area with equipment such as protective clothing, welding unit, lathe, grinder etc.;
- storage areas for engine tools and spare parts;
- electrical instrument section; and
- male and female toilets, washing facilities and changing rooms.

3.6.6 Plant Water Supply and Cooling System
Water is required for the washing of gas turbine compressor, and general service water to the plant and potable water to the office buildings. Water will be sourced from boreholes to be drilled to meet the power plant's daily water requirement.

A water storage tank with sufficient capacity to meet the plant's water needs will be installed to provide water in the advent of disturbance to the water supply.

Turbines will be air-cooled through an enclosed air cooling system to be delivered as part of the turbine equipment.

3.6.7 Control System and Instrumentation
PEL will operate a control room. The control room will be close to the plant area. The control room will form an annex to the gas turbine building so that the operators can access the gas turbine hall from the control room.

The Siemens SGT-800 control system is based on the Simatic PCS7 system which has two controllers from the S7-400 series, one AS417 and one AS414F. The AS417 is used for sequencing, interlocks, open loop control and for closed loop control for fuel valve positioning. The AS414F is used as a SIL proven safety system. The human-machine interface comprises a WinCC operator station with a full graphic colour TFT screen. The Simatic PCS7 control system may also communicate with external systems via standard protocols.

3.6.8 Compressed Air and Ventilation Systems
The compressed air system compresses, stores and delivers medium pressure (30 bars) compressed air to start the diesel engines. The system includes:

- dual air compressors;
- compressed air storage tanks;
- air-start system for engines; and
- instrument and service air system.

The onsite administrative office, control room and control equipment rooms will be air conditioned. The gas and steam turbine buildings will be ventilated by natural ventilation through louvers.

3.7 Project Design Basis

The design intent of the proposed power plant facility is to develop environmentally sustainable system that satisfies applicable regulations (local and international), industry standards and codes. Furthermore, the design, construction and operation of this project shall be conducted to:

- protect the safety, health and security of employees, customers and other stakeholders;
- maintain environmental integrity;
- comply with applicable laws and regulations;
- apply sound geo-science, engineering, technical and commercial best practices;
- focus on flawless execution with minimum re-works;
- meet the reasonable aspirations of the project-impacted community;
- achieve facility performance objectives.

Applicable Codes and Standards

The concept and design of the proposed power plant project are based on TCN specifications and are in line with national and international standards/codes. These cover various aspects such as electrical, mechanical, civil, generation and transmission process. Codes and standards applicable to the proposed project are detailed in **Appendix 3.3**.

3.8 Project Execution Phases

3.8.1 Pre-Construction Phase

This is the preliminary phase and it involves a number of activities which includes the following:

- Acquisition of land;
- MoU agreement with host community;
- Request for Proposal for EPC and OEM contractors;
- Preliminary Front End Engineering Design (FEED) as basis for engineering works;
- Conduct of survey, geotechnical, topography and EIA studies;
- Negotiations with investors for project funding– financial close by December 2015.
- Discussion with the Nigerian Bulk Electricity Trader (NBET) towards signing a Power Purchase Agreement in advanced stage.

3.8.2 Construction and Installation Phase

Construction activities will involve personnel and equipment mobilisation, site preparation, construction and installation of project components. Access roads within the site would be constructed to assist the movement of heavy equipment. A temporary base camp will be built adjacent to the power plant on site to cater for accommodation and welfare needs.

There will be between 400 and 500 workers on the site at every interval. It is noted that a sizeable amount of these workers will be employed locally and may already have personal accommodation within the community. In this instance, PEL will provide adequate means of transportation to and fro the site for as many that require it.

The initial stage of construction will involve site clearance of vegetation (to be limited to section only required) and earthworks and levelling of the site. The "lay down" area for the construction of the OCGT power plant will be on the area reserved for the HRSG and steam turbines which would later form part of the CCGT power station.

It would take an estimated 21 months for construction to begin and complete, after which operations would commence following commissioning. At this stage, there will be a relatively small group of highly skilled engineers and technicians managing the power plant.

3.8.3 Operation Phase

The power plant will be operated 24 hours, seven days a week during the operational phase. Number of workers to be employed at this stage is anticipated to be about 40 permanent personnel who include; ancillary workers such as; Site Project Manager, Financial Accountant, Operational Manager, Procurement Officer, Site HSE Officer, security personnel, cleaners, cooks and a Community Liaison Officer.

PEL intends to develop human capacity through the transfer of technologies and expertise to local manpower and local manufacturers. Also, PEL would comply with provisions of the Nigerian law and regulation through the "local content" law.

Maintenance

It is expected that routine maintenance will be conducted by the plant's maintenance team. This will include preventative, corrective and predictive maintenance in addition to any maintenance or repair required because of emergency breakdowns. If major outages occur, it is anticipated that the services of sub-contractors will be engaged to maximize economic efficiency. Routine preventative maintenance will be carried out for the gas turbines, gas turbine auxiliary equipment and the gas turbine alternators. Routine preventative maintenance will be carried out by the operations and maintenance contractor for the period between inspections.

It has been identified that both the gas turbine OEM and several third-party contractors can carry out such long-term maintenance on the gas turbines. In addition, they are required to create preventative maintenance plans for all the plant areas, using software to generate work orders for pieces of machinery and equipment; and all maintenance activities will be recorded on the preventative maintenance programme. Inspections are expected to be carried out annually and will be carried out in the following sequence:

- combustion inspections (weekly);
- hot gas path inspection (monthly); and
- major inspection (60 days).

3.8.4 RFP Process

Request for Proposal (RFP) for EPC and OEM for the turnkey construction of the "Proton Delta Sunrise" Project was prepared by the company. This was done following the World Bank 'Procurement Guidelines'.

In line with World Bank general considerations for an efficient procurement process which are; encouraging development of domestic industries, equal opportunity and access to information, need for economy and efficiency in project implementation, and transparency of procurement process, the RFPs were advertised on the media.

Submission of responses closed on 17 April 2015 with a total of fourteen (14) eligible respondents for both EPC and OEM. Firms or consortia actively engaged in power plant

development and showing significant experience in the lines of work described in RFP were considered.

The decision of PEL to award contracts is determined by the most commercially advantageous solution for the company. Responses were evaluated based on a 52% weight for commercial proposal that details respondent's experience and price, and 48% for technical proposal.

3.9 Appointment of OEM and EPC Contractor

Two (2) companies have been shortlisted as OEM contractors. They are Siemens AG and General Electric. Also, three (3) companies have been shortlisted as EPC contractors. In no order these are: Group Five, China Machinery Engineering Company and Julius Berger Plc. Harmonization of design details between OEM and EPC is well advanced towards award of contract to successful companies by September, 2015.

The selected EPC and OEM Contractors must demonstrate that they have successfully designed, completed and managed a few similar plants in the past.

3.10 Material Procurement and Fabrication

Material and equipment will be procured with respective reliable suppliers, locally or internationally. Depending on the location, materials and equipment will be manufactured in accordance to required standards. Factory acceptance test will be performed to prove the quality and compliance with required standards.

3.11 Security

The site will be secured by a permanent fence at an early stage of construction. Security guards will be employed to patrol the site and control access 24 hours a day when operation commences. All vehicles entering and leaving the site will be searched. All personnel will be required to display personal identification and all visitors will be required to sign in. The EPC Contractor will be responsible for site security during construction.

3.12 Access Road to Site

The proposed site location is accessed via a five (5) kilometer length of tarred road known as "New Ogorode Road", which connects Sapele main town to the proposed PEL site location. The road is associated with light traffic during peak hours (i.e. during the day) and is in excellent condition. In addition, there will be turning areas for trucks and parking areas for cars within the existing NIPP facility.

It is anticipated that there will be more vehicles during the construction and operational phases of this project. During construction, an estimate of 20 project vehicles will use this road daily. A maximum of 10 project vehicles will use the road daily during operation. The peak number of heavy vehicle movements during both construction and operation is estimated at between 10 to 15 trips per day.

PEL will liaise with the Delta State Government and Ogorode community representatives to ensure road damaged by project activities are repaired and incidence of traffic are managed during construction.

3.13 Project Waste Streams and Emissions

Anticipated waste types from project activities are captured in the following sub sections:

Solid Waste

Solid wastes expected from construction activities include; sand fill, domestic waste such as sanitary and food remains, refuse, organic material, packing materials, glass, wood and metal scraps.

Waste expected during operational phase include waste chemicals, office waste (such as paper cardboard, cans, food wastes, bulbs and mercury tubes) and minute amount of hazardous waste such as pigging wastes, diesel, cleaning solvents and sludge from oil tanks.

All solid wastes generated will be collected, segregated, stored and disposed at Olutee Engineering, an Integrated Waste Management Facility. The waste center is in Warri Town, Delta State and the center is registered with the Delta State Waste Management, Pollution and Sanitation Authority. Specific details of waste disposal methods are presented in **Chapter Seven**, **Table 7.3**.

Liquid Effluent

Effluent in form of oily water and chemical waste water will be generated by the power plant operations; from pressure filters, regeneration effluent from the plant as well as from used battery, gas turbine compressor and wash water waste. Effluent generated will be collected, stored and then sent to a disposal center for treatment and proper discharge. The dispoal centre is registered with the Delta State Ministry of Environment and associated agencies and approved to handle, treat/dispose waste.

Sanitary wastewater generated shall be treated and disposed using a decentralized wastewater system which will be properly designed and installed in an area with stable soil and sufficient soil percolation. Non-contaminated water from rainwater, floor drains, and other water drains from the site will be routed into a storm water system and discharged to Ethiope River in line with Nigerian and World Bank requirements.

Air Emission

The key point source of emissions from the power plant will be from the gas turbine stacks (i.e. combustion of natural gas), and from black start diesel engine stacks (i.e. generator use). Both processes would lead to the release of some amounts of oxides of nitrogen (NO_x), carbon (iv) oxide and some inert gases. Zero amount of Sulfur dioxide (SO_2) is expected to be released from the turbine stacks. For a range of 70 to 100% load operation, CO emissions are estimated at 5ppmv at the turbine stacks. Annual CO_2 emissions from the plant could be up to approximately 734,042 tonnes per annum. It should be noted that gases from black start diesel engine would be less significant by volume compared to gas turbine emissions.

The level of NO_x in the stack gases is usually controlled using a dry low NO_x burner as will be applied in this project. Efficient turbine control system will ensure proper air to gas mixture which will control levels of CO released. Air dispersion models have been used to determine the level of NO_x and SO_x dissipation to nearest receptors (see **Chapter Five**, **Section 5.8.2**).

The amount of H_2S released into the air is dependent on the quantity of sulphur in the gas supplied to the power station. Natural gas usually contains negligible quantities of sulphur. PEL will use and has specified natural gas with zero sulfur and H_2S content for use in the turbine.

Design measures to increase efficiency were considered, including conversion to CCGT technology as earlier stated. PEL would convert the power plant to CCGT at phase 2.

The turbines will use dry low NO_x combustion system which will form a key mitigation measure during the operational phase. In addition, all emissions will be regularly monitored and shared with the original equipment manufacturer.

Noise Emission

Noise emissions will come from a number of sources which include noise from the plant gas turbines during operation and from pilling works during construction. Noise would also emanate from the movement of personnel and vehicle all through the project phases.

In general, noise sources from the proposed power plant would be from:

- steam turbine generator;
- turbine rotating equipment;
- combustion induced noises;
- flow induced noises; and
- steam safety valves.

PEL intend to design and build the gas plant using noise reducing components for the roof and ceiling section of the plant. This would reduce noise levels impact on sensitive receptors. High performance silencers will be used and will be tuned to attenuate low frequencies from the gas turbine exhausts.

3.14 Decommissioning and Restoration Plan

When the life span of the plant facility comes to an end, the facility would be decommissioned and put off use. A decommissioning process or plan would be activated. The following steps would be undertaken by PEL, in decommissioning the facility:

- Regulatory Compliance and Approval;
- Site Preparation and Clearing;
- Uninstall Plant Components;
- Gas Pipeline Removal;
- Materials Disposal; and
- Site Clearance and Restoration

PEL shall implement a restoration plan for the power plant facility area unless otherwise requested by the host communities. This would be done after full documented agreement has been reached. If this situation arises, the information would be included in the restoration and post impact assessment reports.

Site recovery shall include taking steps to restore project site to their original conditions by promoting the growth of lost natural vegetation so that the area is made accessible to local inhabitants. All installations and structures shall be completely removed and taken to the manufacturer for proper disposal or recycling.

3.15 Project Schedule

The proposed project construction for phase 1 is expected to commence in third quarter, 2017 and be completed in third quarter, 2019. Operation is proposed to start by fourth quarter, 2019.

The timeline indicated would be followed through except for unforeseen delays/ situations. **Figure 3.4** presents the proposed schedule for the power plant project.

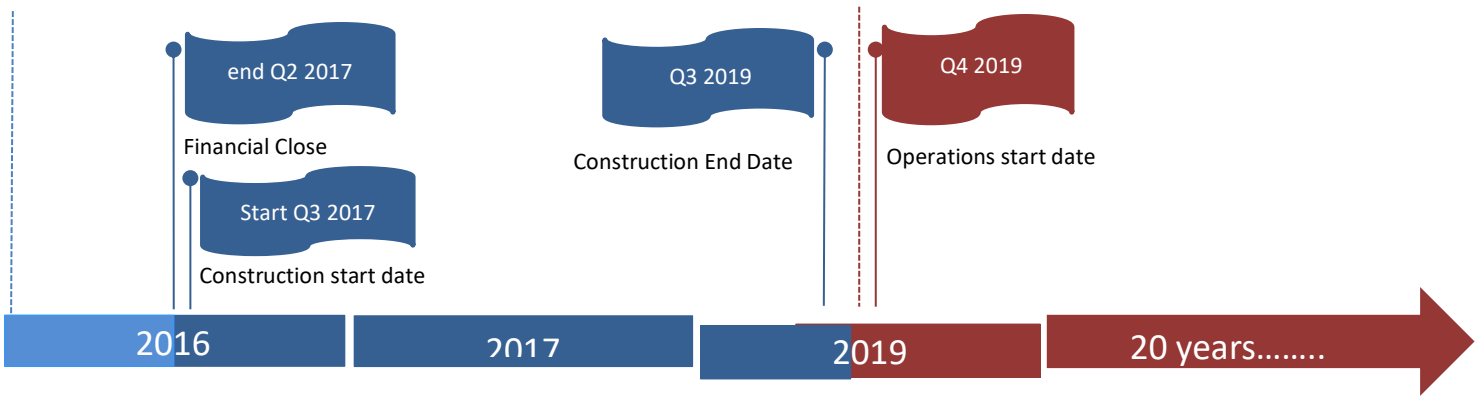


Figure 3.4: PEL Power Plant Project Timeline

CHAPTER FOUR

EXISTING ENVIRONMENTAL CONDITION

CHAPTER FOUR

EXISTING ENVIRONMENTAL CONDITION

4.1 General

The prevailing environmental conditions of the study area within which the proposed Gas-Fired Powered Plant would be sited, as well as the socio-economic and health profile of host community (Ogorode) is presented in this chapter. Components described herein include:

- physio-chemical environment (meteorology, geology, sediment, soil type and distribution, surface water and groundwater characteristics);
- biological environment (benthos, plankton, fisheries, flora and fauna characteristics); and
- Socio-economic conditions describing; demographic structure, culture, social and health status of the host community.

Baseline conditions presented is based on information sourced from literature as well as findings from two seasons (dry and wet) field sampling survey. Also reported are laboratory analyses and interpretation of samples obtained. Information acquired during this EIA will be used in further environmental management decisions and future monitoring of changes, if any, in the environmental components.

4.2 Baseline Data Acquisition Methods

Baseline data acquisition was conducted in line with Fugro Nigeria Limited (FNL) quality, health, safety and environment management system. Elements of this approach include literature research, designing and development of field sampling strategy to meet regulatory requirements; pre-mobilisation activities (job hazard analysis, sampling equipment/ materials calibrations and checks) and mobilisation to field. Fieldwork included: sample collection (including field observations), handling, documentation, storage protocols and procedures as well as demobilisation from field. Samples obtained were transferred to FNL laboratory located at 91 Odani Street, Elelenwo, Port Harcourt, Rivers State for analyses. The laboratory is an FMEnv accredited laboratory.

Detailed descriptions of baseline data acquisition methods as well as laboratory analyses are presented in **Appendix 4.1**.

4.2.1 Literature Research

This was carried out prior to field data gathering campaign to obtain relevant background information on the study area, as well as during report preparation. Further research was conducted at the end of the field campaign to compare literature information with generated field data and for additional information on the study area. Generally, literature research involved consulting relevant textbooks, journals and articles.

4.2.2 Field Sampling

To effectively characterise the study area, a comprehensive field data gathering exercise was carried out for dry and wet seasons. Sample points obtained during site visit were keyed into hand held Global Positioning System (GPS) device which was used to identify and establish sampling points in the field.

Sampling co-ordinates logged into the GPS prior to mobilisation were then checked for accuracy using the Google Earth Map. **Table 4.1** overleaf presents the number of sampling stations, station co-ordinates and sampling requirement at each point based on terms of reference (ToR) approved by the Federal Ministry of Environment (FMEnv).

Table 4.1: Sampling Requirement and Co-ordinates

Sample Code	Sampling Requirement	Co-ordinates	
		Latitude (N)	Longitude (E)
SW1	Sediment+ Surface Water +Benthos+ Plankton + Air +Noise	5.891981	5.705472
SW2	Sediment+ Surface Water +Benthos+ Plankton	5.890597	5.698147
SW3	Sediment+ Surface Water +Benthos+ Plankton+ Air +Noise	5.896389	5.694083
SW4	Sediment+ Surface Water +Benthos+ Plankton	5.903342	5.689497
SW5	Sediment+ Surface Water +Benthos+ Plankton	5.902844	5.682425
SW6	Sediment+ Surface Water +Benthos+ Plankton	5.906081	5.675275
SW7	Sediment+ Surface Water +Benthos+ Plankton +Air +Noise	5.910294	5.669189
SW8	Sediment+ Surface Water +Benthos+ Plankton	5.915228	5.663356
SW9	Sediment+ Surface Water +Benthos+ Plankton	5.919444	5.656114
SW10	Sediment+ Surface Water +Benthos+ Plankton	5.924656	5.649183
SW11	Sediment+ Surface Water +Benthos+ Plankton	5.932350	5.645764
SW12	Sediment+ Surface Water +Benthos+ Plankton	5.941556	5.646258
SW13	Sediment+ Surface Water +Benthos+ Plankton	5.945994	5.639508
SW14	Sediment+ Surface Water +Benthos+ Plankton +Air +Noise	5.943456	5.629842
SW15	Sediment+ Surface Water +Benthos+ Plankton +Air +Noise	5.933136	5.626583
SW Cnt 1	Sediment+ Surface Water +Benthos+ Plankton	5.903753	5.697686
SW Cnt 2	Sediment+ Surface Water +Benthos+ Plankton	5.928381	5.621554
SS1	Soil+ Air +Noise	5.891264	5.662917
SS2	Soil	5.898667	5.659611
SS3	Soil+ Air +Noise	5.901669	5.657380
SS4	Soil	5.906494	5.651894
SS5	Soil +Air +Noise	5.911008	5.648678
SS6	Soil	5.910556	5.643419
SS7	Soil +Air +Noise	5.911756	5.637728
SS8	Soil	5.915886	5.647225
SS9	Soil +Air +Noise	5.921144	5.646156
SS10	Soil +Air +Noise	5.926725	5.643861
SS11	Soil	5.889744	5.695214
SS12	Soil +Air +Noise	5.901278	5.682417
SS13	Soil +Air +Noise	5.914761	5.660914
SS14	Soil+ Air +Noise	5.945154	5.645538
SS15	Soil	5.943444	5.629842
SS Cnt	Soil	5.928042	5.622311
BH1	Groundwater	5.925925	5.640614
BH2	Groundwater +Air +Noise	5.922344	5.641295
BH Cntrl	Groundwater	5.923477	5.645430

Source: FNL GIS, 2013

Field observations were made and documented in field notebooks. Also, a number of events were captured using still photographs (details of these are presented in sub-sequent sections of this chapter). Field visit was carried out for dry season from 2nd to 6th December, 2013 and wet season from 28th to 30th July, 2014. A two-season study was approved by FMEnv.

Area of Influence

Sample stations were distributed within and outside the project site. The zone of influence from project site covered 10 km for surface water, sediment, soil, air and noise.

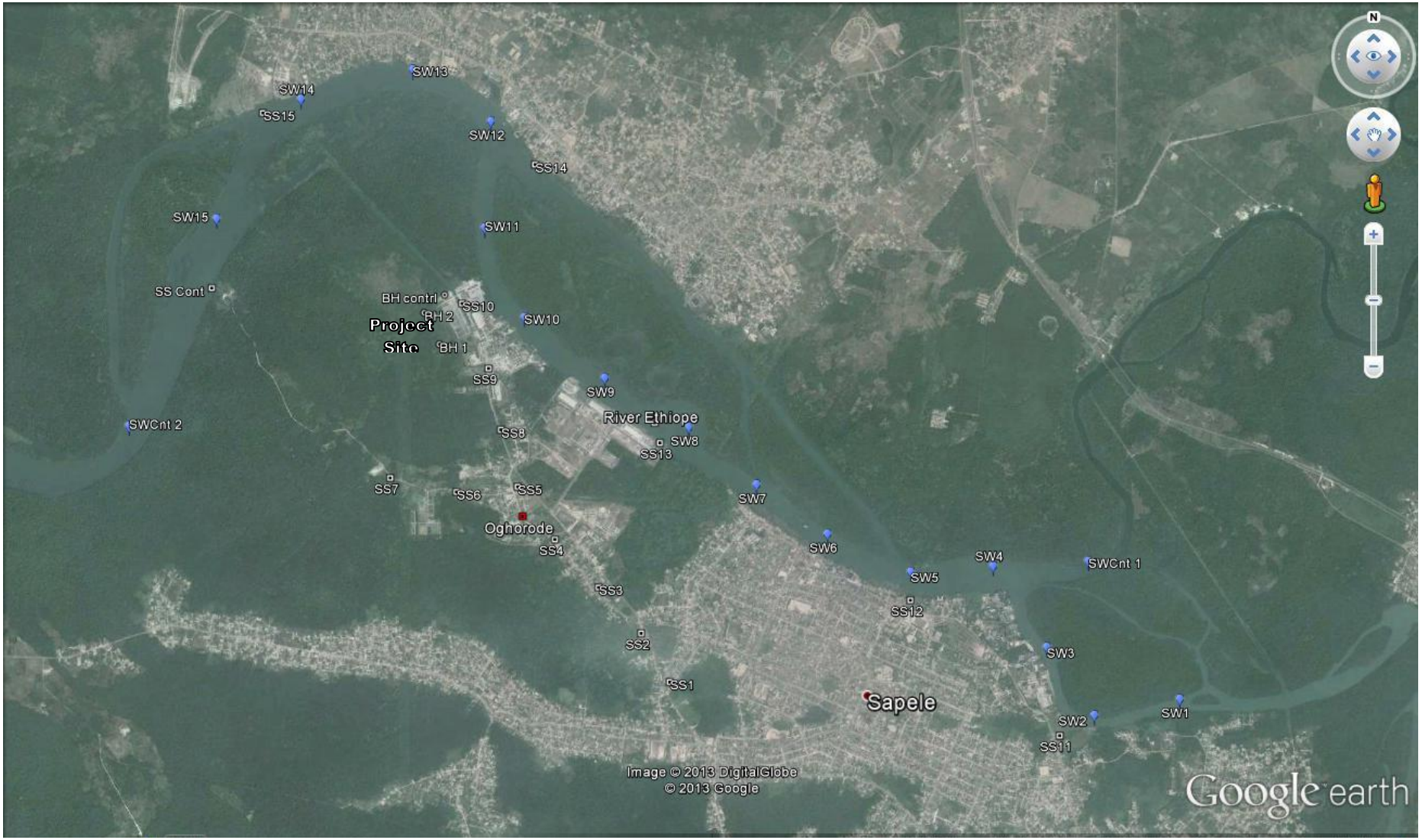
Environmental factors considered when selecting sample points were sensitivity of physical and biological receptors (e.g. location of water body, flora and fauna, settlements, existing facilities) as well as geographical dynamics of the study area such as wind direction, upstream/ downstream system and topography of the area.

Receptors within the study area include; facilities (such as NIPP plant, CMEC/Eurafric Energy Limited Plant, Regadas Nigeria Bitumen Company, Nigeria Gas Company), Ogorode community and Ethiope River directly behind the project area. Also considered were pristine vegetation around the study area which were predominantly undisturbed vegetation (i.e. rainforest and mangrove).

Samples obtained and measured in the two seasons in line with the FMEnv ToR are as follows:

- surface water - seventeen (17) stations;
- sediments - seventeen (17) stations;
- soil samples - sixteen (16) stations;
- groundwater sample - three (3) points;
- air/ noise quality measurement in fifteen (15) stations; and
- benthos and plankton samples - seventeen (17) stations.

Figure 4.1 overleaf is the field sample guide map used for the study.



Source: Google Earth Map, 2013

Figure 4.1 Sample Stations Distribution

4.2.3 Laboratory Analysis

Laboratory analysis was carried out in line with international American Society for Testing and Material (ASTM) and American Public Health Association (APHA) as well as FMEnv Standard protocols. Quality Assurance/ Quality Control (QA/QC) measures adopted for laboratory analyses are in Accordance with FMEnv recommendations. Other QA/QC measures adopted are:

- use of trained personnel at all phases of the study;
- written analytical standard operating procedures were followed during analyses and
- routine auditing and checking of analyses results, including control solutions and midpoint standards, were introduced into every batch or ten samples as applicable, and analyses for which deviation of these quality control / mid –point standards are outside 90 to 110% of expected value were repeated.

A summary of data collection and analytical methods together with test equipment employed for the study are shown in **Table 4.2** below, while discussions and details are provided in **Appendix 4.1**.

Table 4.2: Ecological Components, Analytical Methods and Test Equipment

Sample Matrix	Parameters	Test Method	Test Equipment
Water	pH	APHA 4500H+B	multi 340i/set Meter
Water	Temperature (^{0}C)	APHA 2550B	multi 340i/set Meter
Water	Chloride	APHA 4500 Cl^-	Titration
Water	Nitrate	EPA 352.1	Uv/ Visible light
Water	Sulphate	APHA 4500-SO^4	Uv/ Visible light
Water	Magnesium	APHA 3111B/ASTM D 3561	FAAS
Water	Potassium	APHA 3111B/ASTM D 3561	FAAS
Water	Sodium	APHA 3111B/ASTM D 3561	FAAS
Water	Calcium	APHA 3111D	FAAS
Water	Cadmium	APHA 3111B	FAAS
Water	Total Chromium	APHA 3111C	FAAS
Water	Copper	APHA 3111B	FAAS
Water	Total Iron	APHA 3111B	FAAS
Water	Lead	APHA 3111B	FAAS
Water	Nickel	APHA 3111B	FAAS
Water	Zinc	APHA 3111B	FAAS
Water	Silver	APHA 3111B	FAAS
Water	Manganese	APHA 3111B	FAAS
Water	Mercury	APHA 3112B	AAS* / Hydrite unit
Water	Vanadium	APHA 3111D	FAAS
Water	salinity	APHA 2520	multi 340i/set Meter
Water	DO	APHA 4500-OG	multi 340i/set Meter
Water	Turbidity	APHA 2130B	Dr / 890 colorimeter
Water	Redox Potential	ASTM D1498	HANNA Multimeter
Water	TOC	BS 1377	Titration
Water	TDS	APHA 2510A	multi 340i/set Meter
Water	TSS	APHA 2540D	Gravimetry
Water	BOD_5	APHA 5220D	WTW oxitop
Water	COD	APHA 5220D	Titration
Water	Total Hardness	APHA 2340C	Titration
Water	Oil & Grease	ASTM D 3921	FTIR
Water/Soil/Sediment	BTEX	EPA 8240	GC/MS
Water	Microbiology	ASTM D5465-93	Microscope
Water	Zooplankton	APHA 10200 G	Counting (microscope)
Water	Phytoplankton	APHA 10200 F	Counting (microscope)
Soil/Sediment	pH	ASTM D 4972	multi 340i/set Meter
Sediment	PSD	ASTM D 422	Hydrometer / water bath
Soil/Sediment	All heavy metals	USEPA 6200	XRF
Soil/Sediment	Extractable Sulphate	CAEM/APHA 4500 SO_4^{2-}E	UV /visible spectrphoto
Soil/Sediment	Extractable Phosphate	CAEM/APHA 4500 PD	UV /visible spectrphoto
Soil/Sediment	Growth in MCB media	ASTM D5465-93	Incubators, Petri Dishes, etc.
Sediment	Macrobenthos	APHA 10500C	Microscope
Soil/Sediment	TOC	BS 1377	Titration
Soil/Sediment	THC	ASTM D 3921	FTIR

Source: FNL Laboratory 2014

4.3 Climate and Meteorology

An overview of the climate and meteorological data (relative humidity, ambient air temperature, rainfall and wind speed/ directions) of the study area are presented in subsequent sections. Climatic and meteorological information described are from field measurements, literature/ desktop research and climatic data obtained for Warri from Nigerian Meteorological Agency (NIMET). Data presented are for a period of thirty (30) years; from 1984 to 2013, except for wind direction.

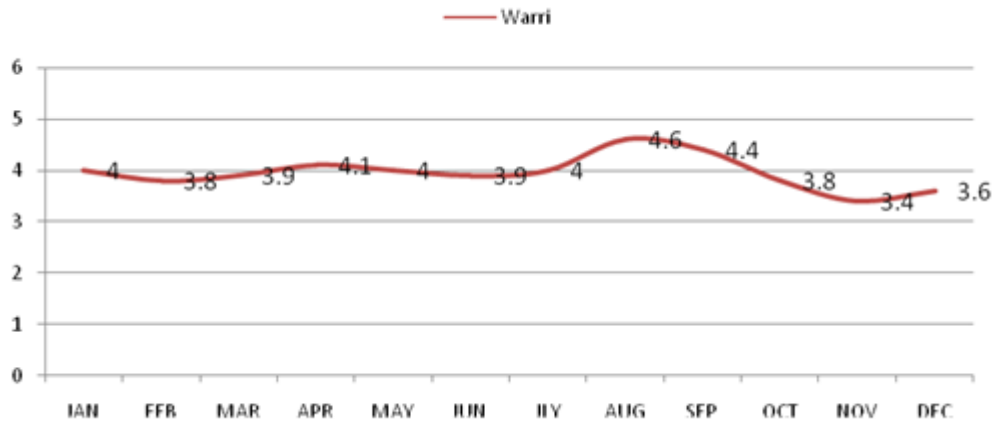
The study area which is in the Niger Delta region of Nigeria, is situated in the tropics and experiences a varying climate which is characterised by two distinct conditions of wet and dry seasons. The wet season occurs between April and October with a brief break in August, while the dry season occurs between November and March.

The wet season can also extend into mid-November, while the North-East trade wind that brings about the dry (harmattan) season is fully felt around late November till early February.

4.3.1 Wind Speed

Winds in the study area include; the south-westerly wind which prevails during the wet season (July- October) accounting for about 33% of annual wind and the southerly winds dominating from March to June as well as the beginning of the dry season in November accounting for about 50% of annual winds. The north-easterly wind predominates during the dry season (December– January) and amounts to about 16% of the annual winds.

The monthly mean wind speed varies from 3.4 to 4.6 meters per second (m/s) for the period of fifteen years reviewed as shown in **Figure 4.2**. Wind speed is strongest at the middle of the rainy season with a mean value range of 4.4 to 4.6m/s during August and September. The wind speed drops slightly during the wettest period but rises towards the end of the rains and drops again on the set of the dry season in November. Nevertheless, wind speed does not vary much all year round.



Source NIMET, 1984 – 2013

Figure 4.2: Average Wind Speed of Study Area

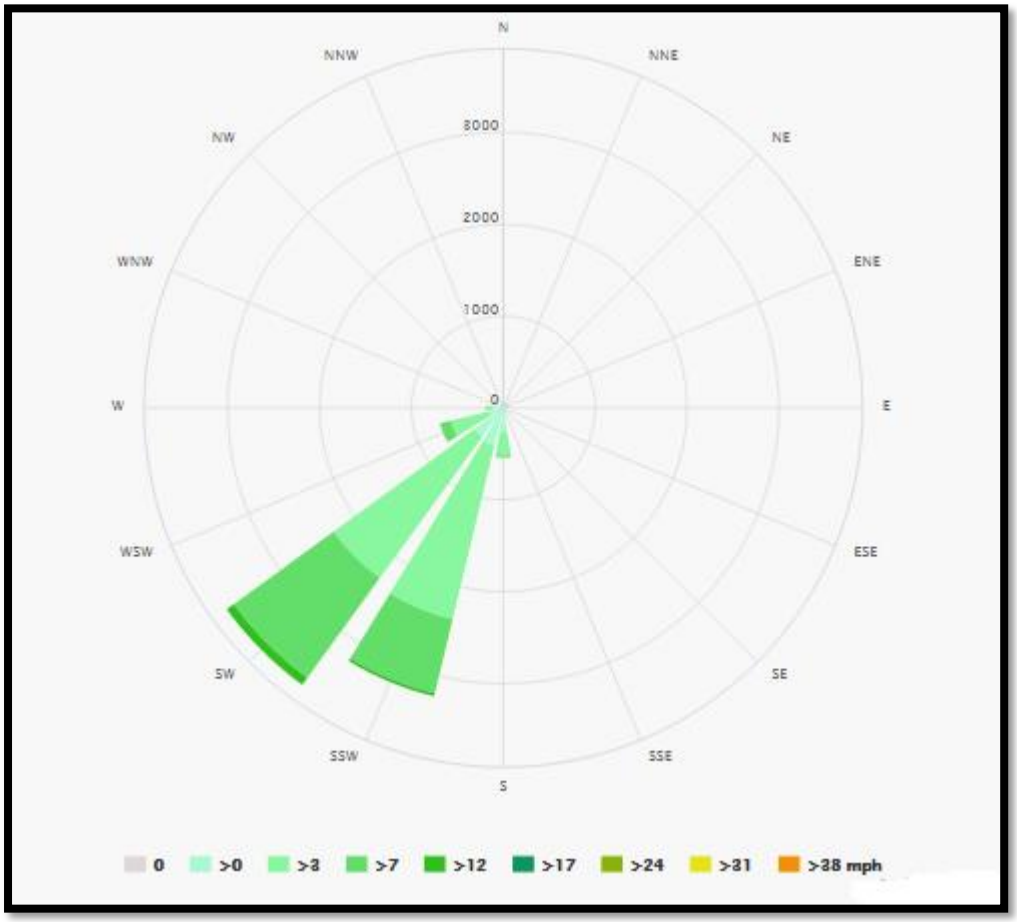
4.3.2 Wind Direction

The average wind direction recorded for the study area and obtained from NIMET for 2006 to 2013 are presented in the table below.

Table 4.3: Average Wind Direction

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006	W	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
2007	SW	S	SW	S	SW	SW	SW	SW	W	S	SW	SW
2008	W	W	W	W	W	W	W	W	W	W	W	NE
2009	W	N	S	S	SW	SW	SW	SW	SW	S	S	SW
2010	SW	S	S	S	S	S	S	SW	SW	S	S	SW
2011	W	W	W	W	W	W	W	W	W	W	W	NE
2012	W	W	SW	SW	SW	SW	SW	SW	SW	SW	W	SW
2013	W	SW	W	SW	SW	W	SW	SW	SW	SW	W	W

Source: NIMET, 2006 – 2013



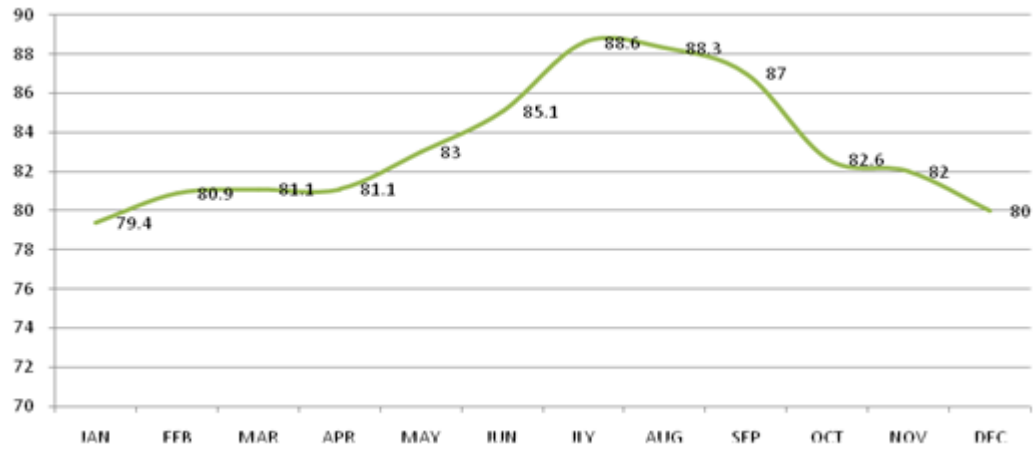
Source: https://www.meteoblue.com/en/weather/forecast/modelclimate/asaba_nigeria_2349276

Figure 4.3: Wind Rose

It can be concluded that the wind direction for most part of the year was south westerly and westward as can be seen from **Table 4.3** and **Figure 4.3** above.

4.3.3 Relative Humidity

Relative humidity is the condition of the atmosphere with respect to water vapour content. Average relative humidity values obtained from NIMET is presented in **Figure 4.4** below.



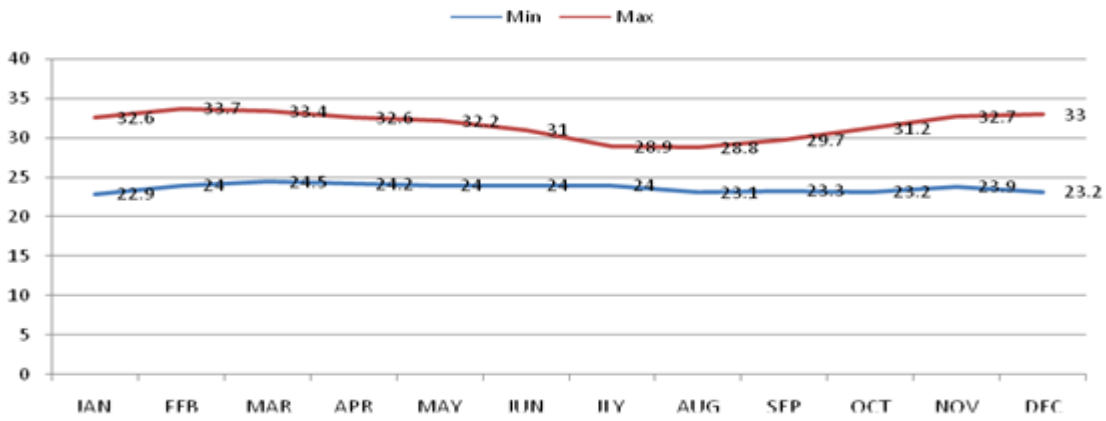
Source NIMET, 1984 – 2013

Figure 4.4: Average Relative Humidity of Study Area

Relative humidity values of the study area obtained range from 79.4 to 88.6%, with a mean monthly value of 83.3%. The relative humidity trend shows a gradual increase from January through to July (highest value) corresponding to time of wet season and reduction from October to December corresponding to end of the rainy season and beginning of dry season.

4.3.4 Ambient Air Temperature

Air temperature is a measure of the heat content of air in an area. The minimum and maximum air temperature of the study area is presented **Figure 4.5** overleaf.



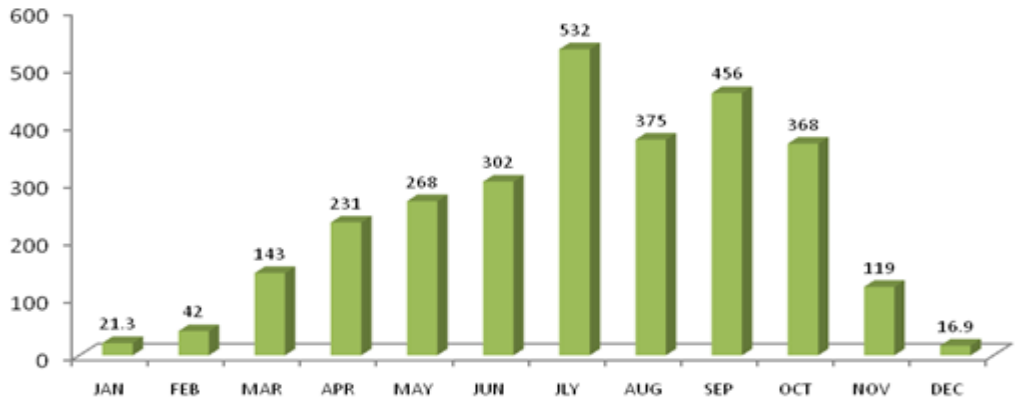
Source NIMET, 1984 – 2013

Figure 4.5: Minimum and Maximum Temperature of Study Area

The minimum mean monthly temperature (lowest temperature measured for a day) from the study area is 22.9 ^{0}C and occurred in January, while the maximum mean monthly temperature (highest temperature measured for a day) was 33.7 ^{0}C in February.

4.3.5 Rainfall

Rainfall determines a lot of factors, which include; availability of food, breeding/ migratory period and formation of acid rain. Rainfall can also affect the project execution work rate i.e. when installation and construction of the power plant commences. The rainfall distribution in the study area is presented in **Figure 4.6** below. The rainfall range within the period measured is between 16.9 and 532mm, and average monthly mean of 240mm. The total annual rainfall for this period is 2,874mm.



Source NIMET, 1984 – 2013

Figure 4.5: Average Rainfall Data of Study Area

The figure above shows a gradual increase in rainfall from February till July, followed by a slight drop in August and an increase in September. This is the wet season period within the study area which is associated with heavy rainfall. The rainfall decrease in August is referred to as the August break. Rainfall then decreases from November till February (dry season).

August break is caused by the shift in monsoon systems which bring rains to West Africa. Generally, rainfall over West Africa is controlled by the advection of moisture from the Gulf of Guinea in the low levels of the atmosphere. Following the seasonal excursion of the Sun, the monsoon develops over West Africa during the northern spring and summer, bringing the Inter-Tropical Convergence Zone and the associated rainfall maxima to their northernmost location in August. The onset of the monsoon system over West Africa is linked to the northward migration of the Inter-Tropical Convergence Zone (ITCZ) during the northern spring and summer. This leads to a break in rainfall during this period (Sultan and Janicot, 2000).

4.4 Ambient Air Quality

Field measurements of ambient air quality parameters (SPM, CO, SO_x, NO_x, H_2S, NH_3, C_xH_y, and VOC) were carried out in fifteen (15) sampling stations over two seasons. Results obtained were compared with the Federal Ministry of Environment (FMEnv) regulatory limits as well as World Health Organisation (WHO) Air Emissions and Ambient Air Quality standards.

<u>Sampling Methods</u>

The sampling equipment used for the ambient air quality measurements for each parameter is tabulated in **Table 4.4**. Detailed methods are in **Appendix 4.1**. Results are presented in **Table 4.5a** and **b**.

Table 4.4: Air Parameters and Monitoring Equipment

S/N	Parameters	Equipment
1	Suspended Particulate Matter (SPM)	In-situ source pointer probe (Aerocet)
2	Carbon Monoxide (CO)	In-situ Gas Monitor Analyser (Multi RAE IR)
3	Sulphur Oxide (SO_x)	In-situ Gas Monitor Analyser (Multi RAE IR)
4	Nitrogen Oxide (NO_x)	In-situ Gas Monitor Analyser (Multi RAE IR)
5	Hydrogen Sulphide (H_2S)	In-situ Gas Monitor Analyser (Multi RAE IR)
6	Ammonia (NH_3)	In-situ Gas Monitor Analyser (Multi RAE IR)
7	Hydrocarbons (C_xH_y)	In-situ Gas Monitor Analyser (Multi RAE IR)
8	Volatile Organic Compounds (VOC)	In-situ Gas Monitor Analyser (Multi RAE IR)

Table 4.5a: Air Quality Measurement Results – Dry Season[10]

Sample Stations	Parameters							
	$SPM_{2.5}$ (mg/m³)	CO (mg/m³)	SO_2 (mg/m³)	NO_2 (mg/m³)	H_2S (mg/m³)	NH_3 (mg/m³)	C_xH_y (%)	VOC (%)
SS1	0.036	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SS3	0.081	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SW1	0.60	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SW3	0.018	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SW7	0.017	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SW13	0.034	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SW14	0.041	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SS5	0.075	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SS7	0.05	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SS9	0.016	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SS10	0.020	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SS12	0.012	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SS13	0.022	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SS14	0.014	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
BH2	0.071	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
Range	0.012 – 0.60	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
FMEnv Limits	0.25	0.011	0.282	0.075-0.11	0.008	0.20	0.1	0.06
WHO Limits	0.025	-	0.02	0.04[11]		-	-	-

Source: Field Survey, 2013-2014, FMENV, 1991 for 24-hour average
WHO limits, 2005 for 24-hour average, except H_2S (=1 hour average)

Table 4.5b: Air Quality Measurement Results – Wet Season

Sample Stations	Parameters							
	$SPM_{2.5}$ (mg/m³)	CO (mg/m³)	SO_2 (mg/m³)	NO_2 (mg/m³)	H_2S (mg/m³)	NH_3 (mg/m³)	C_xH_y (%)	VOC (%)
SS1	0.024	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SS3	0.026	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SW1	0.006	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SW3	0.013	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SW7	0.002	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SW13	0.015	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SW14	0.003	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SS5	0.014	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SS7	0.02	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SS9	0.007	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SS10	0.005	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SS12	0.009	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SS13	0.012	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
SS14	0.019	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
BH2	0.01	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
Range	0.002 – 0.026	<0.123	<0.282	<0.203	<0.15	<0.075	<0.01	<0.10
FMEnv Limits	0.25	0.011	0.026	0.075-0.11	0.008	0.20	0.1	0.06
WHO Limits	0.025	-	0.02	0.04		-	-	-

Source: Field Survey, 2013-2014, FMENV, 1991 for 24-hour average.
WHO limits, 2005 for 24-hour average, except H_2S (=1 hour average)

Suspended Particulate Matter

Suspended particulate matter (SPM) are finely divided particles which can be anthropogenic or natural in origin. It is present in ambient air in the form of dust, smoke

[10] Values with the less than sign "<" indicate measurements are below the equipment detection limit
[11] Annual mean WHO guideline value

and other aerosols. The most significant of these are particles of less than 10µm in diameter i.e., of respirable size range (UNEP, 2009).

High concentrations of SPM are known to irritate the mucous membranes and may initiate a variety of respiratory diseases, aggravate bronchitis, emphysema and cardiovascular diseases and can cause cancer, corrosion, destruction to plant life etc. (CCDI, 2001; UNEP, 2009). They can also constitute nuisance, and interfere with sunlight at high concentration. Annual mean concentrations of 80µg/m^3 could result in adverse health effects.

SPM value recorded in the study area ranged between 0.012 and 0.6 mg/m^3 in the dry season and between 0.002 and 0.026 mg/m^3 in the wet season. Results from all stations sampled were generally below the WHO and FMEnv limits of 0.025 mg/m^3 and 0.25 mg/m^3 respectively, except for sample stations SS1, SS3, SW1, SW13, SW14, SS5, SS7 and BH2 in the dry season and SS3 in the wet season. The elevated SPM value obtained could be attributed to dust, smoke from Timber Saw Mills and boats traversing the survey area daily.

Carbon monoxide

Carbon monoxide (CO) is the most common air pollutant. It is a colourless, odourless, tasteless and poisonous gas produced by the incomplete combustion of carbonaceous materials or fossil fuels (gas, oil, coal and wood). Adverse health effect has been observed with CO concentrations of 12 – 17mg/m^3 for 8 hours (Richard and John, 2012) while prolonged (45 minutes to 3 hours) exposure to concentrations between 200mg/m^3 and 800mg/m^3 often results in severe headache, dizziness, nausea and convulsions (Derek, 2013). It also induces fatigue, impairs alertness, inhibits foetal development and aggravates cardiovascular diseases.

CO concentrations measured in the study area during field sampling were lower than equipment detection limit of 0.011 mg/m^3 in both seasons. This exceeds FMEnv limit for CO. PEL shall take new measurements three months to construction, during construction, and periodically during operation to ensure proper control and mitigation measures are taken.

Sulphur Oxides

SO_x also produced from the combustion of sulphur-containing fuels, smelting, and manufacture of sulphuric acid, incineration of refuse as well as production of elemental sulphur. The gas is known to be a harsh irritant, and is capable of aggravating asthma, bronchitis and emphysema. It can also cause coughing and promote impaired functions in the human system (CCDI, 2001). Also sulphuric acid aerosols (formed from dissolved sulphur dioxide) will readily attack building materials, especially those containing carbonates such as marble, limestone and mortar.

Sulphur dioxide also occurs as natural releases from volcanoes, oceans, biological decay and forest fires. The most important man-made sources of sulphur dioxide are fossil fuel combustion, smelting, manufacture of sulphuric acid, conversion of wood pulp to paper, incineration of refuse and production of elemental sulphur. The health effects from exposure to high concentrations for short periods include irritation of the eyes and mucous membranes and narrowing of the respiratory tract, as in asthmatic conditions. Also, long-term exposure to lower concentrations may result in higher mortality from cardiac and/or respiratory diseases and increased prevalence of related symptoms (Derek, 2013).

Sulphur dioxide (SO_2) measured in all sample stations for the two seasons were generally below equipment detection limit of 0.282 mg/m^3. This exceeds FMEnv and WHO limits.

PEL shall take new measurements three months to construction, during construction, and periodically during operation to ensure proper control and mitigation measures are taken.

Oxides of Nitrogen

Nitrogen dioxide (NO_2) is one of a group of highly reactive gases known as "oxides of nitrogen," or "nitrogen oxides (NO_x). Other nitrogen oxides include nitrous oxide and nitric oxide usually formed at high temperature e.g. flares, industrial combustion and vehicle engines (Senfield, 1986). Nitric oxide (NO) and nitrogen dioxide are the two major toxic oxides of interest. NO is rapidly formed by partial oxidation of nitrogen and emitted from the combustion engine exhaust. It is unstable and quickly oxidizes to NO_2.

NO_2 acts mainly as an irritant affecting the mucosa of the eyes, nose, throat, and respiratory tract. Extremely high-dose exposure to NO_2 may result in pulmonary edema and diffuse lung injury. Continued exposure to high NO_2 levels can contribute to the development of acute or chronic bronchitis and may cause increased bronchial reactivity in some asthmatics, decreased lung function in patients with chronic obstructive pulmonary.

NO_2 levels in the ambient air of the study area measured during the field study (i.e. both seasons) were below equipment detection limit of 0.203 mg/m^3. This exceeds FMEnv and WHO limits. PEL shall take new measurements three months to construction, during construction, and periodically during operation to ensure proper control and mitigation measures are taken.

Hydrogen Sulphide

Hydrogen sulphide (H_2S) is a toxic, odorous and corrosive gas, which is rapidly oxidised to sulphur dioxide in the atmosphere. It can be present in natural gas in certain areas and can be released by sulphate reducing bacteria in certain aquatic environments. Exposure to excessive concentrations can be fatal and injurious to health. Sustained exposure to H_2S gas above 500mg/m^3 could result in death (Derek, 2013).

H_2S measured in the study area (two seasons) were generally below equipment detection limit of 0.15mg/m^3. This exceeds FMEnv limit for CO. PEL shall take new measurements three months to construction, during construction, and periodically during operation to ensure proper control and mitigation measures are taken.

Ammonia

Ammonia (NH_3) is a colorless gas, with a characteristic pungent smell and is highly soluble in water. Although ammonia occurs naturally in the environment, it is an important by-product of the manufacture and combustion of fuel gases. Ammonia is found in trace quantities in the atmosphere, being produced from the putrefaction (decay process) of nitrogenous animal and vegetable matter (organic matter).

Ammonia is used to scrub SO_2 from the burning of fossil fuels, and the resulting product is converted to ammonium sulphate for use as fertilizer. Ammonia neutralizes the nitrogen oxides (NO_x) pollutants emitted by diesel engines. At high levels, effects may include death of birds, animals and fish as well as low growth in plants. Long term exposure effects of ammonia may include shortened lifespan, reproductive problems, lowered fertility as well as changes in appearance and behaviour.

The levels of NH_3 recorded in sample stations within the study area were generally below equipment detection limit of 0.075mg/m^3 in both seasons. This is below the FMEnv limit of 0.2 mg/m^3.

Hydrocarbons

Hydrocarbons (C_xH_y) are organic compound consisting entirely of carbon and hydrogen, they can be straight-chain, branched chain, or cyclic molecules. They are mainly grouped into aliphatic and aromatic organic compounds. The majority of hydrocarbons found naturally occur in crude oil, where decomposed organic matter (fossil) provides an abundance of carbon and hydrogen which when bonded can catenate to form limitless chains.

Hydrocarbon vapour in the atmosphere arises from fugitive emissions, vents, organic chemical production, and distribution of natural gas, transportation and processing of crude oil. Others are incomplete combustion of fuel, particularly where fuel to air ratios are too high. Most members of this group are significantly toxic and exposure to high concentrations in the atmosphere could result in interference with oxygen intake and acute leukemia (Derek, 2013).

Although measurements across all sample stations for both seasons was found to be below equipment detection limit of 0.01%, this value is below the FMEnv limit of 0.1%. .

Volatile Organic Compounds

VOCs are released into the atmosphere by anthropogenic and natural emissions. They include a variety of chemicals, some of which may have short and long term adverse health effects although higher indoors than outdoors, VOCs are emitted by a wide range of products which include but not limited to, paint, paint strippers, cleaning supplies, pesticides, building materials, office equipment (printers, copiers, correction fluids etc.), photographic solutions, fuels disinfectants etc.

The health effects of VOC's vary from those which are highly toxic to those with no known health effect and this may also be dependent on the level of exposure. Eye and respiratory tract infections, dizziness, impaired memory as well as visual disorders are among immediate symptoms experienced soon after exposure to some organics.

VOC's measured in the study area were generally below equipment detection limit of 0.1% for both seasons. This exceeds FMEnv limit for VOC of 0.06%. PEL shall take new measurements three months to construction, during construction, and periodically during operation to ensure proper control and mitigation measures are taken.

4.5 Noise Level

Noise affects everybody in everyday life, at home, at leisure, during sleep, when travelling and at work. It is generally defined as unwanted sound. Noise enables us to communicate and can create pleasure in the form of music and speech. However, exposure to excessive noise can damage hearing. Hearing is a permanent process that involves the use of cortical and sub-cortical structures to filter and interpret acoustical information, the analysis of acoustical signals is essential for human survival and communication.

A given sound constitutes annoying noise depending on many factors such as pitch, irregularities, duration, rhythm, unexpectedness or whether the noise has a meaning for the observer. The most common factor is its loudness. This loudness depends on the physical sound pressure that is measured on the sensitivity of the human ear. The sensitivity of the human ear responds to frequencies in the range of 20Hz to 20,000Hz. It is within these frequencies that acoustic waves that stimulate the human ear and brain to the sensation of hearing reside.

The decibel (dB) scale is used to quantify sound pressure levels. Although decibels are most commonly associated with sound, "dB" is a generic descriptor that is equal to ten times the logarithmic ratio of any physical parameter versus some reference quantity. In addition to causing disturbances, excessive noise can damage health and have physiological effects to both man and other living organisms.

Measurement Method

One-off measurement was taken using the Pulsar II Noise Meter at fifteen (15) points spread within the project area and residential area (community). The noise ranges obtained from the study area were compared with the FMEnv/ WHO limits for noise exposure in industrial and residential areas (**Table 4.6a-b**).

Table 4.6a: Noise Levels within Study (Industrial) Area

Sample Stations	Noise dB(A)		FMEnv (dB(A))	WHO(dB(A))
	Dry Season	Wet Season		
SW1	51.6	47.5	**105 (1hr)** or **90 (8hrs)** [Industrial]	**70 (1hrs)** [Industrial]
SW3	49.4	48.7		
SW7	53.6	49.7		
SW13	52.5	57.2		
SW14	48.8	58.1		
SS9	58.8	49.5		
SS10	59.2	53		
SS13	52.9	50.6		
SS14	60.6	46.6		
BH2	54.9	57.1		
Range	43.9 – 60.6	42.2 – 58.1		

Source: Field Survey 2013-2014; FMEnv, 1991; WHO, 1999

Table 4.6b: Noise Levels within Study (Residential) Area

Sample Stations	Noise dB(A)		WHO(dB(A)) Residential	
	Dry Season	Wet Season		
SS1	43.9	42.7	55 Daytime: (7:00-22:00)	45 Nighttime (22:00-7:00)
SS3	50.8	49.8		
SS5	53.6	42.2		
SS7	44.5	45.4		
SS12	56.6	54.8		
Range	43.9 – 60.6	42.2 – 58.1		

Source: Field Survey 2013-2014; WHO, 1999

Noise values obtained from the study area during both seasons for the industrial area were lower than the FMEnv and WHO specified limits. The residential areas were also lower than the stipulated WHO limit except for sample station 12 (dry season). This point is on the river bank where noise from speed boats was observed.

4.6 Hydrology

The project area is basically marked with thick vegetation flanked by the Ethiope River which forms a major tributary to Benin River. The area geographical position is characterised with considerable rainfall each year. Rainfall reaching the surface of the earth is separated into two flow components; the horizontal (storm runoff) and vertical infiltration. Infiltration and subsequent percolation of vertical flow component serves as source of recharge for the aquiferous layers in the area.

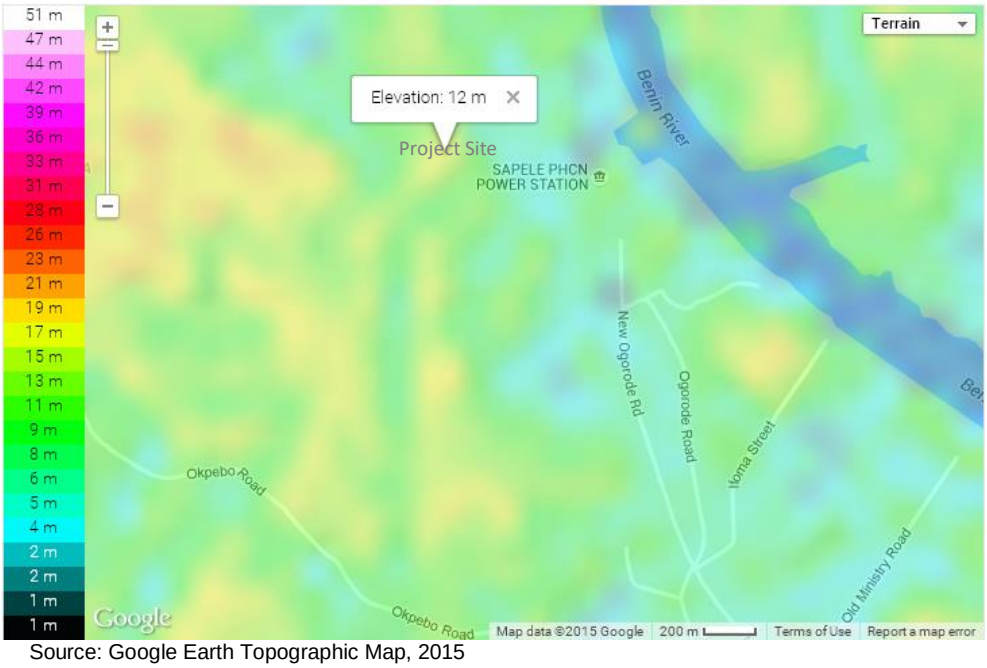
Ethiope River takes its source from a spring at Umuaja in Delta State and flows over 100km to empty into Benin River. This river serves as the terminal point for storm runoff in the area. Inhabitants of the area rely on the river for activities such as washing, fishing, sand-mining and inter-village transportation. At the lower reaches of the river, it is subjected to tidal influence of the Atlantic Ocean (Omo-Irabor and Olobaniyi, 2007).

4.7 Topography

Delta State is 18,050 km^2 in size and is bounded in the north and west by Edo State, in the east by Anambra, Imo and Rivers States, at southeast by Bayelsa State, and on the

southern flank is the Bight of Benin. The state is generally low-lying without many hills. The State has a wide coastal belt inter-lace with rivulets and streams, which form part of the Niger-Delta (DSG, 2011).

The project area in Sapele, Delta State is generally low-lying, elevation height above sea range from 2 to 17 m. **Figure 4.7** presents the topography details of the area obtained through Google Topography map, 2015.



Source: Google Earth Topographic Map, 2015

Figure 4.7: Topography Map of Project Area

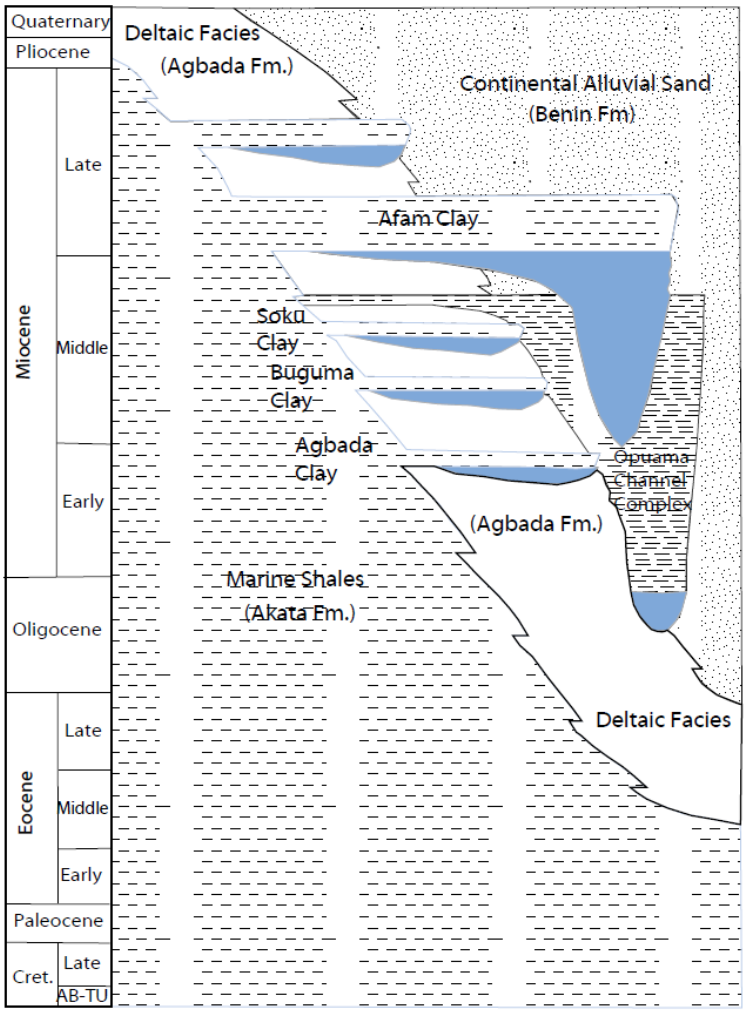
4.8 Geology

Sapele is part of the coastal sedimentary basin called the Niger Delta. The basin is chiefly made up of three formations; Akata, Agabada and Benin formations- from the oldest to the youngest [Short & Stauble, 1967 and Murat, 1970].

Beginning in the Paleocene era and through the recent, the Akata Formation formed during lowstands in the terrestrial organic matter and clays were transported to deep water areas characterized by low energy conditions and oxygen deficiency it is estimated that the formation is up to 7,000 meters thick. The formation underlies the entire delta, and is typically over-pressured.

Deposition of the overlying Agbada formation, the major petroleum-bearing unit, began in the Eocene and continues into Recent. The formation consists of paralic siliciclastics over 3700-meter-thick and represents the actual deltaic portion of the sequence. The clastics accumulated in delta-front, delta-topset, and fluvio-deltaic environments. In the lower Agbada Formation, shawl and sandstone beds were deposited in equal proportions, however, upper portion is mostly sand with only minor shale interbeds.

The Benin Formation underlies much of the Niger Delta basin. However, from Abraka and Sapele areas to the coast, is masked by the younger Holocene deposits of the Sombreiro-Warri Deltaic Plain (Allen, 1965; Amajor 1991, Akpoborie, 2011). **Figure 4.8** shows the Niger Delta formation stratigraphic.



Source: Muslim and Moses, 2012

Figure 4.8: Niger Delta Stratigraphic Column Formations

4.9 Groundwater Characteristics

Groundwater samples were obtained from three boreholes within the study area in the two seasons (i.e. two dug and one existing which served as control point). Physico-chemical characteristics of the groundwater samples obtained are presented in **Table 4.7**. Results are compared with the Federal Ministry of Environment (FMEnv) Groundwater Limit, 1991 and WHO Drinking Water Quality Limits, 2011 respectively.

<u>Sampling Method</u>

Two boreholes within the project site were manually drilled, while one was obtained from existing borehole beyond the facility (serves as control). *In-situ* measurements were carried out to determine parameters with short holding time such as pH, temperature, turbidity, conductivity, total dissolved solids, salinity and dissolved oxygen using WTW Multi-Parameter Meter.

Table 4.7: Groundwater Physico Chemical Characteristics

Parameters	Results						FMEnv Limits	WHO Limits
	BH 1		BH 2		BH Control			
	Dry	Wet	Dry	Wet	Dry	Wet		
pH	4.06	6.75	4.17	6.51	4.53	5.78	6.5- 8.5	6.5- 8.5
Water Depth	4.4	4.0	5.8	5.2	-	-		
Temperature (ºC)	22.9	28.3	22.4	27.3	25.0	28.7	-	-
Elect. Cond. (µS/cm)	15.1	656	16.7	840	16.9	20	-	1000
Turbidity (NTU)	3.00	357	4.00	304	4.00	<1.00	-	5
Salinity (g/l)	<0.10	0.2	<0.10	0.3	<0.10	<0.10	-	-
TSS (mg/l)	4.00	3,260	2.00	1,070	2.00	5	>10	-
Total Hardness (mg/l)	1.63	318	1.81	385	1.83	36.5	200	200
THC (mg/l)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	-	-
DO (mg/l)	5.28	5.59	5.36	5.56	4.84	4.22	0	-
BOD (mg/l)	6.00	<0.50	8.00	<0.50	10.0	20	0	-
COD (mg/l)	9.60	63.1	11.5	137	17.8	<0.80	-	-
Nitrate (mg/l)	0.04	2.21	0.02	2.44	0.02	0.48	10	50
Sulphate (mg/l)	0.69	<0.02	0.77	<0.02	0.78	<0.02	500	250
Phosphate (mg/l)	0.07	0.23	0.10	0.13	0.06	0.05	-	-
Potassium (mg/l)	0.10	8.02	0.11	7.25	0.11	0.19	-	-
Lead (mg/l)	<0.008	0.23	<0.008	0.15	<0.008	<0.008	0.05	0.01
Total Iron (mg/l)	0.41	53.7	0.42	35.1	0.31	2.08	1.0	0.3
Copper (mg/l)	<0.02	0.06	<0.02	<0.02	<0.02	0.03	0.1	2.0
Barium (mg/l)	<0.03	<0.20	<0.03	<0.20	<0.03	<0.20	1.0	0.7

Note: BH – Borehole; Field Survey, 2013-2014, FMEnv, 1991; WHO, 2011

Parameters analysed from groundwater samples generally compared well with FMEnv and WHO limits for drinking water, as well as with control point result. However, total iron concentrations were above the WHO limits for BH 1 and 2 in both dry and wet seasons. The slightly high level of iron can be associated to the nature of Niger Delta rocks known for its high iron content.

In the wet season total hardness and lead were noticeably higher than their recommended limits. The high total hardness is connected to the high electrical conductivity and high TSS observed during the analyses. Lead may be from the borehole piping system.

Total hydrocarbon content was generally below equipment detection limits in both seasons, as such indicates that they are no oil contamination in the aquifer.

Groundwater Microbial Characteristics

Bacteria and fungi load analysed in groundwater samples from the study area (both seasons) are presented in **Tables 4.8a** and **b**.

Table 4.8a: Groundwater Microbiological Characteristics – Dry Season

Sample Station	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
BH 1	*Bacillus, Pseudomonas, Proteus, Micrococcus, Flavobacterium*	780	*Micrococcus, Pseudomonas*	7	*Candida, Rhodotorula, Fusarium, Penicillium*	34	*Mucor, Fusarium, Candida*	27
BH 2	*Proteus, Pseudomonas, Bacillus, Staphylococcus, Actinomyces*	2,800	*Staphylococcus Bacillus, Pseudomonas, Micrococcus*	10	*Mucor, Aspergillus, Penicillium, Candida, Rhodotorula*	41	*Candida, Mucor, Aspergillus, Penicillium*	35
BH Control	*Proteus, Pseudomonas, Bacillus, Staphylococcus, Micrococcus*	2,510	*Pseudomonas* and *Bacillus*	51	*Rhodoturla and Mucor*	20	*Mucor*	10

Source: Field Survey, 2013-2014

Table 4.8b: Groundwater Microbiological Characteristics – Wet Season

Sample Station	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
BH 1	*Bacillus, Pseudomonas, Staphylococcus, Micrococcus*	5,200	*Pseudomonas*	10	*Rhizopus and Mucor*	120	*Mucor*	3
BH 2	*Staphylococcus Pseudomonas, Bacillus*	3,900	*Bacillus and Pseudomonas*	40	*Rhizopus, Mucor, Candida and Penicillium*	660	*Rhizopus and Mucor*	4
BH Control	*Staphylococcus, Pseudomonas, Bacillus*	2,700	*Pseudomonas and Bacillus*	90	*Penicillium sp*	50	*Penicillium sp*	5

Source: Field Survey, 2013-2014

Bacteria

Heterotrophic bacterial populations in the groundwater sample obtained from the study area were 780 and 2,800cfu/ml (dry season) and 3,900 to 5,200 cfu/ml (wet season). Values were similar to control point values.

Hydrocarbon utilising bacteria range from 7 to 10cfu/ml (dry season) and from 10 to 40cfu/ml (wet season). The predominant bacteria species encountered in the groundwater sample were *Pseudomonas, Bacillus, Staphylococcus* and *Micrococcus* species. Values recorded were slightly lower than control point.

Fungi

Heterotrophic fungi count in the study area range between 34 to 41cfu/ml, higher than control point value which was 20cfu/ml in the dry season. The wet season count range between 120 and 660cfu/ml and was lower than control point value of 50cfu/ml.

Hydrocarbon utilising fungi (HUF) count range between 127 and 35cfu/ml in dry season, slightly higher than control point value of 10cfu/ml. wet season range between 3 and 4cfu/ml, lower than control point value. The predominant fungal species were *Candida, Rhizopus, Penicillium and Mucor species.*

Table 4.9: Groundwater Anaerobic Bacteria Characteristics

Parameters	Species	Concentration Range (cfu/ml)
Dry Season		
Anerobic Bacteria	Clostridium, Proteus and Bacillus	15 – 60
Wet Season		
Anerobic Bacteria	Clostridium, Proteus and Bacillus	5 – 3,600

Source: Field Survey, 2013-2014

Anerobic bacteria recorded in the groundwater samples were higher in the wet season.

4.10 Soil Characteristics

Soil is one of the most dynamic sites of biological interactions in nature. It contains a vast array of bacteria, fungi, algae and protozoa. Many of the biochemical reactions concerned in the mineralisation of soil organic matter and in the nutrition of plants occur in this medium. Soil's texture and properties are used to determine the nature and type of structures to be built in an area.

Soils Types

Soils in the study area represent the humid, tropical forest soil types typical of the southern region of Nigeria. Soil particle size distribution in the area from investigation shows that soil in the area is predominantly sandy silt.

The soil samples obtained (**Figure 4.9**) across all stations generally range between sandy silt and sandy clay soil types. Organic matter composition in the soil from the area is high, so also is the nutrient level.

Source: FNL Field Survey, 2013-2014

Figure 4.9: Soil Types from Study Area

Soil Physico-chemical Characteristics

The physico-chemical characteristics of soil samples obtained from sixteen (16) stations within the study area after insitu/ laboratory measurement and analyses is summarised in **Table 4.10** below. Details of the results are presented in **Appendix 4.2**.

Table 4.10: Soil Physico-chemical Characteristics

Parameters		Dry Season			Wet Season		
		Mean	**Range**	**Control**	**Mean**	**Range**	**Control**
pH		6.25	5.30 - 7.30	7.00	6.30	5.32 -7.27	5.55
Moisture Content (%)		15.1	11.0 – 23.3	16.3	17.1	12.5 -32.1	14.6
THC (mg/kg)		-	<5.00	<5.00	751	<5.0 -1,440	<5.00
PSD	Clay (%)	13.5	13.0 – 14.0	-	-	-	-
	Silt (%)	28.5	28.0 – 29.0	-	24.2	10 -36	18
	Sand (%)	94.4	57.0 - 100	100	75.8	64 -90	82
Ext. Nitrate (mg/kg)		0.16	0.09 – 0.47	0.22	48.1	4.81 -113	79
Ext. Sulphate (mg/kg)		210	145 - 320	248	136	67.5 -270	148
Ext. Phosphate (mg/kg)		22.4	16.9 – 33.8	19.6	309	1.94 -2,865	5.6
Total Iron (mg/kg)		10,054	8,224- 11,430	10,540	9,954	8,037 -11,010	8,887
Copper (mg/kg)		24.5	1.50 – 89.2	8.00	5.60	1.20 -15.1	10.9
Lead (mg/kg)		31.3	8.10 – 60.3	43.5	27.4	4.8 -85.5	155
Nickel (mg/kg)		12.2	6.30 – 29.3	8.80	9.30	2.50 -22.0	10.9
Zinc (mg/kg)		119	15.1 - 698	305	144	33.6 -410	61
Vanadium (mg/kg)		26.8	14.7 – 44.3	7.80	15.0	4.80 -35.9	13.3

Source: Field Survey, 2013-2014

pH

pH is the most commonly measured parameter of soil properties. It is regarded as a useful indicator of other soil parameters. The main value of pH measurements is that it shows soil to be acid, neutral or alkaline and yields useful information about the availabilities of exchangeable cations (e.g. Ca^{2+}, Mg^{2+}, K^{+} etc.) in soils.

A high pH can induce trace element deficiency. Microbial activity is also strongly pH-dependent. Some plants are sensitive to acidity and some to alkalinity. Soils that are about neutral or on the acid side of neutrality are the best suited for agriculture.

The pH of the soil samples obtained in the study area was measured in-situ. pH value ranged between 5.30 and 7.30 for dry season and between 5.32 and 7.27 for wet season. Soil results obtained shows an acidic to slightly alkaline medium. pH values compared well with control point results.

Moisture Content

Water or moisture content is the quantity of water contained in a material, such as soil (called soil moisture), rock, ceramics, fruit, or wood. Water content is used in a wide range of scientific and technical areas. It can range from 0 (completely dry) to the value of the materials porosity at saturation.

Moisture content analysed in the soil samples obtained from the study area during the dry season ranges from 11% to 23.3% for the dry season and from 12.5% to 32.1% for the wet season. These values were similar when compared to control point values.

Total Hydrocarbon Content

Total hydrocarbon content (THC) concentrations measured across all stations in the dry season including control point were less than 5.0mg/kg. In the wet season, it ranges from less than 5.0mg/kg to 1,440mg/kg. Elevated concentration of THC was recorded in stations (SS3, SS5, SS9 and SS10). These stations are along the popular Ogorode road where vehicular movement is high.

Particle Size Distribution

Soil particle size distribution (PSD) investigations carried out on samples obtained shows that sand was the most dominant particle, followed by silt and lastly by clay. Silt and clay were only observed in sample stations 2 and 4 as shown below in **Figure 4.10a** for the dry season.

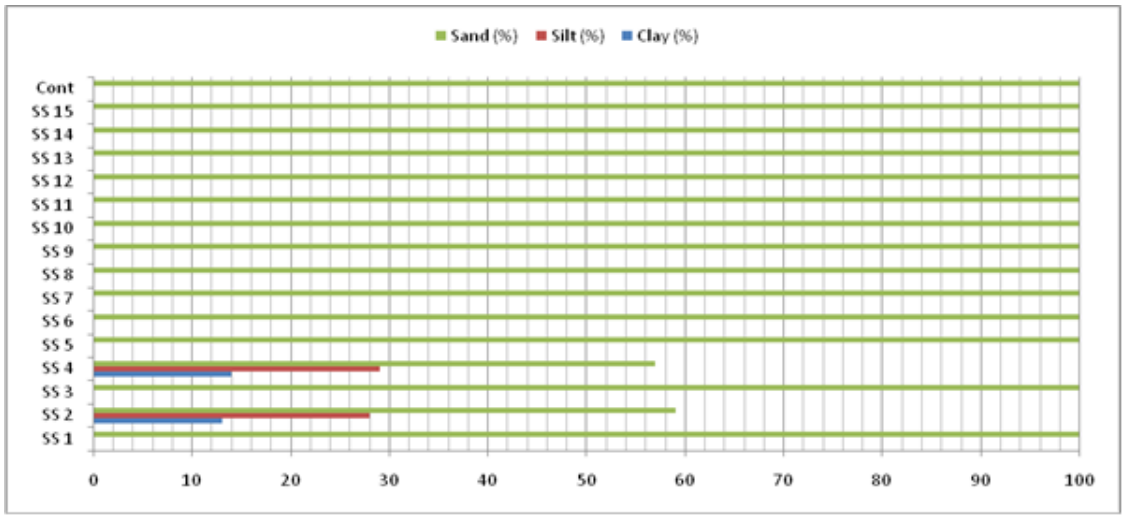


Figure 4.10a: Soil Particle Size Distribution –Dry Season

For the wet season, sand also dominated, followed by silt, clay was not analysed. **Figure 4.10b** below shows the particle distribution.

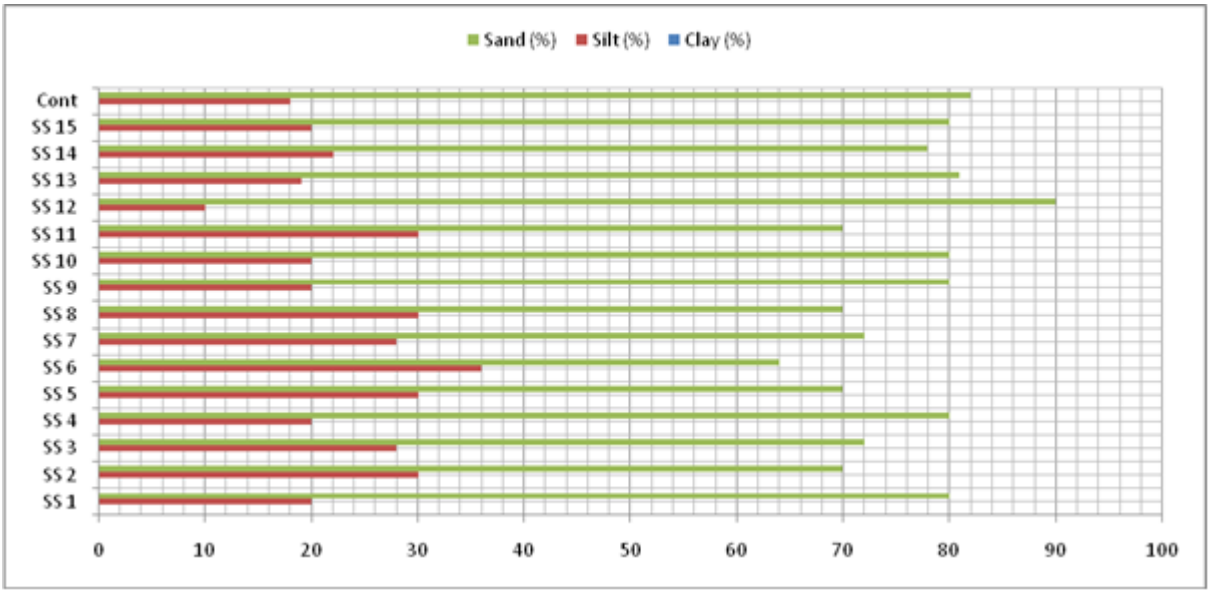


Figure 4.10b: Soil Particle Size Distribution –Wet Season

Nutrients

Nitrate

Nitrate concentration analysed in the soil samples obtained from the study area range between 0.09 and 0.47mg/kg (dry season), while wet season range from 4.81 to 113mg/kg. Concentrations were similar to their respective control point concentration.

Sulphate

Sulphate concentrations analysed in the soil samples from study area range between 145 and 320mg/kg for dry season, wet season concentration range between 67.5 and 270mg/kg. Concentrations were like their control points.

Phosphate

Phosphate concentrations analysed in the soil samples from the study area range between 16.9 and 33.8mg/kg (dry season), wet season concentration range from 1.94 to 2,865mg/kg. Concentrations measured per season were like their respective control point.

Heavy Metals

Heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations. Heavy metals analysed in this study include; iron (Fe), copper (Cu), lead (Pb), nickel (Ni), zinc (Zn) and vanadium (Va). Heavy metals are natural components of the earth's crust. Traces of heavy metals as well as others are present in most soil but their minerals are relatively rare.

Concern over the presence of heavy metals in an environment arises from the fact that they cannot be broken down to non-toxic forms. Thus, once they get into natural ecosystems they cannot be degraded or destroyed. To a small extent they enter our bodies via food, drinking water and air. As trace elements, some heavy metals (e.g. copper, selenium, zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning.

Total Iron

Iron is a major component of most soils. The predominant iron minerals are the oxides but iron is also present in many other minerals (notably carbonates, micas, amphibolites and clays). Although widely distributed, iron deficiencies can occur due to its low solubility in alkaline (calcareous) soils and in phosphate fixation.

Iron occurs in the respiratory pigment porphyrin which is required in electron transfer (cytochrome) process in plants and animals. It also activates some oxides and is necessary for chlorophyll synthesis. Iron is not considered hazardous to health. In fact, iron is essential for good health because it transports oxygen in blood, but it is considered a secondary or aesthetic contaminant.

Concentrations of iron in the soil samples obtained within 0.5m depth range from 8,224 to 11,430mg/kg in the dry season, while the wet season was from 8,037 to 11,010mg/kg.

Copper

Copper is generally higher in soils derived from igneous rocks and tends to be lower in extreme acid and alkaline soils. The soil availability levels are similar to that of zinc although its requirements by plants are generally lower. It activates certain enzyme systems in plants, especially those linked with oxidation processes. It is also essentially those linked with oxidation processes. It is essential for animals. However, copper in excess can be harmful and pollution occurs in areas where copper ores are found.

Copper can interrupt the activity in soils, as it negatively influences the activity of microorganisms and earthworms. The decomposition of organic matter may seriously slow down because of this. When the soils of farmland are polluted with copper, animals will absorb concentrations that are damaging to their health. Mainly sheep suffer a great deal from copper poisoning, because the effects of copper manifest at fairly low concentrations.

Copper concentration in soil samples obtained ranged from 1.5 to 89.2mg/kg in the dry season, with mean of 24.5mg/kg. Wet season was from 1.2 to 15.1mg/kg, with mean of 5.6mg/kg.

Lead

Lead is toxic to many plant species although a few are relatively tolerant. It is a cumulative poison to mammals. Waste products from certain industries result in polluted soils and high levels of lead are associated in drainage systems. Although lead has been disused has an antiknock ingredient in petrol used in Nigeria, high-level of lead in soil around roads can be linked to mixing of lead from car exhaust with soil. Lead is also widely distributed through its use in batteries, pigments, dyeing and glass. It is used in combination with arsenic as lead arsenate in sprays.

Concentrations of lead in soil samples obtained range from 8.1 to 60.3mg/kg in the dry season and from 4.8 to 85.5mg/kg in the wet season.

Nickel

Nickel occurs in nature mainly in combination with sulphur, arsenic and antimony. It enters the environment mainly through the weathering of minerals and rocks and as a result of anthropogenic activities (GEMS, 1992). Nickel sulfide fume and dust is believed to be carcinogenic, and various other nickel compounds may be as well. Nickel carbonyl, [$Ni(CO)_4$], is an extremely toxic gas. The toxicity of metal carbonyls is a function of both the toxicity of the metal as well as the carbonyl's ability to give off highly toxic carbon monoxide gas.

Nickel is generally less than 100ppm in soils but it could be exceptionally high in some cases especially where ultra-basic rocks are present. Plants appear to be more sensitive to nickel toxicity than animals.

Nickel concentration in the soil samples obtained range from 6.3 to 29.3mg/kg (dry season), and from 2.5 to 22.0mg/kg during the wet season.

Zinc

Zinc is a very common substance that occurs naturally. Zinc occurs naturally in air, water and soil, but zinc concentrations are rising unnaturally, due to addition of zinc through human activities. Most zinc is added during industrial activities, such as mining, coal and waste combustion and steel processing. Some soils are heavily contaminated with zinc, and these are to be found in areas where zinc has to be mined or refined, or were sewage sludge from industrial areas has been used as fertilizer. Water is polluted with zinc, due to the presence of large quantities of zinc in the wastewater of industrial plants. One of the consequences is that rivers are depositing zinc-polluted sludge on their banks. Zinc may increase the acidity of waters. When zinc enters the bodies of these fish it is able to biomagnify up the food chain.

Zinc concentrations ranged from 15.1 to 698mg/kg in the dry season and from 33.6 to 410mg/kg in the wet season.

Vanadium

Vanadium is abundant in most soils, in variable amounts, and it is taken up by plants at levels that reflect its availability. Vanadium causes the inhibition of certain enzymes with animals, which has several neurological effects. Next to the neurological effects, vanadium can cause breathing disorders, paralyses and negative effects on the liver and kidneys. Laboratory tests with animals have shown that vanadium can cause harm to the reproductive system of male animals, and that it accumulates in the female placenta. Vanadium can cause DNA alteration in some cases, but it cannot cause cancer with animals.

Vanadium concentrations in soil samples range between 14.7 to 44.3mg/kg. Concentrations were higher than control point value of 7.8mg/kg in the dry season. The wet season was from 4.8mg/kg to 35.9mg/kg and corresponded to wet season.

Soil Microbial Characteristics

Bacteria and fungi load analysed in soil samples from the study area are presented below in **Tables 4.11**

Table 4.11: Soil Microbiological Characteristics

Sample Station	Total Heterotrophic Bacteria	Range Count (cfu/g)	Hydrocarbon Utilising Bacteria	Range Count (cfu/g)	Total Heterotrophic Fungi	Range Count (cfu/g)	Hydrocarbon Utilising Fungi	Range Count (cfu/g)
Dry Season								
Soil samples	*Bacillus, Pseudomonas, Proteus, Micrococcus, Flavobacterium, Streptomyces, Klebsiella, Arthrobacter, Nocardia*	45,000–750,000	*Micrococcus, Pseudomonas, Bacillus, Proteus, Staphylococcus*	8,500 – 53,000	*Candida, Rhodotorula, Fusarium, Penicillium, Aspergillus, Mucor, Trichoderma*	190 – 2,240	*Mucor, Fusarium, Candida, Penicillium, Aspergillus, Rhizopus*	150 – 1,980
Wet Season								
Soil samples	*Bacillus, Pseudomonas, Proteus, Micrococcus, Flavobacterium, Chromobacteriu, Paenibacillus*	71,000–460,000	*Micrococcus, Pseudomonas, Bacillus, Flavobacterium*	1,100 – 20,400	*Candida, Fusarium, Penicillium, Aspergillus, Mucor, Rhizopus*	110 – 990	*Mucor, Fusarium, Aspergillus, Rhizopus*	30 – 350

Source: Field Survey, 2013-2014

Bacteria

Heterotrophic bacterial (HB) populations in the soil sample obtained from the study area ranged from 45,000 and 750,000cfu/g in the dry season, and from 71,000 and 460,000cfu/g. Values were similar to control point result.

Hydrocarbon utilising bacteria (HUB) range from 8,500 to 53,000cfu/g in the dry season and from 1,100 to 20,400cfu/g in the wet season. The predominant bacteria species

encountered in the soil samples were *Pseudomonas, Bacillus Micrococcus* and *Flavobacterium* species. Values recorded were similar to control point.

Fungi
Heterotrophic fungi (HF) count in the area range between 190 and 2,240cfu/g in the dry season, similar to control point. Wet season range from 110 to 990cfu/g, similar to control point.

Hydrocarbon utilising fungi (HUF) count range between 150 and 1,980cfu/g in the dry season and between 30 and 350cfu/g Predominant fungal species include *Candida, Mucor, Fusarium, Candida, Penicillium, Aspergillus, species.*

Table 4.12: Soil Anaerobic Bacteria Characteristic

Parameter	Species	Concentration Range (cfu/g)
Dry Season		
Anerobic Bacteria	*Clostridium, Proteus and Bacillus*	1,810 – 5,000
Wet Season		
Anerobic Bacteria	*Clostridium, Proteus, Bacteriodes and Bacillus*	420 – 1,120

Source: Field Survey, 2013-2014

Anaerobic bacteria recorded in soil samples were higher in the dry season.

4.11 Sediment Characteristics

Sediment quality is an important aspect of aquatic ecosystems. It can influence the quality of overlying waters and also supports benthic communities. Monitoring the chemical content and physical composition of sediments provides information on how the environment is changing and the natural or human factors that may be linked to such changes.

Physico-chemical results of sediment samples obtained from seventeen (17) stations within the study area (Ethiope River) including two (2) control stations are summarised in **Table 4.13** below, details are in **Appendix 4.3**.

Table 4.13: Sediment Physico-chemical Characteristics

Parameters		Dry Season				Wet Season			
		Mean	Range	Cont. 1	Cont. 2	Mean	Range	Cont. 1	Cont. 2
pH		4.04	3.55- 4.25	4.24	4.03	5.39	5.00 -5.90	5.49	5.58
Elect. Cond. (µS/cm)		155	56.0 -572	109	121	196	91.3 -372	115	285
THC (mg/kg)		1,717	<5.00 -3,990	<5.00	<5.00	1,625	<5.00- 2,618	2,543	307
PSD	Clay (%)	6.0	4.0 – 8.0	-	-	4.33	2.0- 6.0	4	-
	Silt (%)	36.5	36.0 -37.0	-	-	61.3	20- 80	76	60
	Sand (%)	94.3	55.0 - 100	100	100	36.9	20 -74	20	40
Ext. Nitrate (mg/kg)		0.18	0.08 -0.29	0.21	0.19	18.0	4.02 -32.5	15.8	23.1
Ext. Sulphate (mg/kg)		138	38.0 -248	148	185	293	173- 528	240	395
Ext. Phosphate (mg/kg)		26.6	10.0 – 76.4	24.1	47.0	2.88	<0.02- 4.50	<0.02	<0.02
Magnesium (mg/kg)		1,223	485 – 2,144	510	347	615	186- 1,462	211	485
Sodium (mg/kg)		1,684	251 – 2,920	2,000	1,940	200	120- 265	221	280
Potassium (mg/kg)		2,076	1,263 – 2,655	1,892	1,159	1605	907- 4,940	984	1,361
Calcium (mg/kg)		761	306 – 1,450	357	106	277	47- 516	85.8	544
Total Chromium (mg/kg)		33.2	<1.0 – 47.1	29.2	20.6	54.2	12.1- 142	53.5	44.2
Total Iron (mg/kg)		8,504	5,078 – 10,760	8,108	4,848	12,465	2,886- 27,680	11,320	19,640
Copper (mg/kg)		14.9	0.9 – 60.5	7.20	6.10	27.9	9.40 -50.0	24.5	28.4
Lead (mg/kg)		31.5	<1.0 – 57.9	35.4	16.2	30.4	<1.0- 49.9	32.9	29.9
Nickel (mg/kg)		9.81	3.20 – 20.4	8.80	8.60	29.1	16.7- 58.1	31.1	30.8
Zinc (mg/kg)		46.4	2.10 - 187	26.7	18.6	54.4	24.3- 83.7	48.4	96.3

Silver (mg/kg)	4.55	<2.0 – 6.20	<2.00	<2.00	11.5	4.90- 83.3	6.8	8
Cobalt (mg/kg)	20.8	<3.0 – 22.5	<3.00	<3.00	21.9	13.4- 28.6	19.7	28.8
Barium (mg/kg)	-	<2.00	<2.00	<2.00	165.2	112- 259	170	230
Manganese (mg/kg)	63.8	32.4 - 144	45.5	60.3	145	110- 194	138	161
Cadmium (mg/kg)	1.1	<0.1 – 12.0	<0.10	<0.10	<2.00	<2.00	<2.00	<2.00

Source: Field Survey, 2013-2014

pH

The pH of the sediment samples obtained from the study area range between 3.55 and 4.25, in the dry season, and from 5 to 5.90 in the wet season. The pH values show that the sediment samples are acidic in nature. Values obtained compared well with control points.

Electrical Conductivity

Electrical conductivity (EC) measured in the sediment samples range between 56 and 572µS/cm in the dry season and between 91.3 and 372µS/cm in the wet season. EC values recorded compared well with control point values.

Total Hydrocarbon Content

Total hydrocarbon content (THC) concentration recorded range from less than 5.0mg/kg to 3,990mg/kg (dry season). Wet season was from less than 5.0mg/kg to 2,616mg/kg. High levels of THC suggest hydrocarbon presence in the sediment.

Particle Size Distribution

Sediment particle size distribution (PSD) investigations carried out on samples obtained shows that sand was the most dominant particle, followed by silt and lastly by clay. Silt and clay were analysed in sample stations 5 and 6 only as shown below in **Figure 4.11a** for dry season study.

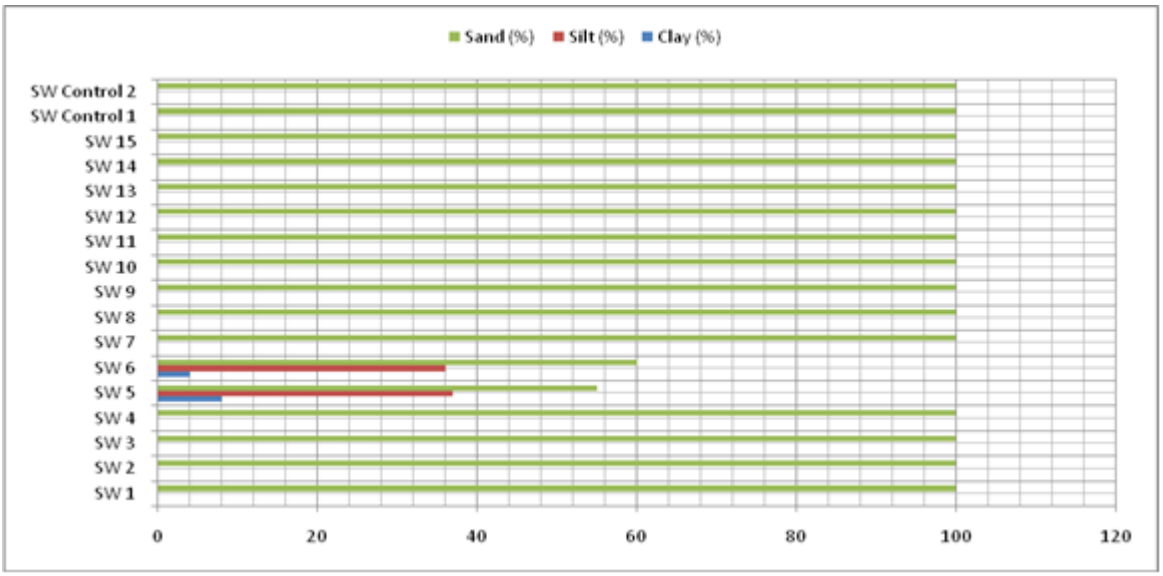


Figure 4.11a: Sediment Particle Size Distribution – Dry Season

In the wet season, silt dominated, followed by sand and lastly clay as shown below in **Figure 4.10b**.

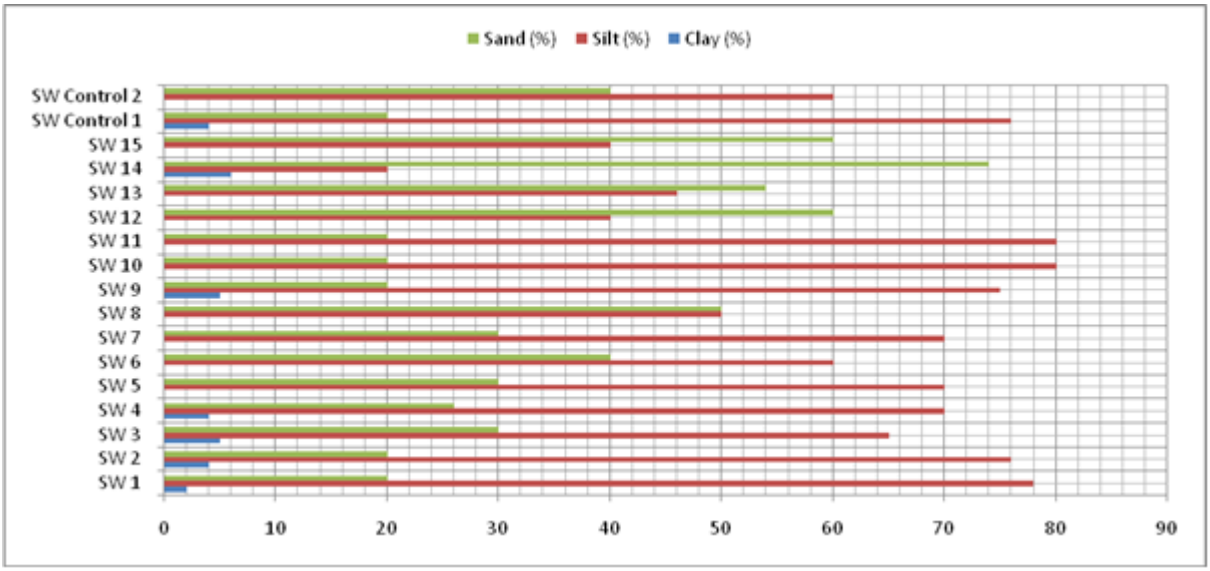


Figure 4.11b: Sediment Particle Size Distribution – Wet Season

Nutrients and Heavy Metals

Sediment nutrient and heavy metal concentrations did not vary much over the two seasons (except for nitrate, phosphate, copper and barium). Respective parameter concentrations were also similar to control point concentrations.

Sediment Microbial Characteristics

Bacteria and fungi load analysed in sediment samples from the study area are presented below in **Table 4.14**

Table 4.14: Sediment Microbiological Characteristics

Sample Station	Total Heterotrophic Bacteria	Range Count (cfu/g)	Hydrocarbon Utilising Bacteria	Range Count (cfu/g)	Total Heterotrophic Fungi	Range Count (cfu/g)	Hydrocarbon Utilising Fungi	Range Count (cfu/g)
Dry Season								
Sediment samples	*Bacillus, Pseudomonas, Proteus, Micrococcus, Flavobacterium, Staphylococcus*	17,000–650,000	*Micrococcus, Pseudomonas, Bacillus, Staphylococcus*	10 – 3,900	*Candida, Rhodotorula, Mucor, Trichoderma, Ulocadium, Rhizopus* etc.	90 – 1,210	*Mucor, Fusarium, Candida, Penicillium, Aspergillus,, Rhizopus, Rhodotorula etc.*	40 –90
Wet Season								
Sediment samples	*Bacillus, Pseudomonas, Proteus, Micrococcus, Staphylococcus*	8,000–840,000	*Pseudomonas and Bacillus*	10 – 900	*Candida, Rhodotorula, Fusarium, Penicillium, Aspergillus,*	10 – 450	*Mucor, Fusarium, Candida, Penicillium, Aspergillus*	0 –50

Source: Field Survey, 2013-2014

Bacteria

Heterotrophic bacterial populations in the sediment sample obtained from the study area ranged from 17,000 and 650,000cfu/g in the dry season, and from 8,000 to 840,000cfu/g in the wet season. Values recorded correspond to those from control point.

Hydrocarbon utilising bacteria range from 10 to 3,900cfu/g (dry season), wet season range from 10 to 900cfu/g. The predominant bacteria species encountered in the sediment samples were *Pseudomonas, Bacillus, Staphylococcus* and *Micrococcus* species. Values recorded were similar to control point.

Fungi

Heterotrophic fungi count in the area range between 90 and 1,210cfu/g for dry season and from 10 to 450cfu/g for wet season. Similar counts were recorded in control point.

Hydrocarbon utilising fungi (HUF) count range between 40 and 90cfu/g in the dry season and from 0 to 50cfu/g in the wet season. Results were similar to control point. Predominant fungal species include *Candida, Mucor, Fusarium, Candida, Penicillium, Aspergillus, species.*

Table 4.15: Sediment Anaerobic Bacteria Characteristic

Parameter	Species	Concentration Range (cfu/g)
Dry Season		
Anerobic Bacteria	Clostridium, Proteus and Bacillus	201 – 2,300
Wet Season		
Anerobic Bacteria	Clostridium, Proteus, Prevotella and Bacillus	340 – 2,780

Source: Field Survey, 2013-2014

Anerobic bacteria recorded in sample medium over the two seasons were similar but slightly higher in the wet season.

4.12 Surface Water

Surface Water Characteristics

The project area is surrounded by Ethiope River which interconnects to the sea through Benin River at Sapele Town. The river is about 100km long from its source at Umuaja community in Delta State, Nigeria (Ikomi and Happy, 2002). To obtain an accurate description of water composition/ characteristics of the area, water samples for analyses were obtained from the river as presented below.

Surface water samples were obtained from a total of seventeen (17) stations, inclusive of two (2) control stations. Summary of results obtained are presented in **Table 4.16**, while **Appendix 4.4** contains the detailed results. Results are also compared to the FMEnv Standards for Water Quality (Supporting Aquatic Life).

Table 4.16: Surface Water Physico-chemical Characteristics

	Dry Season		Wet Season		
Parameters	**Mean**	**Range**	**Mean**	**Range**	**FMEnv Limits**
pH	5.48	5.02- 5.82	5.57	5.33- 5.93	6.0 -9.0
Temperature (ºC)	22.9	21.1- 25.4	26.7	24.3- 27.5	20.0 -33.0
Conductivity (µS/cm)	13.2	12.5- 13.9	17.8	12.4- 53.2	-
Salinity (g/l)	-	<0.1	-	<0.1	-
DO (mg/l)	4.68	4.05- 5.30	6.53	6.24- 6.65	6.8
Turbidity (NTU)	3.87	1.0 -7.0	7.07	4.0 -9.0	-
TSS (mg/l)	2.87	1.0 -7.0	10.1	1.0- 40	-
TDS (mg/l)	7.91	7.50 – 8.34	10.7	7.44- 31.9	-
Oil & Grease (mg/l)	-	<0.40	-	<0.40	-
Bicarbonate (mg/l)	5.73	2.0 -14.0	7.73	3.51- 14.3	-
BOD (mg/l)	14.4	8.0- 30.0	9.96	<0.5- 20.0	4.0
COD (mg/l)	23.9	12.5- 50.8	10.9	3.83- 35.1	-
Lead (mg/l)	-	<0.008	-	<0.008	0.002
Zinc (mg/l)	0.03	<0.02 – 0.07	-	<0.02	0.05
Copper (mg/l)	-	<0.02	-	<0.02	0.002 – 0.004
Total Iron (mg/l)	0.40	0.27 – 0.73	0.18	0.1- 0.24	0.001
Nickel (mg/l)	-	<0.06	-	<0.06	0.025 – 0.15
Vanadium (mg/l)	-	<0.20	-	<0.20	0.0001

FNL Field Survey 2013-2014; FMEnv National Guidelines for Water Quality

pH

The pH of an aquatic medium is an indication of its hydrogen ion activity and is used widely to express the intensity of acid or alkaline condition of the medium. It plays an important role in all chemical reactions associated with formation, alteration and dissolution of minerals. pH is critical to the aquatic ecosystem because it affects the

functioning of virtually all enzymes, hormones, and other proteins of the body which control all aspects of metabolism, growth and development (Keily, 1998).

The pH value of surface water recorded insitu range from 5.02 to 5.82, during the dry season, and from 5.33 to 5.93 during the wet season indicating an acidic medium. Values were higher than control point results in dry season, but similar in wet season.

Temperature
Insitu measurement of temperature values during sampling, range between 21.1 and 25.4 ^{o}C for dry season and from 24.3 to 27.5 ^{o}C in the wet season. Values recorded were similar to control points.

Electrical Conductivity
The conductivity of water, gives an indication or measure of its ability to carry an electric current. This is dependent on certain factors which include the presence of ions, total concentration, mobility and valency and also on the temperature of water at the points of measurement.

Electrical conductivity values obtained during sampling range between 12.5 and 13.9µS/cm in the dry season, while it ranges between 12.4 and 53.2µS/cm in the wet season. Values were similar to control points.

Salinity
Salinity is a measure of the amount of dissolved inorganic materials (salts) in an aquatic medium. Salinity affects vapour and osmotic pressure, viscosity and temperature.

Salinity concentration obtained was less than 0.1g/l in all sample stations including control point results in both seasons.

Dissolved Oxygen
Dissolved oxygen (DO) measures the amount of gaseous oxygen (O_2) dissolved in an aqueous solution. The values obtained in-situ range between 4.05mg/l and 5.30mg/l, similar to control points in the dry season. The wet season was higher between 6.24mg/l and 6.65mg/l.

Turbidity
Turbidity is a measure of the degree to which water loses its transparency due to the presence of suspended particulates. The more suspended solids in the water, the murkier it is and the higher the turbidity. Turbidity is considered a good measure of the quality of water. Factors that influence the suspended materials in water may include: phytoplankton activities, sediments from erosion and re-suspension from the river bottom caused by frequently stir up by bottom feeders like carp, waste discharge, algae growth, and urban runoff etc. Turbidity concentrations measured ranged from 1 to 7NTU.

Total Suspended Solids
Total Suspended Solids (TSS) are solid materials, including organic and inorganic, that are suspended in the water. These would include silt, plankton and industrial wastes etc. High concentrations of TSS can lower water quality by absorbing light. This makes the water bodies to become warmer and lessen the ability of the water to hold oxygen necessary for aquatic life. When aquatic plants receive less light, photosynthesis decreases and less oxygen is produced. The combination of warmer water, less light and less oxygen makes it impossible for some forms of life to exist. Total suspended solids (TSS) concentrations and turbidity both indicate the amount of solids suspended in the water, whether mineral (e.g., soil particles) or organic (e.g. algae). TSS concentration measured ranged from 1.0 – 7.0mg/l in the dry season, and from 1.0 – 40mg/l in the wet season.

Total Dissolved Solids
Total Dissolved Solids (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionised or micro-granular (colloidal sol) suspended form. TDS concentrations in the surface water samples range between 7.5 and 8.34mg/l in the dry season and from 7.44 to 31.9mg/l in the wet season.

Oil and Grease
Oil and grease concentrations were below equipment detection limit of 0.4mg/l in all sampled stations, including control points in both seasons.

Bicarbonate
Bicarbonate concentrations range between 2 and 14mg/l in the dry season and from 3.51 to 14.3mg/l in the wet season. Values were similar to control point values.

Biological Oxygen Demand
Biological Oxygen Demand (BOD) is a measure of the relative oxygen-depletion in a medium; both have been widely adopted as a measure of pollution effect. This test is based on the amount of oxygen needed by microorganisms to biodegrade organic compounds.

BOD levels recorded in the surface water samples range from 8 to 30mg/l in the dry season and from to less than 0.5 to 20mg/l in the wet season.

Chemical Oxygen Demand
Chemical oxygen demand (COD) is the amount of oxygen required to chemically stabilise organic matter contained in a solution under aerobic conditions. It is also used as a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by strong chemical oxidant (GEMS, 1992).

COD level recorded in the surface water samples range from 12.5mg/l to 50.8mg/l in the dry season and from 3.83mg/l to 35.1mg/l in the wet season.

Heavy Metals
Surface water heavy metal concentrations did not vary much over the two seasons. Respective parameter concentrations were also similar to control point concentrations.

Surface Water Microbial Characteristics
Bacteria and fungi load analysed in surface water samples from the study area in both seasons are presented in **Table 4.17**.

Table 4.17: Surface Water Microbiological Characteristics

Sample Station	Total Heterotrophic Bacteria	Range Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Range Count (cfu/ml)	Total Heterotrophic Fungi	Range Count (cfu/ml)	Hydrocarbon Utilising Fungi	Range Count (cfu/ml)
Dry Season								
Soil samples	*Bacillus, Pseudomonas, Proteus, Micrococcus, Flavobacterium, Staphylococcus, Actinomyces Chromobacterium, Paenibacillus, Dactylosporangium*	440–6,100	*Micrococcus, Pseudomonas, Bacillus, Staphylococcus, Flavobacterium, Proteus, Arthrobacter*	5 -67	*Candida, Rhodotorula, Fusarium, Penicillium, Aspergillus, Mucor, Trichoderma, Acremonium, Rhizopus*	11- 79	*Mucor, Fusarium, Candida, Penicillium, Aspergillus,, Rhizopus, Rhodotorula,*	3 –61
Wet Season								
Soil samples	*Bacillus, Pseudomonas, Proteus, Micrococcus, Staphylococcus, Chromobacterium*	180–4,400	*Micrococcus, Pseudomonas, Bacillus, Staphylococcus,*	5 -440	*Candida, Rhodotorula, Fusarium, Penicillium, Aspergillus, Mucor, Rhizopus*	1- 280	*Mucor, Candida, Penicillium, Aspergillus*	0 –120

Source: Field Survey, 2013-2014

Bacteria

Heterotrophic bacterial populations in surface water sample obtained from the study area during the dry season range between 440 and 6,100cfu/ml, while it ranges from 180 to 4,400cfu/ml in the wet season. Counts were similar to control point values.

Hydrocarbon utilising bacteria range from 5 to 67cfu/ml in the dry season and from 5 to 440cfu/ml in the wet season. The predominant bacteria species encountered in the water samples were *Pseudomonas, Bacillus, Staphylococcus, Flavobacterium, Proteus* and *Micrococcus* species. Values recorded were similar to control point counts.

Fungi

Heterotrophic fungi count in the area range between 11 and 79cfu/ml for the dry season, while the wet season ranges from 1 to 280cfu/ml.

Hydrocarbon utilising fungi count range between 3 and 61cfu/ml in the dry season and ranges between 0 and 120cfu/ml in the wet season. Count were similar to control point. Predominant fungal species include *Candida, Mucor, Fusarium, Penicillium, Aspergillus, species.*

Table 4.18: Surface Water Anaerobic Bacteria Characteristic

Parameter	Species	Concentration Range (cfu/ml)
Dry Season		
Anerobic Bacteria	Clostridium, Proteus and Bacillus etc.	12 – 96
Wet Season		
Anerobic Bacteria	Clostridium, Proteus, Peptococcus, Bacteriodes and Bacillus etc.	6 – 200

Source: Field Survey, 2013-2014

Anerobic bacteria recorded in surface water sample were higher in the wet season.

4.13 Hydrobiology

Hydrobiology data as presented in this section is for two seasons (dry and wet). Water samples and sediment for analyses were obtained from Ethiope River. Information would be used for monitoring environmental changes in future and for predicting impacts/ mitigation measures for the project.

Plankton Sampling

Phytoplankton, zooplankton and benthic samples were analysed at seventeen (17) surface water stations. Plankton net was towed along horizontal path at sub-surface (20 cm) of the water for a minimum of five minutes before retrieving for collection of samples for phytoplankton. Zooplankton was collected by towing the net in a vertical position, while benthos was obtained from sieving sediment samples as described in **Appendix 4.1**. The sampling was carried out in daylight.

Comparative qualitative and quantitative taxonomic inventorisation of observed phytoplankton species among the sampling stations for both seasons indicated relative differences in both the taxonomic compositions and total abundance values.

While a total plankton abundance of 3,296 cells/ml was recorded in wet season against a significantly higher 7,633 cells/ml during the dry season, a lower total plankton species diversity of 77 was recorded during the wet season against 85 in dry season. The higher plankton abundance and diversity observed during the dry season could be attributed to higher concentration nutrients, lower run-offs and more stability in the environment. (Nwankwo, 1998, Timothy *et al* 2001) noted that anthropogenic and natural stress may change the structure, function and organisation of dissipative system at any level, comprising self-regulation and making unstable incoherent responses more probable. They further noted that variations in the hydrodynamics governing any freshwater ecosystem makes it to exist in a state far from thermodynamic equilibrium. It was further emphasised that interactions within the aquatic ecosystem involves large number of biotic and abiotic entities which are nonlinear dynamic systems with feedback mechanisms. These mechanisms are responsible for variations in successions in the taxonomic compositions of species.

Figure 4.12 and **4.13** shows plankton (phyto and zoo) percentage count and specie richness (i.e. number of species observed) in both seasons. See **Appendix 4.5** for result details

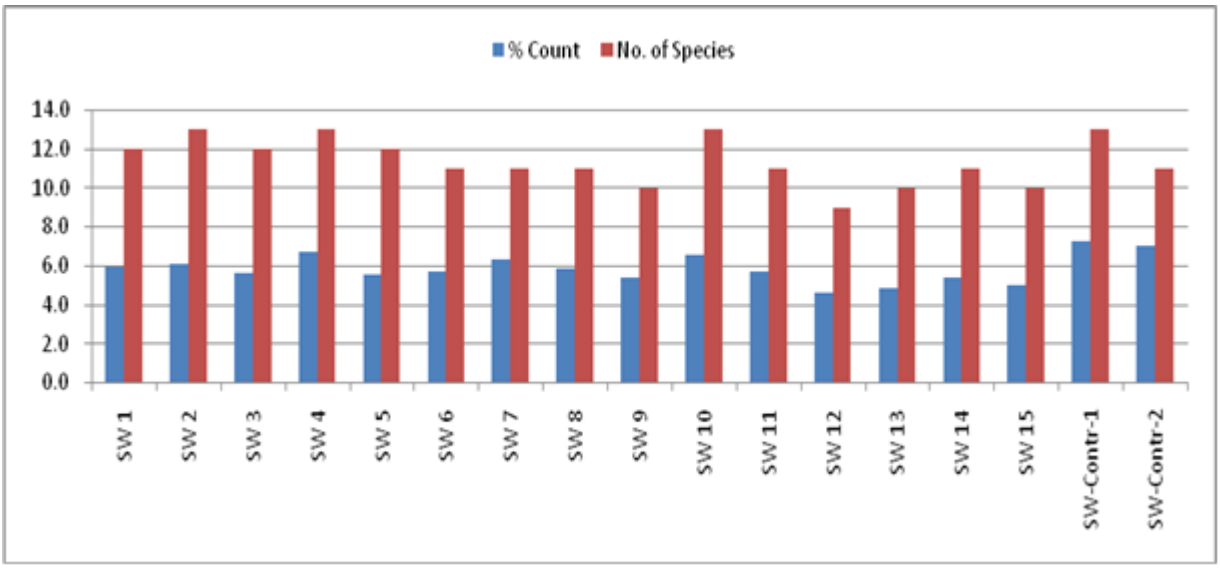


Figure 4.12: Plankton Percentage Count and Species Richness -Dry season

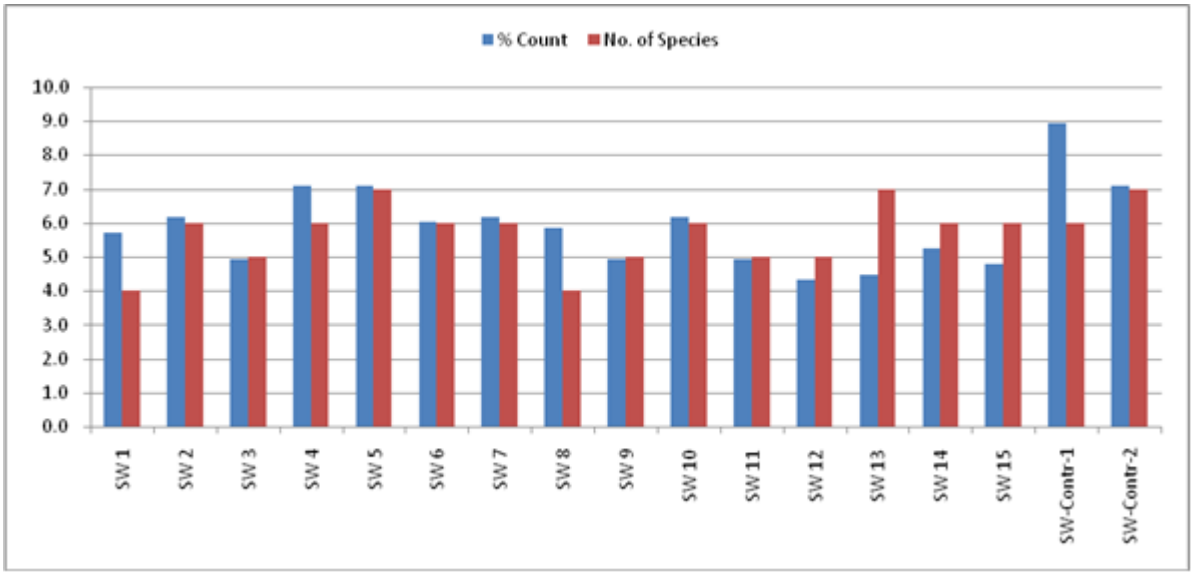


Figure 4.13: Plankton Percentage Count and Species Richness -Wet season

Various researchers had previously noted similar species diversity and abundance for wet and dry seasons respectively Kadiri (1999), Opute (1990), Dahlin *et al* (1985), Onuoha (1986) and Powell and Onwuteka (1980). Dahlin *et al* observed that species diversity and composition of algae in the Niger Delta varied seasonally, with its peak in the dry season. Nwankwo (2001) noted that the high temperature of the dry season may have caused a rapid decomposition of oxidisable organic matter immediately after the rains. This increase in available nutrients coupled with reduced current speed, higher transparency and shallowness ensures effective light penetration, higher pH, probably accounted for the observed relative increase in diatom taxa at this period. UNESCO Report (1981) and Blum (1956) pointed out that whereas rapid currents during wet season damaged and reduced phytoplankton density, moderate current enhanced the development and abundance of phytoplankton species during dry season. Low phytoplankton density during the wet season could also be due to poor penetration of sunlight, effect of flood regimes associated with tropical storms, low pH and inhibitory effects of heavy metals which form complexes that precipitates phosphate-phosphorous and nitrate-nitrogen beyond the reach of phytoplankton. (Ajao and Fagade (1990), Eborge (1971) and Wright (1982) also noted that most African rivers creeks had lower pH and total alkalinity which inhibits phytoplankton growth and abundance during wet season. Similarly, Adeniyi (1986) reported that rivers and creek basins around the Niger Delta are acidic, coloured, poorly aerated, and rich in organic matter and biogenic nutrients. At low pH, some salts notably Aluminum and Iron form insoluble complexes with phosphate which makes them unavailable to the algal community. This was observed to be contrary to the situation during dry season where higher pH and total alkalinity stimulates algae growth and abundance.

Phytoplankton

Generally, observed phytoplankton species diversity and abundance could be adjudged flostically, more diverse and abundant than zooplankton species in both seasons. A total of (55) taxa and percentage abundance of (90.6%) was observed in the phytoplankton species, while (30) taxa and (9.45%) were observed in zooplankton species during the dry season. Similar trend occurred during the wet season though, with lower values. This was well expected, as phytoplankton serve as potential food for herbivorous zooplankton and has shorter and initial higher regeneration rate (Waiffe and Frid (2001). The planktology of any aquatic ecosystem generally witness early positive correlation between phytoplankton and zooplankton, due to some factors like nutrients turbulence and increasing temperature. Later reciprocal relationship between the density of phyto and zooplankton exist, due to overgrazing on phytoplankton.

The *Bacillariophyta* (Diatoms) dominated the spectrum of phytoplankton species in both seasons (**Figure 4.14 and 4.15**), though with a higher percentage abundance of (83.8%) in the dry season The centric diatom (*Melosira granulata*) was the most dominant diatom species during both seasons, though with a higher percentage (53.1%) during the dry season. Centric diatoms had been observed to dominate species of diatoms during the dry season, while Pinnate diatoms demonstrate higher preponderance during the wet season (Nwankwo (1996).

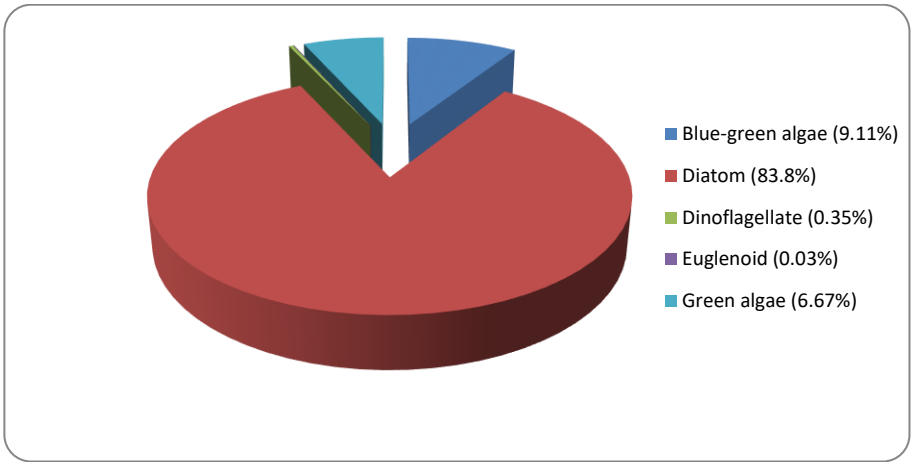


Figure 4.14: Phytoplankton Group – Dry Season

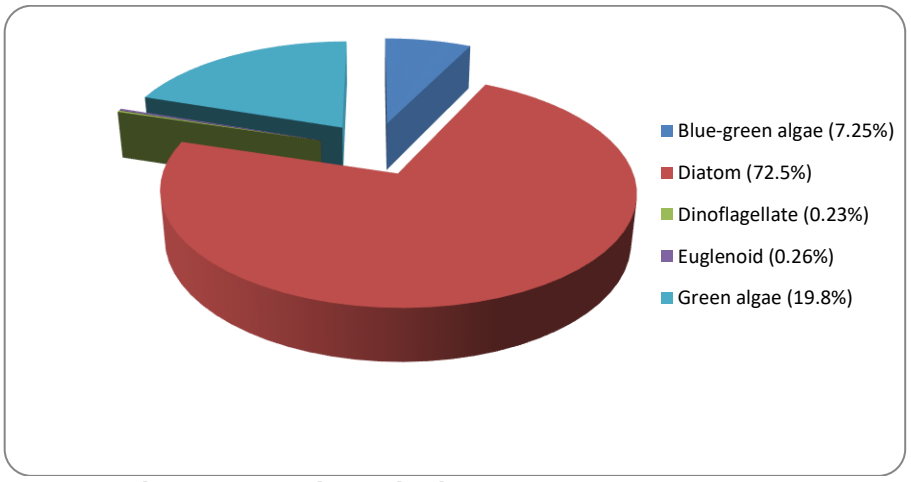


Figure 4.15: Phytoplankton Group –Wet Season

Blooms of *Melosira* species during dry season had been noted by previous researchers with similar physico-chemical variables (Nwankwo 1988, Chinda *et al* 1993). The prominence of *Melosira* adds to the impressive array of evidence attesting to the cosmopolitan nature of this species. Its prevalence has been described in other prominent water bodies in Nigeria (Nwankwo 1988 and 1996). The prevalence of blue-green algae (*Cyanophyta*) during the dry season and Green algae (*Chlorophyta*) during wet season indicates eutrophic and oligotrophic conditions respectively (Chinda et al (1993) and Kadiri (1999). *Synedra* sp was the sub-dominant species of phytoplankton during both seasons indicating shallowness or flood conditions within the field. These differences and species specific responses to different light intensities, temperature, nutrients, selective grazing by zooplankton and other parameters, mean that heterogeneous and fluctuating environmental conditions favour different species at different times and allow many species to co-exist at different concentration in the same body of water.

Ecologically, Diatoms are significant not only as important ultimate source of food for herbivorous zooplankton and fish respectively, but also serve as indicators of water quality and pollution. They also have direct and indirect economic significance for humans (Nwadiora and Ezefili (1986). Though, some harmful algal species were noted in both seasons especially among the Dinoflagellates, Cyanobacteria and Diatoms, their concentrations are below the threshold level to cause any form of toxicity or nuisance in the water (Nwankwo (2001), Adriana and Henrik (2001).

Zooplankton

Arthropod-Crustacean dominated the observed zooplankton community in both seasons, with percentage compositions of (70.2%) and (66.7%) for dry and wet seasons respectively (**Figures 4.16 and 4.17**) below. This is in conformity with the findings of previous researchers who stated that Crustaceans dominated the zooplankton community of aquatic ecosystems (Waiffe and Frid (2001), and Hallegraff (1995).

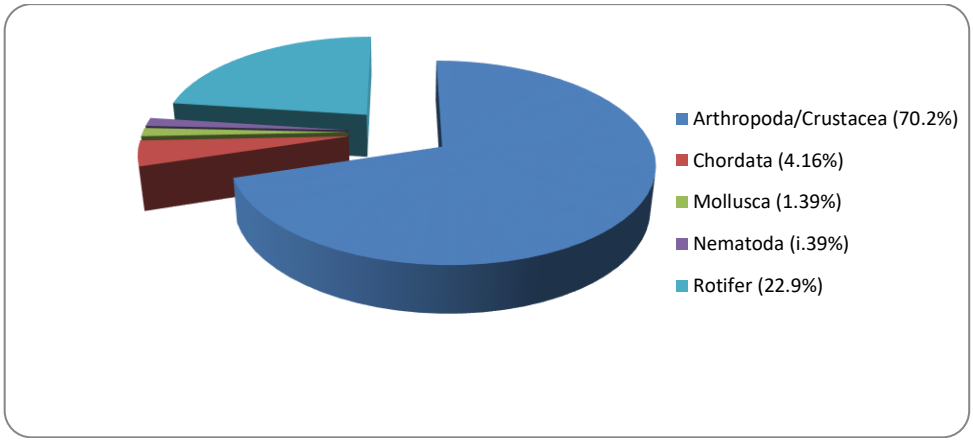


Figure 4.16a: Zooplankton Group – Dry Season

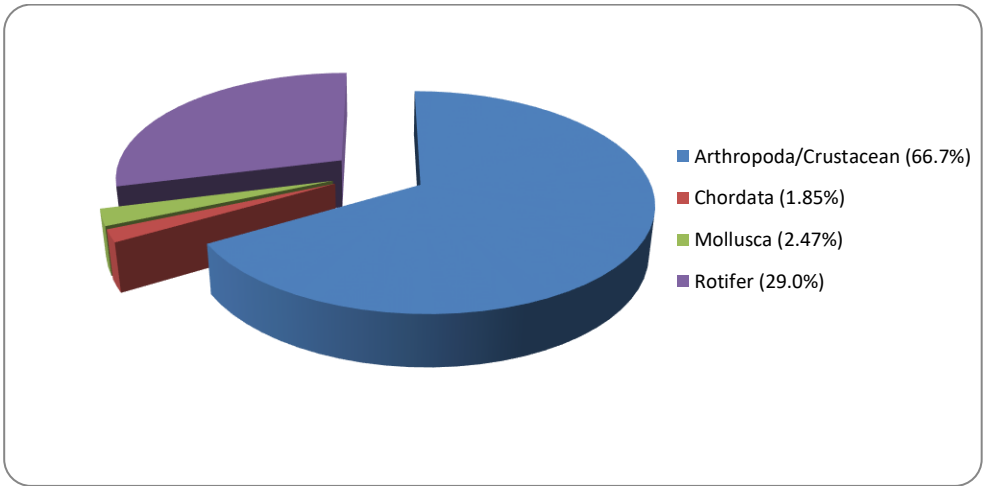


Figure 4.16b: Zooplankton Group – Wet Season

Higher species diversity and abundance occurred among the sampling stations during the dry season than in the wet season. This could be attributable to greater stability of the ecosystem, occasioned by reduced current and flushing, lesser anthropogenic inputs from run-offs, higher transparency and effective light penetration, and better determining condition of nutrients, temperature and grazing activity (Nwankwo 1986).

Margalef Index

Most of the sampled stations during the dry season, recorded higher Margalef index (species richness index) than during the wet season. Margalef (1968) indicated that stations with higher diversity index are more stable or experiencing lesser stress than stations with lower values.

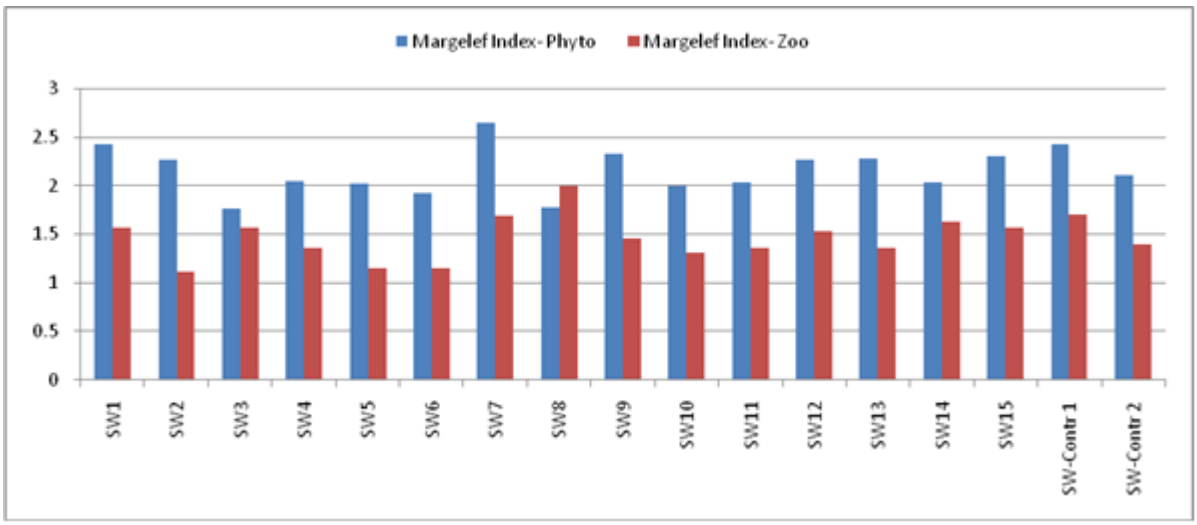


Figure 4.17: Margalef Indices in Dry Season

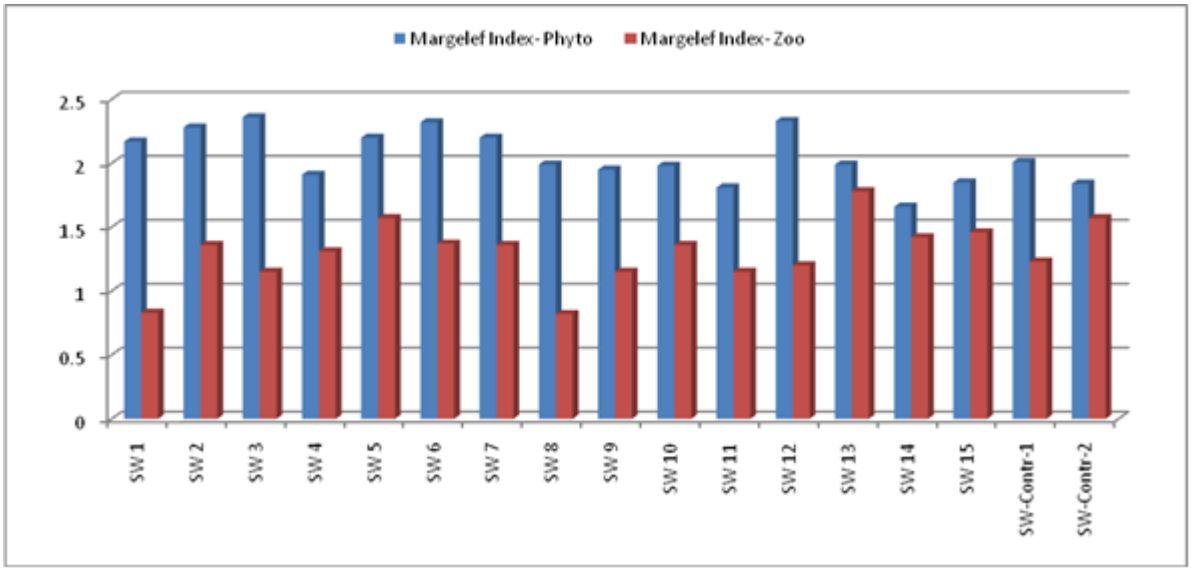


Figure 4.18: Margalef Indices in Wet Season

Macro-benthos

Comparative qualitative and quantitative results on macro benthos survey and analysis among the sampling stations for dry and wet seasons also showed relative variations in species diversity and abundance values. Total species diversity of 5 and abundance value of 28 were recorded during the dry season, while the wet season recorded 3 and 6 for species diversity and abundance respectively (**Figures 4.19 and 4.20**). This could be attributable to not only variations in the adaptability of species of benthos to nature of water current, but also to nature of sediment type, preferred food species and physico-chemical parameters of the water (Ranan and Ganapati 1983; Ajao 1989).

Out of all the observed phyla among the sampling stations, for both wet and dry seasons respectively, Annelida had the highest percentage value. This could be due to better determining conditions of sediment type and other physico-chemical parameters. Timothy

and Richard (2001) noted that macrobenthos have active role in biotic and abiotic interactions characterising aquatic ecosystems.

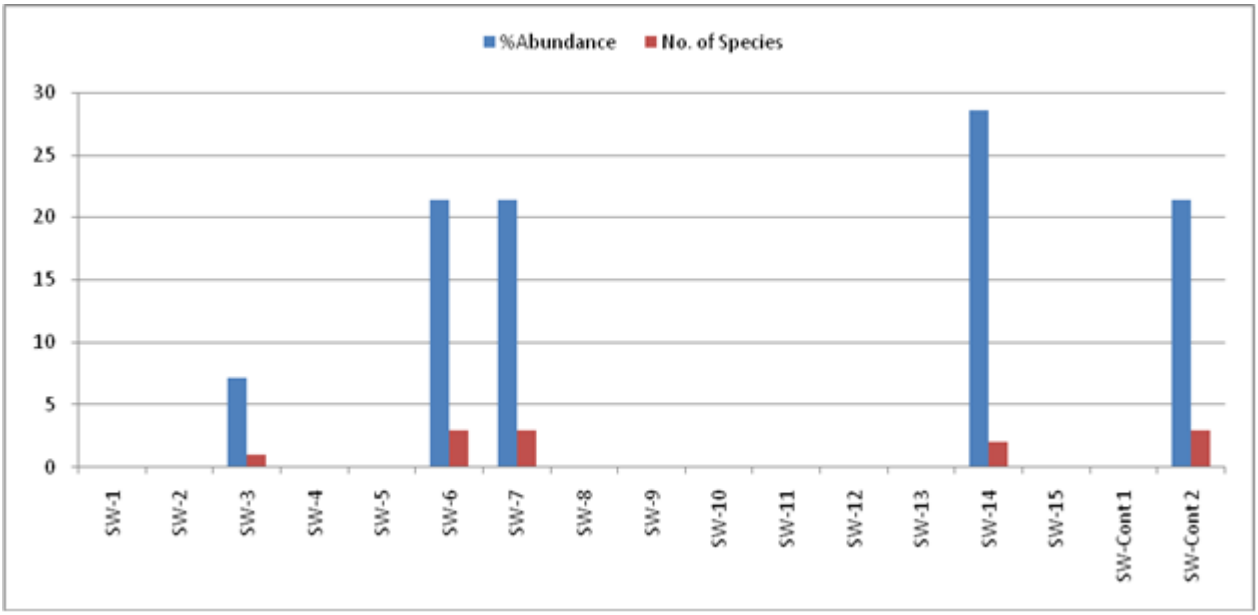


Figure 4.19: Percentage Abundance of Observed Macro-benthos Species -Dry Season

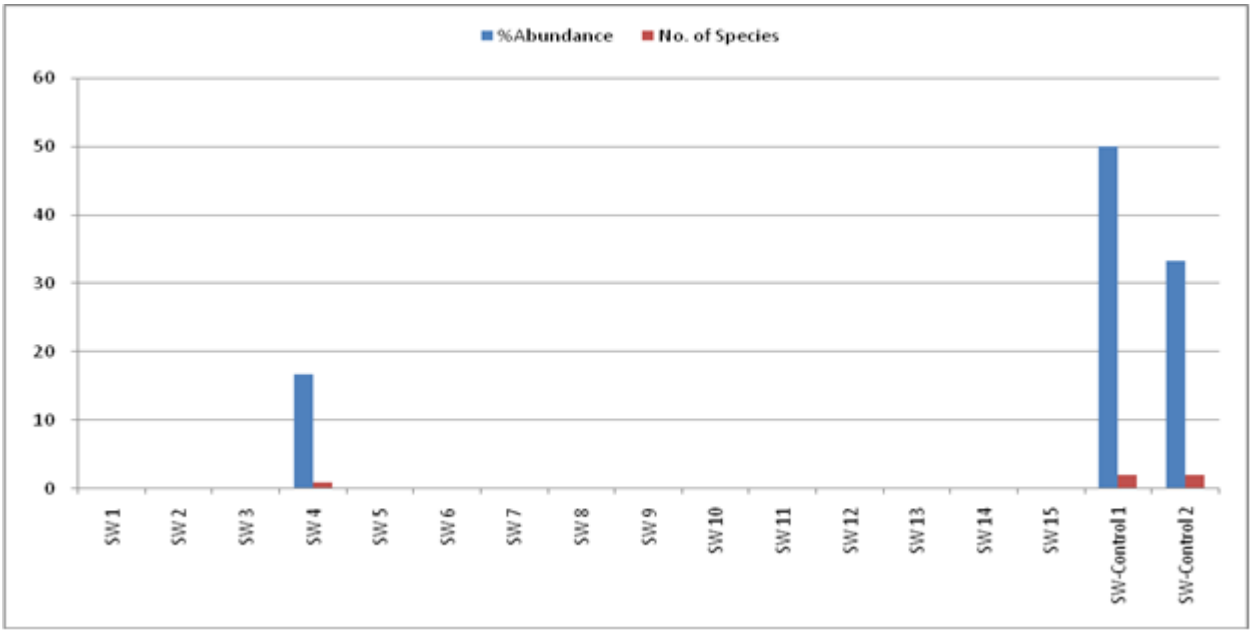


Figure 4.20: Percentage Abundance of Observed Macro-Benthos Species - Wet Season

Benthic invertebrate cycle nutrients and influence microbial production of greenhouse gases, toxic gases and nitrogen. Benthos species transforms organic detritus to dissolved nutrients taken up by macrophytes and algae, enhancing primary productivity. Omnivorous benthic species feed on macrophytes and plankton. Many benthic species are consumed by fish. Clearly, widespread ecotoxicity at the benthos level will propagate up through the food web and also disrupt nutrient cycles. Karr, 1993 noted that if recovery of lost benthos restores ecological function (biodiversity, community structure, nutrient functions), ecosystemic toxicity has not occurred and resilience is intact.

Most of the sampled stations had no benthos species during the wet season, while dry season recorded zero benthos species fewer stations. Station SW-Control 1 had the highest percentage abundance of 50% during the wet season and the least in occurred in stations without benthos species. Similar trend occurred in the dry season. These could be attributed to variations in physico-chemical parameters.

Stations SW Control 2, SW6 and SW7 recorded both the highest Margalef index (1.12) and Shannon Weiner index (1.46) during the dry season, while station SW Control 2 had the highest Margalef index of (1.45) and Shannon Weiner index (0.97). Margalef (1968) indicated that stations with higher Margalef index are experiencing lesser stress than stations with lower values.

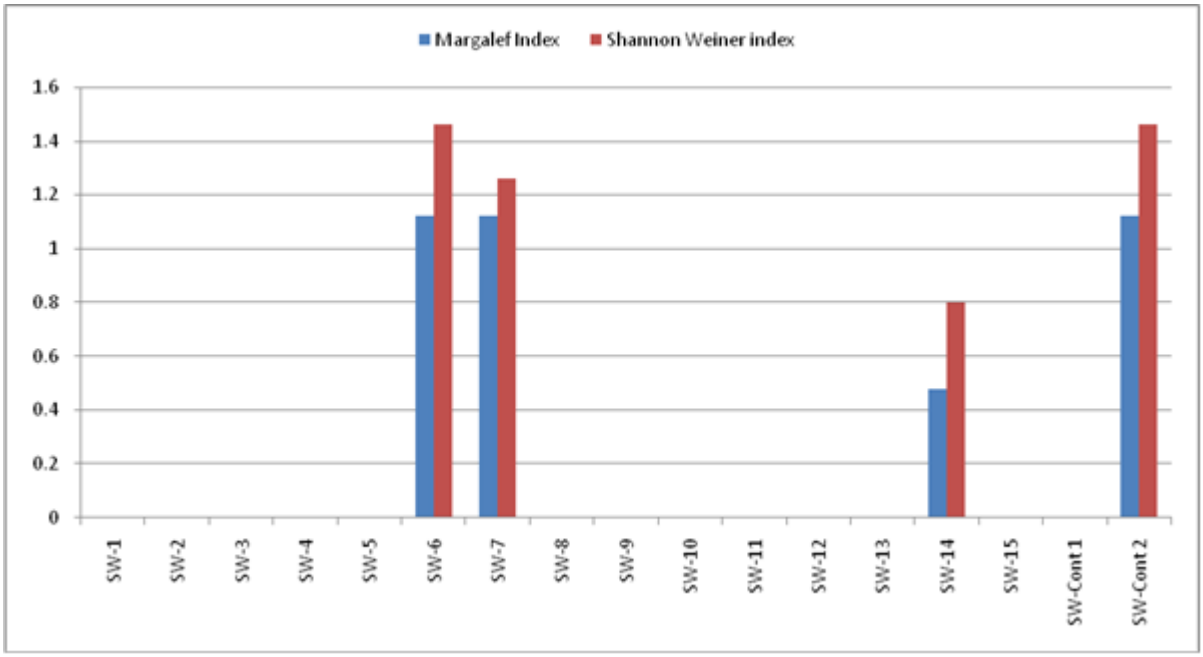


Figure 4.21: Specie Indices-Dry Season

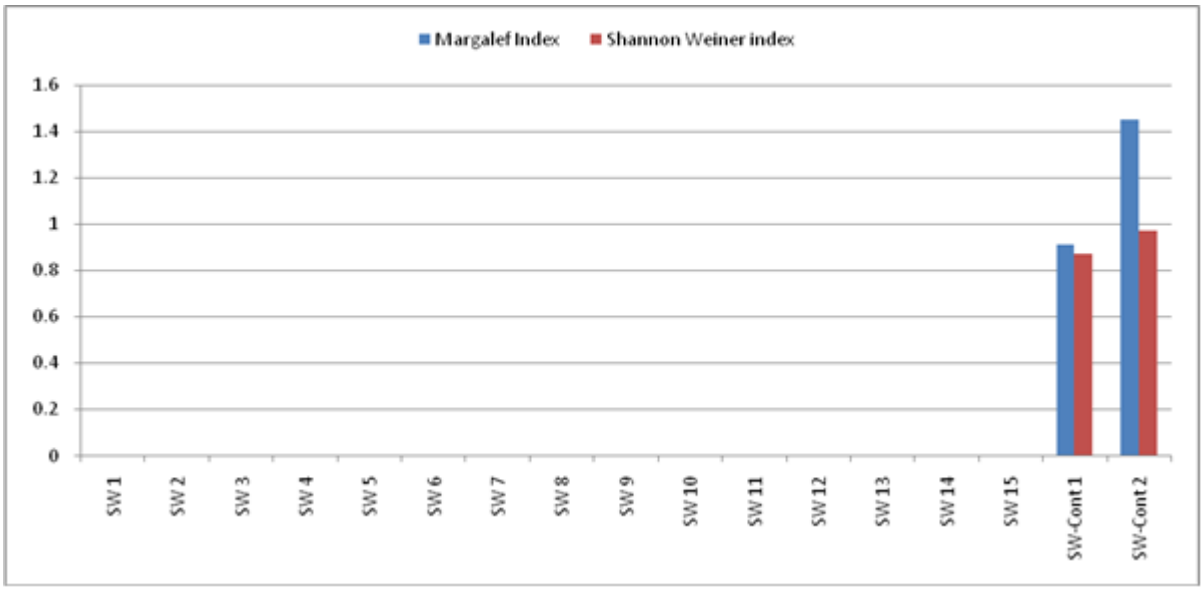


Figure 4.22: Specie Indices -Wet Season

In summary, the observed seasonal variations in species diversity, abundance and distribution could be because of the prevailing hydrographic forcing conditions, leading to changes in the hydrodynamics governing the area. According to Pieterse and Zyl, 1988, Proulx, *et al* (1996),

an alteration in environmental factors consequently leads to a change in diversity. Watson *et al* (1997) stated that differences in biomass and taxonomic diversity, could also be attributed specifically to morphological diversity, differential herbivory and mixing regimes.

The above plankton diversity and abundance is reflected in the benthic ecology of the area. This is in conformity with the findings which indicated how stressors on biotic and abiotic components can impact other components via thermodynamic and socio-dynamic interactions. Due to small-scale response of plankton to environmental changes, its community composition represents a synthetic parameter to interpret the dynamics of pelagic ecosystem synopsis of toxic and nuisance species of plankton in this area and the hydrodynamics governing their abundance and distribution showed that this area is safe, in line with standards on International Union for Conservation of Natural Resources (IUCN). Since plankton diversity and abundance influence the fishery of the area, knowledge of the above base line information has valuable consequences for the recognition of environmental endpoints among the stations, as well as the timing of management restoration plans.

Laboratory and field studies had indicated that zooplankton fish eggs and larvae are very sensitive to dissolved hydrocarbons with acute lethality observed at concentration between 0.1-10mg/l. Adverse effects on zooplankton feeding have been observed in the laboratory as petroleum concentrations approached spill conditions. Most zooplankton appears to be more sensitive to dispersed and dissolved petroleum constituents and less to floating oil. Lethal effects of oil spill in the field would be expected if hydrocarbon concentration is greater than 0.5mg/l.

Construction activities increase concentration of suspended solids leading to high turbidity. This affects the ecosystem negatively by impairing photosynthetic rate and reduction in primary production. Homogenous beds are, also created as a result of sedimentation of suspended materials leading to exclusion of some benthos species that are sediment specific.

It can also create canals that separated habitats, cut off nutrient flow, lengthened flood conditions in the swamps and left dredge spoils on the surrounding swamps. These activities influence the hydroclimate of surrounding environment and determine the diversity, abundance and distribution of flora and fauna of the area.

Oil impacted areas will lead to alteration in the community structure of algal species from the current observations to largely blue green algal dominated spectrum of phytoplankton species. The probable consequences of this change in community are as follows:

- Algal bloom will occur, leading to taste and odour problems in water;
- Organismal mortality due to anoxic conditions;
- Loss of submerged vegetation due to shading; and
- Production of cyanotoxins and decrease in ecosystem stability by interfering with food web dynamics through displacement of native phytoplankton species.

Ecosystem health around within the river can therefore be sustained or disrupted by undermining probabilistic mechanisms acting at multiple levels—molecular, genetic, cellular, organism, population, community and ecosystem for the dissolution of syntropy towards entropy, that is, from ecosystem health to ecosystem pathology.

4.14 Fish Study

A number of fish species were identified and photographs taken as part of primary data source for Ethiope River. Secondary data source was from literature review of past fish studies conducted within the same river.

Fishes recorded were identified at the Sapele Main Market (**Figure 4.23**) which lies close to Ethiope River and about 5km from the project site. Geographical co-ordinate of the fish market is given as latitude-5.901904, longitude-5.677105.

Source: Google Map, 2014

Figure 4.23: Sapele Main Market Location

Generally, fishing activities are well known and a common practice among inhabitants of the study area. The type of fishing here is mainly artisanal, in terms of scale, where the catch is usually for family consumption and a few for sale. Fishing gears commonly used for fishing in the area include; dragnets, hook and line, hand pole, hand nets, cast nets, gillnets, lift-nets, long line and traditional basket traps. These gears are typical for use by artisanal fishermen and similar to the ones reported by Meye and Ikomi, 2012.

Fish processing within the study area is basically traditional. Traditional smoking kiln or earthen ovens are often used to smoke fish. The smoked fish is consumed within the family unit and/ or sold at the local markets directly to wholesale buyers.

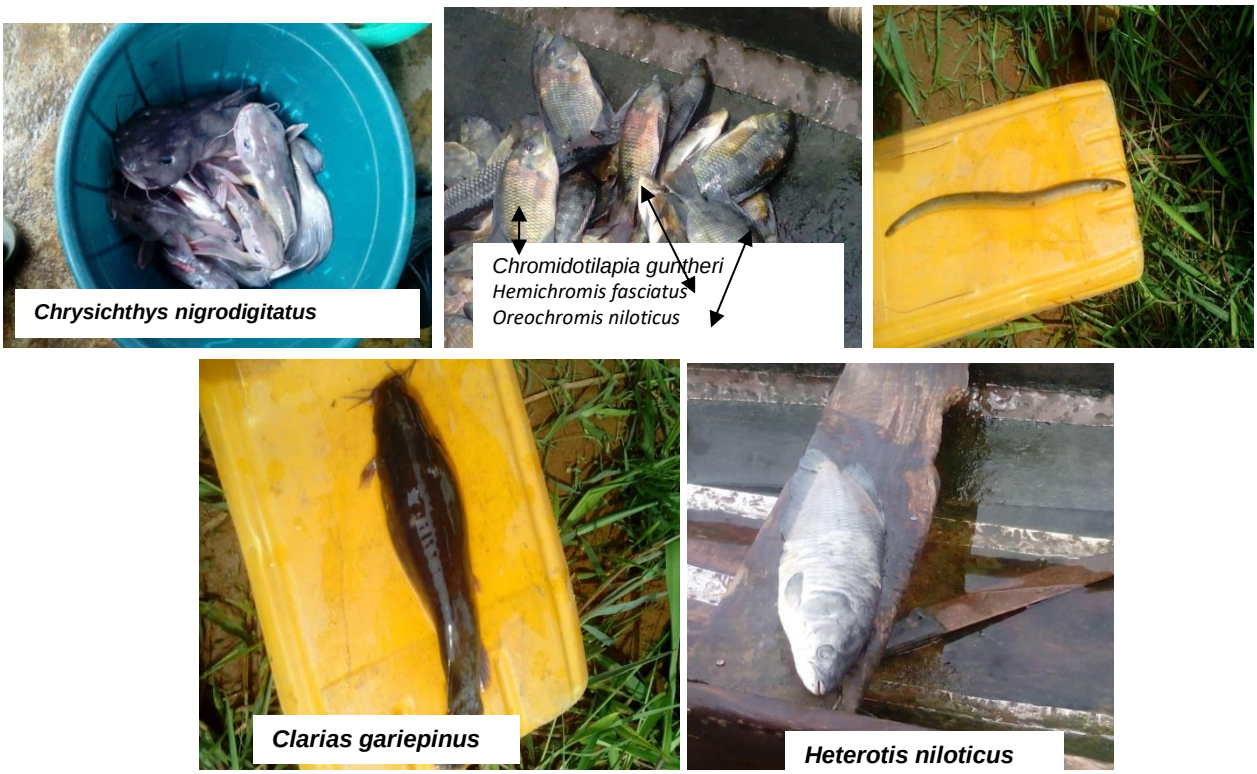
Fishes reported in the area are presented in **Table 4.19**. Also presented are common, biological and local names as well as ranking based on 2015 International Union for the Conservation of Nature (IUCN) Red List of Threatened Species, version 2. Pictorial evidence of fishes observed in the market area presented in **Plate 4.1**.

Table 4.19: Fish Composition within Ethiope River

Common Name	Scientific Name	Local Names	IUCN Ranking
Bagrid Catfish	*Chrysicthys nigrodigitatus*	Obokun, Ojan	Least Concern
Cat Fish	*Synodontis nigrita*	Okokoniko	Least Concern
Electric Eel	*Electrophorus electricus*	-	Least Concern
Nile Tilapia	*Oreochromis niloticus*	Epia, Ukuobu	Not Evaluated
Sharptooth Catfish	*Clarias gariepinus*	Igungun	Least Concern
Bony Tongue	*Heterotis niloticus*	Arowana, Slapwater	Least Concern
Red belly Tilapia	*Tilapia zilli*	Epia, Owe	Not Evaluated
African Electric Fish	*Malapterurus electricus*	Uma, Ojiji, Oriri	Least Concern

Common Name	Scientific Name	Local Names	IUCN Ranking
Nile Perch	*Lates niloticus*	-	Least Concern
Jewel Fish	*Hemichromis fasciatus*	-	Least Concern
African Butter Catfish	*Schilbe mystus*	Dibawe	Least Concern
Schilbe	*Eutropius niloticus*	-	Least Concern
Obscure snakehead	*Parachanna obscura*	-	Not Evaluated
African Lungfish	*Protopterus annectens*	-	Least Concern
True Big-scale Tetra	*Brycinus macrolepidotus*	Elei	Least Concern
-	*Tilapia dageti*	Epia	Least Concern
African pike Characin	*Phago loricatus*	-	Least Concern
African Jewelfish	*Hemichromis bimachulatus*	Epia	Not Evaluated
Giraffe Catfish	*Auchenoglanis occidentalis*	Opai, Kankan	Least Concern
West African Clariid	*Clarias macromystax*	Oluma	Least Concern
Snake Fish	*Erpetoichthys calabaricus*	Agbaroko, Ogboro	Near Threatened
Guenther's Mouthbrooder	*Chromidtilapia guentheri*	-	Not Evaluated
Nurse Tetra	*Brycinus nurse*	Kawara	Least Concern
Black Mangrove Cichlid	*Tilapia mariae*	Ifunu	Least Concern

Source: FNL Field Survey, 2014, Ikomi and Happy, 2002; Meye and Ikomi, 2012, IUCN 2015, version 2.



Source: Field Survey, 2014

Plate 4.1: Fish Species Observed in Study Area

4.15 Fauna Study

Mammals

Based on information obtained during the field survey, the project area contains a rich diversity of wildlife. Mammals known to occur in these areas are presented in **Table 4.20**. No seasonal difference was observed in the composition of the mammalian fauna, but perhaps as a result of breeding and dispersal, there appeared to be less game during the dry season as reported by hunters and trappers.

Hunting pressure in the area was relatively low. Some inhabitants depend mainly on fishing from the adjoining water body (Ethiope River) for their livelihood. However, it is believed that some species, like the Cape Clawless Otter (*Aonyx capensis*), Spotted-necked Otter (*Hydrictis maculicollis*), Maxwell's Duiker (*Philantomba maxwelli*), Manatee (*Trichechus senegalensis*) and the Red River Hog (*Potamochoerus porcus*) were being selectively hunted and may be under threat of extinction locally. Indeed, hunters confirmed that a few animals like the Bush pig (*Potamochoerus porcus*), Manatee (*Trichechus senegalensis*), and the Sitatunga (*Tragelaphus spekii*) have declined in numbers over the past 20-25 years, while the Hippopotamus (*Hippopotamus amphibius*) and the Yellow-backed Duiker (*Cephalophus sylvicultor*) have probably disappeared from the area in recent times. Mammals reported in the study area are presented below together with the 2015 IUCN rankings and local names.

Table 4.20: Mammals Reported in the Study Area

Common Names	Species/Scientific Name	Local Names	IUCN Ranking
Primates			
Mona Monkey	*Cercopithecus mona*	Kesi-Obugo	Least Concern
White-throated Guenon	*Cercopithecus erythrogaster*	Obugo	Vulnerable
Pholidota (Pangolins)			
White-bellied Tree Pangolin	*Manis tricuspis*	Epu	Vulnerable
Long-tailed Tree Pangolin	*Phataginus tetradactyla*	Epu	Vulnerable
Rodentia (Rodents)			
Forest Giant Squirrel	*Protoxerus stangeri*	Gbeguru	Least Concern
Red-legged Sun-Squirrel	*Heliosciurus rufobrachium*	Gbeguru	Least Concern
Greater Cane Rat (Grass-cutter)	*Thryonomys swinderianus*	Wari-eke	Least Concern
Gambian Pouched Rat	*Cricetomys gambianus*	Wari-eke	Least Concern
Carnivora (Carnivores)			
Cape Clawless Otter	*Aonyx capensis*	Teu	Near Threatened
Spotted-necked Otter	*Hydrictis maculicollis*	Punu	Near Threatened
Two-spotted Palm Civet	*Nandinia binotata*	Punu	Least Concern
Marsh Mongoose	*Atilax paludinosus*	Kewa	Least Concern
Long-nosed Mongoose	*Herpestes naso*	Kewa	Least Concern
Egyptian Mongoose	*Herpestes ichneumon*	Kewa	Least Concern
Sirenia (Manatee)			
West African Manatee	*Trichechus senegalensis*	-	Vulnerable
Artiodactyla (Even-toed ungulates)			
Red River Hog (Bushpig)	*Potamochoerus porcus*	Imbi	Least Concern
Hippopotamus	*Hippopotamus amphibius*	-	Vulnerable
Maxwell's Duiker (Antelope)	*Philantomba maxwellii*	Ogodo	Least Concern
Yellow-backed Duiker	*Cephalophus silvicultor*	Ogodo	Least Concern
Sitatunga ("Water Deer")	*Tragelaphus spekii*	-	Least Concern

Source: FNL Field Survey, 2013/ 2014; IUCN 2015, version 2.

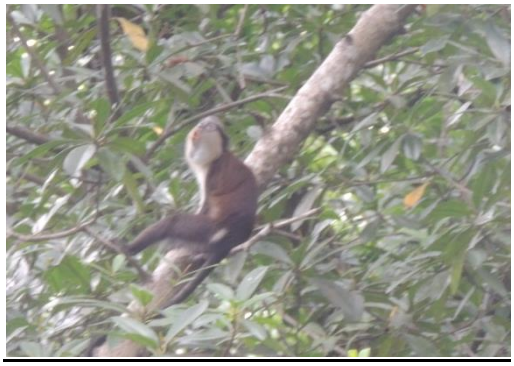


Plate 4.2: Mona Monkey

Birds

A total of 63 species of birds belonging to 26 families were reported and a few sighted during the study (**Table 4.21**). Thirty-eight species (60.3%), including twelve partial Palaearctic migrants, were recorded in both seasons. Nineteen species (30.2%) were classified as local migrants, while six species (9.5%) are regarded as dry season Palaearctic visitors. Some of the migratory species are known to arrive as early as September and commence their homeward journey in March or April (Elgood *et al*. 1994). However, some individuals may remain till May, while some, notably waders (terns, sandpipers, curlews, etc.) and herons may remain throughout the year.

Table 4.21: Bird Species Reported in the Study Area

Common Names	Species/Scientific Names	IUCN Ranking
Pelecanidae (Pelicans)		
Pink-backed Pelican	*Pelecanus rufescens*	Least Concern
Ardeidae		
White-crested Tiger Heron	*Tigriornis leucolopha*	Least Concern
Little Egret	*Egretta garzetta*	Least Concern
Cattle Egret	*Bubulcus ibis*	Least Concern
Yellow-billed Egret	*Ardea brachyrhyncha*	Least Concern
Black Egret	*Egretta ardesiaca*	Least Concern
Great White Egret	*Ardea alba*	Least Concern
Grey Heron	*Ardea cinerea*	Least Concern
Scopidae (Hamerkops)		
Hamerkop	*Scopus umbretta*	Least Concern
Ciconiidae		
Yellow-billed Stork	*Mycteria ibis*	Least Concern
Woolly-necked Stork	*Ciconia episcopus*	Vulnerable
Anatidae		
White-faced Whistling Duck	*Dendrocygna viduata*	Least Concern
Accipitridae		
Osprey	*Pandion haliaetus*	Least Concern
Palm-nut Vulture	*Gypohierax angolensis*	Least Concern
African River Eagle	*Haliaetus vocifer*	Least Concern
Black Kite	*Milvus migrans*	Least Concern
Marsh Harrier	*Circus aeruginosus*	Least Concern
Burhinidae		
Water Thick-knee	*Burhinus vermiculatus*	Least Concern
Charadriidae		
Grey Plover	*Pluvialis squatarola*	Least Concern
Scolopacidae		
Bar-tailed Godwit	*Limosa lapponica*	Least Concern
Wood Sandpiper	*Tringa glareola*	Least Concern
Common Sandpiper	*Actitis hypoleucos*	Least Concern
Common Greenshank	*Tringa nebularia*	Least Concern
Whimbrel	*Numenius phaeopus*	Least Concern
Eurasian Curlew	*Numenius arquata*	Least Concern
Sanderling	*Calidris alba*	Least Concern
Little Stint	*Calidris minuta*	Least Concern
Laridae (Gulls)		
Lesser Black-backed Gull	*Larus fuscus*	Least Concern
Sternidae (Terns)		
Caspian Tern	*Hydroprogne caspia*	Least Concern
Common Tern	*Sterna hirundo*	Least Concern
Sandwich Tern	*Thalasseus sandvicensis*	Least Concern
Little Tern	*Sternula albifrons*	Least Concern
Rhynchopidae (Skimmers)		
African Skimmer	*Rhynchops flavirostris*	Near Threatened
Columbidae (Pigeons and Doves)		

Red-eyed Dove	*Streptopelia semitorquata*	Least Concern
Laughing Dove	*Spilopelia senegalensis*	Least Concern
Blue-headed Dove	*Turtur brehmeri*	Least Concern
Rock Pigeon	*Columba livia*	Least Concern
Psittacidae (Parrots)		
African Grey Parrot	*Psittacus erithacus*	Vulnerable
Apodidae (Swifts)		
Little Swift	*Apus affinis*	Least Concern
African Palm Swift	*Cypsiurus parvus*	Least Concern
Alcedinidae (Kingfishers)		
Woodland (Senegal) Kingfisher	*Halcyon senegalensis*	Least Concern
Blue-breasted Kingfisher	*Halcyon malimbica*	Least Concern
Pied Kingfisher	*Ceryle rudis*	Least Concern
Malachite Kingfisher	*Corythornis cristatus*	Least Concern
Coraciidae (Rollers)		
Blue-throated Roller	*Eurystomus gularis*	Least Concern
Bucerotidae (Hornbills)		
African Pied Hornbill	*Tockus fasciatus*	Least Concern
West African Pied Hornbill	*Lophoceros semifasciatus*	Least Concern
Piping Hornbill	*Bycanistes fistulator*	Least Concern
Capitonidae (Barbets)		
Speckled Tinkerbird	*Pogoniulus scolopaceus*	Least Concern
Eastern Yellow-billed Barbet	*Trachylaemus purpuratus*	Least Concern
Hirundinidae (Swallows)		
Ethiopian Swallow	*Hirundo aethiopica*	Least Concern
Fanti Saw-winged Swallow	*Psalidoprocne obscura*	Least Concern
Motacillidae (Wagtails, Pipits)		
Yellow Wagtail	*Motacilla flava*	Least Concern
Plain-backed Pipit	*Anthus leucophrys*	Least Concern
Sturnidae (Starlings)		
Splendid Glossy Starling	*Lamprotornis splendidus*	Least Concern
Pycnonotidae (Bulbuls)		
Common Garden Bulbul	*Pycnonotus barbatus*	Least Concern
Nectariniidae (Sunbirds)		
Carmelite Sunbird	*Nectarinia fuliginosa*	Least Concern
Corvidae (Crows)		
Pied Crow	*Corvus albus*	Least Concern
Passeridae (Sparrows)		
Grey-headed Sparrow	*Passer griseus*	Least Concern
Ploceidae (Weavers)		
Orange Weaver	*Ploceus aurantius*	Least Concern
Viellot's Black Weaver	*Ploceus nigerrimus*	Least Concern
Estrildidae (Finches, Mannikins)		
Bronze Munia	*Lonchura cucullata*	Least Concern
Bar-breasted Firefinch	*Lagonosticta rufopicta*	Least Concern

Source: FNL Field Survey, 2013/ 2014, IUCN 2015, version 2.

Black Kite (*Milvus migrans*)

Little Egret (*Egretta garzetta*)

Hamerkop (*Scopus umbretta*)

Plate 4.3: Bird Species Observed in Study Area

Reptiles

The reptilian fauna of the study area is made up of crocodiles, turtles, land tortoises, snakes and lizards (**Table 4.22**). The commonest turtle, widely consumed in the area, appears to be the West African Black Turtle (*Pelusios niger*). Marine turtles are well known to the inhabitants of the area, who presumably hunt them for food when they come ashore to breed. The Monitor Lizard (*Varanus niloticus*), the African Python (*Python sebae*) are also hunted for meat.

Several species of snakes were noticed in the area. They include the Black Cobra (*Naja melanoleuca*), and the Night Adder (*Causus maculatus*).

Table 4.22: Reptiles in the Study Area

Common Names	Species / Scientific Names	IUCN Ranking
Crocodylidae (Crocodiles)		
Nile Crocodile	*Crocodylus niloticus*	Lower Risk/ Least Concern
Dwarf Crocodile	*Osteolaemus tetraspis*	Vulnerable
Pelomedusidae (Swamp terrapins)		
West African Black Turtle	*Pelusios niger*	Not Evaluated
Varanidae (Monitor Lizards)		
Nile Monitor Lizard	*Varanus niloticus*	Not Evaluated
Boidae (Pythons)		
African Python	*Python sebae*	Not Evaluated
Elapidae (Cobras and Mambas)		
Black Cobra	*Naja melanoleuca*	Not Evaluated
Viperidae (Vipers)		
West African Night Adder	*Causus maculatus*	Not Evaluated

Source: FNL Field Survey, 2013/ 2014; IUCN 2015, version 2.

Amphibians

Amphibian species observed during the study are presented in **Table 4.23**.

Table 4.23: Amphibians Observed in the Study Area

Common Names	Species / Scientific Names	IUCN Ranking
Bufonidae (Toads)		
Striped Toad	*Amietophrynus maculatus*	Least Concern
Hyperoliidae		
Edible Bullfrog	*Pyxicephalus edulis*	Least Concern
African Bullfrog	*Pyxicephalus adspersus*	Least Concern
Ranidae (True Frogs)		
African wart Frog	*Acanthixalus sonjae*	Near Threatened
Striped Spiny Reed Frog	*Afrixalus dorsalis*	Least Concern

Source: FNL Field Survey, 2013/ 2014; IUCN 2015, version 2.

Species of Concern for Conservation

Threatened and vulnerable species recorded in the study area include; the White-throated Guenon, Tree Pangolins, Otters, Manatee, Hippopotamus, Dwarf Crocodile, Woolly-necked Stork, African Skimmer, African Grey Parrot and African wart Frog as classified in the 2015 IUCN Red List of Threatened Species. The hunting, capture, or trade in these endangered species is absolutely prohibited.

4.16 Vegetation Study

Vegetation study was conducted by dividing the study area into transects and each transect studied. Information from the field survey serves as primary data source. This was augmented by information/ data from secondary sources such as articles, text books, journals etc.

A preliminary assessment of the study area was conducted by the biodiversity specialist on the 5th November, 2013. The reconnaissance survey formed the basis for transect size determination. Study area (i.e. project area and zone of influence) was demarcated into 4 belt transects.

Transects were established based on accessibility to the area and proximity to project site as show in **Figure 4.24**.

Source: Google Map, 2014

Figure 4.24: Vegetation Study Map

Within each transect the associated vegetation was characterised using the segmented belt transect techniques (Oosting 1956), to ensure maximum chances of finding most of the component species in the area. Among the parameters investigated in each transect were floristic composition, percentage frequency of occurrence and pathological conditions.

Vegetation Types in Study Area

The major ecological habitats found within and around the study area include undisturbed fresh water rain forest, secondary regenerating rain forest and pockets of mangrove vegetation.

The study area to the north and west of project site and away from the community experiences minimal disturbance from human activities, ensuring the pristine nature of that section. Human disturbance is felt to the south of the plant i.e. community area and along Ethiope River where water transportation activities is common. Agricultural practices observed is typically subsistence farming.

Transect 1

Section delineated as *transect 1* is 2km x 2.5km size. The area comprises of the proposed project site, existing plant facilities and areas west of project site. The vegetation observed here is typically fresh water rainforest. Identified plant species in this transect include; *Chromolaena odorata*, *Paspalum spp., Entandrophragma cylindricum*, *Celosia trigyna*, *Vernonia amygdalina*, *Piper umbellatum*, *Musa spp* and the most dominant -*Elaeis guineensis* tree which covers about 65% of sampled site. Other identified plant species are presented in **Table 4.24**.

It should also be noted that about 20% of the transect area was observed to be secondary regenerating freshwater forest. Observed sections with re-growth (and within the project site) could be as a result of cattle grazing and tower line construction in the past from nearby existing plants. Regenerating vegetation species has a rich floristic composition with

Acrostichum aureum, Paspalum scrobiculatum and *Mariscus spp* being the major plant species.

Plate 4.4: Plant Species Observed in Transect 1

<u>*Transect 2*</u>

This area (3.5km x 2.5km) includes sections north and northwest of the project site and along Ethiope River. Vegetation here is chiefly freshwater rainforest and mangrove. Plant species identified includes *Rhizophora spp*., *Bruguiera spp., Lumnitzera racemosa, Aegiceras corniculatum*, *Acrostichum aureum*, *Raphia hookeri, Elaeis guineensis, Nymphaea lotus, Mariscus spp.* and *Paspalum spp*. Other identified plant species are presented in **Table 4.24**. Plant species in this sampling location appeared healthy and luxuriant.

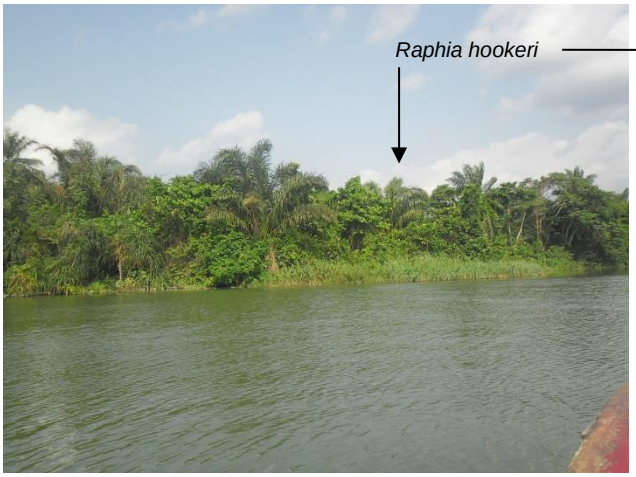


Plate 4.5: Plant Species Observed in Transect 2

Transect 3

This is along Ethiope River and east of project site. Area survey is 2.5km x 1.5km. Here mangrove swamp vegetation was identified and was characterised by *Rhizophora spp., Bruguiera spp., Paspalum spp., Panicum spp., Phoenix paludosa, Nypa fruticans, Raphia hookeri* as well as those presented in **Table 4.24**. The plant species all appeared healthy and luxuriant.

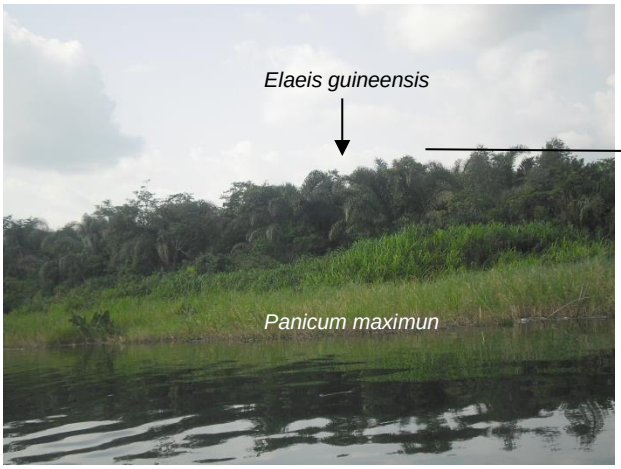


Plate 4.6: Plant Species Observed in Transect 3

Transect 4

The area within the surveyed transect is between 1.5km x 2km, and is also along Ethiope River, further east of project site. Plant species identified includes *Rhizophora spp., Bruguiera parviflora, Ceriops spp., Nypa fruticans, Sonneratia caseolaris, Aegiceras corniculatum, Paspalum spp., Cocos nucifera, Eichhornia crassipes, Raphia hookeri and Mariscus spp.* along with others presented in **Table 4.24**. These plant species appeared healthy and luxuriant as well.

Plate 4.7: Plant Species Observed in Transect 4

Table 4.24: List of All Plant Species Observed within Study Area

S/n	Plant Species	Common name	IUCN Ranking	Transects			
Woody Species				**T 1**	**T 2**	**T 3**	**T 4**
1.	*Aegiceras corniculatum*	River mangrove	Least Concern	–	+	–	+
2.	*Bruguiera cylindrica*	Small-leafed orange mangrove	Least Concern	–	–	+	+
3.	*Bruguiera gymnorrhiza*	Large-leafed orange mangrove	Not Evaluated	–	+	+	+
4.	*Bruguiera parviflora*	Orange mangrove	Least Concern	+	+	+	+
5.	*Ceriops decandra*	Common mangrove	Near Threatened	–	+	–	–
6.	*Cissus populnea*	Bush mango	Not Evaluated	+	+	–	–
7.	*Cocos nucifera*	Coconut	Not Evaluated	–	–	–	+
8.	*Distemonanthus benthamianus*	Satinwood	Not Evaluated	+	+	–	–
9.	*Elaeis guineensis*	Oil palm tree	Not Evaluated	+	+	–	–
10.	*Entandrophragma cylindricum*	Sapele mahogany	Vulnerable	+	–	–	–
11.	*Laccosperma secundiflorum*	Large rattan	Not Evaluated	+	+	–	–
12.	*Lumnitzera racemosa*	Black mangrove	Least Concern	–	+	+	+
13.	*Lumnitzera littorea*	-	Least Concern	–	–	+	+
14.	*Musanga cecropeiodes*	Umbrella tree	Not Evaluated	+	+	–	+

15.	*Nypa fruticans*	Nipa palm	Least Concern	–	+	+	+
16.	*Phoenix paludosa*	Mangrove date palm	Near Threatened	+	+	+	–
17.	*Raphia hookeri*	Wine palm	Not Evaluated	–	+	+	+
18.	*Rhizophora mangle*	Red mangrove	Least Concern	–	+	+	+
19.	*Sonneratia alba*	Mangrove apple	Least Concern	–	+	–	–
20.	*Terminalia catappa*	Bengal almond	Not Evaluated	+	+	+	–
21.	*Thespesia populnea*	Portia tree	Not Evaluated	+	–	–	+
22.	*Xylocarpus granatum*	Mangrove cannonball	Least Concern	+	+	–	+
Shrubs/ Herbaceous Species							
23.	*Acrostichum aureum*	Golden leather fern	Least Concern	+	+	+	+
24.	*Acrostichum speciosum*	Mangrove fern	Least Concern	–	+	–	–
25.	*Aeschgnome indica*	budda pea	Not Evaluated	+	–	–	–
26.	*Celosia trigyna*	Woolflower	Not Evaluated	+	+	–	–
27.	*Chromolaena odorata*	Siam weed	Not Evaluated	+	–	–	–
28.	*Crassocephalum crepidioides*	Thickhead	Not Evaluated	+	–	–	–
29.	*Cyperus esculentus*	Yellow nutsedge	Least Concern	+	–	–	+
30.	*Hibiscus tiliaceus*	cottonwood	Not Evaluated	+	–	–	–
31.	*Mariscus alternifolius*	Water grass	Not Evaluated	+	+	+	+
32.	*Momordica foetida*	Lyon bean	Not Evaluated	+	–	–	–
33.	*Musa paradiriaca*	Wild banana	Not Evaluated	–	–	–	–
34.	*Musa sapientum*	Banana	Not Evaluated	+	–	–	–
35.	*Nymphaea lotus*	Water lily	Not Evaluated	–	+	+	–
36.	*Paspalum orbiculare*	Cow grass	Not Evaluated	+	–	–	–
37.	*Paspalum conjugatum*	Buffalo grass	Not Evaluated	+	+	–	+
38.	*Paspalum scrobiculatum*	Native paspalum	Least Concern	+	+	+	+
39.	*Panicum maximum*	Guniea grass	Not Evaluated	+	+	+	+
40.	*Piper guineense*	West African pepper	Not Evaluated	+	–	–	–
41.	*Piper umbellatum*	cow-foot leaf	Not Evaluated	+	+	–	–
42.	*Pityrogramma calomelanus*	Silver fern	Not Evaluated	–	–	+	+
43.	*Salvinia nymphellula*	-	Not Evaluated	–	–	+	–
44.	*Urena lobata*	Caesar weed	Not Evaluated	+	–	–	–
45.	*Vernonia amygdalina*	Bitter leaf	Not Evaluated	+	–	–	–
Total Species				**29**	**26**	**17**	**20**

Source: Field Survey, 2013/ 2014; IUCN 2015, version 2; Key: + =Present –=Absent

4.17 Protected Areas

It should be noted that there are no protected areas in close proximity to the study area or any that will be directly affected by the project development. The closest Government Reserve Forest is Ukpe-Sobo Forest Reserve, Delta Sate, which is about 7 km from south of project site (**Figure 4.25**).

Other forests reserve (and in Edo State, Nigeria) are Okomu National Park, Gili-gili Forest Reserve and Ologbo Game Reserve which are about 55 km, 29 km and 36 km respectively, north-west of the project site.

The principal legislation in force for the regulation of forest sector in Nigeria is the Forestry Act 1958 prohibits any activity that may lead to the destruction of or cause injury to any forest produce, forest growth or forest property.

Source: Google Earth Map, 2015

Figure 4.25: Proximity of Plant Location to Protected Forest Reserves

4.18 Habitat Categorisation and Ecosystem Services

A habitat and ecosystem services assessment was carried out for the project. The aim of the exercise was to identify key habitat types within the PEL boundaries as well as ecosystem services that may be impacted directly by the project. The exercise commenced with a desktop study of the biodiversity of the area.

Desktop Studies

A review of available biodiversity reports with regional coverage was carried out. The reviews cut across regional biodiversity maps, baseline reports, inventory reports as well as specialised and research studies/works near the project area. The desktop study also re-visited the biodiversity section of this EIA report.

Rapid Field Survey

Though much of the biodiversity baseline characteristics has been documented in section 4.16 of this report, the rapid survey is part of an additional assessment to establish specific biodivesrsity requirements as stated above. This section provides a summarised description of methodologies employed.

A one-day rapid ecological survey (walkover and ground trutting) around the 27 hectares of PEL site as well as areas of specific interest and areas sensitive to potential disturbance was undertaken. This survey was designed to define the PEL area of influence on biodiversity. The survey basically included:

- Flora and vegetation surveys;
- Mammals surveys;
- Birds, Reptile and Amphibian surveys

A walkthrough survey of habitats and floral diversity within the PEL boundary and around the area of influence was undertaken. It involved:

- Physical observation of flora groups and charateristics;

- Identification of pre-dominant flora species and vegetation covers;

Using information from publicly available satellite imagery as well as habitat ground trutting, the land-use and habitat classification of immediate coverage of the DSP Phase 1 site was carried out. The delineation of other habitat types covering the other boundaries of the PEL 27 hectares was also possible through interpretation of satellite imagery, UAV data/imagery and GIS geodatabase.

Plate 4.8: Flora Rapid Assessment

Mammals were observed visually and by field signs, e.g. footprints findings, feacal droppings, and hunters interviews. Smaller rodents were accesed through their burrows and crevices. Birds and bats were also assessed by surveys of forest canopies, long range sightings using binoculars, trees, underground roosts, existing structures and river banks around the PEL project area.

Plate 4.9: Fauna Rapid Assessment

Walkover around key habitats including ditches, fragmented niches, river edges and riparian vegetation was undertaken for reptiles and amphibians. Visual sightings of moulted skins and remains of these groups was identified.

Mapping

GIS based extraction, geo-referencing, digitization, overlay, analysis and mapping works were carried out based on data retrieve from an un-manned aeral vehicle, publicly available satellite imagery, hand-held global positioning system (GPS), ground trutting and review of local map data. Large scale maps were developed using the ArcGIS 10.0 series and habitat types and spread were effectively digitized for visualization.

Area of Influence

The Area of Influence (AoI) is described as the direct footprint of a project covering its facilities, routes, operations and personnel. It also includes areas (e.g. habitats, ecosystems services, livelihoods, etc) that can be directly or indirectly affected from unplanned but predictable developments caused by the project that may occur in the future.

The total land acquired by PEL for purpose of the DSP project is approximately 27 hectares. Based on the phased development plan of the project, it is expected that Phase 1 development will have a footprint of about 6 hectares. See **Figure 4.26** below:

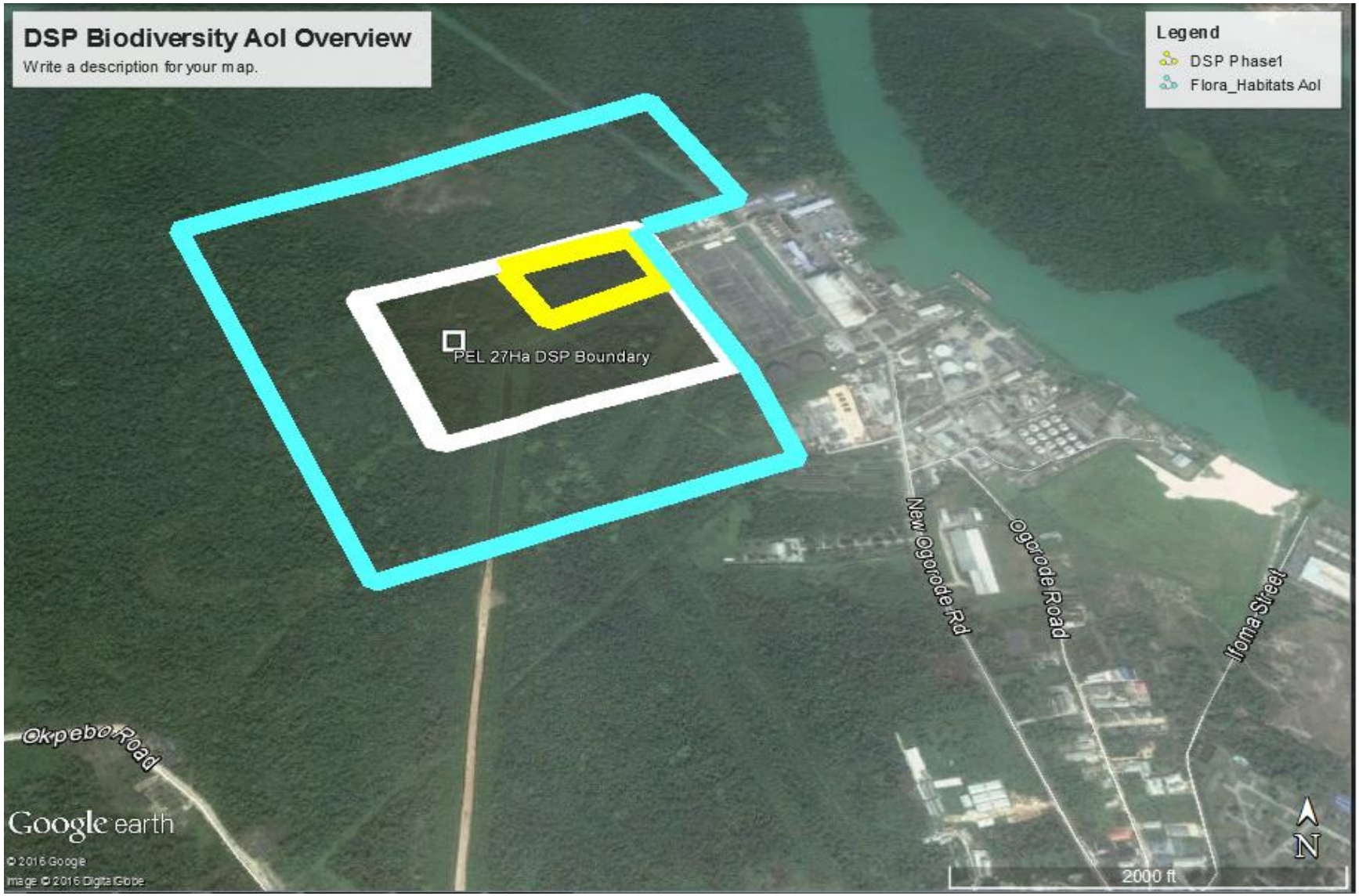


Figure 4.26: Biodiversity AoI Overview

Based on information presented in Figure 4.26 above, the AoI for biodiversity features have been defined as such:

- *Flora and and Habitat AoI* is described as the entire plant life and habitats/niches covered by the 27 hectares footprint of the PEL boundary. It also includes a 250m vegetation cover spread from the edges of the PEL boundaries on the northeast, north, west, and southern boundaries. It excludes the existing facilities (Ogorode and Sapele Power Switchyard) to the east of the PEL boundary which have already been impacted. The 250m of AoI was based on an assumption that the direct impacts from flora and habitat loss will be restricted to the boundaries of the 27Ha while indirect impacts from habitat fragmentation, edge effect and potential hazardous events such as fires and explosions that may affect vegetation will be limited to the 250m exterior boundaries.
- *Fauna and Wildlife AoI is described* as all animal life covering vertebrates and invertebrates found within the 27 hectares footprint. Since animals are dynamic it is expected that a larger population of the mammals and relatively larger vertebrates will migrate away from the boundaries of the 27Ha. Thus, the AoI is limited to the boundaries of the PEL acreage;
- *Ecosystem Services AoI* for purpose of the DSP project covers the provisioning, regulating and supporting services offered within the boundaries of the 27 Ha. As at time of field visit and based on information from PEL, there are no livelihood activities within the 27 Ha and thus priority type 1 of affected community dependence for provisioning ecosystem services insignificant. There are no evident cultural uses (no sanctuaries, or worshiped trees or shrines used by locals, etc) of the vegetation cover within the 27 Ha.

Note:
It is important to state that the existing transmission line and proposed access road RoW cutting across the PEL boundary and running southwest about 1km to connect to the Okpebo road is not included within the AoI as a direct project effect. However, it can be regarded as an example of major anthropogenic activities on the project site and area.

4.18.1 Habitat Categories and Types

The secondary pal forest, riparian vegetation, flowing River Ethiope, River Ethiope and bare soil material and bush fallows along the corridor of the existing transmission line RoW are predominant habitats found within the study area.

The additional bidoversity survey which further substantiates earlier ecological characteristics presented in this report suggests that although these varying habitats presented above exist within the area, the secondary palm forest is the most predominant within and around the study area.

Habitat Types
The habitats within context of the DSP project are discussed in two presentations:

- Overall landuse cover/ecological zoning of the PEL project boundaries extending into wider coverage of the project area;
- Specific habitat types only within the DSP project 27Ha boundaries and AoI; and

<u>Overall Landuse / Ecological Zoning</u>
The project area (27ha) foot print falls within the secondary forest major ecological zone. This zone has overtime been influenced by anthropogenic activities either for industrial purposes or for rural livelihood activities. It is charcterised by secondary regenerating forests mixed with intensive cropping. The key tree crop species within this zone are the palm trees (*Elaeis guinensis*).

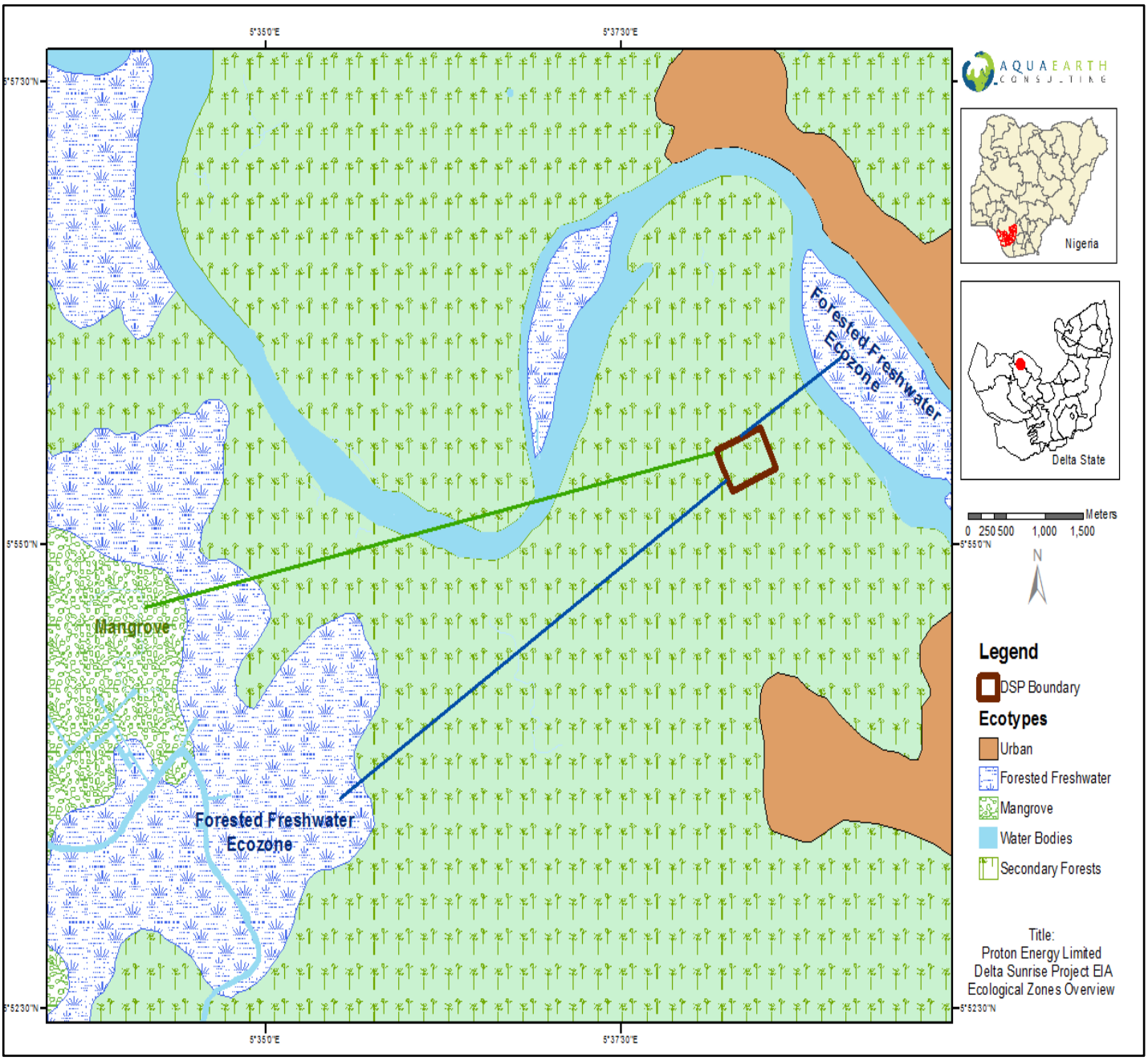


Figure 4.27: Major Ecological Zones Around DSP Area

The closest ecological zones to the project area are the forested freshwater zones about 1 km north east and 2km North West. The mangrove ecosystem is about 7km south west of the project area.

Main Habitat Types and Categories within DSP 27Ha and AoI

The predominant habitat types within the entire 27Ha and biodiversity AoI are presented in this section. As earlier mentioned and referring to a regional ecological zone the project area is categorized as a secondary regenerating forest with intensive tree crops of *Elais guinensis*. Specific habitats have been classified in accordance with the IFC habitat type classification (natural, modified and critical) as well as basic vegetation cover charateristics and biodiversity importance levels.

Based on habitat map below, there are five (5) main habitat types around the project area and AoI:

- Regenerating Forests;
- Palm Forests;
- Riparian Forests;
- Bush Fallows; and
- Secondary Rain Forests

The habitats are further grouped based on IFC habitat categories as either:
Modified Habatats; or
Natural Habitats.

There are no critical habitats within the project boundaries or within its AoI. The closed potential critical habitat which is the Ukpe-Sobo Native Adminsitration Forest Reserve (a protected area) is about 7km west of the DSP boundary.

Table 4.25 below highlights the habitat types and categories within the study area, while **Figure 4.28** is a map spread of the habitat types. The table further highlights the distribution of these habitat types around the North-east (NE), North-west (NW), South-west (SW) and the South-east (SE) axis of the PEL project area.

Table 4.25: Habitat Types and Categories

Habitat Type (Vegetation Cover Based)	Habitat Category (IFC)	Ecological Importance	NE	NW	SW	SE
Regenerating Forests **Predominant flora:** ***Hevea brasiliensis, Elaeis guineensis, Alchorniea cordifolia, Dissotis tubulosa, Alstonia boonie, Acanthospermom hispidum, Musanga cercropodes.*** **Predominant fauna:** ***Diplopoda sp, Cricetomys gambianus, Naja nigricollis, Bitis gabonica, Herpestes naso,*** **Thryonomys swinderianus,** ***Bufo maculatus, Ptychadena bibroni, Civettictis civetta.***	Modified	Medium	x	x	x	x
Palm Forest Predominant flora: *Raphia hookeri,* ***Raphia vinifera****, Elaeis guineensis,* ***Musanga cercropodes, Gnetum africanum, Anthiocleista vogili, Chromolaena odorata, Lasienthera africanum, Mimosa pudica*** Predominant fauna:	Modified	Medium	x	-	-	x

Habitat Type (Vegetation Cover Based)	Habitat Category (IFC)	Ecological Importance	NE	NW	SW	SE
Ardea cinerea, Bubulcus ibis, *Cricetomys gambianus, Bitis gabonica,* ***Thryonomys swinderianus,*** *Bufo maculatus, Ptychadena bibroni,* ***Milvus migrans, Gypohierax angolensis***						
Riparian Forest Predominant flora: ***Dryopteris sp, Costus afer, Diplazium sp., Raphia hookeri, Bambusa vulgaris, Glyphaea brevis, Nymphae odorata****, Diplazium sp* Predominant fauna: ***Egretta garzetta, Cephalophus maxwelli, Thryonomys swinderianus****, Bufo* ***maculatus, Ptychadena bibroni, Milvus migrans, Gypohierax angolensis, Agama agama, Herpestes naso***	Natural	High	x	-	-	-
Bush Fallows Predominant flora: ***Chromolaena odorata,*** *Panicum maximum****, Gongronema latifolium, Glyphaea brevis, Costus afer, Dryopteris sp., Dissotis tubulosa, Cyathula spp., Ficus exasperate****,* ***Heliotropium indic****um* Predominant fauna: *Agama agama, Cricetomys gambianus, Egretta garzetta, Cephalophus maxwelli, Gypohierax angolensis, Herpestes naso, Naja nigricollis, Bitis gabonica*	Modified	Low	x	x	-	x
Secondary Rainforest Predominant flora: ***Hevea brasiliensis, Entandrophragma cylindricum, Raphia hookeri,*** *Costus afer, Dryopteris sp., K****haya grandifoliola****,* ***Musa paradisiaca, Elaeis guineensis, Alchorniea cordifolia, Dissotis tubulosa, Alstonia boonie, Acanthospermom hispidum, Musanga cercropodes.*** Predominant fauna: **Xerus erythropus, Epomops franqueti,** *Cephalophus maxwelli, Gypohierax angolensis, Herpestes naso, Thryonomys swinderianus, Diplopoda sp,* **Perodicticus potto,** ***Cercopithecus sclateri***	Natural	High	-	x	x	-

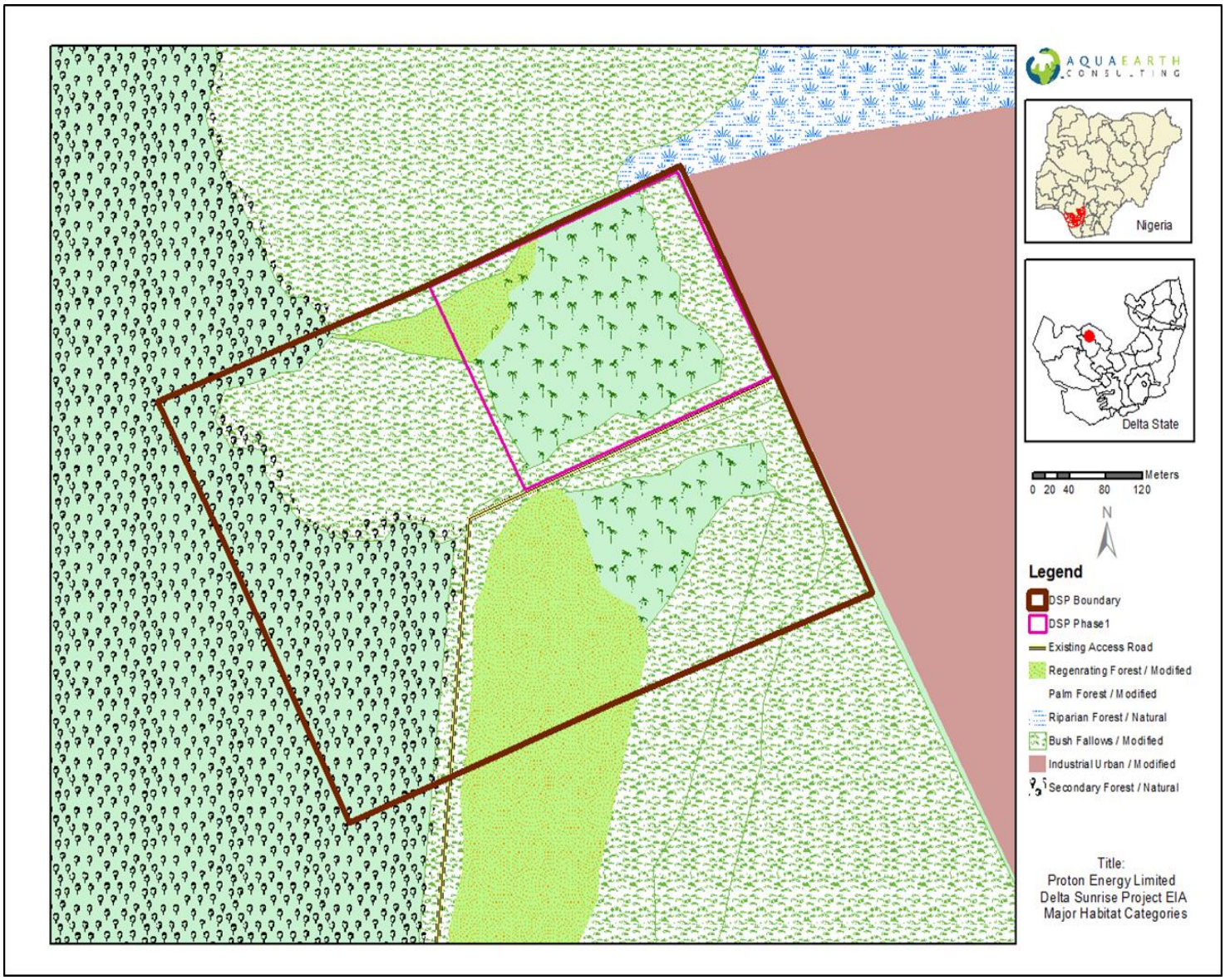


Figure 4.28: Habitat Types and Categories

The flora checklist below (**Table 4.26**), highlights photos of some of the sections of the habitat types occurring within each area.

Table 4.26: Dominant Species Photo Log

Habitat Type	Dominant Species Photo Log
Regenerating Forests	
Palm Forest	Musanga cercopodes
Riparian Forest	
Bush Fallows	

Habitat Type	Dominant Species Photo Log	
Secondary Rainforest		*Musanga cercopodes*

4.18.2 Ecosystem Services

The key types of ecosystem services applicable to the PEL foot print as well as bidoeversity AoI are:

- Provisioning Ecosystem Services;
- Regulating Ecosystem Services; and
- Supporting Ecosystem Services

As at time of the EIA studies as well as recently conducted biodiversity additional assessment/survey no cultural services were recorded for the project area and AoI. Information from stakeholder interviews, on-site walkthrough and available literature did not identify any community sacred groves, shrines, forbidden forests, tangible and intangible artifacts, recreational centres, scientific research zones or sanctuaries.

The regulating and supporting services are charterised by the following:

Regulating

- Climate regulation;
- Flood regulation;
- Water purification

Supporting

- Primary production;
- Nutrient cycling;
- Soil formation

For purpose of this report, discussions on baseline ecosystem services will focus on the provisioning services. The regulating and supporting services of the ecosystem within the area are well understood on a scientific basis and more important on a regional scope rather than a micro-level like that of PEL's 27ha footprint.

Provisioning Services

Information from available literature and baseline reports from the area suggest that the locals (villagers) around the area make use of both flora and fauna components of the ecosystem. Example of these are for food, fuel and medicine.

The following sub-heading discusses the provisioning services played by ecosystem to the affected communities and persons around the project area.

Protein and Fuel Gathering

Although access into the DSP boundaries before and after purchase has been highly restricted. However, unauthorizedaccess is provided by the under-construction road as well as existing gas pipeline RoW. Villagers around the project area are either hunters, gatherers, fishermen, traders or public/private employees.

Hunting around the Sapele region is basically around the secondary forest axis which may also extend into the secondary forest patches of the DSP 27ha boundary depending on access. Hunting is carried out using bamboo traps, ditches, spears and local rifles. Hunting frequency around this area is also low compared to areas up north around Mosogar, Koko and Oghara where demand is high and trad is lucracious especially for highway travelers. Hunting is done primarily for market sales in bush meat markets along the Warri-Sapele major highways.

Protein gathering is characterized by subsistence fishing by locals around the Ethiope River on the northern axis of the project area which is about 800m to 1.5km away from the DSP area of influence. Fishing is done primarily for household consumption. However, when surplus exists, it is sold in fish landing markets within the village or neighbouring villages.

On the other hand, firewood gathering is also carried out by women around forest / bush fallows in the Sapele region which may include the DSP project boundaries depending on access. Women and their children go into the bushes especially the bush fallow areas, regenerating forest and palm bushes to source for firewood. The woods are cut into small logs and tied unto their bicycles or carried on their head and taken back home to serve as source of fuel for daily cooking.

It is important to note that, dependence on natural resources by locals is largely associated with accessibility. Thus, the provisioning services of the ecosystem offered to locals in the DSP project is basically access driven to actual source of these needs which may be within or largely outside the DSP AoI.

4.19 Socioeconomic and Health Profile

Information on the socio-economic and health baseline condition of the proposed project area is provided in this section. The baseline provided details to identify and assess potential impacts of the proposed development. Information presented has been obtained through primary data collection, resource assessments, socio-economic surveys and consultations undertaken in December, 2013.

The socio-economic survey has also been carried out by PEL as part of its corporate social responsibilities and commitment to ensuring that stakeholders actively participate in the proposed project.

The socio-economic study was conducted in Ogorode Community in Sapele Local Government Area (LGA) of Delta State, being the community having direct impact from the project. The community is about 1.5 km from the project site.

This section examines various issues in the socio-economic and health environment including demographic conditions, natural resources and endowments, exploitation of natural resources for sustenance, livelihoods and quality of life. It also covered health conditions, prevalent diseases, the infrastructural frame work and its functional status, settlement pattern and housing conditions, socio-cultural resources and migration trend in the community. Others are

proposed project sensitivities such as perceptions, concerns and expectations of residents in relation to the project.

Study Methodology

The study was designed to obtain relevant socio-economic and health data on the community as well as key stakeholders through primary and secondary sources. This led to adopting a study strategy that involved the following activities:

- Conducting literature search and reviews;
- Conducting field visits to the study area;
- Design and pretesting of household questionnaire/ appraisal tools for the study;
- Determining target population and sample size for participatory rural appraisal and interviews;
- Conducting consultations and socio-economic survey (Focus Group Discussions [FGDs] General Group Discussion [GGD] and In-Depth Interviews [IDI] with various stakeholder groups and interviews with key informants in the community);
- Conduct interviews with key stakeholders (see below) involved with the project;
- Direct observations;
- Collating and analysing data obtained from all the sources; and
- Report preparation.

4.19.1 Project Stakeholder

Stakeholders are persons, group or organization that shares a common interest. In EIA studies, stakeholders are usually concerned with the project or impacted from the project. Stakeholders that were consulted and participated with this project are listed below:

- Delta State Ministry of Lands, Surveys and Housing;
- Delta State Ministry of Environment;
- Sapele Local Government;
- Federal Ministry of Environment;
- Benin Electricity Distribution Company:
- Leaders and members of Ogorode Community, Sapele; and
- Proton Energy Limited

4.19.2 Consultations

Consultation is a major feature of the socio-economic component of this Environmental Impact Assessment (EIA) process. In this case, it incorporates all stakeholders that may be directly or indirectly affected by the proposed project. Consultations aim to inform relevant stakeholders about the intentions/ plans of project proponents. It also attempts to record the concerns and perceptions of the generality of stakeholders and helps to ensure general acceptability of research results with a view to ensuring that disagreements and conflicts do not arise during project implementation.

The consultation programme for the socio-economic and health impact assessment for PEL power plant development project consisted of a two-tier process as described below.

- Reconnaissance visits to Ogorode community and Sapele LGA. Visit include meeting with political leaders/ traditional rulers/ civic leaders). This was done for legitimating purposes, as to secure permission and co-operation for the study; and
- Direct Consultation with Identified Stakeholders. This involved consultation with various identified stakeholders and community groups.

Consultation makes use of participatory tools to elicit information from stakeholders on community baseline data and expected project impacts. Consultation for this project would be a continuous activity and source of feedback for envisaged project development,

community integration and sustainable co-existence for the benefit of all stakeholders and the environment.

Consultation activities include; socio-economic engagement meetings, public disclosure and public forum. Dates and discussion agenda for each session are presented below.

Table 4.27: Project Consultation Program

Activities	Stakeholders/ Participants	Meeting Agenda
Reconnaissance (site visit) **Date**: 5th November, 2013	➢ Sapele Local Government; ➢ Ogorode community members; ➢ State Ministry of Environment; ➢ Proton Energy Limited	• Project details; • Potentially affected communities; • Details on memorandum of understanding (MoU) with community; • Possible environmental issues • Community perceptions and concerns on proposed project; • Suggested mitigation and enhancement measures; • Community needs and developmental prospects; • Collection of environmental and socio-economic baseline data
Socio-economic engagement (Focus group discussion, General group discussions and In depth interviews sessions at Ogorode) **Date**: 4th to 6th December, 2013	➢ Community chiefs and elders; ➢ Ogorode CDC and women groups and youths ➢ Proton Energy Limited	• Traditional governance; • Socio-cultural resources; • Social vices; • Conflict management; • Livelihood activities; • Household income levels and expenditure pattern; • Infrastructural network: • Environmental issues from project; • Perceptions and concerns from proposed project; • Suggested mitigation and enhancement measures; • Community needs and development; Collection of environmental and socio-economic baseline data
	➢ NEPA Staff School personnel ➢ Proton Energy Limited	Details on existing educational centers within community to include; number of schools, population, types of school
	➢ Delta State Ministry of Lands, Surveys and Housing; ➢ Delta State Ministry of Environment; ➢ Sapele Local Government ➢ Proton Energy Limited	• Project details and benefits; • Environmental issues; • Information on population status; • Health and educational centers; • Conflict resolution practices; • Socio-cultural resources; • Social vices; • Infrastructural network; • Environmental issues; • Perceptions and concerns about the proposed project • Possible resettlement issues (although not required for this study, as project site is undisturbed and no persons residing in it)
Stakeholders Public Forum **Date**: 16th May, 2015	➢ Delta State Government; ➢ Sapele Local Government representatives; ➢ Ogorode community leaders/ members; ➢ Federal and State Ministry of Environment; ➢ Proton Energy Limited	• Information from the Minister of Environment on the proposed project; • Proton Energy Ltd. presentation on the draft EIA report; • Expert comments on the report; • Stakeholder comments on the presentation/ report • Community members comment including concerns and expectation

Meeting dates, times, and agendas were agreed with the leadership of each group to be consulted who in turn notified those who were to be in attendance ahead of the schedules. Usually the meetings would start with introductions of participants, the objectives, and the programs for the meeting. Agendas include the proposed project description, areas likely to be affected, potential impacts, and planned mitigation strategies. In some cases, presentations were made by proponent and attendance sheets passed around.

Issues discussed were documented by nominated representatives of the group and by the socio-economic consultant. The comments received and issues documented have been used extensively in this EIA.

A summary of the responses, issues and concerns raised by the stakeholders are presented in Table 4.28.

Table 4.28: Summary of Responses during Project Consultation

Name of Stakeholder	Language of Communicator	Responses of Stakeholders/ Comments/Issues raised	Feedback to Stakeholders	Remarks/ Recommendation
Ogorode women group and youths	English/Pidgin English	Women were excited about the upcoming development and opportunites to improve their socio-economic status. Women were interested in knowing what empowerment opportunities would be provided for them in form of jobs at the plant, and vocational training. Youth Group assured to support the project in any way possible and ensure a conducive environment. Youths also requested that a fair number be given employment at the plant during construction and operation.	Stakeholders were assured that their concerns will be addressed.	PEL will need to ensure continued community liaision to fully incorporate community's hopes in project.
Community chiefs and elders	English	The Chiefs expressed their pleasure in having the project in the community and assured on their support. They were interested in knowing the time frame before the plant starts operation as they expect the plant's commencement will	The Consultant informed that PEL is also eager to see the plant development and will ensure a sustainable solution to power needs is provided. They were assured the projects aim is to improve the electricity supply in the country.	PEL to engage actively with the community to ensure developmental needs are well captured.

		see an end to incessant power supply in the community		
Sapele Local Government	English	The Director expressed appreciation to the proponent for engaging in the project. No concerns were raised. He however urged the proponent to maintain active engagement with the community.	Stakeholder was assured the comments will be incorporated in the ESIA and passed on to the proponent	PEL to maintain active community engagement

Evidences of consultation in pictures are presented in **Plate 4.10** below, while attendance sheets for meetings are presented in **Appendix 4.6.**

Focus Group Discussion with Ogorode Community Leaders

Public Review Meeting with Stakeholders

Plate 4.10: Consultation Session

Data Collection Techniques

A reconnaissance project site visit was carried out to identify the likely impacted communities. This guided planning for the scale of surveys required for the community. For key informant interviews, the leaders of the community (shown in **Plate 4.8** above) were selected. FGDs were conducted with different groups in each of the communities with stakeholders including the traditional chiefs/ elders, community leader, men and women. This ensured that representative sample of groups in the community were consulted.

A total of three FGDs/ GGDs and four interviews were conducted in the community. All numerical data acquired was analysed, to understand demographic trends within communities. All qualitative data was assessed according to professional judgment of consultants.

Target Population and Sample Size

Sixty copies (60) of the pre-designed questionnaire (sample in **Appendix 4.7**) were administered for the study. The sampling method was done randomly. Fifty-five (55) copies of properly completed questionnaire were retrieved and used for analyses.

Age and sex distribution of respondents to the household questionnaires are presented in **Table 4.29**. All of the respondents were adults, aged 18 years and above.

Table 4.29: Age and Sex Distribution of Respondents

Age Groups (Years)	Male	Female	Total	
			(No.)	(%)
18-24	11	8	19	34.5
25-64	18	9	27	49.1
65 and above	6	3	9	16.4
Total	35	11	55	100

4.19.3 Demographic Conditions

Population Size and Growth

Specific population data of Ogorode Community was not available from the national census conducted by the National Population Commission (NPC) in 2006. The NPC has, however, published population estimates at LGA and State levels. Ogorode located in Sapele LGA has a population of 174,273 in 2006 (NPC Priority Table Vol. IV, 2010).

Population of the LGA is projected at 3.2% and 5.0% annual growth rates (**Table 4.30**). The 3.2% projections are based on NPC's estimated annual growth rate of Nigeria's population (NDHS, 2008) while the 5.0% projections assume that the proposed project will attract significant numbers of workers and camp followers and their dependants into the study area. At 3.2% annual growth rate and using the exponential growth model, the projected population of Sapele LGA in 2013 is 224,289 growing to 254,264 by 2017. Using 5.0% and assuming 2013 as the base year the projection will grow from 224,289 in 2013 to 257,401 in 2014 and 298,007 in 2017.

Delta State had a population density of 240.4 per square kilometer in 2006 (NBS, Annual Abstract of Statistics, 2010). Given the estimated annual population growth rate of 3.2%, the population density in 2013 is estimated at 309.4 per square kilometer.

Table 4.30: Projected Population of Sapele LGA (2013- 2017)

Years	Projections	
	2.3% Annual Growth	**5.0% Annual Growth**
2013	224,289	224,289
2014	231,435	257,401
2015	238,754	270,297
2016	246,422	283,716
2017	254,264	298,007

Fertility, Mortality and Life Expectancy

Fertility, mortality and life expectance rates in the study area are influenced by a number of factors. These factors include acceptance of the marriage institution, relatively early marriage and procreation, and the practice of polygamy. The specific fertility, mortality and life expectancy rates for Ogorode have not been determined but existing State and regional values provide an indication.

A good measure of fertility is the Total Fertility Rate (TFR) which gives an estimate of the total number of children a woman would have in her reproductive life time, given her present birth history. The TFR for Delta State is 4.6 while the national average is 5.7 (NBS, Annual Abstract of Statistics, 2010). Given this TFR for Delta State, the rate of fertility in the state is lower than the national average. Another measure of fertility is the Crude Birth Rate (CBR) which is estimated at 18.93% in Delta State and 13.65% nationally (NBS, Annual Abstract of Statistics, 2010). The value of this measure of fertility is higher in Delta State than what is averagely obtained in Nigeria.

Available mortality measures include the Neonatal Mortality Rate (NMR), Infant Mortality Rate (IMR) and Under Five Mortality Rate. The NMR, IMR and Under Five Mortality Rate for Delta State are 53 per 1000, 120 per 1000 and 176 per 1000, respectively. The national averages are NMR 48 per 1000, IMR 100 per 1000 and Under Five Mortality Rate 201 per 1000 (NBS, Annual Abstract of Statistics, 2010). The NMR and IMR indicate that there are more deaths among neonates and infants in Delta State than the average occurrence in Nigeria. However, Under Five Mortality is lower in Delta State than the average in Nigeria.

Life Expectancy estimates for Delta State are the same as the available national estimates. The World Health Organization (WHO) in its World Health Statistics 2006 estimated that life expectancy for males and females in Nigeria were 42 years and 47 years, respectively.

Household Composition, Structure and Size

The household, rather than family, was used as the unit of enquiry for gathering some of the primary socio-economic data. The household, in this study, has been defined by the following:

- They live together and share or depend on a common source, to which one, two or more of them contribute, i.e. ‘eating from one pot;
- They accept the authority of one head; and
- They have lived together in this relationship for some time before this study. Staying together is not time specific, but none of the members of the household is a visitor who has come for a brief stay.

The typical household in the study area has a head who is the father or in the case of his demise, his wife or adult son. It comprises the father, mother, children and wards. The wards could be children of relations, friends and also domestic staff, especially house helps. These are usually fed and generally catered for from the resources of the household.

From questionnaire responses, a mean household size of 4.1 was obtained in the study area. This is higher than the NPC estimated mean household size of 3.3 in Delta State following the 2006 national census (NBS, Annual Abstract of Statistics, 2010).

4.19.4 Population Distribution

Age and Sex Distribution

NPC published population estimate for Sapele LGA in 2006, at five yearly intervals, (NPC, 2010) is presented in **Table 4.31**. Children (0-14 years) constitute 38.7% of the total population of Sapele LGA while those aged 15-64 years constitute 57.3% and the elderly (65 years and above) 4.0% of the population. The proportion of those aged less than 20 years in the LGA is

about 49.7%. Nearly half of the population in communities across the LGA is less than 20 years. This is very significant and has implications for resource management in households as well as labour input and income per capita.

The sex ratio which is an indication of the number of males in a population, to every 100 females in same population (Haupt and Kane, 2004) shows a higher female than male population in Sapele LGA. The sex ratio is about 97.8 (0.978:1). There are about 98 males to every 100 females in the LGA. By comparison, the sex ratio in both Delta State and Nigeria show that there are slightly more males than females. Delta State has a sex ratio of about 101.3 (1.013:1) and Nigeria has a ratio of about 103.3 (1.033:1).

Table 4.31: Age and Sex Distribution in Sapele LGA, 2006 Census

	Sapele LGA			
			Total	
Age Groups	Male	Female	(No.)	(%)
0-4	12,221	11,910	24,131	13.8
5-9	11,313	10,913	22,226	12.8
10-14	10,950	10,139	21,089	12.1
15-19	9,415	9,683	19,098	11.0
20-24	8,554	9,562	18,116	10.4
25-29	6,814	8,170	14,984	8.6
30-34	5,290	6,058	11,348	6.5
35-39	4,280	4,869	9,149	5.2
40-44	3,847	4,086	7,933	4.6
45-49	3,383	3,361	6,744	3.9
50-54	2,955	2,668	5,623	3.2
55-59	2,029	1,705	3,734	2.1
60-64	1,646	1,423	3,069	1.8
65 and Above	3,470	3,559	7,029	4.0
Total	86,167	88,106	174,273	100

Source: NPC Priority Table Vol. IV, 2010

Dependency Ratio

The dependency ratio shows the proportion of children and the elderly to the population aged between 15 and 64 years. It is an indication of the economic burden borne by the population. Children (in this case, aged 0-14 years) and the elderly (65 years and above) are considered dependent on the potential workforce (the proportion of population aged 15- 64 years). The dependency ratio in Sapele LGA (**Table 4.28**) is about 0.75 (75%). This dependency ratio is less than 1, implying that the potential workforce in the LGA is greater than the dependent population.

However, with the proportion of the dependent at about 75.0% of the work force, the population of the dependent is very significant. It implies that considerable portions of the resources of households in the LGA are devoted to the care of children and the elderly. Typically, this would mean significant investments in services like education, health and welfare which are necessary in the care of children and the elderly. Additionally, the age distribution that has given rise to this type of dependency ratio where the dependent account for a large portion of the population, implies reduced labour input per capita and also reduced income per capita in the economy in question (UNDP, 2006).

Adult Literacy and Education

Adult literacy is determined by ability to read and write in the English language among the population aged 15 years and above. Adult literacy level in Delta State is 69.5% and the national rate is 57.9% (NBS, National Literacy Survey, 2010). In comparison, adult literacy rate is higher in Delta State than the Nigerian average. This relatively high level of literacy notwithstanding, public education facilities in both the LGA and the state have functioned poorly. Public education facilities in the LGA are inadequate. Public schools do not have

adequately equipped and functional laboratories and libraries, sufficient instructional materials and teachers. There is no functional public primary or secondary school in Ogorode Community. Residents use facilities in Sapele town. The closest public primary and secondary schools to Ogorode Community are located on Mission Road in Sapele Town which is about six kilometers away. In the past the public school was the NEPA Staff School but is now operated as private school (**Plate 4.11**)

Plate 4.11: NEPA Staff School Entrance

Education attainment among people aged six years and above in Sapele LGA is presented in **Table 4.32**. The highest proportion of the population (41.6%) has attained secondary school education. It is also noteworthy that 56.9% of the population has attained primary and secondary school level of education. About 17.0% of the population has not acquired any form of education. There are more females (62.5%) than males (37.5%) in the category of those who have never attended school.

Table 4.32: Education Attainment in Sapele LGA, 2010

Level of Education	Males	Females	Total	
			(No.)	(%)
No Education	9,200	15,357	24,556	16.9
Nursery	11,487	11,054	22,541	15.5
Primary	10,680	11,860	22,540	15.5
JSS/SSS	31,012	29,054	60,066	41.4
Tertiary	8,742	6,391	15,133	10.4
Other	254	166	420	0.3
Total	71,375	73,881	145,256	100

Source: NPC Priority Table Vol. VII, 2010

Ethnic Composition of the Population

Ogorode is located close to Sapele Town and as such has acquired some of the urban outlook of Sapele town. One aspect of life in the community that has imbibed much urban characteristics is the diverse ethnicity of its residents. Many of the residents work in the ex-PHCN facility in the community and with companies in Sapele town. The community is a native Okpe-Urhobo community but it has provided residence and home to many other Nigerians. Traditionally, apart from the indigenous residents other Urhobo speaking people, Itsekiri and Isoko are major residents but with industrialization and urbanization Nigerians of other ethnic groups like Igbo, Hausa, Yoruba, Ibibio and Ijaw have become major residents. Local sources suggest that the number of non-indigenous residents is very significant, and could account for between 45% and 50% of the local population.

Migration Trend and Pattern

Oral traditions of origin insist that Okpe-Urhobo kingdom was started by four men namely Orhue, Orhorho, Evwreke and Ezesi. Not much is said about the origins of these men.

However, some historical accounts locate the Okpe-Urhobo among the wider Urhobo group and trace their ancestry to Bini in ancient Benin Kingdom (Asagba J.O., 2005).

Responses to the question on birth place of the household head were used to determine the migration trend and pattern in Ogorode Community. Household heads who were born in the community and those who had lived there continuously for ten or more years were considered non-migrant. The responses showed that 14 household heads, about 47% of the sampled population, were either born or had lived in community for more than ten years. This suggests that the proportion of migrant households in the community is high. The closeness of Sapele town and availability of industries in both the community and Sapele town have encouraged non-indigenous workers to reside in the community, and access their work places from there. The proposed project has the potentials of attracting more residents to the community which may increase its migrant outlook.

Apart from this, members of some households have relocated from the community over the years for various reasons. The most common reasons are marriage, school and work. The most affected age bracket is between 18 years and 35 years. More females than males have relocated to join family members after marriage. While a few household members have travelled abroad, most have relocated to other towns in Nigeria especially Lagos and Abuja.

4.19.5 Socio-Cultural Resources of the Community

Language, Marriage and Family

Ogorode is an ethnic Okpe-Urhobo community and its indigenes speak Okpe-Urhobo. Okpe-Urhobo is one of the Urhobo dialects. Urhobo is spoken in Delta State and a few villages in Bayelsa State. It is the dominant group in Delta State Central Senatorial district and a major ethnic group in the Niger Delta region. Urhobo is linguistically classified as an edoid language. This implies it is related to other languages spoken in Edo State area like Bini and Eshan. English is, however, the major language of communication in the study area. English is spoken in both its formal and the pidgin forms. Pidgin English is the very popular medium of communication given the increasing cosmopolitan nature of Ogorode Community.

The marriage institution is revered in the community. Marriages are contracted between adult males and adult females; there are no accounts of either same sex or juvenile marriages. Monogamy and polygamy are practiced. The marriage process involves stages, which include the knocking stage, the introduction stage and the traditional marriage proper. The stages involve the intending couple, their parents and relations, friends and well-wishers, with parents and relations being more prominent in the first stage. Drinks and gifts are presented by the groom's family to the bride's family during these meetings (the stages).

Information obtained during discussions with community members indicate that between 70% and 80% of adult residents who are up to 30 years old are married. In addition, an analysis of the marital status of respondents to the household questionnaire, **Table 4.33**, shows that 66.7% are married, 20.0% are single, 10.0% divorced or separated and 3.3% widowed. Polygamy is still practiced by many but it is generally believed to be on the decline. Community members estimate that about 20% of marriages in the community are polygamous. Reasons for decline in polygamy in the community include adherence to the Christian faith and increasing urbanization with the attendant cost implications of maintaining more than one wife and a large family.

Traditionally, the family is a very important social unit to which every member of Ogorode belongs. Both nuclear and extended families exist in the community. The typical nuclear family has a father who is the head, a mother and the children. Use of the term children transcends biological off spring of the parents and often includes relations who live with the household and are equally cared for as the biological off spring. A family where the father is dead could be headed by the mother if the children are juveniles or by the eldest son (if he has come of age).

Table 4.33: Marital Status of Respondents to Household Questionnaire

Marital Status	Frequency	
	No.	(%)
Single	6	20.0
Married	20	66.7
Divorced/ Separated	3	10.0
Widow/ Widower	1	3.3
Total	30	100

Source: FNL Survey, 2013

Social Structure and Organisation

Every member of the community belongs to one extended family or the other, and may also belong to one socio-cultural group or another. Social structures are a part of the community and they are well organized and useful in carrying out various functions in the community. They provide for order and help in the formation of groups that play significant and varying roles in the community. The community generally reveres the elderly and has structures that utilize their perceived spiritual and leadership qualities. For instance, there are two socio-cultural groups for women Egwesi-emesi for the elderly and Egbotor-Amua for young women. Egwesi-emesi assists the community chief priest in purification rituals whenever the land is believed to need purification. Each group plays a cultural role, serves as an agent for social mobilization, conflict resolution and welfare promotion. Similarly, social clubs actively participate in improving the welfare conditions of their members and in providing succor for members in their times of need.

Ogorode-Sapele is also traditionally organized around compound and family lines. These families are extended families and they spread across four compounds. Each indigene of the community is a member of an extended family as well as a compound.

Traditional Governance

Ogorode-Sapele is part of Etamua quarters in Sapele. Etamua is one of four quarters in Sapele. The others are Egborode, Otom and Ogodo. It is a part of Okpe Kingdom and recognizes the authority of the Orodje of Okpe as the traditional ruler of the kingdom. The traditional headquarters of the kingdom is Orerokpe which is also the administrative headquarters of Okpe LGA in Delta State. The kingdom is made up of twelve districts and Sapele is one of them. The Orodje is represented in each district by a chief he appoints. Apart from his representative he is generally responsible for the appointment of chiefs in the kingdom. The chief representing the Orodje works with the oldest male in Sapele, the Okpako-amua, and oldest male in each of the four quarters, Okpako-udumu to affect traditional governance. Usually the Okpako-amua meets weekly with the elders (males) from the communities that make up the quarter. These have responsibility for providing traditional governance and maintaining the cultural heritage of the kingdom.

Apart from these traditional institutions, Sapele elects a leader, the Chairman Sapele-Okpe Community who heads a council made up of other elected persons. The chairman and members of the council serve for four years and they can be re-elected to serve a second term if their service is satisfactory. This council is responsible for development planning and general maintenance of law and order in the four quarters that make up Sapele.

The women group consists of the Egwesi-emesi and Egbotor-Amua. Egwesi-emesi is made up of post-menopausal women who assist the chief priest in performing purification rites. Egbotor-Amua is the group of middle aged and young women who play a role in decorating, beautifying and serving as hostesses during community functions

There are no youth groups in Okpe kingdom as the formation of youth groups has been suspended in the kingdom. The youth in each community are mobilized through the traditional governance structure whenever there is a need for that. The entire traditional governance structure does not take away the role of daily administration of each of the constituent communities from its chiefs and elders.

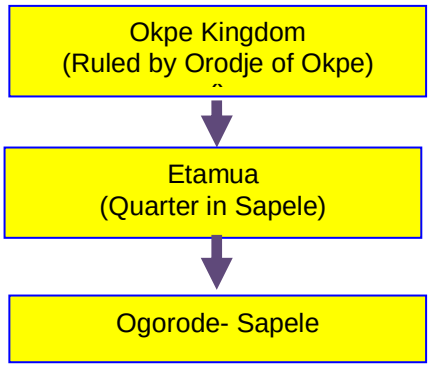


Figure 4.26: Traditional Organisation

Belief Systems and Practices

Many residents (70%) indicated that they are Christians. There are non-indigenous residents of Hausa and Yoruba extraction mostly working in the PHCN facility who are Muslims. Several Christian worship places belonging to various denominations like Deeper Life Bible Church, Living Faith, Redeemed Christian Church of God, Church of God Mission and Assemblies of God, among others are located in the community.

Among traditional religious worshippers the communal deities are Urhiapele-ame, Ekpokpase and Ibuerimin. Urhiapele-ame is the deity responsible for water bodies. Ekpokpase is a female deity and responsible for protection in the community. Ibuerimin is deity of the dead. These deities have shrines around the community but none is located within the proposed project site. Egbuku forest, which can only be accessed by authorized indigenes, was originally located within the proposed project site. This forbidden bush can be relocated if appeasement rites are performed. These rites are determined by the community chief priest. The community confirmed during group discussions that Proton Energy Ltd. has fulfilled the traditional requirements and the Egbuku bush has been relocated from the proposed project site.

The major Christian festivals of Christmas and Easter are celebrated in the community. Two main traditional festivals are also celebrated. These are Urhiapele-ame traditional festival and Edjokpa traditional festival. Urhiapele-ame holds periodically as determined by the community chief priest and it involves masquerade dances and various cultural displays. Edjokpa is an end of year celebration that holds annually in December. It is usually a festivity.

Socio-cultural demands and the demands of living with people from different backgrounds have influenced moral codes and norms in the community. This setting has given rise to prohibition of some perceived harmful practices with a view to ensuring security of life and property and fostering harmonious co-existence and habitation. These prohibited practices include committing suicide, having sexual intercourse with a married woman who is not one's wife and cannibalism. There were no confirmed food taboos in the community.

Conflict Management

Conflict situations occur in the community and most do not have violent outcomes. Many are resolved daily. Different organs of society are traditionally involved in resolving these conflicts. These include the chiefs, elders and family heads. The decisions of these bodies are usually respected by parties involved in most intra communal conflict situations.

Residents also turn to the Nigeria Police and the Judiciary to resolve some of the conflicts that arise among them. Community sources claimed that they had not experienced any inter or intra community conflicts with violent outcomes in the last five years.

Roles of Women and Youth in the Community

Given that the population of females is more than that of males in Sapele LGA, they would be expected to significantly determine household conditions and influence the socio-economic environment. Females participate in various livelihood activities identified in the study area. A lot of them are engaged in trading, artisanship practices especially as tailors and caterers, and in providing service under the civil/public services. Women contribute significantly to household incomes in the community. The two women groups Egwesi-emesi and Egbotor-Amua play significant traditional and cultural roles.

Although there is no official youth body, the youth generally take responsibility for security in the community. They participate significantly in the identified economic activities. They are also available to carry out tasks that the community chiefs and elders may demand of them.

Life Style and Indulgent Practices of Residents

The community identified and confirmed the existence of some social vices like heavy drinking of alcohol, cigarette smoking and use of hard drugs, prostitution, teenage pregnancy and child labour among them. There is extensive use of spirits and alcoholic beverages among adult residents of both genders. Roots, barks and leaves of trees are soaked in local gin and drunk for their perceived medicinal value. Local gin is a popular traditional product of the area which informs the common reference to local gin as Sapele water. Cigarette smoking is also quite common among adult males.

Prostitution is a common phenomenon of urban and semi urban areas. Given the proximity of the community to Sapele town, it has been exposed to the activities of commercial sex workers. Teenage pregnancy is said to occur in the community, but it is not very common.

Child labour, occurs in the common practice of sending children to hawk things like sachet water (pure water) and kerosene, sometimes during school hours. There are also children of school going age who live as house helps in households in the community. Some of these house helps are not given the opportunity to attend school.

The project is expected to attract itinerant workers, camp followers and others seeking business opportunities. Among these could be those who indulge in excessive drinking, smoking and abuse of drugs and commercial sex workers.

4.19.6 Quality of Life

Settlement Pattern and Housing

Ogorode Community is a nuclear settlement. It can be described as having two sections; one is the traditional quarters where most indigenes live and the other where most non-indigenes live. Houses in traditional quarters are not planned with definite layouts but there is adequate spacing of between four and six meters between houses. The section of community where most of the non-indigenes live is also the part that has most of the houses with modern designs and where the streets are properly laid out. Houses are built with about six meters set back from the road. Most houses in both sections of the community are fenced in with cement blocks (**Plate 4.12**).

Plate 4.12: Cement Block Houses in the Community

The most common types of accommodation in the community are tenement (rooming) houses, **Table 4.34**. These constitute about 63.3% of houses while family bungalows constitute about 36.7% of houses in the community. The most common material used for walling houses is cement block; about 90% of houses are walled with cement blocks. A few houses, about 10% are built with plastered mud walls. Corrugated iron sheets which are the roofing material used in about 80% of houses in the community is the dominant roofing material. Others are aluminum and asbestos which account for the roofing of about 13.3% and 6.7% of houses, respectively. Generally, houses in the community are built with durable materials. Designs of most houses within the community are modern providing for kitchen, toilet and bath, in-house.

Given their design, durability of construction materials and availability of modern facilities like kitchen, toilet and bath, in-house many of the houses would provide suitable accommodation for workers on the proposed project.

Table 4.34: Housing Attributes in Ogorode Community

Attributes	Proportion (%)
House Types	
Family Bungalow	36.7
Tenement/Rooming House	63.3
Construction Material (Wall)	
Cement blocks (plastered and unplastered)	90.0
Plastered mud wall	10.0
Construction Material (Roof)	
Corrugated Iron Sheet (zinc)	80.0
Aluminum	13.3
Asbestos	6.7
Main Source of Water	
Private Borehole	86.7
Well	13.3
Toilet	
Water closet	86.7
Bush	13.3
Main Source of Electricity	
Public Electricity	63.3
Private Electricity Generator	36.7
Sources of Energy for cooking	
Fire wood	40.0
Kerosene	36.7
Gas	23.3

Source: FNL Survey, 2013

Sources of Energy for Lighting and Cooking in Households

The community is on the national grid and the houses are supplied public electricity by Power Holding Company of Nigeria (PHCN). However, supply is not steady and reliable. During periods of electricity outage, which often last for long hours, households resort to alternatives like use of private electricity generating sets. Many households have acquired various kinds of diesel and petrol powered sets. A very common one is the small and portable 1 kVA generator.

Most households in the community, 40.0% use fire wood to cook their meals. About 36.7% cook with kerosene stoves, and about 23.3% use cooking gas which is clean and quick. Electricity is also clean and quick but most households do not think it is reliable because of the frequent outages. Fire wood and kerosene which jointly account for the cooking fuel used in 76.3% of households in the community produce fumes which can contribute to respiratory and other health problems, especially in those houses where cooking is done in rooms and corridors and not in ventilated places where the fumes can easily be dispersed.

4.19.7 The Economy

Natural Endowment

The major natural resource which has been exploited by generations of residents in the community is the land mass. The land has been put to various uses including farming, development of housing and provision of sand for building and construction purposes. A large part of the lands used to be developed into farmlands that yielded crops for food and sale, but due to increasing acquisition of lands for industrial purposes, very little farmland is left in the community. It is on part of this land mass that the proposed project will be sited.

Land Ownership and Tenure

Land is owned by families. Individuals can buy from willing sellers but mostly for construction of living houses. Ownership rights over lands are handed down from one generation to another within the family. Such land is put to any use as desired by the owner(s). Males exercise ownership rights and control over family lands. Lands required for development of common facilities or other communal use is donated to the community by families.

Over the years, lands in the community have been developed to house public and private facilities. The largest and most significant are PHCN Sapele Electricity Generating Plant and the Nigerian Navy Operations Base. Other significant uses have been for housing development and development of infrastructure in the community, especially roads.

Livelihood Activities

The traditional livelihood activities in Ogorode-Sapele community are farming, tapping of palm wine and production of local gin, trading and fishing. Apart from trading, the prominence of these livelihood activities in the community has waned considerably. In their place, residents now engage more in artisanship practices, provision of several services for industries located in Sapele and environs and for the civil and public services. They also provide contracting, transportation and other services. For some, a major source of livelihood is the rent collected on their landed property, which have been put on lease or developed into residential and business premises.

Farming, fishing and production of local gin are no longer significant livelihood activities, **Figure 4.27**. Less than 20% of residents are engaged in these activities and community sources estimated the monthly income from any of these activities at about ₦20,000. Trading is a significant livelihood activity in the study area. It basically consists of the buying and selling that is done in the markets in Sapele town and shops in the community. Residents access two daily markets in Sapele town, Gana and Sapele central market. Gana market is located about three kilometers from Ogorode Community and it is built up but has only open stalls. Sapele central market is about five kilometers from the community. This market has open and lock-up stalls, but mainly lock-up stalls.

Apart from the markets there is a lot of trading along the streets in the study area. This type of selling is conducted from a variety of places. Some can only afford to sell a few things like confectioner, fruits and others from table tops set up beside their houses while several trade from rented shops where they stock different goods. There are also those who hawk items like sachet water and fruits along the streets.

Artisanship practices represent another major form of livelihood activities. Some of the artisanship practices identified in the study area include tailoring, welding, carpentry and masonry, electrical and electronic fittings and repairs. Others are activities in the auto industry including mechanics, electrical, vulcanizing and panel beating. In addition to artisans a number of residents work in Sapele town with the Delta State and Sapele Local Governments as civil and public servants.

Some residents collect rental income from landed property, others work at activities including contracting, working as employees of companies in the organized private sector, providing sundry administrative services and transportation services among others. These have been identified in the study as other livelihood activities.

Some residents practice more than one livelihood activity. Engaging in multiple livelihood activities provides household members complementary sources of income. In many cases it is an indication that each one of these activities only provides subsistence income.

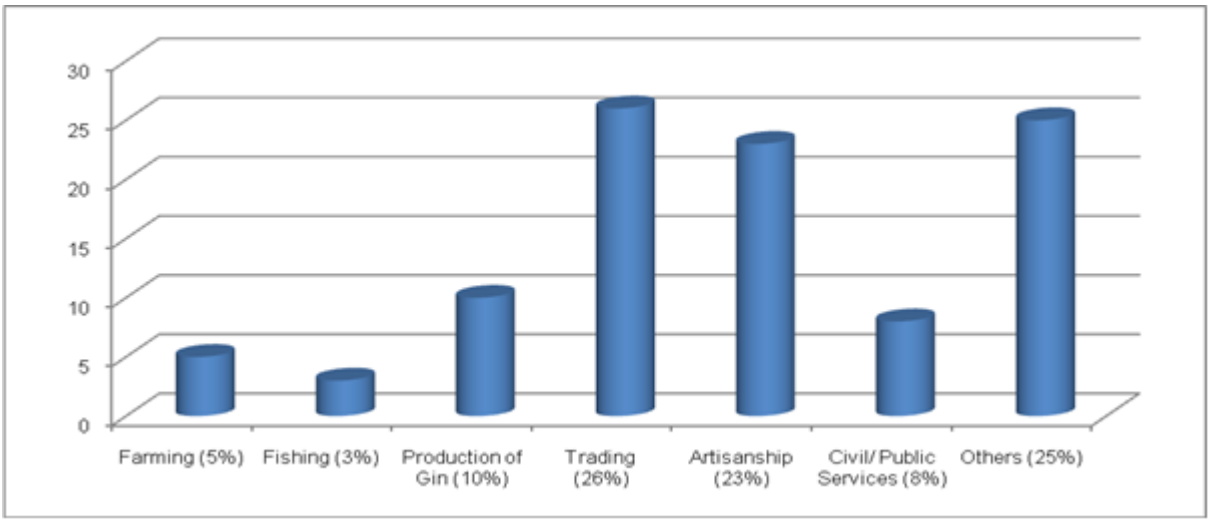


Figure 4.30: Livelihood Activities of Ogorode Residents

Income Levels and Expenditure Patterns of Households in the Study Area

Significant variations were noted in the monthly income levels of households in the study area. Factors responsible for this include the number of people employed in a household, their livelihood activities and the volume of investment. Household monthly incomes in the study area are presented in **Table 4.35**. The mean monthly income of households in the community (obtained from dividing total income by number of households) is about ₦57,623. The modal income bracket (most frequently occurring, in 30% of households) is ₦35,100- ₦50,000. An income poverty analysis, based on the UN poverty line of a minimum of 1USD per person per day, using both the mean and modal income levels suggests that most households live above the line. Assuming the mean monthly income of ₦57, 623; 30 days a month, currency conversion rate of ₦160 to 1USD and mean household size of 4.1, a household member earns ₦468 or 2.9USD daily. This suggests that the average household member earns more than poverty wage. Repeating the analysis and using the midpoint (₦ 42,550) of the modal income bracket (₦35, 100-₦50,000), the average household member earns ₦246 or 1.5USD. This is higher than the poverty income. The result using modal income may; however, be a more

suitable indicator of the level of income poverty among residents given that it is the most occurring income bracket. Using similar analysis, the NBS in its Nigerian Poverty Profile estimates that 63.6% of the population of Delta State lives below the poverty line (NBS, 2010).

Table 4.35: Household Monthly Income Levels in the Study Area

Income Levels (Range) (₦)	Income Midpoint (₦)	Income Frequency			
		(No.)	(%)	Total Income (₦)	(%)
1,000-10,000	5000	-	-	-	-
10,100-20,000	15,050	5	16.7	75,250	4.4
20,100-35,000	27,550	8	26.7	220,400	12.7
35,100-50,000	42,550	9	30.0	382,950	22.2
50,100-100,000	75,050	2	6.6	150,100	8.7
Above 100,000	150,000	6	20.0	900,000	52.0
Total	-	30	100	1,728,700	100

Source: FNL Survey, 2013

Expenditure pattern of the typical household in the community is presented in **Figure 4.31**. The main expenditure items include food, education, health care, residential accommodation, transportation, clothing and household items, and utilities. Community members indicated during discussions that these account for about 85% of their incomes. Most foods eaten in households in the community are bought. This is because there is very little farming and crop production going on in the community. Most households also spend considerable sums in paying school fees, buying learning materials and also hiring part time teachers to coach their wards at home after normal school hours. Given the proportion of non-indigenous residents in the community, the demand for accommodation is expected to be high. Many residents live in rented accommodation.

Health care services are accessed at a cost. Over periods of one month households typically spend significant sums of money, especially to buy drugs from drug stores. Other items, on which residents spend their incomes, include transportation to various locations especially work, school, market and church. Purchases of clothing and other household items, especially electricity and fuels to operate private electricity generators are done on a regular basis.

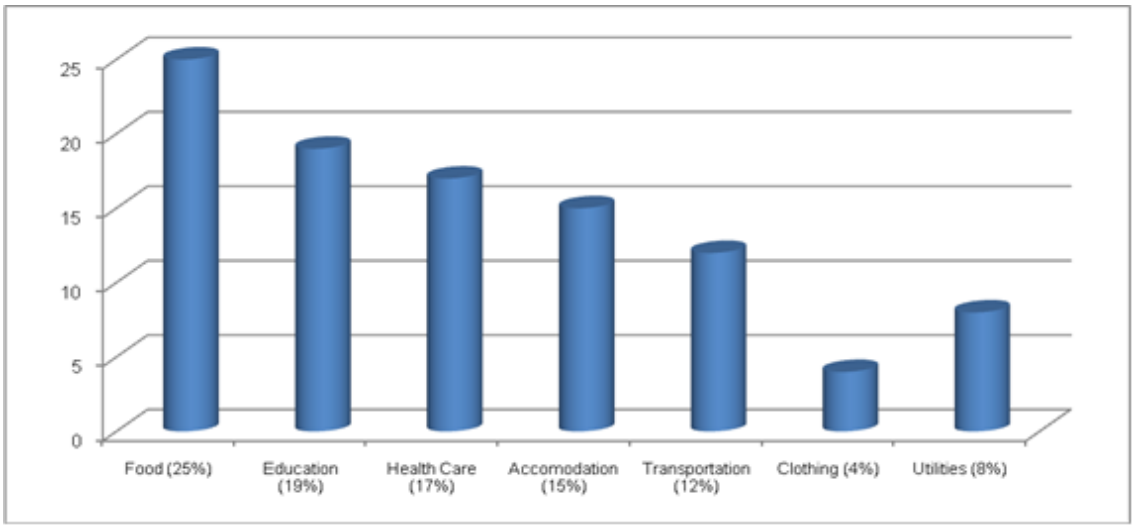


Figure 4.31: Expenditure Pattern of Households

Employment Status of Households

The employed in the study area include all who are aged between 15 years and 64 years who work for pay, inclusive of those who work for themselves, the work maybe on a full time or part time basis. The unemployed, on the other hand, are those of same age bracket who are not full time students and have been willing to work and looking for work and not able to secure one in the last six months preceding this study. While many residents are employed in industry, public service or engaged in self-employment a number of others are unemployed. The survey revealed that in 26.7% of the sampled households, there were unemployed members. Local sources indicated that the situation is largely because there are few job openings in the community and these household members lack the required skills. There is also very limited access to credit, particularly to finance new businesses and business ideas in Ogorode Community.

The NBS (NBS, 2011) estimates the unemployment rate among uneducated urban residents across Nigeria at 19.0% and 15.5% among those with only primary school education. Among JSS graduates estimated unemployment rate is 16.6% and 13.9% among SSS graduates. By the same publication, the age distribution of unemployment in Nigeria is estimated at 33.5% among 15-24 year olds in urban communities and 16.3% among 25-44 year olds. For those aged 45-59 years and 60-64 years the rates are 12.5% and 18.0%, respectively. The sex distribution of unemployment in urban areas is 16.9% among males and 17.2% among females.

Given the urban nature of Ogorode Community, these unemployment rates estimated by NBS for urban parts of Nigeria would apply. By these estimates the rate of unemployment in Ogorode, Sapele, as in other urban areas in Nigeria, is highest among females aged between 15 and 24 years who are uneducated.

4.19.8 Health Characteristics

Status of Available Health Facilities

There are no public orthodox health facilities in Ogorode Community. The two facilities in the community are privately owned and not available to the public. One is the PHCN Staff clinic located within the PHCN facility and the Nigerian Navy Hospital located within the naval base. The public facilities residents receive orthodox health care services from are Gana Health Centre located about three kilometers from Ogorode, Sapele Central Hospital and Sapele Health Centre both located in Sapele Town, about six kilometers from the community. Gana Health Centre does not have a medical doctor, visiting or resident. For this reason, many residents do not patronize the services there. Sapele Central Hospital and Sapele Health Centre both have resident medical doctors. The Central Hospital is most frequently visited by residents when they are ill. It is about 100 bed facility with wards for males, females, children, emergency cases and a private/executive ward. There is also a functional theatre for surgeries, a medical laboratory and a pharmacy department.

Apart from these public orthodox facilities there are a number of private clinics in Sapele Town which some residents of Ogorode, Sapele go to for medical care. The number of these facilities could not be determined during the study.

There are traditional birth attendants (TBAs) and those who dispense herbal medicines. The services of TBAs are mostly used by women during pregnancy and child birth. The use of herbal medicine is employed by several residents. Many times, leaves, barks and roots of trees are soaked in local gin or brandy and drunk as remedy for ailments.

Health Conditions of Household Members

Households indicated the last time any of their members felt sick enough to seek medical help in the last four weeks preceding this study (**Table 4.36**). The responses suggest that household members are quite healthy and do not fall ill often. About 50% of households in the community indicated no member had visited a facility for medical attention in the last four

weeks preceding this study. About 39.3% visited health facilities once or twice during the period and about 10.7% visited three to four times.

Although there are no public orthodox health facilities in Ogorode, those that residents access in Sapele town provide antenatal services, immunization services and general medical services. Antigens dispensed at the facilities during immunization services include BCG, HBV, OPV, Yellow Fever, Measles, Vitamin A and Penta 1, 2, 3. Antenatal care and general medical services are provided 24 hours daily. Sapele Central Hospital is the largest, most staffed and equipped of these facilities and it attends to an average of 65 out-patients daily.

Apart from the orthodox facilities, there are about 10 drug stores (chemists) in Ogorode. These sell mainly over the counter drugs (OTCs), anti-malarial drugs, some antibiotics and balms. Some of them also sell cosmetics and household provisions in addition to these drugs.

There are TBAs and those who sell herbal remedies in and around the community. The TBAs mostly take delivery of babies. Some of the women like them because of the body massage services which they provide. A number of places in the area sell concoctions of herbs and alcohol which are believed to cure several ailments especially malaria, waist pain and hemorrhage (pile). The number and distribution of these could not be determined during the study.

Table 4.36: Times Household Members Sought Medical Attention in a Month

	Frequency	
Number of Medical Visits	**(No.)**	**(%)**
None	14	50
1-2 Times	11	39.3
3-4 Times	3	10.7
5 Times	-	-
More than 5 Times	-	-
Total	28	100

Source: FNL Survey, 2013

Prevalent Diseases and Disease Vectors

Health workers in the orthodox health facilities indicated that malaria, diarrheal diseases, RTIs, skin rashes and trauma from accidents and fights are the most commonly reported and treated ailments. Other diseases like STIs, diabetes, and hypertension, dental and ophthalmic ailments are also reported at the facilities but not as frequently. Sapele Central Hospital is equipped with the relevant kits to detect HIV/AIDS. The occurrence of diabetes and hypertension which are mostly associated with sedentary living may have been influenced by the increasing exposure to the urban culture of eating processed and preserved foods, and doing little or no physical exercise.

Disease vectors identified in the area are presented in **Table 4.37.** The most common is mosquito which transmits plasmodium responsible for causing malaria in humans. Other common vectors are house flies and rats. Unkempt environment around the houses in the community provides the necessary breeding grounds for these disease vectors.

Table 4.37: Common Disease Vectors in the Study Area

Disease Vector(s)	Common Habitat	Parasite(s) Transmitted and Disease(s) Caused
Mosquito (anopheles and culex)	Stagnant water, bushes	Plasmodium causing malaria
House fly and Latrine fly (musca domestica and fannia canicularis).	Toilets, refuse heaps and dumps	Diarrheal diseases
Rats	Varieties of places including houses, bushes, drains and refuse dumps	Diseases including laser fever, although there was no report in the period before the study

Source: FNL Survey, 2013.

Use of Health Care Services

Questionnaire responses indicated use of health care services by household members in the community (**Table 4.38)**. Patronage of the services of drug stores is common among household members in the community. At 50%, it is the most frequently used. Just about 23.3% of households indicated that their members visit orthodox facilities when they are ill. It is usually the women that visit TBAs, and 16.7% indicated that they go to TBAs for delivery of their babies. Only about 10% either consult herbalists or their churches when they need medical attention.

These responses are indicative of a rather high level of self-medication in the community. Drugs are bought across the counter in drug stores without a doctor's prescription. The level of patronage of orthodox facilities is quite low at 23.3%.

Table 4.38: Use of Health Services by Household Members

Available Health Care Service Providers	Frequency	
	(No.)	(%)
Hospitals/ Health Centers	7	23.3
Drug Stores (chemist)	15	50
Traditional Birth Attendants (TBAs)	5	16.7
Herbalists/ Traditional Medicine Practitioners	2	6.7
Churches/ Spiritual Healing Homes	1	3.3
Total	30	100

Source: FNL Survey, 2013

Sources of Water for Domestic Use

There is no functional public water supply and distribution facility in Ogorode. Households obtain their water mainly from private water boreholes and from hand dug artisanal wells, **Table 4.37**. Some households get water for their domestic use from private water boreholes in the PHCN facility. About 86.7% of the households sampled use water from boreholes. About 13.3% use water from open and covered wells. The safety of these sources of water cannot be assured because regular tests are not conducted to confirm their status.

Household Waste Disposal Practices

Disposal of household refuse is managed through an organized arrangement put in place by Sapele LGA. Under this arrangement, each household in Ogorode is expected to pay the sum of ₦500 to designated refuse disposal contractors appointed by Local Government Council (LGC). Payment is made monthly and the contractors come regularly to cart away household refuse from designated drop sites. The arrangement is generally acceptable to residents, but some complained that the monthly fee of ₦500 is high.

There is no general arrangement for the evacuation of sewage. Most houses have water closet toilet facilities with the sewage flushed into a septic tank and soak away. Responses presented in **Table 4.37** show that about 86.7% of residents live in houses with in-built water closet toilets. The other 13.3% of households do not have this facility and their members defecate in the bush. Usually some of these are uncompleted houses and others are old and poorly designed houses without in-house provisions for toilets.

The water closet toilet ensures that sewage from households is safely disposed, but sewage disposal in the bush is unhygienic and unsafe. Generally, the existing household waste disposal system may not cope with the increased pressure anticipated from increased number of residents when the proposed project takes off.

Nutrition

Frequency in difficulties to satisfy household food needs in one year preceding this study in Ogorode is presented in **Table 4.39**. The indications are that most households in the

community seldom have difficulties satisfying the food needs of their members. About 55.6% noted that they seldom had difficulties and about 25.9% noted that they never had difficulties. A few households, about 18.5%, sometimes had difficulties satisfying the food needs of their members in the last one year preceding this study. Food is a major household expenditure item but most can provide two to three meals daily.

The typical household meal consists majorly of carbohydrate, fats and protein. Commonly available sources of protein are fish, beef and poultry. These proteins are usually available in the soups and stews with which gari, fufu, starch, yam and rice (the most common staple foods) are eaten. Malnutrition was neither commonly reported nor physically evident in the community. Additionally, NBS (2010), reports that the occurrence of underweight in children less than 5 years old in the South-South region is 18 per 1000, against the national average of 29 per 1000. The estimate of women who are too thin (BMI < 18.5) in the region is 11 per 1000, with national average of 15 per 1000, and women who are overweight (BMI > 25) is 25 per 1000 while the national average is 21 per 1000. The estimate for underweight in children under 5 years and women is better in the region than the national average while it is worse in the case of women who are overweight.

Table 4.39: Frequency in Difficulties to Satisfying Household Food Needs

	Frequency	
Parameters	**(No.)**	**(%)**
None (no time)	7	25.9
Seldom	15	55.6
Sometimes	5	18.5
Often	-	-
Always	-	-
Total	27	100

Source: FNL Survey, 2013.

4.19.9 Infrastructural Base of Study Area

Functional Status of Available Infrastructure

The community does not have infrastructural amenities. The only existing and functional ones are the road and telecommunications networks. Residents access every other amenity at Sapele town, about six kilometers away. The existing road network is adequate and it consists mostly of tarred and motorable streets. Telecommunication services are provided by GSM operators namely; MTN, Globacom, Airtel and Etisalat. The services are functional and accessible to all residents of the community. Functional status of available amenities in the community and Sapele town is described in **Table 4.40**.

Public education facilities are accessed in Sapele town. They are mainly a primary school and a secondary school, both located on Mission Road in Sapele town. Apart from these there are several private primary and secondary schools which are also located in the town. Public orthodox health facilities are Gana Health Centre located about three kilometers away in a suburb of Sapele; Sapele Central Hospital and Sapele Health Centre all located in Sapele town about six kilometers away from Ogorode Community. There are also several private orthodox facilities in Sapele town.

There is no function public water facility in the community. Residents rely on private water boreholes and wells for their supply of water. Public electricity is provided on the national grid which is characterized by long hours of outage. For this reason, several residents have private electricity generating sets.

The markets used by the community are Gana market and Sapele central market. Gana market is about three kilometers away and Sapele central market about six kilometers. Both are daily markets. Gana market only has open stalls while Sapele central market has lock up stalls. Public security is provided by the Nigeria Police which has a Divisional Headquarters

in Sapele town. There is also the presence of the Nigerian Navy represented by a base in Ogorode, Sapele.

Table 4.40: Infrastructural Framework of the Study Area

Infrastructural Amenity	Functional State of Amenity
Roads	There are about 20 tarred and motorable streets in the community
Telecommunication	Telecommunication services are received all over the community from GSM service providers including MTN, Globacom, Airtel and Etisalat
Electricity	The community is on the national grid, but outages are a common occurrence
Water	No functional public water supply facility. Residents depend on private water boreholes and hand dug artisanal wells
Education	No public school in the community. The nearest are a primary school, and a secondary school, both in Sapele Town about 6km from the community. In the past, the public school was NEPA Staff School but it is now operated as private.
Health	No public orthodox health facility. The nearest are Gana Health Centre about 3 km away, and Sapele General Hospital and Sapele Health Centre both in Sapele town about 6 km away
Market	None in the community. Closest are Gana market which only has open stalls and Sapele central market which has lock up stalls
Security	The Nigeria Police has a Divisional Police Station in Sapele town, and there is an operation base of the Nigerian Navy in the community

Source: FNL Survey, 2013

Transportation

Transportation within the study community is by road. Household members go about their businesses by means of commercial motorcycles and private motor vehicles. Commercial motorcycles are popular with commuters as they provide a quick way of going about one's business within the community. Fares vary depending on length of a trip. However, commercial motorcycles charge at least ₦50 per drop. A trip from the community to Sapele town costs ₦100.

Generally, many household members go about their businesses, especially when the distance is less than two kilometers, by trekking.

Environmental Problems

Water erosion is the basic environmental problem faced by residents of the proposed project community. It is most pronounced during the rainy season when torrential rains wash away much of the top soil. The tarred streets and accompanying drains in the sections of the community where they exist have helped to ensure that rain water quickly runs off. They have also acted to protect the top soil in most places from direct impact of the run off.

This problem of erosion has led to the loss of much land in the community. Steady removal of some of the vegetation cover for housing and other development has tended to worsen the problems. Residents have not been able to come up with any solutions to this problem.

4.19.10 Vulnerable Groups

Vulnerability will depend on how well some groups in the community would handle potential socio-economic and health sensitivities associated with the proposed project. These sensitivities include having to safeguard traditional livelihoods and income levels, creating opportunities for employment and contracting, access to amenities and housing. There are also issues of maintaining ethnic balance, degradation of the local language, and culture, and ensuring respect for human rights. Others are life style (social vices), alcohol and drug abuse, and hygiene. In the light of these sensitivities and potential impacts, some of the vulnerable groups are the youth, the uneducated and unskilled, the elderly and widows. The community youth may be exposed to life styles and social vices as they mingle with workers from different backgrounds. The youth group also constitutes a significant proportion of the unemployed.

Many of them may not be skilled and, therefore, have limited access to available employment opportunities on the proposed project. Again, the youth in this area have been born into an urban setting and their knowledge and grasp of the language and culture is already being degraded and may further be with more workers coming into the community.

The elderly constitute another vulnerable group. They usually require special attention which includes provision of welfare enhancing programmes and health intervention schemes. Given the lack of physical and social amenities it is doubtful if the community can cope with pressure from increased demand. The group of the elderly would potentially be most seriously impacted in the event of failure of infrastructural amenities. This increased demand will very likely manifest in increased household waste and indiscriminate dumping of waste. Coupled with lack of potable water, this could lead to hygiene problems in households and the community.

Safeguarding livelihoods, income and financial flows is a serious socio-economic sensitivity. The proposed project site is land from which community members derive their livelihood and possible use for housing developing in the future. The loss of livelihood will potentially impact widows and minors (less than 18 years and especially those who have lost their fathers); given that lands are owned by families and these groups cannot go into transactions involving family lands. Because the acquired lands are family lands, these groups will not be involved in the negotiations for compensation and may not be paid any significant sums by their families to enable them invest in the pursuit of alternative livelihoods. The loss of lands will also potentially impact the uneducated and unskilled because they may not be able to transit to other livelihood activities.

The native community has lost a lot of its land to industrialization and further loss of the project site will imply reductions in available land for the indigenous youth to build their houses in future. The project would, therefore, potentially limit access to housing for the youth.

4.19.11 Perceptions, Concerns and Expectations of Residents

Residents expressed their perception about the proposed project, and their concerns and general expectations from it at group discussions and interviews. There was a general perception of the proposed project as having potential benefits for the community and its residents. Residents were, therefore, very supportive and interested in its completion. This support is not without addressing some concerns about the project and meeting some expectations.

A major concern of the community was the completion of the proposed project. This concern stems from the residents' belief that projects which are not completed in the lifetime of any regime are hardly ever continued by the regime's successor. They, therefore, have fears that the proposed project would be abandoned at the end of the tenure of the present administration in Delta State.

Apart from the concern, residents have several expectations which include the following:

- Employment of community members and residents during all phases of the project from mobilisation and construction to commissioning and decommissioning;
- Infrastructural development of the community which will specifically include provision of a public school, potable water and a public health facility; and
- Empowerment of community members through skills development and award of contracts.

4.19.12 Project Disclosure

As has been mentioned earlier, the draft EIA report was displayed for twenty-one (21) days and subjected to public review and scrutiny. This is part of the FMEnv regulatory process. The EIA consultant, (FNL) consulted with the FMEnv regarding the disclosure process and notification to ensure it was done to meet Word Bank standards. Notification was done through

announcement on specified newspaper and on radio. See **Appendix 1.2** for FMEnv letter to this effect.

Public stakeholders at the Federal, State and LGA levels were invited to provide their input to the proposed EIA document, with the community members, project proponent (PEL) and consultant involved. A public forum was organised by the FMEnv as part of the review process on the 16th May, 2015.

Subsequently, there will be public disclosure of the EIA report on the World Bank InfoShop website which the FMEnv will be notified.

CHAPTER FIVE

IMPACT ASSESSMENT

CHAPTER FIVE

IMPACT ASSESSMENT

5.1 General

A major objective of this EIA study is to identify, characterise and evaluate the associated and potential impacts from the proposed Proton Delta Sunrise project. These impacts are those that have both beneficial and adverse bearing on the bio-physical, chemical and socio-economic environment. The assessment method involves evaluating interactions between various activities of the project (as described in **Chapter Three**) and environmental components of the project area (as described in **Chapter Four**).

5.2 Impact Assessment Methodology

A systematic approach was adopted for the impact assessment as presented in the chart below (**Figure 5.1**).

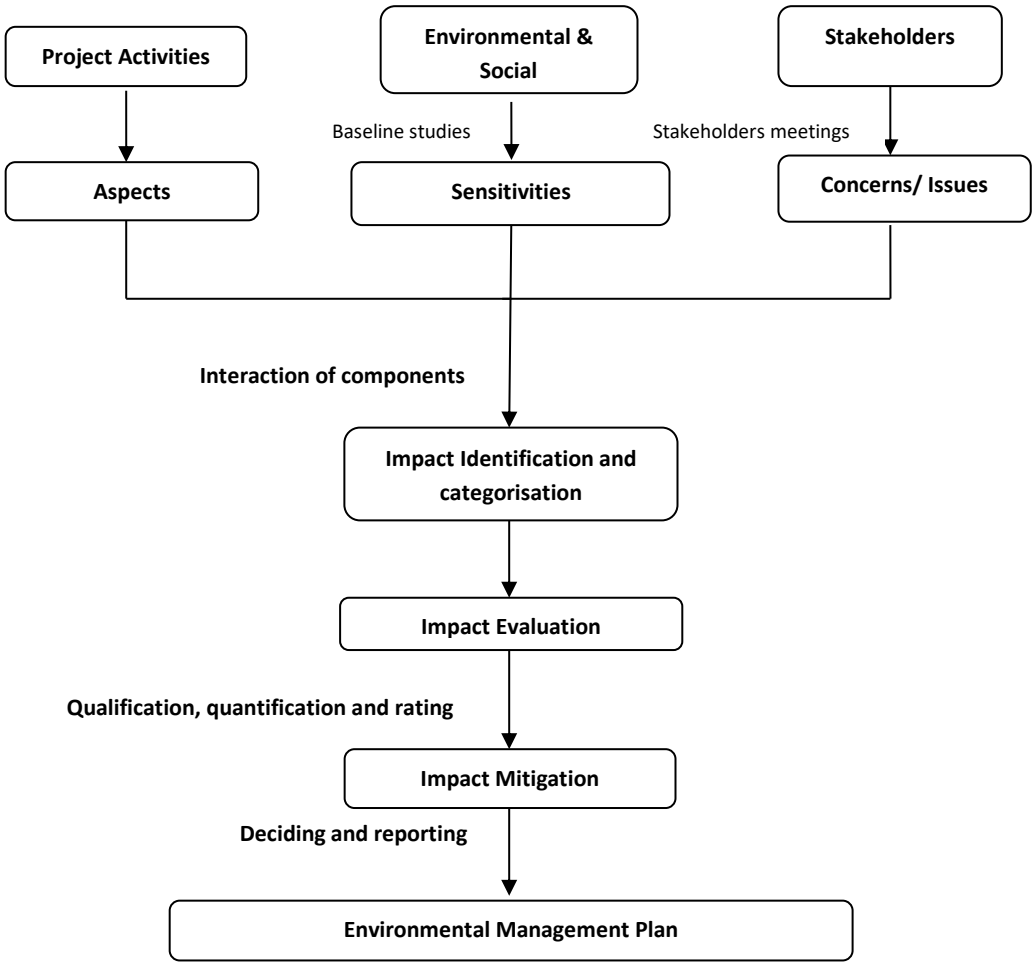


Figure 5.1: Impact Assessment and Management Flowchart

Impact identification, assessment, categorisation and evaluation were carried out by a team of experts proficient in the fields of geology, ecology, engineering, chemist etc. Based on the impact and mitigation, an Environmental and Social Management Plan was developed for the project (see **Chapter Seven**).

5.3 Project Activities

A number of project activities would be carried out in phases. These planned activities are what would impact on the environmental components positively or negatively. The power plant project activities are grouped into four phases as follows:

Pre-Construction phase: Involves activities such as award of contract, project design and planning, consultation, recruitment, site preparation and transportation of the OCGT power plant components to site.

Construction phase: It involves activities such as mobilisation of men and equipment to site, digging, trenching, bulldozing, grading, soil compaction; and installation of temporary camp and power plant components, usually short term.

Operational phase: This is usually long 'term', involving activities from post construction to decommissioning. It commences once the power plant has been commissioned for use. Activities include use of natural resources (water and gas for plant process), plant and equipment operations, routine maintenance of equipment and plant.

Decommissioning/ abandonment phase: It begins once the power plant use is discontinued or project life span has come to an end.

It should be noted that impacts can occur at any time; during these phases mentioned above i.e. pre-construction, construction and operational phases of the project. Some impacts may however occur in some or all phases of the project.

5.4 Impact Identification

The first step in identifying impacts associated with the project is the development of an interaction matrix which shows the relationship/ interaction between the project's environmental components and planned project activities.

As with a project of this nature, the main environmental components or receptors are soil, sediment, surface water bodies, flora and fauna, air and noise, socio-economic/ occupational health. The detailed interaction matrix table (**Table 5.1**) is presented on the next page.

Table 5.1: Project Activities – Environmental Interaction Matrix

Project Activities	Pre-construction Phase			Construction & Installation										Operation / Maintenance									Decommissioning		
Environmental Components	Mobilisation of Power Plant Components and Personnel	Recruitment/ Community Engagement	Site Preparation (access clearing & camping)	Onsite Fabrication and Carpentry Works	Plant Foundation Construction (piling, trenching etc.)	Plant Installation Activities	Waste Management	Fuel / Hazardous Material Handling	Painting and Coating (i.e. use of aerosols)	Logistics (support, supply & servicing)	Fires / Explosions	Depletion of Natural Resources (i.e. surface / ground water use)	Incidents /Accidents	Commissioning/ Testing	Power Generation	Plant Maintenance/ Servicing	Depletion of Natural Resources (gas and water for plant use)	Waste Management	Logistics (support, supply & servicing)	Emission to Atmosphere	Fires / Explosions	Incidents and Accidents	Mobilisation of Personnel and Equipment	Power Plant Decommissioning	Abandonment /Restoration
Air Quality and Noise																									
Particulates	■		■	■	■	■	■			■	■												■	■	
NO_X, SO_X, CO_X, etc.	■		■	■		■	■		■	■				■	■	■		■	■	■			■	■	■
Gaseous hydrocarbons	■		■				■		■	■	■			■	■	■		■	■	■	■		■		
Noise disturbance	■		■	■	■	■				■	■			■	■				■		■		■	■	
Vibration	■				■					■									■				■		
Water Quality																									
Surface water physico-chemistry			■		■	■	■	■	■			■			■		■	■						■	
Groundwater physico-chemistry					■		■	■				■			■		■	■						■	
Aquatic Ecology																									
Plankton			■		■	■	■	■				■					■	■						■	
Fishes			■		■	■	■	■				■					■	■						■	
Macro-benthos			■		■	■	■	■				■					■	■						■	
Terrestrial Ecology																									
Fresh water swamps	■		■		■		■	■										■					■	■	■
Mangrove swamps																									
Rainforests	■		■		■		■	■			■							■			■		■	■	■
Avifauna	■		■	■	■	■				■	■	■		■			■		■		■		■	■	
Mammals	■		■	■	■	■	■			■	■	■		■			■	■	■		■		■	■	
Sediment Quality																									
Physico-chemistry			■				■	■										■							
Seabed disturbance							■	■										■							

Table 5.1: Project Activities – Environmental Interaction Matrix – cont'd

Project Activities	Pre-construction Phase			Construction & Installation										Operation / Maintenance									Decommissioning		
Environmental Components	Mobilisation of Power Plant Components and Personnel	Recruitment/ Community Engagement	Site Preparation (access clearing & camping)	Onsite Fabrication and Carpentry Works	Plant Foundation Construction (piling, trenching etc.)	Plant Installation Activities	Waste Management	Fuel / Hazardous Material	Painting and Coating (i.e. use of	Logistics (support, supply & servicing)	Fires/ Explosions	Depletion of Natural Resources (i.e. surface / ground water use)	Incidents /Accidents	Commissioning/ Testing	Power Generation	Plant Maintenance/ Servicing	Depletion of Natural Resources (gas and water for plant use)	Waste Management	Logistics (support, supply & servicing)	Emission to Atmosphere	Fires / Explosions	Incidents and Accidents	Mobilisation of Personnel and Equipment	Power Plant Decommissioning	Abandonment / Restoration
Soil Quality																									
Physico-chemistry	■		■		■	■	■	■		■	■							■	■		■		■		■
Topography/ natural drainage	■		■		■	■	■	■		■								■	■				■		■
Public Perceptions																									
Aesthetic quality	■						■	■										■					■	■	■
Stakeholder participation	■	■					■						■	■				■				■	■	■	■
Socio-Economics/ Human Health																									
Employment opportunities	■	■		■	■	■			■						■	■							■	■	■
Public health	■			■			■	■	■		■							■		■	■		■		
Land Use			■		■	■									■										■
Macro & micro economics		■								■						■			■						
Worker safety/ Occupational health	■		■	■	■	■			■	■	■		■	■	■	■			■		■	■	■	■	■
Traffic on local roads	■									■									■				■		
Conflict and agitation from host community	■	■								■				■					■				■		

5.5 Impact Characterisation

Based on the interaction matrix developed above, impacts at various phase of the project are further characterised using the checklist approach. This involves categorising impacts (i.e. potential and associated) based on the following terms as presented in **Table 5.2**.

Direct Impacts	These are impacts resulting directly (direct cause-effect consequence) from the power plant project activities
Indirect Impacts	These are impacts that are at least one step removed from the power plant project activities. They do not follow directly from the project activities
Adverse Impacts	Adverse impacts are those that would produce negative effects on the biophysical or socio-economic environment
Beneficial Impacts	These are impacts that would produce positive effects on the biophysical or socio-economic environment
Reversible Impacts	These are impacts where environmental components can recover over time
Irreversible Impacts	These are such that the impacted component cannot be returned to its original state even after adequate mitigation measures are applied
Cumulative Impacts	These are impacts resulting from interaction between the project activities and other activities, taking place simultaneously
Long term	Those predicted adverse impacts which remain after mitigating measures have been applied (period of about 5 years)
Short term	Impacts that are removed after mitigating measures have been applied (period of about 6 months)

Table 5.2: Proton Energy Power Plant Impacts Categorisation

Project Activities	Associated and Potential Impacts	Direct	Indirect	Adverse	Beneficial	Reversible	Irreversible	Cumulative	Long term	Short term
Pre-construction Phase										
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Employment opportunities arising from recruitment of workers									
	Business opportunities for local contractors through sub-contracting activities									
	Skill acquisition and enhancements to locals and future workforce									
	Improvement in quality of life for adequately compensated individuals									
	Conflicts/ community agitations over employment issues (quotas and methods)									

Table 5.2: Proton Energy Power Plant Impacts Categorisation – cont'd

Project Activities	Associated and Potential Impacts	Direct	Indirect	Adverse	Beneficial	Reversible	Irreversible	Cumulative	Long term	Short term
Pre-construction Phase										
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Issues/ dispute on memorandum of understanding with project proponent									
	Influx of people (migrant workers, sub-contractors and suppliers) and increased pressure on existing social infrastructure									
	Increase in social vices (like theft, prostitution) resulting from increased number of people in the area									
	Community agitations over land disputes, wrong stakeholder identification, leadership tussles, etc.									
	Loss of vegetation covers and forest products (fuel wood, timber, medicinal plants) due to site clearing and preparation activities									
	Increased risks of accidents leading to injury/ death and loss of asset during mobilisation									
	Risks of armed robbery attack and hostage taking leading to injury/ death of personnel									
	Nuisance (noise and vibrations) from movement of heavy duty equipment and vehicles affecting site workers and wildlife									
	Dust particles and vehicular emissions from increased movement									
	Generation of wastes such as scrap metal, wood, sand, concrete, paper, domestic waste etc.									
	Contamination of surface water from siltation caused by increased erosion, during site preparation									
Construction and Installation Phase										
• Plant foundation works • Piling, trenching, etc. • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Risks of injury/ death and loss of assets resulting from accidents associated with road transportation to and from construction site									
	Workplace accidents leading to injury or fatalities from burns, cuts, bruises, trips, falls from objects at height									
	Employment of local labour and skills acquisition for workers taking advantage of new opportunities									
	Increased cash flow and stimulation of local economies within the host community									
	Increased revenue opportunities for local population due to presence of non-resident workers and travellers									
	Generation of dust and particles from heavy duty equipment usage									
	Flora/ habitat loss and disturbance from vegetation clearing and earthworks within the power plant site									
	Fauna (birds, mammals etc.) disturbance and displacement as a result of migration away from construction activity areas									

Table 5.2: Proton Energy Power Plant Impacts Categorisation – cont'd

Project Activities	Associated and Potential Impacts	Direct	Indirect	Adverse	Beneficial	Reversible	Irreversible	Cumulative	Long term	Short term
Construction and Installation Phase										
• Plant foundation works • Piling, trenching, etc. • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Soil/ groundwater contamination resulting from accidental leakages and spills of hazardous substances (diesel, petrol, cleaning agents, lubricants, hydraulic oil)	■		■		■	■	■		■
	Light traffic diversion and congestion along Ogorode road during installation and construction phase		■	■		■				■
	Increased risks of accidents leading to injury/ death and loss of asset during mobilisation		■	■		■	■			■
	Potential collapse of power plant structures as a result of unsuitable geotechnical conditions	■		■		■				■
	Hazards from construction of base camp, gas pipeline and electric evacuation lines	■		■		■	■			■
	Cement dust and toxic fumes inhalation by onsite workers during foundation works and welding of plant components	■		■		■	■	■		■
	Risk of electrocution and burns during welding	■		■			■			■
	Noise nuisance (including impulsive noise) from construction activities (e.g. piling, digging) resulting to temporary migration of mammals and rodents	■		■		■	■			■
	Loss of aesthetic quality as a result of alterations to normal landforms from construction activities	■		■			■		■	■
	Risks of fire/ explosions resulting from accidental ignition of onsite petrol/ diesel storage tanks	■		■			■			■
	Generation of wastes from construction activities such as scrap metal, wood, sand, concrete, paper, domestic waste, used oil etc.	■		■		■	■	■		■
Operational Phase										
• Testing and commissioning • Power generation • Power plant maintenance and servicing	Generation and addition of electricity supply to the national grid	■			■	■			■	
	Increased business opportunities and quality of life (small, medium, large scale) due to enhanced power delivery		■		■	■	■		■	
	Improvement in air quality due to reduced emission from privately owned diesel or petrol generators		■		■	■			■	
	Reduced demand on petrol and diesel used for household power generation		■		■	■	■		■	
	Injuries/ fatalities of personnel due to incidents/ accidents from operating the power plant	■		■		■	■		■	
	Greenhouse gas emission from natural gas used as feedstock	■		■			■	■	■	■
	Air pollution from release of NO_x, CO_x, SO_x, and greenhouse gases from powered generating plants	■		■		■		■	■	
	Soil/ groundwater contamination from accidental petrol /engine oil spill during refuelling of vehicle		■	■		■	■	■	■	

Table 5.2: Proton Energy Power Plant Impacts Categorisation – cont'd

Project Activities	Associated and Potential Impacts	Direct	Indirect	Adverse	Beneficial	Reversible	Irreversible	Cumulative	Long term	Short term
Operational Phase										
• Testing & commissioning • Power generation • Power plant maintenance and servicing	Thermal pollution from gas powered generating plants	■		■		■		■	■	■
	Workplace accidents/ incidents (cuts, trip, falls etc.) leading to injury/ death of personnel during operations	■		■		■	■		■	■
	Acquisition of skills by individuals to be employed to operate the plant	■			■	■			■	
	Exposure of workers to gas leaks (from boiler/ turbines) and excessive heat leading to burns and irritation	■		■			■	■	■	
	Exposure of workers to excessive noise from the power plant turbines	■		■		■	■		■	
	Depletion of surface and groundwater resources for cooling plants	■		■		■			■	
	Accidental explosion from gas leakage or nearby ignition resulting to fire outbreaks	■		■			■		■	
Decommission Phase										
• Mobilisation of personnel and equipment • Power plant decommissioning • Abandonment / restoration	Loss of employment, business opportunities and decreased economic activity	■		■			■		■	
	Reduced power generation to national grid and low power supply	■		■		■	■		■	
	Risks of injuries/ death to locals (i.e. farmers and hunters) from possible collision with abandoned structures		■	■			■			■
	Risk of accident and injury to workers during demolition of structures	■		■		■	■			■
	Increased dust and vehicular emissions from decommissioning activities		■	■			■	■		■
	Traffic obstruction on major roads from movement of vehicles during decommissioned process		■	■		■				■
	Availability of land for alternative uses	■			■	■	■		■	
	Loss of site aesthetic qualities due to abandoned and dilapidated structures	■		■			■		■	■

5.6 Impact Evaluation

Evaluation process is based on professional judgment and use of clearly defined criteria (legal/ risk, frequency of occurrence, importance and public concern) to determine the significances or otherwise of the impacts. The modified ISO 14001 method was used in this evaluation. Criteria and weighing scale adopted for the evaluation are described below.

Legal/ Regulatory Requirements (L)

The proposed project activities that resulted in impacts were weighed against existing legal/ regulatory provisions to determine the requirement or otherwise for permits prior to the execution of such activities. Such legal requirements (**Table 5.3**) were identified from laws/ guidelines, which have been reviewed in **Chapter One** of this report as well as those guidelines in the source references relating to the proposed project activity. The weighting scale used is as follows:

Table 5.3: Legal/ Regulatory Requirements

Conditions	Rating
• No legal/ regulatory requirement for carrying out project activity	Low (0)
• Legal/ regulatory requirement exist for carrying out activity	Medium (3)
• A permit is required prior to carrying out project activity which may result in impact on the environment	High (5)

Risk Posed by Impact (R)

The risks (measure of likelihood and magnitude of an adverse effect) associated with the project were evaluated in terms of; risk to human health, risk to asset (commercial and economic risk), risk to biophysical environment and risk to PEL reputation. Based on the various risks, impacts are ranked using the weighting scale below:

Table 5.4: Risk Criteria

Attribute – Environmental, Human Health, Safety and Reputation	Rating
• This means that no further mitigation may be required	Low (0)
• This means that the impact can be mitigated with additional controls and modifications	Medium (3)
• This means that the impact require avoidance or major control/ mitigation	High (5)

Frequency of Impacts Occurrence (F)

Evaluation of the frequency of occurrence was rated as “high”, “medium” or “low” based on the historical records of accidents/ incidents, consultation with experts and professionals. The frequency criterion is summarised below.

Table 5.5: Frequency Criteria

Attribute – Environmental, Human Health and Safety	Frequency
• Major degradation in quality in terms of scale (>1% of project area or habitat within the study area), appearance, duration (beyond duration of project) • Irreversible or only slowly recoverable (change lasting more than 1 year) degradation of environmental ecosystem level (population, abundance, diversity, productivity) • High frequency of impact (occur continuously and almost throughout the project execution period (< 4months) • Geographic extent of impact (e.g. encompassing areas beyond the project area)	High (5)
• Degradation in quality in terms of scale (>0.1% of project area or habitat), appearance, duration (a few months) • Effect beyond naturally occurring impacts variability • Slow reversibility (change lasting a few months before recovery), lasting residual impact • Potential for cumulative impact • Intermittent frequency of impact (occur in only a few occasions during the project execution period) • Limited geographic extent of impact (large area within project area)	Medium (3)
• Minor degradation in quality in terms of scale (<0.1% of project area, habitat, very localised), appearance, duration (a few days to a month) • Effect within range of naturally occurring impacts, changes, dynamics • Rapid reversibility (change lasting only a few weeks before recovery), no lasting residual impact of significance • No potential for significant cumulative impact • Low frequency of impact (occur in just about one occasion during the project execution period) • Only very localised geographic extent of impact (e.g. not more than a few meters from impact source point)	Low (0)

Importance of Impact (I)
The importance of environmental component in respect of identified potential impact was also determined and rated as “high”, “medium” or “low”. The ratings were based on consensus of opinions among consulted experts including project engineers and other stakeholders in the proposed project. The importance criterion is summarised thus:

Table 5.6: Importance Criteria

Attribute – Environmental, Human Health and Safety	Importance
• Highly undesirable outcome (e.g., impairment of endangered, protected habitat, species) • Detrimental, extended flora and fauna behavioural change (breeding, spawning, molting) • Major reduction or disruption in value, function or service of impacted resource • Impact during environmentally sensitive period • Continuous non-compliance with international best practices	High (5)
• Negative outcome • Measurable reduction or disruption in value, function or service of impacted resource • Potential for non-compliance with international best practices	Medium (3)
• Imperceptible outcome • Insignificant alteration in value, function or service of impacted resource • Within compliance, no controls required	Low (0)

Public Interest/ Perception (P)
Here, the interest/ perception of the public on the proposed project and the identified potential/associated impacts were determined through consultation with proposed project stakeholders. The ratings of “high”, “medium” or “low” were assigned based on consensus of opinions among consulted known stakeholders. The public perception/interest criterion is summarised below.

Table 5.7: Public Perception /Interest Criteria

Attribute – Environmental and Human Health	Public Perception
• Elevated incremental risk to human health, acute and/ or chronic • Possibility of life endangerment for community inhabitants and site personnel • Major reduction in social, cultural, economic value • Continuous non-compliance with international best practices • Any major public concern among population in the project region	High (5)
• Limited incremental risk to human health, acute and/ or chronic • Unlikely life endangerment for community inhabitants and site personnel • Some reduction in social, cultural, economic value • Possibility of adverse perception among population • Potential for non-compliance	Medium (3)
• No risk to human health, acute and/or chronic • No possibility of life endangered for community inhabitants and site personnel • Minor reduction in social, cultural, economic value • Unlikely adverse perception among population	Low (0)

5.7 Result of Impact Assessment

Detailed impact evaluations using the criteria mentioned in the previous section are presented in Table 5.7. The impacts for the short-term construction and decommissioning phases and the long-term operational phase were considered where appropriate.

Significant impacts (major, medium and minor) were obtained using this method and these are identified as those impacts to which the following conditions apply.

Major significance = ≥ 4 individual high ratings or 5 medium ratings or overall total of ≥ 15.

Medium significance = ≥2 and <4 individual high ratings or ≥3 medium ratings or overall total of between 10 and 15.

Minor significance = <2 individual high ratings or ≤2 medium ratings of overall total of ≤10

Table 5.8: Potential Impact Evaluation

Project Activities	Potential Impact	Impact Significance Evaluation					Significance Ranking
		Legal Requirement	Risk	Frequency	Importance	Perception	
Pre-Construction Phase							
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Employment opportunities arising from recruitment of workers	-	-	-	-	-	Beneficial
	Business opportunities for local contractors through sub-contracting activities	-	-	-	-	-	Beneficial
	Skill acquisition and enhancements to locals and future workforce	-	-	-	-	-	Beneficial
	Improvement in quality of life for adequately compensated individuals	-	-	-	-	-	Beneficial
	Conflicts/ community agitations over employment issues (quotas and methods)	High (5)	Med (3)	Med (3)	High (5)	High (5)	Major (21)
	Issues/ dispute on memorandum of understanding with project proponent	High (5)	Med (3)	Med (3)	High (5)	High (5)	Major (21)
	Influx of people (migrant workers, sub-contractors and suppliers) and increased pressure on existing social infrastructure	Med (3)	Med (3)	Med (3)	Medium (3)	High (5)	Major(17)
	Increase in social vices (like theft, prostitution) resulting from increased number of people in the area	Low (0)	High (5)	Low (0)	Med (3)	Med (3)	Medium (11)
	Community agitations over land disputes, wrong stakeholder identification, leadership tussles, etc.	High (5)	High (5)	Med (3)	High (5)	High (5)	Major (23)
	Loss of vegetation cover which is basically modified habitat consisting of bush fallows, and palm forest.	Med (3)	Med (3)	Low (0)	Med (3)	Med (3)	Medium (12)
	Increased risks of accidents leading to injury/ death and loss of asset during mobilisation	High (5)	Med (3)	Low (0)	High (5)	High (5)	Major (18)
	Risks of armed robbery attack and hostage taking leading to injury/ death of personnel	Low (0)	High (5)	Low (0)	Med (3)	Med (3)	Medium (11)

Table 5.8: Potential Impact Evaluation- cont'd

Project Activities	Potential Impact	Impact Significance Evaluation					Significance Ranking
		Legal Requirement	Risk	Frequency	Importance	Perception	
Pre- Construction Phase							
• Permitting • Community engagement • Recruitment • Mobilisation to site • Land preparation and clearing	Nuisance (noise and vibrations) from movement of heavy duty equipment and vehicles affecting site workers and wildlife	High (5)	Low (0)	Med (3)	Med (3)	Low (0)	Medium (11)
	Dust particles and vehicular emissions from increased movement	Med (3)	Low (0)	Med (3)	Med (3)	Med (3)	Medium (12)
	Generation of wastes such as scrap metal, wood, sand, concrete, paper, domestic waste etc.	High (5)	Med (3)	High (5)	Med (3)	Med (3)	Major (19)
	Contamination of surface water from siltation caused by increased erosion, during site preparation	Low (0)	Med (3)	Low (0)	Med (3)	Low (0)	Minor (6)
Construction and Installation Phase							
• Plant foundation works • Piling, trenching, etc. • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Risks of injury/ death and loss of assets resulting from accidents associated with road transportation to and from construction site	Med (3)	Med (3)	Low (0)	High (5)	High (5)	Major (16)
	Workplace accidents leading to injury or fatalities from burns, cuts, bruises, trips, falls from objects at height	High (5)	Med (3)	Med (3)	High (5)	High (5)	Major (21)
	Employment of local labour and skills acquisition for workers taking advantage of new opportunities	-	-	-	-	-	Beneficial
	Increased cash flow and stimulation of local economies within the host community	-	-	-	-	-	Beneficial
	Increased revenue opportunities for local population due to presence of non-resident workers and travellers	-	-	-	-	-	Beneficial
	Generation of dust and particles from heavy duty equipment usage	Med (3)	Med (3)	Med (3)	Med (3)	Low (0)	Medium (12)

Table 5.8: Potential Impact Evaluation- cont'd

Project Activities	Potential Impact	Impact Significance Evaluation					Significance Ranking
		Legal Requirement	Risk	Frequency	Importance	Perception	
Construction and Installation Phase							
• Plant foundation works • Piling, trenching, etc. • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Flora/ habitat loss and disturbance from vegetation clearing and earthworks within the power plant site	Med (3)	Medium (3)	Low (0)	Med (3)	Medium (3)	Medium (12)
	Fauna (birds, mammals etc.) disturbance and displacement as a result of migration away from construction activity areas	Med (3)	Low (0)	Med (3)	Med (3)	Med (3)	Medium (12)
	Soil/ groundwater contamination resulting from accidental leakages and spills of hazardous substances (diesel, petrol, cleaning agents, lubricants, hydraulic oil)	High (5)	High (5)	Med (3)	Med (3)	Low (0)	Major (16)
	Light traffic diversion and congestion along Ogorode road during installation and construction phase	Low (0)	Med (3)	Med (3)	Low (0)	Med (3)	Minor (9)
	Increased risks of accidents leading to injury/ death and loss of asset during mobilisation	Med (3)	Med (3)	Low (0)	High (5)	High (5)	Major (16)
	Potential collapse of power plant structures as a result of unsuitable geotechnical conditions	High (5)	Med (3)	Low (0)	High (5)	Med (3)	Major (16)
	Hazards from construction of base camp, gas pipeline and electric evacuation lines	Med (3)	Med (3)	Low (0)	High (5)	High (5)	Major (16)
	Cement dust and toxic fumes inhalation by onsite workers during foundation works and welding of plant components	High (5)	High (5)	Med (3)	High (5)	High (5)	Major (23)
	Risk of electrocution and burns during welding	High (5)	Med (3)	Low (0)	High (5)	Med (3)	Major (16)
	Noise nuisance (including impulsive noise) from construction activities (e.g. piling, digging) resulting to temporary migration of mammals and rodents	High (5)	Low (0)	Med (3)	Med (3)	Low (0)	Medium (11)
	Loss of aesthetic quality as a result of alterations to normal landforms from construction activities	Med (3)	Low (0)	Low (0)	Low (0)	Med (3)	Minor (6)

Table 5.8: Potential and Associated Impact Evaluation- cont'd

Project Activities	Associated and Potential Impact	Impact Significance Evaluation					Significance Ranking
		Legal Requirement	Risk	Frequency	Importance	Perception	
Construction and Installation Phase							
• Plant foundation works • Piling, trenching, etc. • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Risks of fire/ explosions resulting from accidental ignition of onsite petrol/ diesel storage tanks	High (5)	High (5)	Med (3)	High (5)	Med (3)	Major (21)
	Generation of wastes from construction activities such as scrap metal, wood, sand, concrete, paper, domestic waste, used oil etc.	High (5)	Med (3)	High (5)	Med (3)	Med (3)	Major (19)
Operational Phase							
• Testing and commissioning • Power generation • Power plant maintenance and servicing	Generation and addition of electricity supply to the national grid	-	-	-	-	-	Beneficial
	Increased business opportunities and quality of life (small, medium, large scale) due to enhanced power delivery	-	-	-	-	-	Beneficial
	Improvement in air quality due to reduced emission from privately owned diesel or petrol generators	-	-	-	-	-	Beneficial
	Reduced demand on petrol and diesel used for household power generation	-	-	-	-	-	Beneficial
	Injuries/ fatalities of personnel due to incidents/ accidents from operating the power plant	High (5)	Med (3)	Med (3)	High (5)	High (5)	Major (21)
	Greenhouse gas emission from natural gas used as feedstock	High (5)	Med (3)	Med (3)	Med (3)	Med (3)	Major (17)
	Air pollution from release of NO_x, CO_x, SO_x, and greenhouse gases from powered generating plants	High (5)	Med (3)	Med (3)	High (5)	Med (3)	Major (19)
	Soil/ groundwater contamination from accidental petrol /engine oil spill during refuelling of vehicle	High (5)	Risk (5)	Med (3)	Med (3)	Low (0)	Major (16)
	Thermal pollution from gas powered generating plants	Med (3)	Low (0)	Med (3)	Med (3)	Low (0)	Medium (9)

Table 5.8: Potential Impact Evaluation- cont'd

Project Activities	Potential Impact	Impact Significance Evaluation					Significance Ranking
		Legal Requirement	Risk	Frequency	Importance	Perception	
Operational Phase							
• Testing and commissioning • Power generation • Power plant maintenance and servicing	Workplace accidents/ incidents (cuts, trip, falls etc.) leading to injury/ death of personnel during operations	High (5)	Med (3)	Med (3)	High (5)	High (5)	Major (21)
	Acquisition of skills by individuals to be employed to operate the plant	-	-	-	-	-	Beneficial
	Exposure of workers to gas leaks (from boiler/ turbines) and excessive heat leading to burns and irritation	High (5)	Med (3)	Low (0)	High (5)	High (5)	Major (18)
	Exposure of workers to excessive noise from the power plant turbines	High (5)	Med (3)	Med (3)	Med (3)	Med (3)	Major (17)
	Depletion of surface and groundwater resources for cooling plants	Med (3)	Low (0)	Med (3)	Med (3)	Med (3)	Medium (12)
	Accidental explosion from gas leakage or nearby ignition that is resulting to fire outbreaks	High (5)	High (5)	Med (3)	High (5)	High (5)	Major (23)
Decommission Phase							
• Mobilisation of personnel and equipment • Power plant decommissioning • Abandonment / restoration	Loss of employment, business opportunities and decreased economic activity	Low (0)	Med (3)	Low (0)	Med (3)	High (5)	Medium (11)
	Reduced power generation to national grid and low power supply	Low (0)	Med (3)	Low (0)	High (5)	High (5)	Medium (13)
	Risks of injuries/ death to locals from collision with abandoned structures	Low (0)	Low (0)	Low (0)	Med (3)	Med (3)	Minor (6)
	Risk of accident and injury to workers during demolition of structures	High (5)	Med (3)	Med (3)	High (5)	High (5)	Major (21)
	Increased dust and vehicular emissions from decommissioning activities	Med (3)	Low (0)	Med (3)	Med (3)	Low (0)	Medium (9)
	Traffic obstruction on major roads from movement of vehicles during decommissioned process	Low (0)	Med (3)	Med (3)	Low (0)	Med (3)	Minor (9)
	Availability of land for alternative uses	-	-	-	-	-	Beneficial
	Loss of site aesthetic qualities due to abandoned and dilapidated structures	Med (3)	Low (0)	Low (0)	Med (3)	Med (3)	Minor (9)

5.8 Impacts Assessment Discussion

The identified, evaluated and ranked impacts are further discussed in this section. The impacts mentioned in the preceding sections for the proposed PEL power plant project are grouped into two (beneficial and adverse impacts).

The impacts are then discussed in line with the two major project phases; construction (merged with pre-construction phase) and operational phase (includes maintenance and decommissioning). Discussions made here are intended to provide an insight into the significance or otherwise of identified impacts.

5.8.1 Beneficial Impacts

The proposed project as mentioned in **Chapter Two, Section 2.2** is to be executed with the aim of adding electricity to the national grid for supply to households and commercial establishments. The benefits expected from the power plant grouped into the two project phases are as follows:

Construction Phase

The project benefits to stakeholders during pre-construction, construction and installation phases are as follows:

- Stimulate economic growth through local contractor participation in providing construction materials, equipment and services;
- Ensure social development through job creation (both direct and indirect);
- Increased economic activities in Ogorode community from influx of workers and visitors to the project site;

Operational Phase

Benefits accrued from project during operations include:

- Power plant to provide additional 500 MW electricity power upon completion to the national grid;
- Provide reliable power supply to reduce dependence on private power generators used by individuals and corporate bodies;
- Reduce thermal pollution associated with the use of private power generators;
- Demonstrate Federal Government’s commitment to improved electricity supply;
- Source of income to the government through royalties and tax revenue generation;
- Income for PEL from sales of power generated;
- Promote indigenous Nigerian investor-led independent power production;
- Promote secondary social development/ services such as healthcare and hospitals service delivery, etc.; and
- Support technology development through technical assistance and training for Nigerians as part of overall strategy of institutionalising local content in Nigeria's Energy Sector;

5.8.2 Adverse Impacts

The potential adverse impacts from project activities are grouped into the following subjects and discussed further:

- Impacts from equipment, personnel and plant material movement;
- Impacts from power plant emissions;
- Impacts from noise and vibration;
- Impacts on flora and fauna species;
- Impacts from waste generation;
- Impact on groundwater and soil quality;
- Impact on surface water quality;

- Impact on traffic;
- Visual/ aesthetic impact;
- Social economic impacts;
- Health impacts and
- Impacts from work place hazards.

Impacts from Equipment, Personnel and Plant Material Movement
In executing the proposed power plant project, a great deal of haulage/ movement would be undertaken all through the phases of the project by the project owners and stakeholders. Movements would include:

- Transportation of equipment and personnel during construction and operational phases; and
- Movement of plant components to project site for construction.

Construction Phase
As part of the construction phase, personnel and materials would be transported to site daily. Transportation could be from proponent arrangement or visitors to the site. Vehicles to be deployed for construction purposes would include saloon, sedan, SUVs and heavy vehicles (such as trucks, bulldozers, excavators, caterpillars etc.).

Movement of vehicles during this phase is important and cannot be avoided as such would impact significantly on the environment as well as on people living within the area in the following ways:

- Vehicular emission of pollutant gases (such as CO, SO_2 and NO_2) from car exhaust;
- Contribution to global gas warming and ozone layer depletion from pollutant gases emitted from vehicles;
- Increased traffic and road blocks from movement of heavy duty truck within Ogorode roads en-route project site;
- Potential accident to personnel and asset from vehicle movement during construction; and
- Dust emission arising from construction activities at the project site. Although, the potential for dust nuisance is unlikely at locations beyond 200m from the source except in the most extreme wind conditions.

PEL intends to commence construction phase by first quarter, 2016 and complete it by third quarter, 2017. This implies that the above-mentioned impacts are likely to occur for more about 21 months. The impact from equipment, personnel and plant material movement on surrounding receptors is therefore considered to be **major significant** prior to mitigation and steps will be taken to minimise the effects (see **Chapter Six**).

Operational Phase
At operational phase, there are unlikely to be any significant emissions of gases, dust or odour. This is because there will be relatively few vehicle movements associated with the operation of the facility (except for staff and visitor's movement). As a result, impacts associated with movement of equipment, personnel and plant materials during operations would be significantly reduced.

It should be noted that movement of personnel and materials would not hamper fishing activities and other water use. This is because from Sapele Town to the site is a dedicated road which passes through the community. This road would be used for transportation of all materials and equipment as such transportation using waterways is unlikely.

Impacts from Power Plant Air Emission

Emissions of air pollutants would occur from a wide variety of activities during the project development phases. Air emissions are categorised based on the origin or source of the emission (i.e. point sources, fugitive sources and mobile sources) and further, by process such as combustion and material storage. Air emissions may be in form of combustion gases; NO_x, SO_2 and CO from diesel engines (graders, trenchers, excavators, etc.), power generators and gas turbines or from fugitive emissions (in form of volatile organic carbon (VOC) and particulate matter (PM)).

Construction Phase

At installation and construction phases of the project, the potential sources of emissions would include dust, particulate matter (PM), emissions from heavy trucks and earthmoving equipment that will be operated on the site. Exhaust emissions during material transportation, stockpiling and equipment transfer during construction activities. These emissions will be localised to the construction site area and will be short-term, the extent of impact would therefore be **moderate and its significance low**.

Operational Phase

At operation phase, the power plant which will operate on natural gas is expected to release certain principal pollutants such as oxides of nitrogen (NO_x), and sulphur dioxide (SO_2). The concentrations of SO_2 will depend directly on the sulphur content of the fuel to be used.

Decommissioning activities may also generate emission of fugitive dust caused by a combination movement of air materials, machinery contact with soil, and exposure of bare soil and soil piles to wind. A secondary source of emissions may include exhaust from diesel engines of equipment used for dismantling.

Also, Sulphur hexafluoride, a potent greenhouse gas is contained in transformers used in power generation. Upon decommissioning, measures should be taken such that this gas is not released to the atmosphere, but be domesticated for other use (if possible).

Emissions from Natural Gas Combustion

Natural gas is a relatively clean fuel; however, emissions can occur from the plant combustion reaction process. Thus, improper operating conditions such as poor mixing, insufficient air, etc. may cause large amount of smoke, carbon monoxide and hydrocarbon to be produced. Also, where mercaptan (sulphur) containing compound is added to natural gas to permit detection, small amounts of sulphur oxides would be produced in the combustion process. Nitrogen oxides are the major pollutants of concern when burning natural gas. The emissions of nitrogen oxides are functions of combustion chamber temperature and combustion temperature cooling rate.

As a result of continuous, full load operation annual CO_2 emissions from the plant could be up to approximately 734,042 tonnes per annum.[12]

Baseline Air Quality Data

The baseline data obtained and reported in this study prior to construction phase have been assessed and found to be compliant to set regulatory limits (WHO/ IFC and FMEnv), see **section 4.4**, **pages 9** and **10.**

[12] This is based on Siemens 1 x SGT-800 Exhaust gas mas flow rate of 134.7 kg/s at 5.80% CO_2 by weight under 8700 operating hours per year.

Compared with the WHO guideline limits, the baseline data from the study area which comprise of both the residential areas and the project site were below the WHO limits to cause concern, except for particulate matter in the dry season. It is expected that as project activities commences, the amount of pollutant gases in the air would increase.

Air Emission Dispersion Modelling

Air emission dispersion modelling is a technique used for calculating concentrations of pollutants resulting from emission sources. A single equation is usually used to estimate air pollutant concentration at a single receptor from a single uncomplicated source.

The US EPA regulatory dispersion model AERMOD was used in the analysis of projected emission pattern and concentration for project emissions and cumulative impacts taking the ambient air quality standards used by the IFC and United States Environmental Protection Agency National Ambient Air Quality Standards (USEPA NAAQS) as benchmarks. Source parameters used in the modeling were based on equipment manufacturer information, engineering inputs of the power plant, and formulated assumptions (see Appendix 5.1).
Air quality modelling result demonstrates that the Proton Energy power plant will not cause or contribute to a violation of any applicable guideline or standard. Maximum impacts from the Proton Energy combustion turbines are less than 10% of applicable guidelines and standards for all pollutants and averaging times.

Key Parameters Considered

The input parameters for the PEL power plant air emission model are presented in **Table 5.9** below. The power plant type considered for the projection is the Open Cycle Gas Turbine (OCGT).

Table 5.9: OCGT Plant Design Specification

Components	Specification
No. of Units	3 (*)
Stack Height (in m)	18
Stack Internal Diameter (in m) at the exit	3.2
Stack Area (sqm m)	8
Flue gas temperature (^{O}C) at the exit	544
Flue gas velocity (m/s) at exit	20
SO_2 (ppm)	0.73
NO_X (ppm)	15

(*):-There are three stack units, but only one has been used in the model projection

Air pollutant emissions vary with source production rate and/or rate of fuel consumption. Hence, the quantities of the combustion products (particulates, SO_x, NO_x, CO and volatile organics) from the firing of natural gas and fuel oil in the proposed project stack were calculated using appropriate emission factors.

Buildings Downwash

Buildings or structures in the path of an emission plume cause aerodynamic turbulence and changes in wind patterns resulting in downwash (in “area of influence”). With the proposed stack height of 18m (with no buildings in the vicinity), downwash effect was not considered in the model calculations.

The model charts for the dispersion of NO_x and SO_2, emissions from the power plant is based on data obtained and inputted in the model software. The model calculations were performed for 10,000m (i.e. 10km) from the emission point, in compliance to IFC standards. IFC requires an assessment of air quality impacts to about 10 km from the proposed project site.

Nitrogen dioxide (NO_X)
Dispersion projection for nitrogen dioxide from the power plant during open cycle operation is presented in **Figure 5.2.**

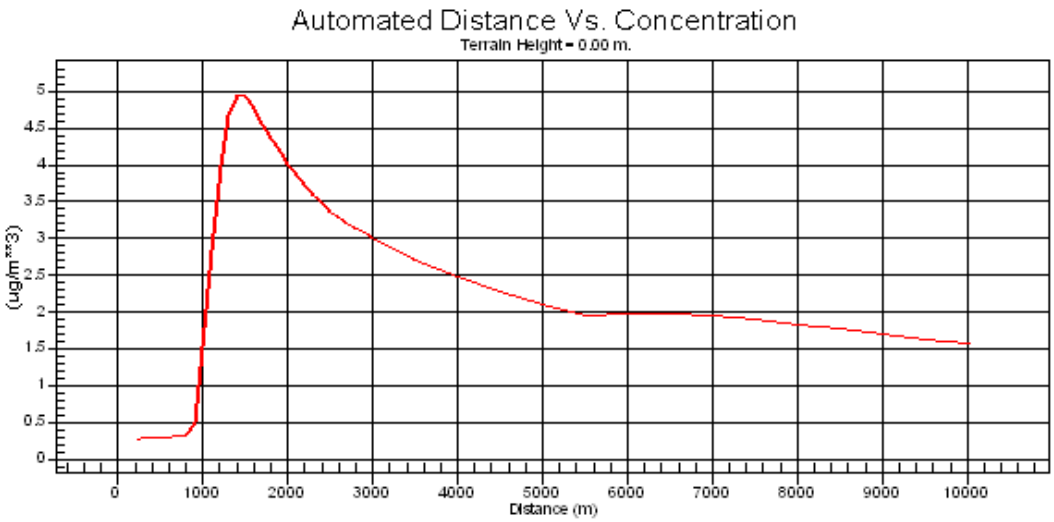


Figure 5.2: Projected NO_x Emission Pattern

The chart above indicates that the maximum NO_x concerntration is 5µg/m^3 and occurs at 1,500 meters (or 1.5 km) from the power plant stack. This point coincide with the location of Ogorode community. However, 5µg/m^3 (equivalent to 0.0024ppm) is lower than the FMEnv and WHO stipulated limit of 0.2ppm. NO_x concentration recorded is therefore negligible and decays progressively into the environment beyond 2 km.

Thermal Impacts from Power Plant
Thermal impacts can be from heat generation and exchange in turbine and compressor system or from air cooling system. Thermal impacts from the power plant will depend on a variety of factors, which include:

- The specification of gas used;
- Efficiency of combustion system;
- Operating temperature of the combustion turbines;
- Site conditions
- Closed cooling system;

Impacts from Noise and Vibration
Construction Phase
The primary short-term noise and vibration impacts are associated with construction and decommissioning activities. **Table 5.10** below presents noise levels of some construction equipment/ machinery that may likely to be used during construction.

Table 5.10: Typical Noise Levels of Construction Equipment

Equipment	Noise Level (dB(A)) from 50ft of Source
Cranes	83
Backhoes	80
Loaders	84

Dozers	85
Scrappers	89
Trenchers	97
Grader	85
Compactor	82
Concrete mixer	85
Jack Hammer	88
Saw	76
Shovel	82
Truck	88

Source: Workers Compensation Board Report, 2000

At a distance of 50 feets (equivalent to 15 meters), the above noise level from use of machinery is expected.

During site preparation and construction activities, work equipment will result in increased noise level and vibration in the area, although noise would not cause a major disturbance to the local inhabitants as Ogorode community is about 1.5 km away from the project site. However workers at the site and facilities closeby would be impacted.

Also, there would be increased noise level during site construction activities from movement of heavy trucks, earth moving equipment and other machinery, gas pipeline and evacuation laying, welding, etc. Noise may cause a major disturbance to fauna species such as birds and mammals in the area, who would move further into the forest.

Heavy construction equipment is the principal source of noise and vibration during construction activity, and the pattern would constantly change as construction progresses. For the most part, construction activity occurs during daytime hours when higher sound levels are generally more tolerable. In addition, any adverse noise impacts due to construction activities would be short term. There may also be some increases during transportation of materials, site preparation activities such as vegetation clearance and trench digging.

Operational Phase

For most gas-fired power plant, the major noise sources during operation are from; air-cooled condenser or cooling tower, steam turbine generator, combustion inlet filter house, exhaust stack, heat recovery steam generator, compressors, pumps and electric motors. During startup or other transient conditions in combined cycle configurations, the high-pressure steam piping and condenser is a major noise producer.

Gas turbine emit extreme levels of noise due to high horsepower output and high speed rotating blades. The major sources of noise are intake, exhaust and casing. Turbines typically have inlet and exhaust sound power levels ranging from 120dB to over 155dB. The inlet and exhaust noises are principally aerodynamic sources. High aerodynamic turbulence and combustion noises are present in the exhaust that is principally broadband in nature (Sonobex, 2015)

Noise impact during the operational phase of the project is expected to exceed the WHO/ IFC regulatory limit of 70dB (A), but would be controlled by installing noise reducing devices, see **Chapter Six**, page 10 of 11, row 2**.** Noise impact is placed as **medium** at construction but **major significant** at operation

Impact on Flora and Fauna Species

As discussed in **Chapter Four**, a number of diverse assemblages of organisms exist within the study area. Organisms observed in the area include mammals, birds, reptiles, amphibians etc.

Within the project AoI the habitat types cover both natural and modified habitat with the following specifc vegetation cover types; regenerating forests, palm forests, bush fallows, riparian forest and secondary rainforest.

The clearing of vegetation cover is planned to accommodate the power plant and ancillary structures. There would be loss of flora species in the site as well as migration of fauna species that make use of the plants for food and shelter further away into the forest.

It is expected that the project development activities will remove about 5.29 hectares of modified habitat (3.56 hectares of palm forest, 0.26 hectares of regenerating forest and 1.47 hectares of bush fallows) and its flora and fauna components. There were no critically endangered species identified within this zone. Outside the 6ha earmarked for the development, there is a mix of both modified and natural habitat types. The natural habitat type is the secondary rainforest which is on the western axis of the site and covers about 5.37 hectares, while a mix of regenerating forests and bush fallows constitute the other 15.7 hectares.

During early field visit, the small patches of grasses were observed to be used as food by cattle owned by nomadic herdsman within the project site (**Plate 5.1**). It should however be noted that these herdsmen move from place to place. Nomadic herdsmen seen grazing cattle within project site are Hausa-Fulani. As is their custom they move with their cattle from place to place based on the season and availability of green pasture. They do not possess any grazing rights in the project site and graze only where they have access. At the time of concluding the report, there was no nomadic or grazing activity within the project site.

Plate 5.1: Cattles Grazing within Project Site

Apart from clearing activities, noise from vehicle and heavy duty machinery use would cause noise and vibration which would scare fauna species away and further into the forest as was earlier mentioned. Generally, the impacts on flora and fauna species are termed **minor significant** considering the area of land to be cleared. PEL shall clear area required for the construction of Phase 1 of the power plant development as well as additional areas required for access to site.

Conservation and sustenance of flora around the direct development area will be maintained throughout the project life. Also, a perimeter fence would be constructed to restrict access to poachers.

Impacts from Waste Generation

As discussed in **Chapter Three**, **Section 3.13**, wastes from the project are grouped into solid wastes, liquid (wastewater) and air emissions. Solid wastes would include; wood, metals, food remains, glass, sand fill, refuse and spoil etc. Liquid wastes include sewage, waste chemicals and oily water, while gaseous air pollutants (NO_x, SO_x and CO) would be from exhausts of vehicles and power plant processes.

Solid Waste

Solid wastes generated can be hazardous or non-hazardous in nature. Improper handling of these wastes or their discharge into the surrounding environment without proper treatment would increase the level of micro-organisms (bacteria, viruses and fungi) that could be pathogenic to staff working in the area or to aquatic organisms.

Solid waste discharged into waterways may become marine debris, and pose as threat to marine organisms, coastal communities and industries that utilise marine waters. They can also injure or kill marine mammals, fish and birds from entanglement with plastics and other solid waste. PEL intends to manage these wastes by a combination of source reduction, waste minimisation, and recycling.

Liquid Wastes

Liquid wastes (wastewater) discharges contain a variety of substances that can cause pollution and they include detergents, oil and grease, organic compounds, hydrocarbons, nutrients, etc. Untreated greywater (sewage) from the plant facility during operation are known to contain strains of fecal coliform bacteria several times greater than is typically found in treated domestic sewage. Greywater has the potential to cause adverse environmental effects because of concentrations levels of nutrients and other oxygen-demanding materials it contains.

Gaseous Emissions

Air pollutant gases contribute to global emission load leading to global warming and increased green house effect. The use of aerosols during painting or spraying of plant components would also lead to the release of chlorofluorocarbons (CFCs), also a chief contributor to global warming.

Exhaust emissions from vehicles, diesel generator and plant stacks are a significant source of air pollution as mentioned earlier. The health effect of these air pollutants are presented below in **Table 5.11**. Direct and long exposure of air pollutants to workers may be potentially detrimental.

Table 5.11: Health Effect of Major Pollutants

Pollutants	Sources	Most Relevant Effects
Carbon Monoxide (CO)	Incomplete combustion of fuels or from gas turbines during plant operation	• Impairment of mental function in high concentration • Death at high levels of exposure • Aggravation of some heart diseases (angina)
Nitrogen oxide (NO_x)	Vehicle exhaust from gas turbines during plant operation	• Aggravation of respiratory illness • Reduced visibility • Formation of acid rain
Volatile Organic Compound (VOC)	Incomplete combustion of fuels of from gas turbines during plant operation	• Reduced lung function • Aggravation of respiratory and cardio respiratory diseases • Increased cough and chest discomfort

		• Reduced visibility • Cancer and premature death
Sulphur oxide (SO_x)	Combustion of sulfur-containing fossil fuels	• Aggravation of respiratory diseases (asthma, emphysema) • Reduced lung function • Irritation of eyes • Reduced visibility

Source: California Air Resources Board, 2002

Impact of waste discharge and gaseous emission on the environment are major significant especially when not properly managed. They could cause problem to aquatic life and human health. In **Chapter Six**, mitigation measures for the management of anticipated waste to prevent indiscriminate discharge or dumping are discussed.

Oil Spill and Diesel/ Lube Oil Leakage
Also to be considered is the possibility of oil spill and diesel/ lube oil leakage from vehicle, storage containers or from maintenance works. A major oil spill may not be possible but the possibility of oil spilling or leaking during transportation, loading and offloading is very high. Spill over time and not managed properly could accumulate and become an issue. It could lead to loss in aesthetic quality and a factor to fire incident.

Impact from waste generation is **medium to major significance** and should be treated with great priority.

Impact on Groundwater and Soil Quality
The operational phase of the project is expected to have effect or bearing on the water aquifer of the area and soil over time. Water for drinking and domestic use will be sourced from the ground using constructed boreholes. Over time the recharge rate of the water level beneath the soil may be disrupted. Although water depth observed for the area is relatively high ranging between 4.4 to 5.8 meters.

Also diesel and oil leakage from vehicle movement, stored oil, maintenance workshops and from plant turbine are likely to sip into the soil if not handled properly and may find its way to nearby river where they become nuisance. The possibility of this occurring is rather low, hence has been ranked **minor significant**.

Impact on Surface Water Quality
The Ethiope River (a freshwater body) happens to be the major river beside the project location and the existing CMEC/Eurafric facility (see **Plate 5.2**). Water from this source could be used to supplement water from boreholes after treatment for plant maintenance operations. The usage of the river for this purpose would not have a major impact on the organism living in it.

Plate 5.2: Existing Plant Facility View from Ethiope River

Any wastewater from such process will be discharged where necessary without exceeding surface water quality standards or using plant waste disposal system.
Wastes and hazardous discharges which could deplete oxygen content in aquatic medium leading to suffocation and possible death of organisms will be disposed offsite and treated prior to discharge. The river is home to a diverse population of aquatic fauna as captured in **Chapter Four**, and should be managed properly.

Impact on Traffic
It is envisaged that movement of personnel and equipment along the local road (Ogorode road) leading to the site would increase once the project commences. The road within the community is slightly busy during the day and as such may lead to intermittent traffic build up which may not last long with proper coordination.

Visual/ Aesthetic Impact
The project development will no doubt bring about change in visual look of the project site. If the structures are architecturally well-designed it could be aesthetically pleasing. On the other hand, if the project is partially developed and then abandoned, its visual impression could be negative. Project abandonment may also lead to resentment and frustration from community inhabitants and as such should not be considered.

Social Economic Impacts
Direct Impact
The major beneficial impact arising from the construction, installation and operation of the power plant is the number of jobs it would provide as has been discussed earlier. It is estimated that between 400 and 500 workers (skilled and unskilled) would be engaged during the construction phase of the project. Personnel with required skills would be employed and possibly trained further while unskilled personnel would be available for capacity increase.

Household income level within the host community is moderate. As much as 30% of those sampled earn between ₦35,100 and ₦50,000. It is expected that the project would subsequently lead to increase income levels of individual to be engaged by PEL.

On a national scale, the actualisation of this project would mean addition of electricity to the national grid and subsequent improvement in quality of life for Nigerians.

Considering the construction of access roads to the facility and clearing of land to be used for the power plant. It is expected that the farming and cattle grazing land will be lost thus causing a reduction in agricultural practices within the affected areas.

Indirect Impact
The project would also mean change in the quality of life for workers who are to be employed and source of income to contractors in the host communities who would seize the opportunity to provide services and goods to PEL or its workers. Families of these individuals are not left out, as they too will benefit in terms of change in lifestyle.

A key aspect of PEL activity in the area is to ensure continuous consultation with community members to avoid the following:

- Bitterness and hatred towards the government and/or for PEL;
- Lack of trust or confidence in future endeavours;
- Increased social vices such as armed robbery, theft etc. due to individuals not being recognised; and
- Youth restiveness and disturbance etc.

Issues such as job creation, settlement of conflict etc. between PEL and the communities would be settled through the grievance mechanism to be activated. The project will not result in any disruption or disturbance of other economic activities beyond those positive elements that are associated with the addition of power and job creation that will be directly and indirectly beneficial to the populace. No negative impacts on employment or economic activities are predicted to occur.

It should also be recognised that once operation commences, another group of individuals would emerge. There are those who would want to cash in on the workers. These groups are the commercial sex workers, miscreants, hoodlums etc. They may be camped outside the facility or stationed within the community and ready to interact with PEL personnel. Interactions of this nature often lead to increased rate of STDs and other communicable diseases in the area, theft and conflict.

PEL will develop a community relations and engagement plan that identifies fair strategies of engagement for all communities.

Health Impacts
As the project progresses, risks to the community may arise from inadvertent or intentional trespassing, including potential contact with hazardous materials, contaminated soils and other environmental media.

Increased incidence of communicable and vector-borne diseases attributable to construction and operational activities represents a potentially serious health threat to project personnel and residents of the community.

In the case of infection, residents and workers would contend with malaria, diarrheal diseases, RTI and STDs. In general, itinerant workers could be transmitters of these and other diseases. As has been commonly experienced in other places, construction work tends to attract commercial sex workers who also are a high-risk group in terms of transmitting STDs and HIV/AIDS. The magnitude and duration of work expected at the construction phase is such that this phenomenon could be expected.

Migrant project workers may have little or no resistance to prevalent diseases within the project area. Non-resident workers and their families may be quartered in camps with inappropriate living conditions. Additionally, social interactions between workers and the local community could lead to pregnancies with the attendant complications and problems of illegal abortions or orphanages. Enhancement of socio-economic status and health infrastructure can result in an improvement in public health care system.

Impacts from Work Place Hazards

Accidents or injuries to personnel during the project construction, installation and operation phases can occur if proper HSE awareness or supervisions are not carried out. The impact of such accidents/ injury is very significant; given the nature of the job which requires work team commitment. Injury of a person or group of people can easily bring resentment and possible temporary close of the project. This may lead to capital and time lost. Likely sources of accident and injury associated with the power plant project include:

- Loading and offloading of equipment for installation and construction purposes;
- Over-exertion, ergonomic injuries such as repetitive motion and manual tool handling;
- Paint spraying or removal leading to hazardous inhalation;
- Metal cutting and fabrication works;
- Trip and fall from elevated surfaces, ladders, scaffolds and gangways;
- During routine plant maintenance works:

- During oil and fuel removal and tank cleaning;
- Operations involving cranes, winch, lift;
- Cutting and welding operations that make use of compressed gas; and

Impact from work place hazards are placed **medium to major significance** ranking depending on the severity of the impact.

5.8.3 Cumulative Impacts

Cumulative impacts result from activities which may not be significant on their own, but are significant when added to impacts of other similar actives probably occurring simultaneously with the project. There are a few cumulative impacts expected in the proposed PEL Power Plant project as such affecting available resources or receptors. The impact(s) of the existing power plants has been considered at their present capacities and possible future expansions to assess the cumulative effect on the environment especially as regards air and noise conditions. A comprehensive and separate cumulative impacts assessment study modelling the two existing power plants and the proposed Proton Energy plant has been carried out and is attached in **Appendix 5.1**. Three scenarios were modelled:

- Scenario 1: Proton Energy Plant alone;
- Scenario 2: PEL plant and two existing plants operating at maximum capacity; and
- Scenario 3: PEL plant at 150 MW and two existing plants at more realistic five-year generation levels set by the Nigerian Electricity Regulatory Commission

Gaseous Emission

Air quality modelling result demonstrates that the Proton Energy power plant will not cause or contribute to a violation of any applicable guideline or standard. Maximum impacts from the Proton Energy combustion turbines are less than 10% of applicable guidelines and standards for all pollutants and averaging times. Cumulative impacts, even with all power plants operating at maximum capacity, are less than 50% of applicable guidelines and standards for all pollutants and averaging times.

Noise

The Brual & Kjaer's Predictor Version 10.10 noise modelling software was used to calculate noise emissions for all scenarios on nine (9) noise sensitive areas. The model incorporates identifiable noise source data, meterological data, surrounding terrain characteristics, and barrier effects of nearby buildings and structures. Noise modelling assessment on noise sensitive areas (NSAs) show that IFC night-time noise guideline of 45 db(A) is complied with in all NSAs under scenario 1, four out of nine receptors comply with the IFC night-time guideline for scenario 2, and all but two NSAs under the more likely cumulative scenario of scenario 3. Mitigation measures such as maintenance of positive community relations to keep public informed of construction and operation activities at instances were noise levels will be noticeably higher, and use of sound reducers has been proffered. The use of low-noise technology is expected to reduce the possibility of significant cumulative noise impact.

However, noise effect on people living in the community would be very low. This is because there no community residents within 760 m to the plants (however, a number of facilities occur within these distance). Changes in population density during the operational phase due to other developments and growth of the settlements may mean encroachment into areas where noise levels may be high. In this case, PEL will rely on communications with host community through the Community Liaison Officer (CLO) and use of the grievance redress mechanism (GRM) which will be established to record and address complaints.

Water Resources

Cumulative impacts here would come from all power plants in the area extracting water from similar water source. The plants have all been sited close to the Ethiope River for easy access to water for the respective plants. Although boreholes exist in the area, and PEL intends to drill more boreholes to collect water for domestic uses, the water extraction trend over time would be monitored. It should be noted that water is readily available in the area and as such the cumulative impact is assessed to be **negligible**.

Also, cumulative potential impacts from accidental spills, contamination and siltation are likely to occur but ranked **minor** with the implementation of mitigation measures.

Waste

The project will generate various types of wastes from various sources as the project progresses, resulting in the potential for the contamination of soil and water resources. Wastes will include spoil, excess concrete, wood, pigging waste, domestic/ office waste, sewage, waste water, machinery parts and building rubble.

A number of these wastes are already being generated by the existing CMEC/Eurafric and NIPP power plants. If not managed properly, could result to accumulation of wastes and contamination to the environment and personnel working.

CHAPTER SIX

IMPACT MITIGATION MEASURES

CHAPTER SIX

IMPACT MITIGATION MEASURES

6.1 General

This chapter presents the mitigation measures proffered for the associated and potential impacts of the proposed Proton Energy Power Plant project as captured in **Chapter Five**. A risk assessment matrix (**Figure 6.1**) was used to determine the mitigation requirements for each of the impacts identified. The frequency, severity, sensitivity, scale, longevity, political, economic, legal requirement, reputation and perception were factors taken into consideration during these assessments.

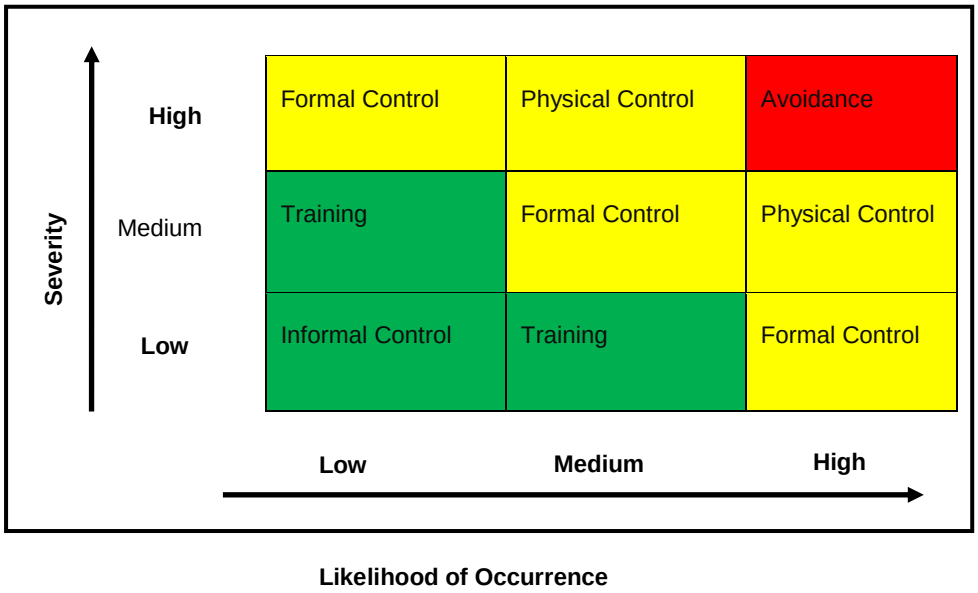


Figure 6.1: Matrix for Determination of Mitigation Measures

In determining the specific mitigation measures for each impact, the following were put into consideration:

- Available resources and competencies;
- On-site conditions; and
- Public concerns and available technology.

The classification of mitigation requirements (formal control, informal control, physical control, training and avoidance) are presented below.

Formal control
This involves the application of documented policy, process or procedures in mitigating the impacts from the proposed power plant project.

Informal Control
This involves the application of sound judgment and best practice in mitigating the impacts from the project.

Physical control
This involves the application of physical processes or instruments (such as pegs, flags, signage, post, barriers etc.), not necessarily requiring any special technology, in order to mitigate the impacts of the project.

Avoidance
This involves the modification of plans, designs or schedules in order to prevent the occurrence of an impact or impacts.

Training
This involves personnel awareness and improvement in specific/ specialised areas.

6.2 Mitigation Measures

The mitigation measures prescribed for identified impacts of the proposed project are presented in **Table 6.1** on the next page. Impacts being mitigated are those with significance rating (i.e. medium and major impacts).

Residual impacts are impacts that remain after mitigation measures have been applied or proffered. These impacts are usually given greater priority when project commences. Depending on the level of mitigation, residual impacts are further grouped into beneficial, minor and negligible.

Table 6.1: Mitigation Measures Proffered for Significant Impacts

Project Activities / Environmental Aspects	Potential Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation / Enhancement Measures	Residual Ranking
Pre-Construction Phase					
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Employment opportunities arising from recruitment of workers	Formal, informal control	Beneficial	PEL shall: • Ensure early stakeholders' engagement sessions are held, and all agreed issues properly documented and signed • Make transparent communication on hiring policies amongst local communities	Beneficial
	Business opportunities for local contractors through sub-contracting activities			PEL shall: • Ensure local suppliers and contractors implement local employment and local procurement policies to the benefit of host community • Continually encourage local contractors through the award of contracts, according to their competence levels • Carry out periodic review of jobs, supplies and contract awards • Ensure consultation throughout project life span	
	Skill acquisition and enhancements to locals and future workforce	Formal and training control	Beneficial	PEL shall: • Ensure employed staff are trained to develop local workforce capacity; • Make sure payment, royalties etc. are paid to benefiting individual as appropriate	Beneficial
	Improvement in quality of life for adequately compensated individuals	Formal and informal control			
	Conflicts/ community agitations over employment issues (quotas and methods)	Formal, informal control	Major	PEL shall: • Ensure early stakeholders' engagement sessions are held, and all agreed issues properly documented and signed • Due consultation of relevant groups within host community at all phases of the project • Ensure that its workers are briefed on the socio-cultural norms and sensitivity of the host communities • Explore ways of encouraging goodwill and friendly relationship between its workers/ service contractors and members of the community • Establish and publicise grievance procedure	Minor

Table 6.1: Mitigation Measures Proffered for Significant Impacts

Project Activities / Environmental Aspects	Potential Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation / Enhancement Measures	Residual Ranking
Pre-Construction Phase					
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Influx of people (migrant workers, sub-contractors and suppliers) and increased pressure on existing social infrastructure Increase in social vices (like theft, prostitution) resulting from increased number of people in the area	Informal and avoidance control	Major	PEL shall: • Provide additional accommodation where required for in-migrant workers • Ensure maximum recruitment of labour from within daily commuting distance from the project site • Encourage the use of local labour from resident community members • Create forums for the integration of immigrant employess with community norms to avoid clashes with locals • Adhere to the length of the construction program to reduce the stay of in-migrant employees where applicable • provide in the future infrastructural facilities in the area to ease pressure on the existing amenities/ infrastructure • Encourage personnel to participate in community development affairs • Ensure that workers are educated on health issues	Minor
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Community agitations over land disputes, wrong stakeholder identification, leadership tussles, etc. Issues/ dispute on memorandum of understanding with project proponent	Formal and informal control	Major	PEL shall: • Ensure early stakeholders' engagement sessions are held, and all agreed issues properly documented and signed • Provide opportunities for all groups (women, elders leaders etc.) to participate in consultations and ensure that all concerns are duly addressed	Minor
	Loss of vegetation cover which is basically modified habitat consisting of bush fallows, and palm forest.	Formal, physical and avoidance control	Medium	PEL shall: • Limit vegetation clearing and site preparatory activities to footpring earmarked for development; • Employ the services of biodiversity specialists to advise procedures on dispersing and transfer of mobile and non-mobile fauna species during land clearing • Prepare a biodiversity action plan to document monitoring and performance improvement measures to biodiversity resoures throughout project lifespan	Minor

	Increased risks of accidents leading to injury/ death and loss of asset during mobilisation	Formal, training and physical control	Major	• Develop and maintain an effective journey management schedule • Enforce speed limits of 100km/hr (major roads) 40-60km/hr (built-up areas) and 10-30km/hr (construction sites); • Ensure its drivers observe road traffic and speed limits • Make sure vehicle drivers undergo competency training on driving, and identification of road signs and traffic codes before mobilisation	Minor

Table 6.1: Mitigation Measures Proffered for Significant Impacts Cont'd

Project Activities / Environmental Aspects	Potential Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation / Enhancement Measures	Residual Ranking
Pre-Construction Phase					
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Increased risks of accidents leading to injury/ death and loss of asset during mobilisation	Formal, training and physical control	Major	PEL shall: • Use road signs at strategic points, sirens and public announcements where necessary to warn people of on-coming heavy duty vehicles • Ensure all its vehicles are certified roadworthy and in good maintenance state • Ensure night trips are avoided	Minor
	Risks of armed robbery attack and hostage taking leading to injury/ death of personnel	Informal and avoidance control	Medium	PEL shall: • Ensure a detailed security plan is developed and communicated to personnel • Make sure there is open communication with security operative in the area • Support local law enforcement agencies to combat crime	Minor
	Nuisance (noise and vibrations) from movement of heavy duty equipment and vehicles affecting site workers and wildlife	Formal avoidance, training and physical control	Medium	PEL shall: • Installing vibration isolation for mechanical equipment • Use equipment with low noise and vibration capacity • Ensure all personnel wear appropriate protective PPE such as earmuffs in area of high noise at work site • Conduct HSE awareness training routinely	Negligible
	Loss of livelihood because of reduction of land that could have been available for farming.		Major	PEL shall ensure Only land mapped out for the project is used for its purpose sustainably.	Minor
	Dust particles and vehicular emissions from increased movement	Formal and avoidance control	Medium	PEL shall: • Ensure site preparation and clearing are conducted in wet season • Maintain all its work equipment at optimal operating conditions • Minimise venting from vehicle and equipment using venturi or impingement scrubbers to control particulate matter emissions	Negligible

Table 6.1: Mitigation Measures Proffered for Significant Impacts Cont'd

Project Activities / Environmental Aspects	Potential Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation / Enhancement Measures	Residual Ranking
Pre-Construction Phase					
	Generation of wastes such as scrap metal, wood, sand, concrete, paper, domestic waste etc.	Formal, training and physical control	Major	PEL shall: • Make sure all waste generated are separated at source to enhance efficiency in waste handling and disposal • Ensure personnel working at site are trained in the handling and management of wastes • Treat and discharge all effluents (wastewater, sewage) in accordance to regulatory requirements and in line with PEL waste management procedure/ plan	Negligible
Construction and Installation Phase					
• Plant foundation works • Piling, trenching, etc. • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Risks of injury/ death and loss of assets resulting from accident associated with road transportation to and from construction site	Formal, training and physical control	Major	PEL shall: • Develop and maintain an effective journey management schedule • Ensure its drivers observe road traffic and speed limits • Make sure vehicle drivers undergo competency training on driving, and identification of road signs and traffic codes before mobilisation • Use road signs at strategic points, sirens and public announcements where necessary to warn people of on-coming heavy duty vehicles • Ensure all its vehicles are certified roadworthy and in good maintenance state • Ensure night movement are avoided	Minor
	Workplace accidents leading to injury or fatalities from burns, cuts, bruises, trips, falls from objects at height	Formal control	Major	PEL shall: • Ensure that HSE briefings are conducted prior to work commencement • Ensure personnel wear adequate PPE • Design work area to meet industrial standards recognizing all ergonomic factors • Encourage employees to maintain good house keeping	Minor

Table 6.1: Mitigation Measures Proffered for Significant Impacts – cont'd

Project Activities / Environmental Aspects	Potential Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Construction and Installation Phase					
• Plant foundation works • Piling, trenching, etc. • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Employment of local labour and skills acquisition for workers taking advantage of new opportunities Increased cash flow and stimulation of local economies within the host community Increased revenue opportunities for local population due to presence of non-resident workers and travelers	Formal and informal control	Beneficial	To enhance this beneficial impact, PEL shall • Retain some of the skilled and unskilled locals to encourage them in acquiring basic skill for self-sustenance • Encourage local contractors through the award of contracts as appropriate and following local content guidelines. • Periodically review local contracts to ascertain the right individuals are used • Create awareness workshop to enlighten beneficiary on ways to invest and use new income	Beneficial
	Generation of dust and particles from heavy duty equipment usage	Formal and avoidance control	Medium	PEL shall: • Ensure construction activities are conducted in wet season, when impact from dust is low • Maintain all its heavy-duty equipment at optimal operating conditions	Negligible
	Fauna (birds, mammals etc.) disturbance and displacement as a result of migration away from construction activity areas	Formal, physical and avoidance control	Medium	PEL shall: • Ensure that machinery, vehicles and equipment that produce high levels of noise should be avoided to reduce the overall impact. • Prepare a biodiversity action plan to document monitoring and performance improvement measures to biodiversity resoures throughout project lifespan	Minor
	Soil/ groundwater contamination resulting from accidental leakages and spills of hazardous substances (diesel, petrol, cleaning agents, lubricants, hydraulic oil)	Formal, training and physical control	Major	PEL shall: • Ensure that fuel storage facilities are leak-free and have bond wall protection • Ensure that only competent and trained personnel are used in handling fuel and chemicals • Hydrocarbon/chemical spill containment and prevention measures and equipment are functional and effective on site	Minor
	Increased risks of accidents to personel, community members and their property leading to injury/ death and damage to property during construction	Formal, training and physical control	Major	PEL shall: • Make sure vehicle drivers undergo competency training on driving, and identification of road signs and traffic codes before mobilisation • Use road signs at strategic points, sirens and public announcements where necessary to warn people of on-coming heavy duty vehicles • Ensure all its vehicles are certified roadworthy and in good maintenance state	Minor

Table 6.1: Mitigation Measures Proffered for Significant Impacts – cont'd

Project Activities / Environmental Aspects	Potential Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Construction and Installation Phase					
• Plant foundation works • Piling, trenching, etc. • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Potential collapse of power plant structures because of unsuitable geotechnical conditions	Formal and avoidance control	Major	PEL shall: • Carry out a comprehensive geotechnical study of the project site before construction works • Ensure geotechnical report provide all strength values and settlement potential required for adequate foundation design • Make use of experts with experience in plant design and construction	Negligible
	Hazards from construction of base camp, gas pipeline and electric evacuation lines	Formal, training and informal control		PEL shall: • Ensure personnel wear appropriate PPE (eye goggles, nose masks etc.) • Make use of competent and well trained personnel for construction works	
	Cement dust and toxic fumes inhalation by onsite workers during foundation works and welding of plant components	Formal and training control	Major	PEL shall: • Ensure personnel wear appropriate PPE (eye goggles, nose masks etc.) • Make use of competent and well trained personnel for construction works • Ensure periodic medical checks are carried out on personnel	Minor
	Risk of electrocution and burns during welding		Major	PEL shall: • Ensure strict adherence to standard work operations including the use of PPE (nose masks, hand gloves, etc.) are maintained as stated in the company's HSE policy • Ensure all electrical and welding equipment are maintained at optimal working conditions • Make sure first aid facility are in place at construction site	
	Noise nuisance (including impulsive noise) from construction activities (e.g. piling, digging) resulting to temporary migration of mammals and rodents	Formal, physical and avoidance control	Medium	PEL shall: • Make sure machinery, vehicles and equipment that produce high levels of noise are avoided • Personnel working with machinery, vehicles and instruments that produce high levels of noise should be supplied with ear plugs and ear muffs • Ensure construction works are avoided at night time • Maintain positive community relations to keep public informed of operational activities when noise levels will be noticeably higher	Negligible

Table 6.1: Mitigation Measures Proffered for Significant Impacts – cont'd

Project Activities / Environmental Aspects	Potential Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Construction and Installation Phase					
• Plant foundation works • Piling, trenching, etc. • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Risks of fire/ explosions resulting from accidental ignition of onsite petrol/ diesel storage tanks	Formal, training and physical control	Major	PEL shall: • Ensure that fuel storage facilities are leak-free and have bond wall protection • Ensure that only competent and trained personnel are used in handling fuel • Develop oil spill contingency plan for prompt clean up • Use booms and other spill containment equipment to ensure that incidental spills/leaks are promptly and adequately contained to prevent fire ignition • Provide fire prevention and fighting apparatus	Minor
	Generation of wastes from construction activities such as scrap metal, wood, sand, concrete, paper, domestic waste, used oil etc.	Formal, training and physical control	Major	PEL shall: • Make sure all waste generated are separated at source to enhance efficiency in waste handling and disposal • Ensure personnel working at site are trained in the handling and management of wastes • Treat and discharge all effluents (wastewater, sewage) in accordance to regulatory requirements and in line with PEL waste management procedure/ plan	Negligible
Operational Phase					
• Testing and commissioning • Power generation • Power plant maintenance and servicing	Generation and addition of electricity supply to the national grid	Formal and informal control	Beneficial	To enhance this beneficial impact, PEL shall • Ensure project is actualised and sustained as planned • Make sure power plant is maintained by professionals to allow for its continued existence • Encourage business growth and SME as appropriate in host community • Discourage locals from sabotage through direct education, newspaper publications, etc. • Proactively assist with the acquisition of new transformers in the host community to boost electricity supply in the area (if possible)	Beneficial
	Increased business opportunities and quality of life (small, medium, large scale) due to enhanced power delivery				
	Improvement in air quality due to reduced emission from privately owned diesel or petrol generators				
	Reduced demand on petrol and diesel used for household power generation				
	Greenhouse gas emissions from natural gas used as feedstock	Formal control	Major	PEL shall: • Ensure possible fugitive gas leakage are avoided • Carry out periodic maintenance test to determine possible leakages in the gas pipeline	Minor

Table 6.1: Mitigation Measures Proffered for Significant Impacts – cont'd

Project Activities / Environmental Aspects	Potential Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Operational Phase					
• Testing and commissioning • Power generation • Power plant • Maintenance and servicing	Injuries/ fatalities to personnel due to incidents/ accidents from operating the power plant	Formal, training and physical control	Major	PEL shall: • Make sure vehicle drivers undergo competency training on driving, and identification of road signs and traffic codes • Ensure adequate transportation system is provided for its personnel to limit number of vehicles • Ensure all its vehicles are certified roadworthy and in good maintenance state • Ensure upon start of operation, signage is erected across the plant site	Minor
	Thermal pollution from gas powered generating plants	Formal and avoidance control	Medium	• Use turbines with improved combustion efficiency and high engine performance • Design closed circuit air-cooling system	Negligible
	Air pollution from release of NO_x, CO_x, SO_x, and greenhouse gases from powered generating plants	Formal and avoidance control	Major	PEL shall: • Make use of dry low- NO_x combustors and natural gas with zero sulfur content • Make use of higher energy-efficient systems • Maintain plant system at optimal operating conditions	Minor
	Soil/ groundwater contamination from accidental petrol /engine oil spill during refueling of vehicle	Formal, training and physical control	Major	PEL shall: • Ensure that fuel storage facilities are leak-free and have bond wall protection • Ensure that only competent and trained personnel are used in handling fuel and chemicals • Use booms and other spill containment equipment to ensure that incidental spills/leaks are promptly and adequately contained to prevent fire ignition	Minor
	Workplace accidents/ incidents (cuts, trip, falls etc.) leading to injury/ death of personnel during operations	Formal control	Major	PEL shall: • Ensure that HSE briefings are conducted prior to work commencement • Ensure personnel wear adequate PPE while working in the plant • Design work area to meet industrial standards recognizing all ergonomic factors • Encourage employees to maintain good housekeeping within work site at all times	Minor

Table 6.1: Mitigation Measures Proffered for Significant Impacts – cont'd

Project Activities / Environmental Aspects	Potential Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Operational Phase					
• Testing and commissioning • Power generation • Power plant • Maintenance and servicing	Exposure of workers to gas leaks and excessive heat leading to burns and irritation	Formal and training control	Major	PEL shall: • Ensure that the turbines are protected from corrosion by maintaining design temperature ranges • Ensure personnel wear appropriate PPE (eye goggles, coverall, nose masks etc.) while at work • Make use of competent and well trained personnel for construction works • Make sure first aid facility are in place at construction site	Minor
	- Exposure of workers to excessive noise from the power plant operations - Exposure of community residents to high noise levels.	Formal and avoidance control	Major	PEL shall: • Make use of noise attenuators and suitable mufflers on plant stacks, engine exhausts and compressors • Ensure walls, roof, windows and doors within the facility have a high noise reduction rating • Ensure plant system are designed to meet WHO/ IFC noise limit for industrial area • Ensure plant areas with high noise are avoided • Ensure personnel working within turbine sections of the plant are supplied with ear plugs and ear muffs • Maintain positive community relations to keep public informed of operational activities when noise levels will be noticeably higher	Minor
	Depletion of surface and groundwater resources for plant operations	Formal control	Medium	PEL shall: • Ensure surface and groundwater levels are monitored to check status • Ensure water pumping and transmission mechanisms are maintained at optimal working conditions	Negligible
	Explosion from gas leakage or nearby ignition that result to fire outbreaks	Formal, training and physical control	Major	PEL shall: • Ensure that plant facilities are regularly checked and all leaks are timely rectified immediately • Ensure that only competent and trained personnel are used in plant operations • Use booms and other spill containment equipment to ensure that incidental spills/leaks are promptly and adequately contained to prevent fire ignition • Provide fire prevention and fighting apparatus in plant operating areas	Minor

Table 6.1: Mitigation Measures Proffered for Significant Impacts – cont'd

Project Activities / Environmental Aspects	Potential Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Decommission Phase					
• Mobilisation of personnel and equipment • Power plant decommissioning • Abandonment/ restoration	Loss of employment, business opportunities and decreased economic activity	Formal and informal control	Medium	PEL shall ensure: • The drafting and funding of a decommissioning plan for workers and the community. • As part of training and awareness programmes, local workers are adequately trained with skills to sustain livelihood. • That host communities are informed prior to decommissioning	Minor
	Reduced power generation to national grid and low power supply	Formal control	Medium	PEL shall ensure: • Plans are made for another plant to continue generating electricity	Minor
	Risk of accident and injury to workers during demolition of structures	Formal control	Major	PEL shall: • Ensure that HSE briefings are conducted prior to demolition activities • Ensure personnel wear adequate PPE while carrying out demolition • Encourage employees to maintain good housekeeping within work site • Make sure trees or shrubs are re-grown on project site to restore its original form	Minor
	Increased dust and vehicular emissions from decommissioning activities	Formal and physical control	Medium	PEL shall: • Ensure demolition activities are conducted after sprinkling of water to prevent dust build up • Ensure personnel wear adequate PPE (i.e. dust mask) while carrying out demolition • Maintain all its vehicles at optimal working conditions	Negligible
	Availability of land for alternative uses	Formal and Informal control	Beneficial	To enhance this impact, PEL shall: • Develop a detailed Decommissioning /Abandonment Plan ensure alignment of all stakeholders (state, local, community) • Clean all excavations to acceptable limits and have then backfilled • Remove all wall fences and structures as advised by the abandonment team • Clean contaminated soils to acceptable limit	Beneficial
	Loss of site aesthetic qualities due to abandoned and dilapidated structures	Formal and Informal control	Medium	Available structures and building not demolished should be used for other beneficial purposes to prevent decay	Negligible

CHAPTER SEVEN

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

CHAPTER SEVEN

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

7.1 General

This chapter presents the Environmental and Social Management Plan (ESMP) developed for the proposed Proton Energy Limited (PEL) Gas Powered Plant Project. The ESMP is essentially a management tool that provides assurance to PEL and regulators that mitigation measures developed for the significant impacts of the proposed project (as documented in **Chapter Six**), will be implemented throughout the project's life span. It also outlines management strategies for complying with health, safety and environmental issues from the project.

The management of PEL has documented goals and policies as part of this ESMP to achieve a conserved, safe and healthy environment. The ESMP provides assurance that a reliable scheme has been put in place to monitor the interaction between the planned operations and the environment throughout the duration of the project. This ESMP was developed in accordance with the general requirements of World Bank Standards, ISO 14001 Environmental Management System (EMS), Equator Principles as well as other national and international regulatory requirements.

7.2 ESMP Objectives and Guiding Principles

The main objective of the ESMP is to ensure that all significant impacts of the proposed project are either prevented or reduced to acceptable limits. Specifically, the ESMP will:

- Show that a systematic procedure to ensure that all project activities with regards to the environment are executed and managed in compliance with applicable legislation/ guidelines and relevant PEL policies;
- Ensure that all mitigation/ enhancement measures prescribed in the EIA document for eliminating or minimising all negative impacts of the project are fully implemented;
- Ensure that appropriate recovery preparedness is in place if control is lost during the implementation of the proposed project;
- Present an effective monitoring plan that would be used for assuring the effectiveness of mitigation measures and for identifying unforeseen impacts arising during the project; and
- Provide a feedback for continual improvement in environmental performance.

These objectives shall be achieved by:

- Ensuring compliance with all stipulated legislation on protection of the environment and with national and local environmental policies;
- Integrating environmental, health and social issues fully into the project development and operational philosophies;
- Promoting environmental, health and socio-economic awareness amongst workers and host community;
- Rationalising and streamlining existing environmental activities to add value to efficiency and effectiveness;
- Ensuring that only environmentally sound procedures are employed during the different project phases and associated activities;
- Continuous consultations with the relevant regulatory bodies (Federal Ministry of Environment, Delta State Ministry of Environment etc.), community leaders (family heads, landlords, etc.), women group, community based organisations (CBOs), and other stakeholders throughout the project lifecycle.

Constructive suggestions by PEL staff and stakeholders shall be assessed and evaluated by the PEL HSE Coordinator and integrated into the ESMP during review process as necessary.

7.3 Project Management and Responsibilities

The Project Associate
The PA shall be responsible for ensuring that all environmental standards and guidelines throughout the project life cycle are followed and implemented. The PA is also responsible for environmental operation, including environmental supervision of contractors through the Site Project Manager and HSE Officer. He shall ensure implementation of the environmental management plan during the project phases. The PA is also responsible for liaising with the relevant stakeholders as well as the local community members through a Community Liaison Officer to be appointed.

Site Project Manager
The overall management of the proposed power project from site preparation through construction, to operation and decommissioning is the sole responsibility of the Site Project Manager (SPM). The SPM supervises all activities during the project and reports to PEL management through the PA.

Engineering, Procurement and Construction
The Engineering, Procurement and Construction (EPC) Company that would eventually be selected between Siemen AG and General Electric would be PEL technical partner in the consortium and have deep understanding of the construction, installation and operation of power plants. They would supervise and ensure the successful execution and commissioning of the project.

Site Health, Safety Environmental Officer
The Site Health, Safety and Environmental (HSE) Officer is to report directly to the SPM. He/ she shall ensure that all safety, health and environmental policies and standards are kept and adhered to during the project execution. As a minimum, the Site HSE officer shall ensure all requirements of the ESMP are met. The designated HSE Officer may, at his/ her discretion, stop any work, activity or process not in accordance with directives of PEL.

Federal Ministry of Environment
The Federal Ministry of Environment (FMEnv) is saddled with the responsibility of enforcing national and international environmental laws which Nigeria subscribed to. As part of this project, the FMEnv would:

- serve as a regulatory oversight body in the implementation of this ESMP;
- in coordination with the Delta State Ministry of Environment ensure that PEL periodically make available, documentations in form of monthly/quarterly reports or as may be designed in the monitoring plan in **section 7.4.12**;
- require PEL to show evidences of caring out monitoring requirements, etc.

PEL shall work closely with the Federal and State Ministry of Environment to ensure that all environmental standards are upheld as agreed. PEL shall conduct her business according to the standards stipulated. The company's implementation organogram defining the general line of authority in PEL is presented overleaf as **Figure 7.1**.

7.4 ESMP Safeguard Guidelines

Mitigation measures are proffered for all significant impacts of the proposed power plant project to avoid, minimize or reduce expected impacts to as low as reasonably practicable (ALARP). To ensure these measures are achieved, responsibilities have been assigned for each task as presented in **Table 7.1**.

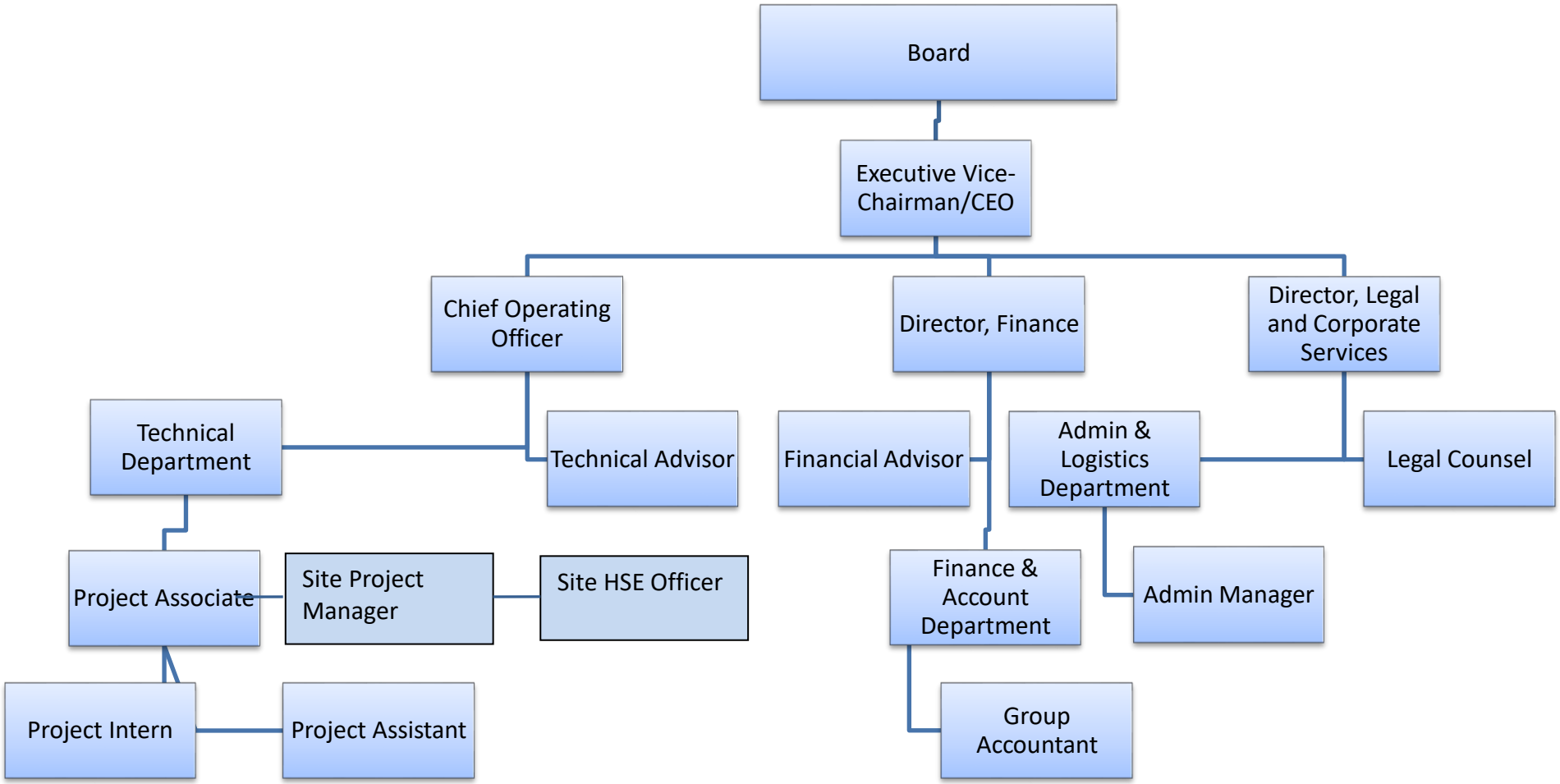


Figure 7.1: Company Organisational Structure

Table 7.1: ESMP Guidelines for the Proposed Power Plant Project

Project Activities / Environmental Aspects	Potential Impacts	Mitigation / Enhancement Measures	Responsible Parties	Estimated Cost (USD)
Pre-Construction Phase				
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Employment opportunities arising from recruitment of workers	PEL shall: • Ensure early stakeholders' engagement sessions are held, and all agreed issues properly documented and signed • Make transparent communication on hiring policies amongst local communities	PEL Management/ EPC Manager	Cost of training programmes approximately 13,000 USD over construction period
	Conflicts/ community agitations over employment issues (quotas and methods)	PEL shall: • Ensure early stakeholders' engagement sessions are held, and all agreed issues properly documented and signed • Due consultation of relevant groups within host community at all phases of the project • Ensure that its workers are briefed on community engagements and security. • Explore ways of encouraging goodwill and friendly relationship between its workers/service contractors and members of the community • Establish and publicise grievance procedure	PEL Management/ Community Liaison Officer	Salary cost to CLO (approximately 15,000 USD per annum
	Influx of people (migrant workers, sub-contractors and suppliers) and increased pressure on existing social infrastructure Increase in social vices (like theft, prostitution) resulting from increased number of people in the area	PEL shall: • In the future construct infrastructural facilities in the area to ease pressure on the existing amenities/ infrastructure • Encourage personnel to participate in community development affairs • Ensure that workers are educated on health issues	PEL Management / Site Project Manager/ Community Liaison Officer	Cost of upgrade of basic services will vary according to infrastructure type, and PEL will setup a Foundation with community partnership
	Community agitations over land disputes, wrong stakeholder identification, leadership tussles, etc.	PEL shall: • Ensure early stakeholders' engagement sessions are held, and all agreed issues properly documented and signed • Transparent communication of hiring policies amongst local communities	PEL Management/Community Liaison Officer	Part of CLO's duties and normal operation

	Loss of vegetation cover which is basically modified habitat consisting of bush fallows, and palm forest.	• Limit vegetation clearing and site preparatory activities to footpring earmarked for development; • Employ the services of biodiversity specialists to advise procedures to dispersing and transfer of mobile and non-mobile fauna species during land clearing Prepare a biodiversity action plan to document monitoring and performance improvement measures to biodiversity resoures throughout project lifespan	PEL HSE Officer	Cost for hiring a biodiversity monitoring specialist (during site preparation and construction is about 5,000USD

Table 7.1: ESMP Guidelines for the Proposed Power Plant Project- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation / Enhancement Measures	Responsible Parties	Estimated Cost (USD)
Pre-Construction Phase				
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Increased risks of accidents leading to injury/ death and loss of asset during mobilisation	PEL shall: • Develop and maintain an effective journey management schedule • Enforce speed limits of 100km/hr (major roads) 40-60km/hr (built-up areas) and 10-30km/hr (construction sites); • Make sure vehicle drivers undergo competency training on driving • Use road signs at strategic points, sirens and public announcements where necessary to warn people of on-coming heavy duty vehicles • Ensure all its vehicles are certified roadworthy and in good maintenance state • Ensure night trips are avoided	Site Project Manager/ Site HSE Officer	Part of HSE Officer's duties
	Risks of armed robbery attack and hostage taking leading to injury/ death of personnel	PEL shall: • Ensure a detailed security plan is developed and communicated to personnel • Make sure there is open communication with security operative in the area • Support local law enforcement agencies to combat crime	Site Project Manager/ Site Security Officer	Part of normal operation
	Nuisance (noise and vibrations) from movement of heavy duty equipment and vehicles affecting site workers and wildlife	PEL shall: • Maintain all its work equipment at optimal operating conditions • Make use of equipment with low noise and vibration capacity • Ensure all personnel wear appropriate protective PPE such as earmuffs in area of high noise at work site • Conduct HSE awareness training routinely • Maintain positive community relations to keep public informed of operational activities when noise levels will be noticeably higher	Site HSE Officer	Part of HSE Officer's duties

	Dust particles and vehicular emissions from increased movement	PEL shall: • Ensure site preparation and clearing are conducted in wet season • Maintain all its work equipment at optimal operating conditions • Minimise venting from vehicle and equipment through the use of venturi or impingement scrubbers to control particulate matter emissions		

Table 7.1: ESMP Guidelines for the Proposed Power Plant Project- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation / Enhancement Measures	Responsible Parties	Estimated Cost (USD)
Construction and Installation Phase				
• Plant foundation works • Piling, trenching, etc. • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Generation of wastes such as scrap metal, wood, sand, concrete, paper, domestic waste etc.	PEL shall: • Make sure all waste generated are separated at source to enhance efficiency in waste handling and disposal • Ensure personnel working at site are trained in the handling and management of wastes • Treat and discharge all effluents (wastewater, sewage) in accordance to regulatory (FMEnv and DPR) requirements and in line with PEL waste management procedure/ plan	Site HSE Officer	Part of HSE Officer's duties; cost associated with the identification and inspection of waste generated is approximately 2000 USD over the recorded monitoring frequency during construction
	Risks of injury/ death and loss of assets resulting from accident associated with road transportation to and from construction site	PEL shall: • Develop and maintain an effective journey management schedule • Ensure its drivers observe road traffic and speed limits • Make sure vehicle drivers undergo competency training on driving, and identification of road signs and traffic codes before mobilisation • Ensure all its vehicles are certified roadworthy and in good maintenance state	Site Project Manager/ Site HSE Officer	Part of HSE Officer's duties
	Workplace accidents leading to injury or fatalities from burns, cuts, bruises, trips, falls from objects at height	PEL shall: • Ensure that HSE briefings are conducted prior to work commencement • Ensure personnel wear adequate PPE • Design work area to meet industrial standards recognizing all ergonomic factors • Encourage employees to maintain good house keeping	Site HSE Officer	Part of HSE Coordinator's duties

	Generation of dust and particles from heavy duty equipment usage	PEL shall: • Ensure construction activities are conducted in wet season • Maintain all its heavy duty equipment at optimal operating conditions		

Table 7.1: ESMP Guidelines for the Proposed Power Plant Project- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation / Enhancement Measures	Responsible Parties	Estimated Cost (USD)
Construction and Installation Phase				
• Plant foundation works • Piling, trenching, etc. • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Fauna (birds, mammals etc.) disturbance and displacement as a result of migration away from construction activity areas	PEL shall: • Ensure that machinery, vehicles and equipment that produce high levels of noise should be avoided to reduce the overall impact. • Prepare a biodiversity action plan to document monitoring and performance improvement measures to biodiversity resoures throughout project lifespan	Site HSE Officer	Part of HSE Officer's duties Part of normal operation
	Soil/ groundwater contamination resulting from accidental leakages and spills of hazardous substances (diesel, petrol, cleaning agents, lubricants, hydraulic oil)	PEL shall: • Ensure that fuel storage facilities are leak-free and have bond wall protection • Ensure that only competent and trained personnel are used in handling fuel and chemicals • Hydrocarbon/chemical spill containment and prevention measures and equipment are functional and effective on site		
	Increased risks of accidents to personnel, community members and their property, leading to injury/ death and damage to property during construction	PEL shall: • Make sure vehicle drivers undergo competency training on driving, and identification of road signs and traffic codes before mobilisation • Use road signs at strategic points, sirens and public announcements where necessary to warn people of on-coming heavy duty vehicles • Ensure all its vehicles are certified roadworthy and in good maintenance state	Site Project Manager/ Site HSE Officer	Part of HSE Officer's daily duties
	Potential collapse of power plant structures as a result of unsuitable geotechnical conditions	PEL shall: • Carry out a comprehensive geotechnical study of the project site before construction works • Ensure geotechnical report provide all strength values and settlement potential required for adequate foundation design • Make use of experts with experience in plant design and construction	Site Project Manager/ EPC Manager	Cost of geotechnical tests will be part of normal operation carried out by EPC Contractor prior to construction

Table 7.1: ESMP Guidelines for the Proposed Power Plant Project- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation / Enhancement Measures	Responsible Parties	Estimated Cost (USD)
Construction and Installation Phase				
• Plant foundation works • Piling, trenching, etc. • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Cement dust and toxic fumes inhalation by onsite workers during foundation works and welding of plant components	PEL shall: • Ensure personnel wear appropriate PPE (eye goggles, nose masks etc.) • Make use of competent and well trained personnel for construction works • Ensure periodic medical checks are carried out on personnel	Site HSE Officer	Part of HSE Officer's duties
	Hazards from construction of base camp, gas pipeline and electric evacuation lines			
	Risk of electrocution and burns during welding	PEL shall: • Ensure strict adherence to standard work operations including the use of PPE (nose masks, hand gloves, etc.) are maintained as stated in the company's HSE policy • Ensure all electrical and welding equipment are maintained at optimal working conditions • Make sure first aid facility are in place at construction site		
	Noise nuisance (including impulsive noise) from construction activities (e.g. piling, digging) resulting to temporary migration of mammals and rodents	PEL shall: • Make sure machinery, vehicles and equipment that produce high levels of noise are avoided • Personnel working with machinery, vehicles and instruments that produce high levels of noise should be supplied with ear plugs and ear muffs • Plan work activities to avoid heavy duty movement during peak hours • Ensure construction works are avoided at night time • Maintain positive community relations to keep public informed of operational activities when noise levels will be noticeably higher	Site HSE Officer/ EPC Manager	Cost associated with monitoring of noise levels at receptors approximately 450 USD per month
	Risks of fire/ explosions resulting from accidental ignition of onsite petrol/ diesel storage tanks	PEL shall: • Ensure that fuel storage facilities are leak-free and have bond wall protection • Ensure that only competent and trained personnel are used in handling fuel • Develop oil spill contingency plan for prompt clean up • Use booms and other spill containment equipment to ensure that incidental spills/leaks are promptly and adequately contained to prevent fire ignition • Provide fire prevention and fighting apparatus	Site HSE Officer/ EPC Manager	Oil spill prevention and management will be part of normal plant operation

Table 7.1: ESMP Guidelines for the Proposed Power Plant Project- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation / Enhancement Measures	Responsible Parties	Estimated Cost (USD)
Construction and Installation Phase				
• Plant foundation works • Piling, trenching, etc. • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Generation of wastes from construction activities such as scrap metal, wood, sand, concrete, paper, domestic waste, used oil etc.	PEL shall: • Make sure all waste generated are separated at source to enhance efficiency in waste handling and disposal • Ensure personnel working at site are trained in the handling and management of wastes • Treat and discharge all effluents (wastewater, sewage) in accordance to regulatory (FMEnv and DPR) requirements and in line with PEL waste management procedure/plan	Site HSE Officer	Cost associated with the identification and inspection of waste generated is approximately 2000 USD; cost of monitoring of levels, sampling and laboratory analysis approximately 800 USD per setup and 4500 USD per analysis
Operational Phase				
• Testing and commissioning • Power generation • Power plant • Maintenance and servicing	Injuries/ fatalities to personnel due to incidents/ accidents from operating the power plant	PEL shall: • Make sure vehicle drivers undergo competency training on driving, and identification of road signs and traffic codes • Ensure a dedicated transport system is provided for its personnel to limit number of vehicles • Ensure all its vehicles are certified roadworthy and in good maintenance state	Site HSE Officer	Part of normal operations
	Greenhouse gas emissions from natural gas used as feedstock	PEL shall: • Ensure possible fugitive gas leakage are avoided • Carry out periodic maintenance test to determine possible leakages in the gas pipeline		
	Thermal pollution from gas powered generating plants	PEL shall: • Use steam turbines with boilers and heat recovery steam generators • Design closed circuit re-circulating cooling system	PEL Management/ EPC Manager/ Site Project Manager	Part of normal operations
	Air pollution from release of NO_x, CO_x, SO_x, and greenhouse gases from powered generating plants	• Make use of dry low- NO_x combustors and natural gas with zero sulfur content; • Make use of higher energy-efficient systems • Maintain plant system at optimal operating conditions		

Table 7.1: ESMP Guidelines for the Proposed Power Plant Project- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation / Enhancement Measures	Responsible Parties	Estimated Cost (USD)
Operational Phase				
• Testing and commissioning • Power generation • Power plant • Maintenance and servicing	Soil/ groundwater contamination from accidental petrol /engine oil spill during refueling of vehicle	PEL shall: • Ensure that fuel storage facilities are leak-free and have bond wall protection • Ensure that only competent and trained personnel are used in handling fuel and chemicals • Use booms and other spill containment equipment to ensure that incidental spills/leaks are promptly and adequately contained to prevent fire ignition	Site HSE Officer	Part of HSE Officer's duties
	Workplace accidents/ incidents (cuts, trip, falls etc.) leading to injury/ death of personnel during operations	PEL shall: • Ensure that HSE briefings are conducted prior to work commencement • Ensure personnel wear adequate PPE while working in the plant • Design work area to meet industrial standards recognizing all ergonomic factors • Encourage employees to maintain good housekeeping within work site at all times		Part of HSE Officer's duties
	Exposure of workers to gas leaks and excessive heat leading to burns and irritation	PEL shall: • Ensure thatturbines are protected from corrosion by maintaining design temperature ranges • Ensure personnel wear appropriate PPE (eye goggles, coverall, nose masks etc.) while at work • Make sure first aid facility are in place at construction site	Site HSE Officer	As part of normal operations
	Exposure of workers to excessive noise from the power plant turbines Exposure of community residents to high noise levels	PEL shall: • Plant areas with high noise should be avoided • Ensure personnel working within turbine sections of the plant are supplied with ear plugs and ear muffs • Maintain positive community relations to keep public informed of operational activities when noise levels will be noticeably higher.		Part of HSE officer's duties
	Depletion of surface and groundwater resources for plant operation	PEL shall: • Monitor and control the use of water to reduce wastages • Ensure all water pumping and transmission mechanisms are maintained at optimal working conditions • Ensure surface and groundwater levels are monitored to check status		Cost of monitoring of levels, sampling and laboratory analysis approximately 800 USD per setup and 4500USD per analysis

Table 7.1: ESMP Guidelines for the Proposed Power Plant Project- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation / Enhancement Measures	Responsible Parties	Estimated Cost (USD)
Operational Phase				
• Testing and commissioning • Power generation • Power plant • Maintenance and servicing	Accidental explosion from gas leakage or nearby ignition that result to fire outbreaks	PEL shall: • Ensure that plant facilities are properly checked and all leaks are reported and rectified immediately • Ensure that only competent and trained personnel are used in plant operations • Use booms and other spill containment equipment to ensure that incidental spills/leaks are promptly and adequately contained to prevent fire ignition • Provide fire prevention and fighting apparatus in plant operating areas	Site Project Manager/ Site HSE Officer	Part of normal operation
Decommissioning Phase				
• Mobilisation of personnel and equipment • Power plant decommissioning • Abandonment/ restoration	Loss of employment, business opportunities and decreased economic activity	PEL shall ensure: • As part of training and awareness programmes, local workers are adequately trained with skills to sustain livelihood.That host communities are informed prior to decommissioning	PEL Management/ Site Project Manager	Cost of re-training programmes for workers and community participants approximately 12,000 USD
	Reduced power generation to national grid and low power supply	PEL shall ensure: • Plans are made for another plant to continue generating electricity	PEL Management	Part of normal operation
	Risk of accident and injury to workers during demolition of structures	PEL shall: • Ensure that HSE briefings are conducted prior to demolition activities • Ensure personnel wear adequate PPE while carrying out demolition • Encourage employees to maintain good housekeeping within work site • Make sure trees or shrubs are re-grown on project site to restore its original form	Site HSE Officer	Part of HSE Officer's duties
	Increased dust and vehicular emissions from decommissioning activities	PEL shall: • Ensure demolition activities are conducted after sprinkling of water to prevent dust build up • Ensure personnel wear adequate PPE while carrying out demolition • Maintain all its vehicles at optimal working conditions		

As part of the Environmental and Social Management Plan for the project, the following guidelines have been developed by PEL to meet both national (FMEnv) and international (World Bank/ IFC) requirements.

7.4.1 Training and Awareness Plan

At the construction phase of the project, the following environmental awareness and trainings programs shall be conducted:

Induction Training

An induction training program shall be a requirement for every construction worker to be engaged in the project and shall be provided by the contractors. The training shall include:

- the proposed tasks for new workers;
- safe work procedures;
- use of personal protective equipment;
- emergency responses and warning notices;
- personal hygiene and site sanitation issues;
- environmental protection; and
- hazard recognition and incident reporting.

Weekly Safety and Environmental Forum

There shall be a weekly environmental and safety awareness forum for construction workers during the construction activities at the project site. PEL shall be responsible for coordinating these meetings.

At the operation phase of the project, PEL shall educate all its workers on environment, health, and safety issues using the following means to disseminate information to staff and workers:

- staff and workers' meetings;
- local area network (intranet)/ the internet; and
- annual bulletins on PEL operations.

7.4.2 Public Participation/ Involvement Plan

PEL shall welcome suggestions and information from relevant stakeholders, contractors, visitors and the public, which would help improve its operations in order to minimise impact on the environment and worker health and safety. The office of the Site Manager/ Community Liaison Officer shall be open to the public for complaints and suggestions.

Complaints received from the public shall be documented and follow-ups made to ensure that such grievances are addressed accordingly and in line with the PEL grievance redress mechanism as indicated below. A grievance or compliant register would be developed for this purpose.

Project Grievance Mechanism Approach

Grievances are feedback, responses or complaints concerning the way a project is being handled or managed. A grievance mechanism provides a formal and ongoing avenue for stakeholders to engage with the project proponent. Grievance monitoring allows for early warning or signals of any escalating conflicts or disputes. Identifying and responding to grievances supports the development of positive relationships between the proponent and the community, and other stakeholders.

An effective grievance management process should include the following components:

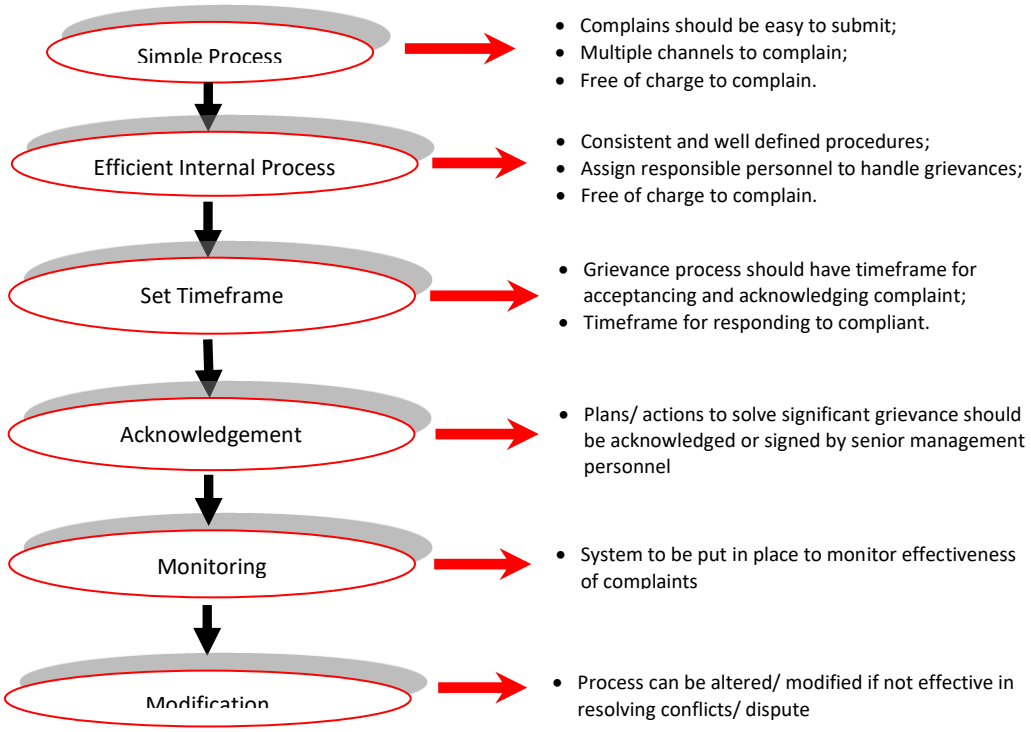


Figure 7.2: Effective Grievance Mechanism Components

According to IFC PS 2 and PS 4, it is expected that projects implement a Grievance Mechanism, in order to accommodate any grievances, complaints or concerns that stakeholders may have.

PEL plans to employ a Community Liaison Officer (CLO) who will serve to meet all community liaison responsibilities and related assignment. He would also ensure the effectiveness and implementation of the grievance mechanism. The grievance mechanism will be advertised and announced to affected stakeholders so that they are aware of their rights to submit comments.

Proton Energy will ensure that all workers engaged by the project directly or by contractors and sub-contactors are aware and have access to the grievance mechanism. It will be the responsibility of the Human Resources Officer in this case to oversee the employee grievance mechanism.

Beyond an active stakeholders' grievance management mechanism, PEL and the project contractor shall ensure adequate information disclosure, engage in stakeholder consultations on key project activities, and implement a stakeholder involvement in project monitoring. Procedures for ensuring adequate and effective stakeholder engagement over the project lifecycle shall be detailed in a Stakeholders' Engagement Plan.

Consultations

PEL recognises the importance of consultations in all phases of the proposed power plant project. This is because it involves soliciting people's views on proposed actions and engaging them in a dialogue. It is characterised by a two-way information flow, from the PEL to people/ stakeholders, authorities, and from people to the PEL. The overall aim of the consultation plan for the proposed project therefore, is addressing the concerns and opinions of the stakeholders with the ultimate view to assuring a smooth project implementation.

While the Federal Government, Delta State Government and Proton Energy Limited retain

decision-making authority, interaction with people and eliciting feedback allows the affected populations to influence the decision-making process by raising issues that should be considered in scoping; project design; mitigation; monitoring and management plans; and the analysis of alternatives. The overall result would be the optimisation of the potentials of the proposed project and maximisation of its benefits.

Consultations, which began during the EIA process, shall continue throughout the project life cycle and shall be by way of:

- Visits and courtesy calls on the community leaders and other stakeholders to discuss the effectiveness of the addressed social issues on the lives of the people;
- Direct visits to the affected communities to consider (through questionnaires, interviews and visual observations) their opinions on the social acceptability and environmental soundness of the project;
- Organising large public meetings (participatory rural appraisal) to discuss public welfare, clarify misconceptions and address new issues about the project;
- Holding workshops and extension courses on resource management (using simply written materials, visual representation, videos and scale models to decode technical languages) and sensitising the indigenous people on the latest impact mitigation techniques; and
- Organising public seminars aimed at identifying new ways of rendering socio-economic assistance for the local people.

Influx Management Plan

As required by the IFC for projects of this scale, Proton Energy shall seek to monitor all forms of project induced in-migration to avoid unplanned and unmanaged, as well as mitigate and manage any adverse impacts caused by the power plant development, whilst promoting and enhancing positive impacts related to in-migration that occurs.

The Influx Management Plan is expected to be a living tool, reviewed periodically over the life of the project – from construction to decommissioning. The project is expected to result in direct or indirect change in population as a result of influx of in-migrant workers and retailers during the project. This may be because of the “pull factor” from the need to hire labour especially during the construction phase. Thus, in-migrants and their families will place demands on already existing services provided by local authorities, health authorities, educational bodies’ accommodation available and all other authorities present in the community.

A critical step in the management of influx into the project area will include the implementation of a regular stakeholder engagement process and a regular monitoring process to identify any issues related to the rate and scale of influx.

These monitoring activities shall be conducted periodically on a six-month basis over the course of the first five years from commencement of construction primarily through household surveys. Monitoring interval will be reviewed after this period.

Proton Energy will in mitigating and managing influx; support the strengthening of local institutional and government capacity towards management of in-migration related issues, promote diversification of economic opportunities and support the provision of infrastructural facilities in the area.

Proton Energy’s Community Liaison Officer and Site Project Manager shall be responsible for managing the influx management plan being developed.

7.4.3 Regulatory Compliance Plan

PEL HSE Officer shall identify and develop a comprehensive checklist of every HSE-related regulation applicable to the proposed project including those contained in this EIA report. The specific requirements of each of the regulations, standards, or codes shall also be clearly defined in a checklist. Project-specific compliance requirements shall be interpreted and documented into a Regulatory Compliance Plan (RCP), which will be approved by PEL and then incorporated into

the detailed project design.

7.4.4 Project Design Guidelines

The specifications to be used for the design, construction, and operations of the proposed power project are based on applicable regulations, industry standards and codes that agree with standard power and electrical industry practices. Applicable requirements to be incorporated into the project design would be clearly approved national and international project specifications and standards (see **Appendix 3.3** for applicable codes).

7.4.5 Project Execution Guidelines

Vegetation Clearance

All clearance works at the construction site shall be carried out within defined perimeters and only when necessary. Clearing of vegetation shall be kept to the minimum necessary to permit safe operations. Trees felled from site shall be re-utilised for the benefit of the neighboring communities or as otherwise desired by PEL in consultation with the communities. Areas cleared in excess of operational requirements shall be reinstated with indigenous topsoil and vegetation. A buffer zone or green belt shall be achieved to incorporate environmental conservation practices and improved aesthetic quality at the site.

Foundation Works, Sand Filling and Surfacing

Work within the construction site shall be carried out in such a manner that there is no interference with existing water courses. Work shall be limited to defined operational perimeter.

If existing watercourse require to be temporarily diverted to enable the works to be carried out, approval for such diversions shall first be obtained from the relevant authorities. The diversion shall be maintained while the work is being carried out and shall be re-instated, including the removal of any obstruction to flow, as soon as practicable after the work is completed. No excavated material or debris shall be discharged into existing watercourses.

Use of Public Access Roads

All transportation, construction, installation and surfacing works shall be executed in such a manner that will ensure that interference with the use of public access roads is minimal. However, if operational safety demands the blockade of public roads, then the Site HSE and Community Liaison Officers after due consultation from relevant State Government approving authorities, may approve such operation only when temporary traffic control and diversion arrangements have been provided. Dumping or storage of litter/debris, tools and equipment in public or private roads shall be prohibited. Contractors shall develop road-clearing strategies to ensure that public roads are kept clear, safe, passable and free of traffic.

Hydrological Properties and Drainage Protection

PEL shall ensure that all hydrological characteristics and qualities of the area is maintained at its present status or improved on. During excavation, construction and installation works the contractors shall where necessary ensure that surface water flows on land areas are controlled and if necessary channeled into temporary discharge pits. Such pits shall be located, designed and constructed in a manner that will minimise the potential threat of erosion. Muddy water and surface runoff from work sites shall be drained into suitable silt traps, bagged and disposed-off with local waste contractors for discharge. The silt trap shall be of adequate size and regularly de-silted. Excessive site clearing shall be avoided and exposed surfaces shall be re-vegetated as soon as practicable to minimise erosion.

In general, PEL intends to carry out the following activities during the project execution phases:

- Schedule project activities to avoid heavy rainfall periods to the extent practical;
- Mulching and re-vegetation to stabilise exposed areas;
- Design channels and ditches for post-construction flows;
- Provide adequate drainage systems to minimise and control infiltration;

- Minimise dust from material handling sources by using covers and/or control equipment (i.e. water suppression and bag house)
- Minimise dust from open area sources, including storage piles, by using control measures such as installing enclosures and covers, and increasing moisture content;
- Totally avoid open burning of solid wastes;
- Using impervious surfaces for refueling areas and other fluid transfer areas at plant site;
- Train workers on the correct transfer, handling of fuels, chemicals and response to spills; and
- Provide portable spill containment and cleanup equipment on site and training in the equipment deployment.

7.4.6 Inspection and Maintenance Plan

In order to maintain technical integrity of the facility upon completion, a well-defined inspection and maintenance management system shall be activated to ensure compliance. PEL's maintenance programme shall deal with establishing processes to develop and sustain necessary maintenance procedures. The system shall identify what procedures are required, classifying procedures to their impact on operating integrity, controlling deviations from procedures, and updating of procedures to capture lessons learned. It will also address training and verifying competency for facility-specific procedures.

The maintenance system will include plans and procedures for:

- Normal maintenance (routine and breakdown maintenance performed by the Maintenance Technicians involved in the project);
- Preventive maintenance (activities carried out at pre-determined intervals);
- Predictive maintenance (as initiated by facility condition monitoring and assessment); and
- Inspection (in accordance with a pre-defined programme and based on statutory and company requirements);

The Site Project Manager will develop a comprehensive Maintenance and Inspection Programme (MIP) for all equipment and machinery before commencement of operations. The programme will cover routine equipment checks; inspection of wastewater discharge units, emissions monitoring; inspection and maintenance of corrosion protection system in serviceable condition; plant component servicing and inspection; and general inspection and maintenance of the turbine generators and diesel tanks; etc. The maintenance and inspection schedule contained in the programme will be designed in line with manufacturer's specifications for each of the equipment and in compliance with specific guidelines as contained in relevant national and international guidelines.

7.4.7 Risk Assessment and Management Plan

Risk assessment and management shall be an integral part of the proposed project's execution. Risks related to project execution and operations shall be identified by a structured approach. Risk assessments shall be planned and conducted in advance of appropriate activities to allow resolution of risk without schedule interruption. Personnel shall be included in risk assessments to ensure that risks are correctly identified and assessed.

The responsibility of risk management in the proposed project lies with the EPC contractor. Monitoring by the PEL Management Team will ensure that contractor processes are being implemented fully and effectively.

Workers to be involved in the construction and operational phases of the project will be employed by the EPC contractor; therefore, PEL will pay attention to applying appropriate contractor control, mitigation and monitoring activities for contractors. PEL expects contractors to have HSE systems in place consistent with Delta State Government (DSG) guidelines. Personnel working in the area shall work in accordance with job specifications developed by EPC/ PEL. They will have the direct responsibility for executing the work using sound engineering, fabrication, installation, and commercial practices, while maintaining adequate controls. The designs will consider applicable laws and regulations, and, in the absence of such, generally accepted industry standards. The contractors will develop operating manuals and appropriate documentation regarding the proper

operation and maintenance of the power plant facility for approval by PEL. This data will be provided in a timely manner such that facility-specific training can be given to personnel prior to start-up.

7.4.8 Worker Safety and Health Plan

Operations within the work site shall be subject to the OHSA 18001 (Occupational Health and Safety) Standard and the World Bank Group's Environmental, Health, and Safety Guidelines. All PEL and contractor staff shall be well informed and trained on the policies and guidelines. Facility will be designed to enhance safety planning.

Contractors shall provide adequate health services as well as first aid services for its workforce. The first aid services shall be extended to visiting personnel and temporary (casual) workers. All construction activities shall be properly managed through careful planning and application of relevant HSE policies including the following:

- Use of permit-to-work;
- Job hazard/ safety analysis and toolbox meetings;
- Use of PPE in designated hazard areas;
- Prohibition to drinking of alcohol during work hours and at work sites and within facilities;
- Prohibition to night trips;
- Regular emergency drills; and
- Prohibition to smoking in plant (fire hazard) areas.

Integrity of Workplace Structures

- All plant surfaces, structures and installations would be design to enable easy cleaning and repair, and limit the accumulation of hazardous compounds;
- Plant buildings will be structurally safe, provide appropriate protection against climate change and have acceptable light and noise conditions;
- Plant design would ensure that fire resistant, noise-absorbing materials are used, to extent feasible, on ceilings and walls;
- Floors would be level, even, and non-skid to prevent trips and fall; and
- Plant heavy oscillating, rotating equipment would be in dedicated buildings or structurally isolated sections within the plant site.

Workspace and Exit

- Space to be provided for each worker would be adequate for safe execution of all activities, including storage of materials and products; and
- All emergency exits route would be unobstructed at all times. Exits would be clearly marked. The number and capacity of emergency exits would be sufficient for safe and orderly evacuation of the people during emergency situations.

Fire Precautions

- PEL shall equip the plant facility with fire detectors, alarm systems, and fire-fighting equipment. The equipment would be maintained in good working condition and be readily accessible; and
- Provision of manual fire-fighting equipment that is easily accessible and simple to use.

Other requirements to be met by PEL include:

- Water supplied for food preparation or for the purpose of personal hygiene (washing or bathing) would meet national and international drinking water quality standards;
- Equipment and installations requiring servicing, inspection, and/or cleaning would have unobstructed, unrestricted, and ready access;
- Hand, knee and foot railings would be installed on stairs, platforms, permanent and interim floor openings, offices and plant building;
- Ensure that well equipped first-aid is provided at designated areas at site. First-aid stations would be easily accessible throughout the place of work;

- Eye-wash stations and/or emergency showers would be provided close to all workstations as first-aid response;
- Sufficient fresh air (ventilation) would be supplied for indoor and confined work spaces;

- Temperature in plant and office areas would, during service hours, be maintained at a level appropriate to the facility;
- Fall prevention and protection measures would be implemented whenever a worker is exposed to the hazard of falling height;

7.4.9 Pollution Control Guidelines

Air Quality Management Plan

In operating equipment, all practical methods and devices available to control, prevent and otherwise minimise atmospheric emissions or the discharge of air contaminants from the power plant shall be utilised. Good engine efficiency of equipment and vehicles shall be maintained. Indiscriminate burning of materials resulting from clearance of trees, bushes and combustible materials shall also not be permitted.

PEL intends to manage air emissions from its facility by ensuring:

- Emissions do not result in pollutant concentrations that exceed the FMEnv and WHO (IFC) ambient quality limits;
- Implementing a leak detection and repair (LDAR) program that controls fugitive emissions by regularly monitoring to detect leaks, and implementing repairs within a predefined period;
- Use of dust control methods, such as covers, water suppression, or increased moisture content for open materials storage piles;
- Use of water suppression for control of loose materials on paved or unpaved road surfaces during construction;
- Vehicle manufacture's recommended engine maintenance programmes are implemented;
- Emissions control devices such as catalytic converters, wet scrubber are installed and maintained;
- Use of natural gas with zero sulfur content; and
- Control of NO_x emissions by flue gas recirculation and use of low-NO_x burners emissions.

As part of pollution control measures, PEL shall ensure annual quantification of greenhouse gas emissions in accordance with internationally accepted methodologies and good practice, such as estimation methodologies provided by the Intergovernmental Panel on Climate Change.

Note: By implimentating the above, PEL would ensure air pollutant gases are below the following WHO (IFC) limits:

- $SPM_{2.5}$= 10µg/m^3 (annual mean), 25µg/m^3 (24 hour mean);
- NO_2 = 40µg/m^3 (annual mean), 200µg/m^3 (1 hour mean); and
- SO_2 = 20µg/m^3 (24 hour mean), 500µg/m^3 (10 minute mean).
-

Water and Soil Pollution

Pollution of surface water by wastewater shall be prevented by proper management practices. Effluent water from the chemical/ fuel storage and processing facilities shall be collected, transported and treated to FMEnv requirements of 10ppm oil in water. Waste shall be managed using wastewater treatment plant being considered or stored and transferred to disposal center with capability of managing such, before discharge.

All excavation, construction and surfacing activities shall be performed by methods that will prevent pollution of the soil media by accidental spills of contaminants, debris, and other objectionable

pollutants. Regular checks shall be conducted on site equipment to minimise minor lube oil and combustible leaks from engines.

Groundwater from boreholes for drinking purposes shall be monitored in line with WHO drinking water quality limits (see **Chapter 4, Section 4.9**).

Noise Pollution

PEL shall comply with all noise control requirements pertaining to FMEnv and IFC standards. All equipment shall be maintained at optimal working conditions and recommended work practices shall be employed to minimise noise. Ear defenders shall be provided for all workers and any other person present within the vicinity of high noise generating equipment or operations. If noise level at any time gives rise to public complaint, the issue shall be treated, as public nuisance and PEL will take appropriate measures to resolve the problem. Safe separation distances and buffer zones shall be established between facilities, work sites and neighboring communities to reduce the impact of high noise levels from the facilities.

PEL intends to manage impact from noise by ensuring that:

- Equipment with lower sound power levels are used;
- Project execution are done during the day to limit noise impact at night;
- Noise control by installing suitable mufflers on engine exhausts and compressor components;
- Acoustic enclosures are installed for equipment casing radiating noise;
- Installation of vibration isolation for mechanical equipment;
- Reduced project traffic routing through community areas wherever possible;
- The re-location of noise sources to less sensitive areas within the site to take advantage of distance and shielding
- That noise levels from the facility do not exceed IFC noise limit of 70dB(A); and
- Continuous noise monitoring is carried out to check levels of noise all through the project phases (see **Table 7.2**).

7.4.10 Emergency Response Plan

PEL and contractors will demonstrate that all potentially significant hazards and potential impacts of the project activities have been identified, the associated risks evaluated and understood, and that controls and recovery measures to effectively manage these risks and impacts are in place before mobilisation to site. PEL will assist the contractors, where necessary, with the provision of a hazard list for guidance.

In case of an emergency during the life span of the power project, the Emergency Response Procedure (ERP) will be activated. Its objectives are:

- To ensure no loss of life;
- To ensure that the environment and community is protected from potential project hazards;
- To ensure that manpower, equipment and funds are available to effectively contain and clean up oil/ chemical spills; and
- To ensure that good record keeping is maintained and accurate information concerning emergencies is disseminated to the workers, public and government.

The ERPs cover the following situations and issues:

- Gas turbine generator shut down;
- Point and fugitive leakages;
- Isolation of supply points;
- Notification of authorities;
- Safety precautions and environmental protection;
- Repair methods and procedures;
- Emergency repair;
- Contractor arrangements;
- Community emergency situations response; and

- Re-commissioning and start-up.

PEL and its contractors shall identify all potential emergency situations and develop procedures to use in such scenarios as explosions and/ or fires, medevac, hydrocarbon/ chemical spills, weather related disasters, hostage taking, community disturbance, kidnapping, etc. Emergency drills will be conducted to demonstrate preparedness for response and a schedule of drills and testing of emergency instruments will be prepared by all contractors on the project.

Every technical contractor on the proposed project will prepare and submit to PEL for approval a contingency plan for emergency situations and possible incidents beyond the capability of site facilities.

7.4.11 Communication Plan

Effective two-way communication between PEL and contractor staff on HSE and security issues will be maintained. This will include awareness programmes to motivate staff and contractors. HSE and security information and experiences will be shared between PEL and contractors to facilitate improvement in HSE and security performance.

PEL shall ensure its staff at all levels involved in the proposed project become familiar with the importance of compliance with the adopted PEL HSE policies, regulatory compliance plan and security plan and their individual roles and responsibilities in achieving compliance. Each person will be aware of their respective work activity risks and hazards and the controls, mitigation measures and emergency response procedures that have been established. They will also be aware of the potential consequence of departure from agreed operating procedures.
Contractors will set up appropriate procedures and lines of communication to handle HSE and security issues (e.g. direct access to the nearest clinic, direct access to emergency services, etc.).

Contractors will be able to communicate easily with their base, work site, their entire workforce and with PEL in an emergency. Appropriate safety programmes and promotion will be employed to effectively promote HSE and create awareness e.g. minutes of meetings, plans and performance targets, HSE performance and news board, posters, bulletins, video, news flash, e-mail, etc.

7.4.12 Environmental Monitoring Plan

All contractors shall be required to monitor their performance with respect to environmental and social performance. The PEL HSE Officer shall also undertake monthly, quarterly and yearly environmental assessment and spot checks throughout the plant project lifecycle. Assessment findings shall be reviewed by the Project Management Team (PMT) and where corrective actions are necessary, specific plans (with designated responsibility and timing) shall be developed to ensure continuous performance improvement.

In addition to assessing operational aspects and monitoring, assessments shall also consider compliance with agreed objectives and targets, and the effectiveness of the ESMP and its implementation programs. The ESMP shall, therefore, be subject to ongoing review and development to ensure that it remains appropriate for all aspects of the project. As is typical with all FMEnv approved projects, the ministry will carry out an assessment before the end of the project to confirm compliance of project activities to the terms and conditions of the EIA approval.

The objectives of the monitoring programme are to:

- Ensure compliance with regulatory emission and discharge limits;
- Monitor changes in existing physico-chemical, biological and social characteristics of the environment, compared both to the environmental baseline and predicted conditions;
- Ensure continual interactions and flow of information between PEL and the stakeholders;
- Determine whether any detected changes in socio-economic and environmental components are caused by the project or by other forces;
- Determine the effectiveness of the control and mitigation/ enhancement measures and provide a basis for recommending additional measures; and
- Ensure sustenance of accountability and a sense of local ownership through the project lifecycle.

Table 7.2: Recommended Environmental and Social Monitoring Programme

Indicator Parameters	Impact Category	Monitoring Method	Location	Frequency	Project Phase	Responsibility	Estimated Cost (USD)
Environment Aspects							
Noise Levels	Noise	Point and ambient measurements	Stations measured in this EIA	Monthly- construction Quarterly- operation	Throughout the project	PEL HSE Officer/ Regulators	noise monitoring beyond that carried out during normal operation approximately 450 USD per monitoring event
Air Pollutants: NO_x, CO_x, SO_x, Hydrocarbons and SPM	Air quality	Point measurement	Plant area and sample point location in EIA	Monthly- construction Quarterly- operation	Throughout the project	PEL HSE Officer/ Regulators	approximately 1000 USD per monitoring event
Soil: Characteristics	Soil	Sample collection using soil auger and analyses	Along sample point location in EIA	3years – after commissioning and every 5 years afterwards	Throughout the project	PEL HSE Officer/ Regulators	approximately 1000 USD per monitoring event
Groundwater Characteristics	Groundwater	Sample collection and laboratory analyses	From installed boreholes with project site	Quarterly-construction Bi annually –operation (for first three years)	Throughout the project	PEL HSE Officer/ Regulators	sampling and analysis of water and receiving water bodies approximately 800 USD per setup and 4500 USD for analysis
Effluent Quality	Waste water quality	Sample collection for laboratory analyses	At sample collection point before evacuation by disposal agency	Quarterly-construction Quarterly-operation	Operational phase	PEL HSE Officer/ Regulators	
Sulphur Content	Natural gas	Point measurement using gas detection meters	At plant area	Monthly-operation	Operational phase	PEL HSE Officer	Part of normal plant operations
Plant Gas Emissions/ Thermal Pollution (SO_2, NO_x, PM and heat)	Stack emission and gas turbine	Point measurement using gas detection meters	At plant area	Yearly-operation	Operational phase	PEL HSE Officer	Part of normal plant operations
Social Aspects							
Engagement Issues: (employment, contractors, suppliers, community)	Socio-economic	Review of MoU, consultation and employment policies	PEL site/ community	Monthly-construction Quarterly-operation	Throughout the project	PEL HSE and CLO Officers	Part of HSE Officer's and CLO's duties
Social Cultural Issues	Socio-economic	Feedback, consultation and review of complaints	Community				
Community health: (prevalent diseases in host community)	Socio-economic/ health	Collection of health statistics from clinic and hospitals with the LGA	Community/ LGA	Yearly-construction Yearly-operation	Throughout the project	PEL Management	Part of normal plant operations and public relations activities

Indicator Parameters	Impact Category	Monitoring Method	Location	Frequency	Project Phase	Responsibility	Estimated Cost (USD)
Livelihood patterns	Socio-economic	Monitoring of livelihood and employment patterns	Community	Quarterly – construction Yearly- Operation	Throughout the project	PEL Management	Part of HSE Officer and CLO's duties
Influx issues	Socio-economic	Monitoring of infrastructural services as a result of likely influx	Community	Quarterly – construction Yearly- Operation	Throughout the project	PEL Management	Part of HSE Officer and CLO's duties

7.4.13 Waste Management Plan

Waste generated shall be managed in accordance with Federal Ministry of Environment guidelines and PEL waste management procedures. The way wastes are to be handled, stored and disposed is dictated by the nature of the waste. PEL's Waste Management Plan (WMP) takes into consideration the nature of all wastes that will be generated during the lifetime of the project. The following objectives form the basis for the WMP for the proposed project:

- Progressive reduction of wastes with the target to minimise overall emissions/ discharges, which have adverse impact on the environment;
- Meet the environmental requirements of FMEnv and Delta State Waste Management Law as well as other international bodies (such as IFC/ World Bank) on waste management;
- To establish, implement and maintain waste segregation aimed at enhancing recycling;
- To ensure that PEL and its contractors are responsible for effective waste handling and disposal process;
- To ensure that waste management programme is in line with provisions of the Environmental Management Programme of ISO 14001;

The WMP would be binding on all staff and contractors involved in the proposed project implementation with respect to the:

- Emission or release of air pollutant and fugitive gases;
- Management of spill and untreated liquid effluent from the plant site;
- Management of solid wastes from plant activities; and
- Generation of noise.

The waste management principles of PEL is designed to ensure that wastes generated are properly handled and disposed off, in an environmental friendly manner by adopting the principle of waste source reduction, recovery and reusing. All wastes, which cannot be reused, are managed and disposed off in accordance to PEL HSE policy and in line the company's Environmental Management System (EMS).

PEL Waste Management Plan

PEL has developed a Waste Management Plan/ Policy containing procedures to be followed in the management of wastes and discharges from its facility. PEL recognizes that her operations produce waste which must be handled from "cradle to grave". The Waste Management Policy is intended to help staff and the general public comply with Local, State, Federal and International Regulations on waste management.

Waste Handling

For proper handling and disposal, wastes shall be well defined at source and labels transmitted along with the wastes to the final disposal points. PEL personnel and contractors shall record and document all wastes generated in the course of work in a Monthly Waste Report, which shall be used to track/ monitor wastes generated from the plant facility. Basic information that must be provided as a minimum for adequate definition of wastes include:

- Waste type identification;
- Proper waste categorization (domestic, office, industrial and hazardous wastes);
- Waste segregation information; and
- Recommended management practices.

Waste Minimisation

Waste minimisation implies reduction to the greatest extent possible the volume of waste materials. The four principles of waste minimisation process are **recycle, reduce, reuse and recover**, and shall be adopted as applicable in this project.

Waste Segregation

Waste segregation and characterisation shall be carried out on wastes that are similar and may be combined to simplify storage, treatment, recycling and/or effective implementation of appropriate waste disposal methods. Wastes shall be segregated, preferably at source into clearly designated bins at strategic locations within the plant facility. Attention shall be given to work area and offices where significant amount of wastes including food packaging would be generated. The Site HSE Officer shall be responsible for the maintenance of the waste segregation scheme.

Waste Disposal

All spoilt materials, rubbish and debris shall be cleared regularly from the site and disposed off, at designated areas and facilities as specified in WMP guideline. Instructions on material safety handling sheet shall be strictly adhered to and would form basis for the disposal of hazardous wastes. Wastes in transit shall be accompanied and tracked by Waste Disposal Notes. Waste streams to be generated in the facility would be collected and handled as shown in **Table 7.3**.

Table 7.3: Waste Handling and Disposal Method

Waste Streams	Category	Frequency of Generation	Recommended Practice	Future Practice	Responsible Party
Bulbs and mercury tubes	H	Monthly	Segregate and transport well bagged wastes to recycling center in Warri Town, Delta State. Wastes must be clearly labeled	Same	PEL / Contractor
Clinical wastes from first aid treatment	H	Daily	Transport to PEL Retainer Clinic in sealed bags for incineration. Wastes must be clearly labeled	Same	PEL / Contractor
Food wastes/ office sweepings, nylon bags etc.	D	Daily	Segregate and store in bags. Disposed-off by PEL's waste disposal agent to be engaged	To be recycled at site	PEL
Glass	O	Monthly	Segregate and transport to recycling center in Warri Town	As currently practiced	PEL / Contractor
Pigging wastes	H	Weekly	Weigh and store in watertight bags placed in drums with lid and transport to the approved dumpsite for incineration	To be incinerated at site	PEL / Contractor
Crude oil/ oily sludge/ fuel filter cartridges	H	Weekly	Transport to collection centre in Warri Town	As currently practiced	Contractor
Papers	O	Daily	Segregate (all confidential papers must be separated from non-confidential) shred at source and transported to a recycling depot	As currently practiced	PEL / Contractor
Printer, cartridges, computer toners, photocopier toners	O	Weekly	Segregate and transport to recycling center	As currently practiced	PEL / Contractor
Aerosol cans and spent lubricants	H	Monthly	Collect, segregate and transfer to disposal centre in Warri for recycling	Same	PEL / Contractor
Oily rags, sorbents; used protective clothing	H	Monthly	Transport to collection centre in Warri Town	As currently practiced	PEL / Contractor
Refrigerants (HCFC) from fridge and air condition units	O & H	Once spoilt	Safely contain in designat locations for return to manufactur or to recycling centre	As currently practiced	PEL

Note: O- office wastes, D- domestic wastes, H- hazardous wastes

Specifically, solid wastes are to be collected/ segregated and stored in waste bins placed in strategic locations around the plant facility by PEL personnel. The bins would be transferred into well labeled bags which would be evacuated and transferred to waste collection center in Warri Town, Delta State. Scrap metals are to be neatly arranged until evacuation, this will be coordinated by PEL HSE personnel. Access to waste storage area would be restricted, except for authorised personnel. This will be carried out by contractors and monitored by PEL's HSE officer.

Liquid wastes such as wastewater and used oil are to be transferred into a collecting tank. This would be evacuated once the storage tank is filled up. Sewage is to be collected in a septic tank which would also be evacuated when the need arises. PEL does not support discharge of waste into the environment and as such the HSE officer and assigned supervisory personnel would ensure that solid and liquid wastes from its facility are transferred to treatment site using an acceptable firm. PEL key elements of its waste management principles are presented in the flow diagram below.

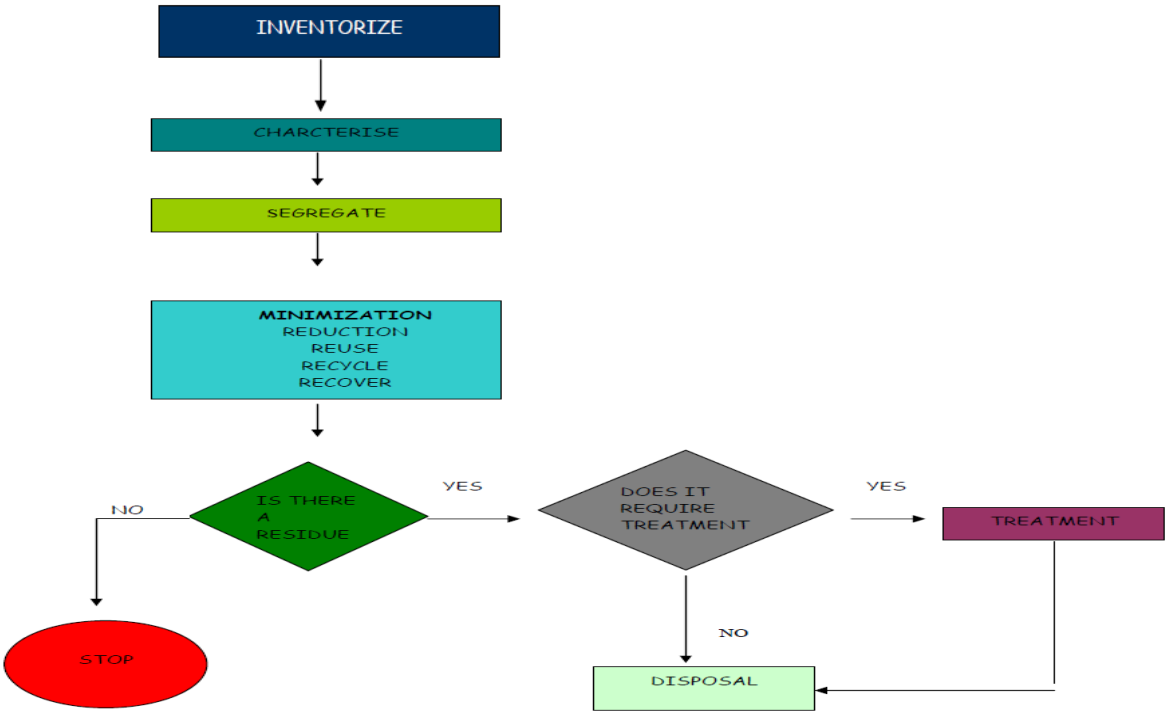


Figure 7.3: PEL Waste Management Principles

Waste management audit for the facility shall be carried out and findings properly documented and followed up. Catering services and camp sites shall maintain acceptable standards of hygiene and good housekeeping. Every employee has a vital role to play in achieving environmental protection.

7.4.14 Security Plan

The project team led by the Site Project Manager shall ensure that adequate security arrangements are made to handle security-related issues effectively. The project team will identify, evaluate and manage the risks to personnel and property arising along different phases of the project development – construction activities, operation and eventual decommissioning. These may include malicious practices, crime, civil disorder or armed conflict.

In addition, each contractor will be required to prepare a Project Site Security Plan and submit it to PEL for review and approval before mobilisation to site. The project team will also organise a security workshop to identify, evaluate and recommend contingency plans for all security risks. A

Site Security Officer would be engaged at the site. All security personnel shall be guided by proper rules of conduct towards workers and local community, and shall be trained adequately in the use of force and crisis management compliant with the United Nation's Code of Conduct for Law Enforcement Officials, and United Nations Basic Principles on the Use of Force and Firearms by Law Enforcement Officials. Use of force will not be sanctioned unless for defensive and preventive purposes in proportion to the nature and scale of the threat.

In the advent of any unlawful or abusive act, or when there is an overriding security concern, employees and local community will be able to get a redress through the appropriate grievance mechanism.

7.4.15 Project Climate-Resilience

It is widely accepted that climate change is underway and cannot be stopped completely. National and international actions to mitigate impacts of greenhouse gas emissions and keep average global temperature to below 2^0C of pre-industrial levels are aimed at avoiding the worst effects over the longer-term. Considerations of reducing contribution of the project to increased greenhouse gas quantities was factored in by Proton Energy Limited in its choice of technology and siting of the plant. Proximity of the plant to key supporting infrastructure (e.g. gas and transmission) implies lower CO_2 equivalent footprint from construction and associated works.
Unless the risks and vulnerabilities from inevitable climate change consequences are managed properly, project performance and investments made on the Proton DSP could be affected by climate change. These consequences mean that extreme events could occur in locations (such as the project location) which were not previously considered vulnerable. Making the proposed power plant development climate-resilient is about adding considerations of climate variability and climate change to the development decision-making to ensure that progress towards development objectives include consideration of climate impacts.

Using the World Bank's Climate and Disaster Risk Screening Tool, an assessment of the impacts of climate change on the Project was carried out. Based on data available on the project location, the key components of the project are exposed to two forms of climate-induced hazards. These are impacts resulting from:

- Extreme Temperature
- Extreme Precipitation and Flooding
- Sea Level Rise

The impact(s) of these hazards on the performance of the project was applied to three sub-sectors/components which determine the likelihood and longevity of the Project's success:

- Oil, Gas and Coal Mining: the project will invest in natural gas development through the installation of a gas pipeline to convey gas to the power plant.
- Thermal Power Generation: the project will invest in a gas-fired simple cycle power plant. Key physical investments include three simple-cycle gas turbines, diesel generator for black start, control system, switchyard and transmission lines to evacuate power.
- Transmission and Distribution of Electricity: To evacuate the generated power from the plant, the project will invest in upgrading the existing switchyard owned by the Transmission Company. It will also construct and install transmission tower(s) and a switchyard within the project location to evacuate power to the national grid.

Information fed into the screening tool followed a development-first approach, providing climatic information based on the project location and information which supports the understanding of the business sector and broader development context.

Based on current climatic data and future projections at the project location, the key subsectors/components were scoped at between no risk to moderate risk in current and future time frames. Appendix 5.2 presents the screening report from the screening tool.

Sustainable management of the risks and hazards posed by climate change has been a primary factor considered during the project design and feasibility studies, choice of technology, and choice of location. By mainstreaming climate change issues to the decision-making and operations aspect, Proton Energy ensures that the proposed development is set up to withstand current and projected climate-related impacts. Also, where the project does not have direct influence or control, the impacts of climate change on these sub-sectors/components are either low and temporary or in extreme cases defrayed by insurance.

7.4.16 Environmental Audit and Review

PEL will conduct regular audits in conjunction with applicable regulatory agencies to monitor compliance with its project. The scope shall cover the major project activities including the overall ESMP requirements throughout the life of the project. Contractors' performances towards meeting these requirements will be assessed.

Generally, the audit programme will be conducted in line with the relevant regulatory guidelines. It will be conducted annually during construction and every three (3) years during operations. The findings from these audits will be reported to the Commissioner for Environment and Federal Ministry of Environment, and corrective action plans will be developed and followed-up for performance improvement.

7.4.17 Decommissioning and Abandonment

The design of the facilities shall take due recognition of the need to decommission the power plant and the ancillary facilities at the end of their operational life. The abandonment plan shall take due note of the current national and international legislative requirements for decommissioning and abandonment.

Decommissioning after Construction Phase

Temporary structures (camp, storage yard, offices, etc.) would be installed at the construction phase to support site operations/ activities. Upon actualisation of construction phase, all areas temporarily used will be cleared, cleaned and re-instated.

Decommissioning after Operation Phase

This very last phase of the project is expected to occur after 40 years of usage. The following are activities to be carried out once the plant life span comes to an end:

- Operating processes would be systemically shut down in a safe manner;
- Liquid and solid wastes would be removed for treatment and disposal; and
- Gas pipeline and evacuation line as well as fuel storage tanks would be flushed and cleaned to remove oils and gases.

The fate of the emptied and cleaned structures and equipment are then decided by a feasibility study as part of an "Abandonment Assessment" to determine the best environmental and economic solution consistent with Nigerian requirements for decommissioning power plant facility. The general order of preference of decommissioning options available for redundant structures and equipment are as follows:

- **Re-use:** by sale and/ or transport to another project or company;
- **Re-cycle**: breaking down structures and equipment for raw materials. This is expected to be the fate of majority of metalwork used. The break-up of structures can be done on location or after transport to a breaking or salvage yard, dependent upon ease of transport and safety considerations;
- **Disposal**: some materials not suitable for recycling must be disposed to a licensed waste management facility;
- **Leave in-situ**: in some cases, the best environmental and economic option may be to leave material in-situ. The most obvious case in this respect is pipelines as once emptied and cleaned empty steel pipes do not impose a significant environmental hazard, however pulling such pipes out would cause additional damage in the extraction process.

7.5 Cost for ESMP Implementation and Monitoring

Mitigation measures to be adopted for each of the project phases have been presented in **Chapter Six** and **Seven**. The EPC Contractor will be directly responsible for financing the implementation of mitigation and monitoring measures from inception to the completion of the power plant project as shown in **Table 7.2**. The cost of impacts mitigation monitoring will be included in the EPC contract value and will be monitored by PEL Management Team.

PEL shall be responsible for auditing the activities of the EPC and for the associated funding. During operations, PEL will be responsible for financing and managing mitigation measures and monitoring activities in-line with international practices.

Part of the conditions for the approval of the EIA by the Federal Ministry of Environment (FMEnv) is that there will be regulatory monitoring of the approved project impacts mitigations and monitoring measures. The timing and frequency of the monitoring is determined by the FMEnv. FMEnv works closely with the Delta State Ministry of Environment in monitoring the implementation of the EIA approval terms and conditions.

Funding of the Impacts Mitigation and Monitoring (IMM) is borne by PEL. In the past, FMEnv will request funding for the monitoring while the project is in progress and the monitoring activity will be carried out after payment of the requested fund. Current practice is that FMEnv now issues a pre-approval letter which includes the cost of IMM and other conditions that must be fulfilled prior to the issuance of the approval. Meeting the conditions, along with payment of the funds have therefore become prerequisites to the issuance of the EIA approval. Payment prior to approval also ensures that the funding for monitoring is secured and the activity effected as at when due. The current regulatory cost by the FMEnv for impacts monitoring operation is about five hundred thousand naira only (₦500,000).

CHAPTER EIGHT

CONCLUSION

CHAPTER EIGHT

CONCLUSION

The Environmental Impact Assessment (EIA) of the proposed Proton Energy Limited Gas Powered Plant project has been carried in compliance to the EIA Act Cap E12 LFN 2004 requirements, which stipulates that an EIA is compulsory for projects of this magnitude that have potential for significant environmental impacts.

The EIA has also been carried out in compliance to International Finance Corporation and World Bank requirements for projects of this nature. The EIA process aims at providing detailed information for decision-making and to contribute environmentally sound and sustainable development.

The study demonstrated that proactive environmental actions mentioned in the report shall be incorporated in the project design, installation, construction and operational, decommissioning process.

Consultations with the host community (Ogorode) and other stakeholders have been carried out and shall continue throughout the project lifecycle. Consultation and engagement meeting ensured that all answers to questions concerning the proposed project were provided to the satisfaction of stakeholders.

Environmental baseline conditions (biophysical and socio-economic) as well as sensitive components of the study area were established through field data gathering/ sampling and complemented with information from literature/ desktop research, maps and information from articles on the area. The established baseline data will serve as future reference and for monitoring purposes.

Climatic information was obtained from Nigerian Meteorological Agency. Results from laboratory analyses of surface water, groundwater, soil and sediments as well as air/ noise measurements were obtained from the area studied.

Air quality data shows that all parameters measured were below both FMEnv and WHO limits as well as equipment detection limits (except for SPM in eight stations in dry season and one station during wet season sampling). Noise levels were below regulatory limits. Surface water, groundwater, soil and sediment results showed that analysed parameters were consistent across sample stations and compared well with control points values. However, it was observed that for groundwater, total hardness, total iron and lead concentrations were above the WHO required limit in a number of stations.

Interactions between the biophysical and socio-economic components of the existing environment and the power plant project environmental aspects were used to identify, characterise and evaluate the potential and associated impacts of the proposed project. Thereafter, mitigation measures/ recommendations to ensure the sustainability of the project based on best industry practices, available technology and HSE considerations were developed for the significant impacts.

An Environmental and Social Management Plan (ESMP) was developed during this study to ensure that procedures for managing adverse impacts of the power plant operations as well as the implementation of the environmental and social commitments made are maintained throughout the duration of the project. The ESMP also contains the environmental monitoring programme that would be used to monitor future changes to the environment from project activities. As a result,

PEL would ensure that air pollutants, noise and groundwater are monitored in line with FMEnv and World Bank (IFC) standards.

Finally, it is hoped that all necessary information/ evidence contained in this report is sufficient to meet all extant requirements for the operation of the power plant and the acquisition of necessary permits and development support.

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APPENDIX 1.1

TERMS OF REFERENCE

FEDERAL MINISTRY OF ENVIRONMENT

Environment House

Independence Way South, Central Business District, Abuja - FCT.
Tel. 09-2911 337 , www.environment.gov.ng, ea-environment.org

ENVIRONMENTAL ASSESSMENT DEPARTMENT

FMENV/EA/EIA/2770/27
13th November, 2013.

The Executive Vice Chairman,
Proton Energy Limited,
24, Idejo Street,
Victoria Island,
Lagos State.

RE: ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF THE PROPOSED PROTON ENERGY POWER PLANT IN SAPELE, WARRI SOUTH LGA OF DELTA STATE.

Please refer to your letter dated 30th September, 2013 and our letter with Ref NO: FMENV/EA/EIA/2770/21 dated 23rd October 2013, on the above stated project.

2. Following the conclusion of the site verification exercise, the Ministry has placed the project in Category One (1) requiring mandatory EIA studies and a panel review process. Please be informed that the Terms of Reference submitted to the Ministry should address all identified issues during the scoping workshop that are relevant to the project.

3. The field data gathering and laboratory analyses of the environmental component of the study which will be Two (2) seasons include the followings as minimum, sampling points should be geo-referenced with coordinates in UTM format and tables in spread sheet (excel).

S/N	ENVIRONMENTAL PARAMETERS.	PARAMETER DETAILS	NUMBER OF SAMPLES/ DISTRIBUTION	PARAMETERS TO BE MONITORED.
1.	Climate/Meteorology			Temp, rainfall, relative humidity, wind speed and visibility etc.
2.	Surface Water	Physico-Chemical & Microbial	15 Nos. + 2control samples	Conductivity,PH,TDS,TSS, DO,BOD,COD,Turbidity, Oil& grease, Heavy metals, bicarbonates. Salinity.
3.	Ground water	Physico-chemical & Microbial.	2 Nos. + 1 control samples around the major settlements.	Depth to and thickness, hydraulics, recharge and, uses. Colour, pH, turbidity, Salinity, hardness, heavy metals - Cu, Pb, Fe, K, Ba, DO, BOD, COD, THC, Electrical conductivity, Phosphate, SO_4, NO_3, TSS

4.	**Soil**	Physical	15Nos + control samples	Profile (depth type) colour, permeability, porosity, bulk density, texture(grain size)
		Chemical	15Nos + control samples	Heavy metals (V, Ni, Fe, Pb, Cu, Zn), pH, moisture content, sulphate, sulphate, nitrate.
		Soil Microbiology	15Nos + control samples	Total heterogenic bacteria (total hydrocarbon, fungi, total hydrocarbon bacteria (THB), faecal coliform.
5.	**Air Quality Dispersion Modeling**		15 Nos. (in-situ @ different elevations)	Suspended particulate matter, NO_x, SO_x, CO_2, CO, VOCs, H_2S.
6.	**Noise**	Noise level	15 Nos. (in-situ)	Db
7.	**Ecology**	Vegetation		Flora and Fauna Habitat status, floral composition, density and distribution, vegetation suction, plant pathology.
8.	**Geology/Geotechnical Studies**			Stratigraphy, structure, fractures patterns, flow direction, aquifer level, /Lithological Regional geology, Stratigraphic properties etc
9.	**Socio-Economic**			Education, culture, distribution of livelihood, land use, etc. with structured questionnaire administration.
10	**Health Impact Assessment**			Health status and prevalent diseases in the community.

4. You are to facilitate the participation of Ministry officials and also ensure full quality assurance/quality control (QA /QC) measures for the laboratory analyses in line with standard practices. You should notify us in good time to enable us plan our participation in the field work.

5. I am further directed to request you to pay the sum of Five Hundred Thousand Naira (N500, 000.00) only in bank draft to the Ministry, as the initial processing fee. Upon completion of the EIA studies, you are to submit Ten (10) hard copies and Five (5) soft copies of the draft EIA report to the Ministry.

6. Thank you for your co-operation.

J.A. Alonge
For: Honourable Minister

APPENDIX 1.2

FMENV PUBLIC DISPLAY AND ANNOUCEMENT LETTERS

FEDERAL MINISTRY OF ENVIRONMENT

Environment House
Independence Way South, Central Business District, Abuja - FCT.
Tel: 09-2911 337 www.environment.gov.ng, ea-environment.org

ENVIRONMENTAL ASSESSMENT DEPARTMENT

Ref: FMEnv/EA/EIA/2770/Vol.1/48
Date: 9th December, 2014.

The Executive Vice Chairman,
Proton Energy Limited,
24, Idejo Street,
Victoria Island,
Lagos State.

PUBLIC DISPLAY EXERCISE ON THE ENVIRONMENTAL IMPACT ASSESSMENT (EIA) ON THE PROPOSED PROTON ENERGY POWER PLANT IN SAPELE, SAPELE LOCAL GOVERNMENT AREA OF DELTA STATE.

Please refer to your letter dated 19th November, 2014 on the submission of Draft EIA Reports of the above project.

2. I am directed to inform you that the Honourable Minister of Environment has approved the following review process for the EIA of the project.

- 21 working days public display
- Panel Review.

3. The public display is to take place from 15th December, 2014 – 14th January, 2015, you are please requested to place the enclosed sample of newspaper advert (quarter page) on or before 15thDecember, 2014 in the following newspapers:

- The Telegraph
- The Pointer
- The Nigeria Observer

4. You are further requested under this arrangement to place a radio announcement at prime time in the Delta State Radio for the first and last five (5) days of the display exercise. A sample of the radio announcement is herewith attached. The evidence of newspaper advertisement and radio announcement must be submitted to the Federal Ministry of Environment, Abuja.

5. The date, venue and your company's responsibilities for the panel review exercise will be communicated to you later.

6. Thank you for your co-operation.

J.A. Alonge
For: Honourable Minister.

PUBLIC NOTICE

FEDERAL MINISTRY OF ENVIRONMENT

PUBLIC DISPLAY EXERCISE ON THE ENVIRONMENTAL IMPACT ASSESSMENT (EIA) ON THE PROPOSED PROTON ENERGY POWER PLANT IN SAPELE, SAPELE LOCAL GOVERNMENT AREA OF DELTA STATE.

In accordance with the Environmental Impact Assessment (EIA) Act No. 86 of 1992, which makes it mandatory for proponents of all new major development activities to carry out Environmental Impact Assessment (EIA) of their proposed projects, the Federal Ministry of Environment hereby announces a Twenty-One (21) working days Public Notice for information and comments on the EIA Draft Report submitted by Proton Energy Limited.

The Display Centers Are:

- Headquarters Sapele Local Government Area, Sapele, Delta State.
- Delta State Ministry of the Environment, State Secretariat, Asaba Delta State.
- Federal Ministry of Environment Office, Asaba Delta State.
- Federal Ministry of Environment, Environment House, (Brown Building), Central Business District, Abuja, F.C.T.
- Federal Ministry of Environment, Conservation House (Green Building), Plot 444 Aguiyi Ironsi Street, Maitama, Abuja, F.C.T.

Project Description:

The proposed project entails the construction of an Open Cycle 500MW Gas Fired Power Plant at full operation. The project is to be located on 27.4 hectares of land adjacent to two existing power plants ie National Integrated Power Project (N.I.P.P)Unit and old PHCN Unit in Oghorode community, Sapele Local Government Area, Sapele Delta State.

Duration of Display:

Date: 15th December, 2014 – 14th January, 2015. **Time:** 8:00am – 4:00pm Daily.

ALL COMMENTS RECEIVED SHOULD BE FORWARDED TO THE HONOURABLE MINISTER, FEDERAL MINISTRY OF ENVIRONMENT ON OR BEFORE 21st JANUARY, 2015.

SIGNED
PERMANENT SECRETARY
For: Honourable Minister

RADIO ANNOUNCEMENT

FEDERAL MINISTRY OF ENVIRONMENT

PUBLIC DISPLAY EXERCISE ON THE ENVIRONMENTAL IMPACT ASSESSMENT (EIA) ON THE PROPOSED PROTON ENERGY POWER PLANT IN SAPELE, SAPELE LOCAL GOVERNMENT AREA OF DELTA STATE.

In accordance with the Environmental Impact Assessment (EIA) Act No. 86 of 1992, which makes it mandatory for proponents of all new major development activities to carry out Environmental Impact Assessment (EIA) of their proposed projects, the Federal Ministry of Environment hereby announces a Twenty–One (21) working days Public Notice for information and comments on the EIA Draft Report submitted by Proton Energy Limited.

The Display Centers Are:

- Headquarters Sapele Local Government Area, Sapele, Delta State.
- Delta State Ministry of the Environment, State Secretariat, Asaba Delta State.
- Federal Ministry of Environment Office, Asaba Delta State.
- Federal Ministry of Environment, Environment House, (Brown Building), Central Business District, Abuja, F.C.T.
- Federal Ministry of Environment, Conservation House (Green Building), Plot 444 Aguiyi Ironsi Street, Maitama, Abuja, F.C.T.

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SIGNED
PERMANENT SECRETARY
FOR: HONOURABLE MINISTER

APPENDIX 2.1

PROTON ENERGY LIMITED
COMMUNITY SOCIAL RESPONSIBILITY POLICY

COMMUNITY SOCIAL RESPONSIBILITY POLICY OF

PROTON ENERGY LIMITED

Proton Energy Limited (hereafter known as PEL) is an indigenous Independent Power Plant (IPP) developer committed to contributing positively to the Federal Government of Nigeria's 'Power Sector reform Roadmap" through the development of Independent Power Plants in Nigeria.

PEL is committed to positively influencing the local communities where we do business, ensuring that we support the community by contributing towards meaningful socio-economic development. To us, our responsibility is not just about philanthropy; it is a core value of how we do business. We measure our CSR not by how much we spend in gifts but in how much impact we make on our stakeholders and especially in the communities we live and do business.

We recognize all stakeholders in the development of our projects; our shareholders and partners, our employees, their families and very importantly the communities where our businesses are sited, and are mindful of these groups in the decisions we make. In the addition of value to all our stakeholders, PEL promotes healthy relationships based on trust, transparency and integrity. We are an equal opportunity company encouraging innovation, productivity and sustainability in all our practices. In furthering her commitments to her stakeholders, PEL also promotes gender equality and diversity.

Our commitments to:

Shareholders

These are the people that keep us in business and as such we are committed to continually engaging in best operational practices, integrity and transparency towards creating better value for the company and investors.

Employees

Our employees create our value and exemplify what we stand for - excellence, reliability and integrity. Creating an environment that allows innovation thrive and respects diversity helps cement relationships between different levels of our structure and allows for continuous productivity while keeping turn-overs down. We encourage personal development and trainings, and applaud employee participation in volunteerism.

Our Community and Environment

We support the communities we operate in because it is right thing to do for our neighbors and for our business. By improving lives in the communities we live and work, we believe we are creating better understanding of our business and promoting safety for all stakeholders.

This document is a framework on how PEL relates with the community and would be the basis for the lines of actions, avenues and strategies for our interactions. PEL's actions must be consistent with the interests of society and sustainable development whilst being integrated with the company's business operations.

PEL shall only interact on the basis of sustainability and development. Only programmes and schemes that would further the socio-economic development of the community within the principles of adherence to the rule of law, transparency and integrity which PEL upholds shall be considered.

We realize this commitment through a diverse range of initiatives such as providing sponsorships for meaningful causes in cash or kind.

Support for Education

PEL will continue to support meaningfully worthy educational causes which enable students gain access to quality learning, that would provide them access to better opportunities in a constantly growing world. PEL shall ensure that a considerable share of her support for the community goes towards education. This support could be as scholarships to students in high schools and higher institutions of learning, donations to departments, and support for educational infrastructure. Educational activities which demonstrate a strong role in the development of the community especially those related to the company's operations; for example: energy studies, energy efficiency, electricity and management.

Support for Healthcare

Access to good healthcare service ensures productivity and leads to development. Energy in the form of electricity is a key requirement to the delivery of quality healthcare. PEL in developing power plants in Nigeria to increase supply of electricity believes it is contributing towards making access to quality healthcare possible. In addition to this, PEL is committed to supporting community healthcare service through infrastructure and equipment development in the form of grants and donations.

Support for the Environment

Sustainable use of our finite environmental and natural resources ensures that we and generations unborn can enjoy benefits of living on a friendly planet, and PEL through her respect for best operating procedures is committed to maintaining the environment we all live in. We are

committed to preventing pollution and reducing any negative impact of our operations on the environment. Our commitments and methods for achieving continual improvement in environmental performance are further defined in our *Environmental Management Plan*.

Support for Economic Development

From inception, PEL has been committed to the economic development of the community. We have ensured that human capacity within the community is engaged within the scope of availability in our operations. Even before commencement of plant development, community youths were employed to construct perimeter works on our facility. PEL shall continually engage in capacity building of craftsmen in the community. In line with our belief in gender equality and women participation, we would partner with women organizations in the locality in areas such as improved fishing methods and other crafts.

Community participation and integration

We understand that each community is unique and there is no one size fits all approach, hence we shall regularly conduct stakeholders' consultations through town hall meetings, surveys and focus groups. We believe this is the best way to integrate uniquely with each community where we operate and ensure that our actions reflect their collective desires and expectations.

As an energy company, PEL shall also engage in creating awareness on energy issues such as energy efficiency, waste management through fairs and school enlightenment programmes.

While we work closely with the community directly, we shall continually partner with indigenous and international non-governmental organizations, civil society and groups to enhance impacts on the community. We believe by having formidable partnerships with these groups, we not only ensure that we are closer to the community, our work gets done faster and touches everyone concerned.

Lines of action for Social Responsibility

The Board of PEL shall decide the percentage of operating profits or specific amount which shall be allocated for our community support.

The Board shall also appoint a representative in management to oversee the implementation of her commitments, who shall periodically report on progress on activities. It is the responsibility of such person to ensure that all stakeholders are aware of the policy.

PEL in furtherance of her transparency and integrity values would ensure proper auditing, monitoring and evaluation, and shall periodically review the policy in order to ensure its relevance and applicability to the community.

Selection and Approval

All community requests shall be evaluated on the basis of:

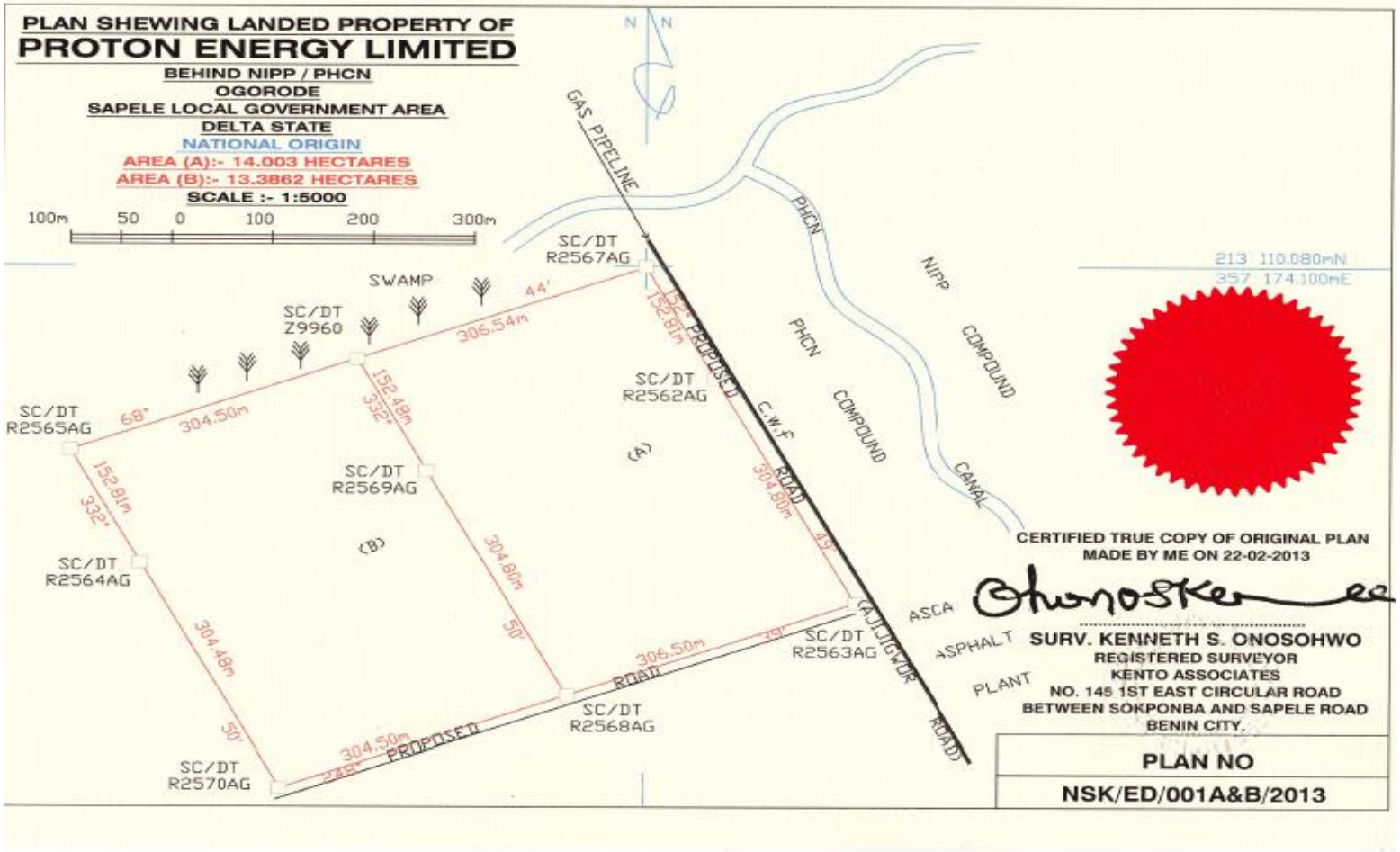
- Appropriateness to the community and the company's objectives,
- Scope and nature of the project, and
- the degree to which it benefits the community.

PEL is committed to upholding best accounting practices, as such all donations and requests shall only be approved upon proper applications (where necessary) and documentation.

This policy is an organic document and shall be reviewed and revised as and when necessary to ensure optimum performance and workability.

APPENDIX 3.1

PROTON ENERGY LIMITED
SURVEY PLAN


PLAN SHEWING LANDED PROPERTY OF
PROTON ENERGY LIMITED
BEHIND NIPP / PHCN
OGORODE
SAPELE LOCAL GOVERNMENT AREA
DELTA STATE
NATIONAL ORIGIN
AREA (A):- 14.003 HECTARES
AREA (B):- 13.3862 HECTARES
SCALE :- 1:5000
100m 50 0 100 200 300m
N N
GAS PIPELINE
SC/DT R2567AG
SWAMP
SC/DT Z9960
44'
306.54m
152.81m
PROPOSED
SC/DT R2562AG
SC/DT R2565AG
68'
304.50m
152.48m
332'
SC/DT R2569AG
(A)
(B)
152.81m
332'
304.80m
SC/DT R2564AG
304.48m
50'
304.50m
PROPOSED
ROAD
SC/DT R2568AG
SC/DT R2570AG
C.W.F
ROAD
304.80m
43'
SC/DT R2563AG
ADJUDIGWOR ROAD
PHCN
PHCN COMPOUND
NIPP COMPOUND
CANAL
ASCA
ASPHALT
PLANT
213 110.080mN
357 174.100mE
CERTIFIED TRUE COPY OF ORIGINAL PLAN
MADE BY ME ON 22-02-2013
SURV. KENNETH S. ONOSOHWO
REGISTERED SURVEYOR
KENTO ASSOCIATES
NO. 145 1ST EAST CIRCULAR ROAD
BETWEEN SOKPONBA AND SAPELE ROAD
BENIN CITY.
PLAN NO
NSK/ED/001A&B/2013

APPENDIX 3.2

EVIDENCE OF ELECTRICITY EVACUATION APPROVAL

Transmission Company of Nigeria

TCN

Tel: 234 (0) 7016839880
7054050057, 7016833541
E-mail: info@tcnng.org
publicaffairs@tcnng.org
Website: www.tcnng.org

Corporate Headquarters
Plot 14 Zambezi Crescent
Maitama, Abuja

Ref. TCN/CEO/07/13.00/1006/2013 Date: 8th November, 2013

The Executive Director
Proton Energy Limited
Ocean Bay Mall
24, Idejo Street, Victoria Island,
Lagos, Nigeria

Dear Sir

PROVISIONAL APPROVAL TO CONNECT 500MW GAS TURBINE PROTON ENERGY POWER PLANT AT SAPELE

We acknowledge the receipt of your letter dated 30th September 2013 forwarding the revised Power Evacuation study report on Proton Energy Power Plant and requesting for approval to connect the 500MW power plant to TCN Grid. We have carefully studied the report and wish to state the followings:

Connection Conditions:

Please note that since the decision to site the power plant at the said location in Sapele area of Delta State is entirely at the instance of Proton Energy Power Limited and not according to TCN plans. Proton Energy Power Limited shall pay for the modification and substation extension to the grid.

Therefore, proton Energy Limited connection to the grid is subject to:-

- Completion of the 330kV Double circuit 2nd Benin main to Onitsha – Capacity 1320MW. (TCN)
- Completion of the 330kV Double circuit transmission lines from Benin North to Oshogbo to allow alternate route for the evacuation of bulk power to the grid and also to maintain the n-1 criteria – capacity 1320MW (TCN)

- Completion of on-going 330kV single circuit transmission line from Benin North to Onitsha 330kV Substation – capacity 660MW (NIPP)
- Completion of 330kV Double circuit transmission lines from Benin mains to Benin north – capacity 1320MW (NIPP)

(2) Construction of 1.5km 330kV Double Circuit Spur Lines and all necessary 330/132kV substation Equipment for Grid Operations.

Please, also note that the existing busbar would be upgraded to accommodate the proposed 500MW power plant.

Proton Energy Limited shall pay for the cost of construction and upgrade of the 330kV busbar and associated substation equipment to aid the evacuation of the 500MW power plant to TCN grid.

Subject to the above conditions being met, a provisional approval is hereby given to Proton Energy Limited to connect the 500MW Proton Energy Power Plant to TCN grid at Sapele 330/132kV Substation.

Please note that the connection procedure which is under consideration by NERC pursuant to the Grid Code, parts 3 and 4 when finally approved shall apply.

Note that this approval may become invalid if not utilized in the next three (3) years from the date of issue.

Please, accept the assurances of my esteemed regards.

Don Priestman
Chief Executive Officer (TCN)

APPENDIX 3.3

APPLICABLE STANDARDS AND CODE

APPENDIX 3.3

APPLICABLE STANDARDS AND CODE

Nigerian Standard Organisations

DPR	Department of Petroleum Resources
FMEnv	Federal Ministry of Environment
PHCN	Power Holding Company of Nigeria
NERC	Nigeria Electricity Regulatory Commission
NBC	Nigerian Building Code

International Standards

ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
API	America Petroleum Institute
ASHRAE	American Society of Heating, Refrigeration And Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
AWWA	American Water Works Association
BS	British Standards
CFR	Code of Federal Regulations
CSA	Canadian Standards Association
EN	European
HEI	Heat Exchange Institute
IBC	International Building Code
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronic Engineers
ISA	Institute Society of America
NACE	National Association of Corrosion Engineers
NAICS	North American Industrial Classification System
NEC	National Electrical Code
NEMA	National Electrical Manufacturer's Association
NFPA	National Fire Protection Association
NESC	National Electric Safety Code
OSHA	Occupational Safety and Health Administration
PCI	Precast Concrete Institute
SJI	Steel Joist Institute
SSPC	Steel Structures Painting Council
UBC	Uniform Building Code
WBS	World Bank Standards

International Applicable Codes

ANSI C2-2002	National Electrical Safety Code - Section 127
API Standard 1104	Welding Pipelines and Related Facilities
API Standard 653.	Tank Inspection, Repair, Alteration and Reconstruction
API Standard RP 1110	Pressure Testing of Steel Pipelines for the Transportation of Gas
API Standard RP 2028	Flame Arresters in Piping Systems
API RP 2216	Ignition Risk of Hydrocarbon Vapours by Hot Surfaces in the Open Air
ASME Section I	Power Boiler
ASME Section II	Materials
ASME Section IV	Heating Boilers
ASME Section IX	Welding and Brazing Qualifications
ASME Section XII	Rules for the Construction and Continued Service of Transport Tanks
ASME B31.2	Fuel Gas Piping
ASME B31.3	Process Piping
ASME B31.4	Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids
ASME B31.5	Refrigeration Piping and Heat Exchanger Components
ASME B31.8.	Gas Transmission and Distribution Piping Systems
ASME B31.9	Building Services
AWS D1.1	Structural Welding Code - Steel
AWS D1.2	Structural Welding Code - Aluminum
AWS D1.4	Structural Welding Code - Reinforcing Steel
AWS D10.10	Heating Practices for Pipe and Tube
AWSD11.2	Welding (Cast Iron) Code
AWSD14.4	Machinery Joint Welding
ASTM 2513 and 2517	Thermoplastic and thermosetting pipe materials
CSA W59	Welded Steel Construction (Metal Arc Welding)
CSA W59.2	Welded Aluminum Construction
EN ISO 5817	Welding – Fusion-welded joints in steel, nickel, titanium and their alloys
EN 45510-5-2 Guide	Procurement of power station equipment. Part 5-2: turbines -Gas turbines
IEC 79-10 (Part 10)	Classification of Hazardous Areas
IEC 79-14 (Part 14)	Electrical Installations in Explosive Gas Atmospheres
IEEE 493	Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems - IEEE Gold Book (Colour Book Series)
IEEE 1127	Guide for the Design, Construction, and Operation of Electric Power Substations for Community Acceptance and Environmental Compatibility
IEEE C37.123	Guide to Specifications for Gas- Insulated, Electric Power Substation Equipment
IEC 60034	Rotating Electrical Machines, Part 3: Specific requirements for synchronous generators driven by steam turbines
ISO 3977	Gas Turbine Procurement Part 1: General introduction and definitions
NAICS 21112 –	Fossil Fuel Electric Power Generation
NFPA 30-2003	Flammable and Combustible Liquids Code
NFPA 70-2005	National Electrical Code

APPENDIX 4.1

DATA GATHERING PROCEDURE

APPENDIX 4.1

DATA GATHERING PROCEDURE

1.1 General

FNL adopted a QHSE management system approach in executing the field data gathering campaign. This approach assured that the required data were collected in accordance with agreed requirements (contractual, scientific and regulatory) using the best available equipment, materials and personnel. The approach also assured that the safety and health of personnel, public, environment and assets were not compromised at any time. The following sections outline the methodology and procedures employed in the ecological data gathering and descriptions of laboratory analytical methods as well as the detection limits for the various parameters analysed. Also presented, is an overview of the general QHSE plan adopted for field data gathering exercise.

1.2 Methodology

The methods employed during the field data gathering campaign was accomplished in line with the requirements of Department of Petroleum Resources (DPR) as outlined in page 38, Appendix 11-4 of EGASPIN (DPR, 1991, revised 2002), and other requirements of various international bodies which include sampling and analysis methods of the American Society for Testing and Materials (ASTM), United States Environmental Protection Agency (USEPA) and American Public Health Association (APHA).

The objective of the field data acquisition is to establish the physical, chemical and biological status of the surface water, groundwater, soil, sediment as well as the air quality/ noise characteristics of the study area through visual observations, on-site measurements and laboratory testing and analyses. Data were also recorded for fishery, vegetation and socio-economic studies.

1.3 Study Team

Field data gathering campaign for the study was carried out for two seasons from 2nd to 6th December, 2013 (dry season) and from 28th to 30th July, 2014 (wet season). The study was approved by Federal Ministry of Environment (FMEnv). The study team comprised of FNL personnel who are experts in areas such as biodiversity and wildlife, socio-economic, chemistry, geology and engineering. Also among the study team were representatives of Proton Energy Limited and FMEnv Regulator. The team members and their responsibilities are presented in **Table 1** on the next page.

Table 1: Study Team Members

Name	Designation	Responsibilities
Dry Season		
Mr. Okusor Emeka	Ecologist	Team leader, field data collection/ report preparer
Mr. Roland Ejims	Lab. Technologist	Sampling and insitu measurement
Mr. Bernard Obi	Hydro-biologist	Drilling and Sampling
Mr. Mike Weli	Chemist	Drilling and Sampling
Mr. Isaiah Victor	Chemist	Drilling and Sampling
Mr. Edache Ochekwu	Vegetation and wildlife	Field data collection
Mr. Uche Allanah	Socio-economics	Field data collection
Mr. Apata Afolabi	Logistics	Logistic co-ordination
Regulator		
Mr. Emeka Onyetenu	FMEnv representative	Supervision
Client		
Mr. Olufemi Adebule	PEL representative	Supervision
Wet Season		
Mr. Okusor Emeka	Ecologist	Team leader, field data collection/ report preparer
Mr. Roland Ejims	Lab. Technologist	Sampling and insitu measurement
Mr. Bernard Obi	Hydro-biologist	Sampling
Regulator		
Mr. Charles A	FMEnv representative	Supervision
Client		
Mr. Olufemi Adebule	PEL representative	Supervision

Equipment and materials used during the sampling activities are presented in **Table 2** below.

Table 2: Field Data Collection Equipment/ Materials

Equipment/ Materials	Uses
Ecological Sampling Materials	
Digital camera	Photographs
Plastic basins	Collection of sediment samples
Sieve (1.0mm)	Sieving for benthic organisms
WTW Multi-Meter	Measurement of samples pH
Coolers	Storage of samples
Soil /sediment colour chart	Description of sediment/ soil
2L plastic bottles	Collection of water for physico-chemistry
1L glass bottles	Collection of water for hydrocarbon
500ml plastic	Collection of filtered water for zoo/phytoplanktor
500ml plastic	Collection of sieved sediment for benthos
200ml glass	Collection of water for microbiology
Sampling bags	Collection of sediment/soil for physico - chemistry/heavy metals
60ml plastic containers	Collection of sediment/soil samples for microbiology
100ml glass containers	Collection of sediment/soil samples for THC
PPE (coverall, hard hat and safety shoe.)	Sampling activities, protection for field personnel
Markers/ masking tapes & serviette	Identification of sample ID
Labels	Identification of sample ID
Notebooks and biros	Data / information logging
Forms (daily project update form, chain o custody form and incident/hazard form)	Quality control

Sulphuric acid	
Nitric acid	
10% Formaldehyde	Preservation of samples
Conductivity /pH /redox standards	Quality control
Aerocet 531 particulate meter	SPM measurement
Pulsar II Digital Sound Level Meter	Noise measurement
Multi RAE IR System	Air quality measurement
Disposable hand gloves	Use when handling chemicals
25ml beaker/250ml beaker	Insitu analysis
100ml volumetric flask, pipettes: 10ml, 5ml	Insitu analysis
Distilled water	Insitu analysis/QC
First aid box	Emergency treatment
Plankton net	Zoo/ Phyto Plankton
Geographic position system (GPS)	Locating sample co-ordinates

1.4 Sampling Design

Field data gathering was designed to cover the project area where the power plant would be positioned as well as the area of influence. Soil sample stations were distributed to ensure major soil types that characterise the area were adequately collected. Surface/ groundwater and sediment were also collected for analyses. A number of these samples were collected from sections of Ethiope River which happens to be the major water body in the area. Further, socio-economic survey was carried out in Ogorode community, who happens to be host community.

On the whole, the following sample requirements were established based on approved Terms of Reference approved by the Federal Ministry of Environment (FMEnv):

Overall, samples obtained and measured in the two seasons were as follows:

- surface water - seventeen (17) stations;
- sediments - seventeen (17) stations;
- soil samples - sixteen (16) stations;
- groundwater sample - three (3) points;
- air/ noise quality measurement in fifteen (15) stations; and
- benthos and plankton samples - seventeen (17) stations.

The sample station codes, co-ordinates, sample types obtained are presented in **Table 3.**

Area of Influence

Wind direction, water flow direction (i.e. towards Ethiope River) and sensitive receptors were factors considered in determining sample points distribution. The zone of influence from project site which covers surface water, sediment, soil, air and noise as well as other receptors covered a 3 km radius. However, surface water and soil samples were spread to 10km and 7.5km distances respectively.

Table 3: Sampling Stations, Co-ordinates and Requirements

Sample Code	Sampling Requirement	Co-ordinates	
		Latitude (N)	Longitude (E)
SW1	Sediment+ Surface Water +Benthos+ Plankton + Air +Noise	5.891981	5.705472
SW2	Sediment+ Surface Water +Benthos+ Plankton	5.890597	5.698147
SW3	Sediment+ Surface Water +Benthos+ Plankton+ Air +Noise	5.896389	5.694083
SW4	Sediment+ Surface Water +Benthos+ Plankton	5.903342	5.689497
SW5	Sediment+ Surface Water +Benthos+ Plankton	5.902844	5.682425
SW6	Sediment+ Surface Water +Benthos+ Plankton	5.906081	5.675275
SW7	Sediment+ Surface Water +Benthos+ Plankton +Air +Noise	5.910294	5.669189
SW8	Sediment+ Surface Water +Benthos+ Plankton	5.915228	5.663356
SW9	Sediment+ Surface Water +Benthos+ Plankton	5.919444	5.656114
SW10	Sediment+ Surface Water +Benthos+ Plankton	5.924656	5.649183
SW11	Sediment+ Surface Water +Benthos+ Plankton	5.932350	5.645764
SW12	Sediment+ Surface Water +Benthos+ Plankton	5.941556	5.646258
SW13	Sediment+ Surface Water +Benthos+ Plankton	5.945994	5.639508
SW14	Sediment+ Surface Water +Benthos+ Plankton +Air +Noise	5.943456	5.629842
SW15	Sediment+ Surface Water +Benthos+ Plankton +Air +Noise	5.933136	5.626583
SW Cnt 1	Sediment+ Surface Water +Benthos+ Plankton	5.903753	5.697686
SW Cnt 2	Sediment+ Surface Water +Benthos+ Plankton	5.928381	5.621554
SS1	Soil+ Air +Noise	5.891264	5.662917
SS2	Soil	5.898667	5.659611
SS3	Soil+ Air +Noise	5.901669	5.657380
SS4	Soil	5.906494	5.651894
SS5	Soil +Air +Noise	5.911008	5.648678
SS6	Soil	5.910556	5.643419
SS7	Soil +Air +Noise	5.911756	5.637728
SS8	Soil	5.915886	5.647225
SS9	Soil +Air +Noise	5.921144	5.646156
SS10	Soil +Air +Noise	5.926725	5.643861
SS11	Soil	5.889744	5.695214
SS12	Soil +Air +Noise	5.901278	5.682417
SS13	Soil +Air +Noise	5.914761	5.660914
SS14	Soil+ Air +Noise	5.945154	5.645538
SS15	Soil	5.943444	5.629842
SS Cnt	Soil	5.928042	5.622311
BH1	Groundwater	5.925925	5.640614
BH2	Groundwater +Air +Noise	5.922344	5.641295
BH Cntrl	Groundwater	5.923477	5.645430

1.5 Pre-Mobilisation/QHSE Checks and Mobilisation

In preparation for field sampling, all materials and equipment were assembled and cross-examined by the field sampling team. Appropriate and fit for the job purpose materials were used for the exercise.

1.6 Field Sampling and Data Gathering

Field sampling and data collection was in line with standard procedures and practices for environmental data collection as defined in the work execution plan in agreement with PEL (project proponent) as well as FNL's QHSE policy and standards. Recording of data and field observations were carried out using digital and still photographs as well as taking notes on field notebooks. Such records include observations of vegetation/ wildlife, fish characteristics, insitu measurement of sediment, soil, ground and surface water characteristics, station co-ordinates and sample information (e.g., identification, date and time of collection, etc.). Description of specific field sampling/ survey activities carried out during the field data gathering exercise are discussed in the following sub-sections.

Positioning

Prior to commencement of sampling, the sample point's coordinates were loaded into a hand-held global positioning system (GPS) to serve as waypoints. The GPS assisted in navigation/ driving, location of sample area and positioning at each sample station. Thereafter, the co-ordinates at which sampling actually took place was recorded by the sampling team.

Socio-economic and Health Survey

Primary and secondary data were used for the study. Instruments used to obtain the primary data include household questionnaire, focus group discussions [FGDs], general group discussions [GGDs], key informant interviews and participatory rural appraisal tools. Secondary data were obtained from published and unpublished documents such as the National Population Commission publication.

A reconnaissance project site visit was carried out to identify the likely impacted communities. This guided planning for the scale of surveys required for the community. For key informant interviews, the leaders of the community were selected. FGDs were conducted with different groups in each of the communities with stakeholders including the traditional chiefs/ elders, community leader, men and women. This ensured that representative sample of groups in the community were consulted.

Target Population and Sample Size

Fifty-five (55) copies of properly completed questionnaire were retrieved and used for analyses. Respondents were chosen from households in Ogorode community. This distribution covered vulnerable groups, all ethnic groups in the community, landlords and migrants, and was a good representation of the key stakeholders directly affected by the project.

Groundwater

Groundwater samples were collected from three (3) boreholes (inclusive of control point) within the study area. Two of the boreholes were drilled (**Plate 1**), while one was obtained from existing borehole. Water samples were collected in appropriate containers. *In-situ* measurements were carried out to determine parameters with short holding time such as pH, temperature, turbidity, conductivity, total dissolved solids, salinity and dissolved oxygen. Water samples for heavy metal analyses were collected in 2ml plastic bottles and acidified with 10% HNO_3, while those for TPH were acidified with H_2SO_4.

Plate 1: Borehole Drilling Activities

Surface Water Samples

Surface water samples were collected from seventeen (17) stations (i.e. fifteen points and two control) from the existing water body (Ethiope River) behind the project area using appropriate containers (**Plate 2**). The containers were lowered into the water body from a boat, and surface water samples obtained. Water samples were collected directly into various ampoules for preservation and sub-sequent transfer to the laboratory for analyses.

In-situ measurements were immediately carried out to determine the following parameters with short holding time; pH, temperature, turbidity, conductivity, total dissolved solids, salinity and dissolved oxygen. Water samples for heavy metal analyses were collected in 2ml plastic bottles and acidified with 10% HNO3, while those for oil & grease were acidified with H_2SO_4.

Plate 2: Surface Water Collection

Soil Samples

Using a hand auger (**Plate 3)** soil samples were collected from different sample points for laboratory analysis. In other to ensure optimum result, soil samples of not less than 500g were collected from depths 0-15cm and 15-30cm. The soil samples were obtained from sixteen (16) sampling stations (fifteen points and a control). Samples for physico-chemical analysis were collected and placed in ziploc bags, those for microbiology analysis where collected in 100ml sterilised plastic bottles, while samples for hydrocarbon analysis were collected in 100ml screw-capped glass bottles.

Plate 3: Soil Collection using Hand Auger

Sediment

Sediment samples were obtained from seventeen (17) stations (sixteen and a control point) as well. The sediment samples were collected using an Eckman grab (**Plate 4**). The grab was tied with a rope and lunched into the river from the boat.

Plate 4: Deploying an Eckman Grab

The top surface of sediment were collected in a plastic basin and homogenised for the analysis of physio-chemical parameters, total petroleum and hydrocarbon (TPH), polyaromatic hydrocarbon (PAH), micro-biology and heavy metals.

Samples for physico-chemical analyses were collected in polythene bags and stored for the analysis of particle size, total organic matter, trace metals, total phosphorous, total hydrocarbon etc. The sediment samples for microbial analyses were collected in a sterile McCartney bottles. The samples were stored in coolers containing ice block while residual sediment were washed for benthos.

After each sampling, the hand auger was washed thoroughly with water from the river to remove adhering particles prior to each sampling.

Plankton Sampling
Zooplankton
Zooplankton samples were collected by pulling plankton net of mesh size of 0.063mm vertically on the surface of the river (**Plate 5**). A weight (iron rod) was attached to the cord holding the net, lowered into the river and then pulled back to the surface for collection of samples.

Plate 5: Zooplankton Collection

After each tow, zooplankton were collected using labeled wide mouth plastic containers and preserved with 10% buffered formalin, the net was thoroughly washed so that particles adhering to the net washed directly into collecting bottle for analysis.

Phytoplankton
Phytoplankton sample collection was done by lowering the plankton net to about 0.5m on the water surface and dragged (horizontally) on the waterway at a speed of about 1.5knots per hour for 5 minutes. The phytoplankton samples were collected in clearly labeled containers and preserved in Lugol's iodine solution.

Benthic Macrofauna
Benthic samples were obtained by washing residual sediment through a 1 mm-mesh sieve using water obtained from the river. This was carried out carefully in order not to destroy the integrity of the benthic organisms. The benthos samples obtained were placed in a plastic container and preserved with Rose bengal solution.

Zooplankton, phytoplankton and benthic macrofauna were all collected from same points as with the surface water.

Air Quality and Noise Measurements
Measurement of atmospheric gas pollutants (CO, H_2S, NO_x, SO_x, C_xH_y and SPM) and noise levels were carried out in fifteen (15) sample stations.

Atmospheric gasses were measured with the aid of Multi RAE IR Gas Monitor. This equipment was calibrated and a sensor connected to the equipment, the equipment was held at arm's length towards the direction of the prevailing wind at every point. The value of the atmospheric concentrations of each gaseous pollutant was read off directly on the equipment screen after 5 - 10 minutes.

The level of suspended particulate matter was established using the Aerocet 53i Particulate Counter. The equipment was switched on and exposed to the atmosphere for about 5 minutes the result obtained was read off from the meter and recorded in a field note book.

Plate 6: Air Quality Measurement

The ambient noise levels were measured with the aid of a Pulsar II Meter. The noise meter was programmed to run for 30 mins at each point. The readings were stored in the memory of the meter from which results were extracted using a computer in the office.

Vegetation and Wildlife

The vegetation and wildlife was studied by dividing the area into transects and each transect studied. Information from the field serves as primary data source. This was augmented by information/ data from secondary sources such as articles, text books, journals etc.

A reconnaissance survey provided insight into the selection of appropriate location, number, size, position and orientation of the transects surveyed. The study was conducted in 4 belt transects. Transects were established at intervals of approximately 1.5km to 3.5 km, alternating on the west, north and east flanks of the proposed project site.

Within each transect the associated vegetation was characterized using the segmented belt transect techniques (Oosting 1956; Odu et al, 1985; Okpon et al 1998), to ensure maximum chances of finding most of the component species in the area

Laboratory Analytical Methods and Procedures

The following sub-sections presents a synoptic description of the laboratory analytical methods and procedures employed for the various physical, chemical and biological parameters. The equipment detection limits of these parameters in water and soil/ sediment samples are presented in **Table 4** and **Table 5**.

Table 4: Analytical Methods and Detection Limits for Water Samples

Parameters	Unit	Test method	Detection limit
Total Suspended Solids (TSS)	mg/l	APHA 2540D	1.00
Dissolved Oxygen (DO)	Mg/l	APHA 4500-O-G	0.50
Chemical Oxygen Demand	mg O_2/l	APHA 5220B	0.80
Biological Oxygen Demand	mg O_2/l	APHA 5210B	0.50
Vanadium (V)	mg/l	APHA 3111B	0.20
Copper (Cu)	mg/l	APHA 3111B	0.02
Iron (Fe)	mg/l	APHA 3111B	0.03
Lead (Pb)	mg/l	APHA 3111B	0.008
Nickel (Ni)	mg/l	APHA 3111B	0.06
Barium (Ba)	mg/l	ASTM D 3651	0.03
Zinc (Zn)	mg/l	APHA 3111B	0.02
Phosphate (PO_4^{3-})	mg/l	APHA 4500 PO_4^{3-}D	0.02
Sulphate (SO_4^{2-})	mg/l	APHA 4500 SO_4^{2-}E	0.02
pH	-	APHA 4500H^+B	-
Total Hydrocarbons (THC)	mg/l	ASTM D 3921	0.40

Table 5: Analytical Methods and Detection Limits for Soil/ Sediment Samples

Parameters	Unit	Test Methods	Detection limit
pH	-	Electrode	-
Grain size distribution (0.002 – 60 mm) (Sieve + hydrometer)	% weight	BS 1377 part 2 '90	-
Total hydrocarbons (THC)	mg/kg	ASTM D 5765/ASTM D3921	5.0
Copper (Cu)	mg/kg dry weight	USEPA 6200	0.50
Iron (Fe)	mg/kg dry weight	USEPA 6200	0.50
Lead (Pb)	mg/kg dry weight	USEPA 6200	1.00
Nickel (Ni)	mg/kg dry weight	USEPA 6200	0.50
Vanadium (V)	mg/kg dry weight	USEPA 6200	0.50
Zinc (Zn)	mg/kg dry weight	USEPA 6200	0.50
Nitrate (NO_3^-)	mg/kg	CAEM/EPA 352.1	0.02
Nitrite (NO_2^-)	mg/kg	CAEMAPHA 4500 NO_2^-D	0.02
Phosphorus total (P)	mg/kg	CAEMAPHA 4500 PO_4^{3-}D	0.02
Sulphate (SO_4)	mg/kg	APHA 4500	0.02

Analytical Procedures

Conductivity and pH

20.0g of fresh sediment sample was weighed into a 50ml beaker and 20ml of distilled water added to the beaker. The mixture was thoroughly stirred and allowed to stand for 30 minutes and the Multi-Parameter Water Quality Monitor was then used to measure the above parameters directly. The APHA 2510A and APHA 4500H $^+$B (for water) were used for conductivity and pH determinations.

Total Suspended Solid

Total suspended solids content of the water samples was determined with a membrane filter apparatus, in accordance with APHA 25400. A 100ml aliquot of the water sample was filtered through dried pre-weighed 0.45f.lm filter paper, through which clean distilled water not less than 100ml and subsequently passed to remove salt.

The filter was then oven dried at 105 ± 5°C for one hour. After drying, the filter paper was cooled and weighed. The difference in filter weights before and after filtering was used to calculate the TSS.

The TSS content was calculated as follows:

$$\text{TSS (mg/l)} = \frac{(A - B)}{\text{Sample volume (ml)}} \times 1000$$

Where A = weight of filter paper (mg) + residue (mg)
B = weight of filter paper (mg)

Chemical Oxygen Demand

Chemical oxygen demand (COD) of surface water was determined titrimetrically according to CAEM. In this method, organic matter was oxidized to carbon dioxide using acid dichromate as the oxidizing agent and its consumption which is equivalent to COD concentration was measured by titrating against a standard ferrous ammonium sulphate solution.

The chemical oxygen demand was calculated as follow:

$$\text{COD (mgll)} = \frac{B - S(\text{ml}) \times \text{titrant molarity} \times 8 \times 1000}{\text{Volume of sample}}$$

B =Titre for Blank
S =Titre for Sample
8 =Atomic mass of Oxygen
1000 =Conversion to litre

Biological Oxygen Demand

BOD_5 of surface water was determined in accordance with APHA 5210B. This was done electro metrically with the OxiTOP BOD instrument in the presence of sodium hydroxide. Each sample was allowed to attain a temperature of within 2°C of its incubation temperature (20°C). 95ml of the samples were measured into BOD Trak sample bottles with channel num!1er tags and magnetic stirrers inserted in each sample bottle. Test duration of 5 days for the sample was selected from the channel key. The test was initiated by pressing the channel number and selecting the BOD range required. The analysis results at the expiration of the set period were reported in mg/1. At the end of 5 days incubation, the readings were taken from the BOD device and multiplied by a factor of 20.

Total Petroleum Hydrocarbon

Infra-red spectrophotometry, as described in ASTM 03921, was used to determine the TPH in sediment/water samples. The method of extraction was calculated as follows.

TPH in water samples is calculated thus:

$$\text{Actual TPH (mg/l)} = \frac{\text{Instrument reading (mg/l)} \times \text{Volume of extractant (ml)}}{\text{Volume of Sample (ml)}}$$

TPH in sediment samples is calculated:

$$\text{Actual TPH (mg/g)} = \frac{\text{Instrument reading (mg/l)} \times \text{Volume of extract (ml)}}{\text{Weight of Sample (g)}}$$

Total Organic Carbon in Sediment Samples
TOC was determined following BS 1377 method.

TOC is calculated thus:

$$\text{Organic Carbon (g/kg)} = \frac{(\text{meq } K_2Cr_2O_7 - \text{meg } FeSO_4) \times 0.003 \times 1000 \times 1.3}{\text{Weight of water free sample (g)}}$$

Total Organic Matter (g/kg) = Total organic carbon (g/kg) x 1.729

Where,

meq K_2CrO_7	=	1N x 10ml
meq $FeSO_4$	=	0.5N x volume of titrant in ml
0.003	=	milliequivalent weight of carbon
1.30	=	Correction factor
1000	=	Conversion factor to kg

Phosphate - Phosphorus
The test method for Phosphate - phosphorus in sediment samples was based on APHA 4500-PD/CAEM. The Stannous Chloride Reduction Method, based on the method described in the Chemical Analyses of Ecological Materials (2nd edition), was applied. Phosphate - phosphorus content of sediment samples was calculated as follows.

$$\text{Phosphate - phosphorus (mg/kg)} = \frac{\text{C (mg/l) x Solution Volume (l) x 1000}}{\text{Aliquot x Sample weight (g)}}$$

Where C = mg phosphate obtained from calibration graph using the UV/Visible spectrometer and Vision software version 3

$$\text{Aliquot} = \frac{\text{Volume (ml) of extract used for analyses}}{\text{Volume (ml) of extractant used for the extraction}}$$

1000 = conversion factor to kg

Nitrate
The USEPA 3521 in combination with the Chemical Analysis of Ecological Matter (second edition) test methods were used to determine the nitrate content of sediment samples. N was calculated as follows.

$$\text{N (mg/kg)} = \frac{\text{mg (N) from calibration graph}}{\text{Aliquot (ml) x Sample weight (g)}} \times 1000$$

Where the 1000 is the conversion factor to kg
Aliquot = volume of extract used/volume of extractant.

Exchangeable Cations
Exchangeable cations (Mg, Ca, K, and Na) were determined as described by APHA 20th edition 3111 Band ASTM D3561. The concentrations were calculated thus:

$$\text{Concentration (mg/l)} = \frac{C \times C \times Y}{}$$

X

Where C=concentration of cation determined from calibration curve
Y=final volume. Ml
X=volume of sample, ml

Cd, Zn, Mn, Cu, Cr, Ni and: APHA 3111 B (20th edition)
Ba: ASTM D3651
V: APHA 3111 D (20th edition)
Hg APHA 3112B

Metal concentration of water samples (mg/l) = $\frac{C \times Y}{X}$

Where C=concentration of cation determined from calibration curve
Y =Final volume made-up (ml)
X = Sample of volume (ml)

Hg is determined using' APHA 3112B 20ed test method

Hg concentration, ug/l= $\frac{(A-B)}{D}$

Where A = concentration of mercury in sample, µg/l as determined by AAS (Instrument Reading)
B = concentration of mercury found in blank, µg/l.
D =. Volume of sample in litres

Heavy Metals in Sediment Samples

Heavy metal content of sediment samples was determined using Perkin Elmer Atomic Absorption Spectrophotometer, Model Analyst 200. The sample digestion/ preparation procedure followed is described in ASTM D5198/D3974. AAS measurement of heavy metal content sediment samples was done following the procedures indicated below.

Cd, Zn, Mn, Fe, Cu, Cr, Ni and: APHA 20th edition 3111 B
Ba: ASTM D3651
V: APHA 20th edition 3111 D

Metal concentration of sediment samples (mg/kg) = $\frac{(A - B) \times C}{D}$

Where A =Concentration of metal in sample (mg/l) as determined by AAS
B =Concentration of the metal found in blank (mg/l)
C=Volume of extract (ml)
D = Weight of dry sample (g)

Hg: APHA 3112B & ASTM D3223

Mercury (Hg) concentration is determined thus, µg/g = (A - B) C D

Where A = concentration of mercury in sample, µg/ml as determined by AAS (Instrument reading)
B = concentration of mercury found in blank, µg/ml (Procedural blank)
C = volume of extract, (ml)
D = weight of dry sample, (g)

Particle Size Distribution

The test method is based on the BS1377 (Part 2; 1990) which is in accordance with the Dutch RAW and the American ASTM D422. PSD was determined using the hydrometer method followed by sieving recommended for sediment samples containing more than 35% fine particles, i.e., clays and silts.

Total Microbial Count (Water and Sediment Samples)

Indirect cell count on sediment and water samples was carried out to determine the total viable microbial populations. The test methods used are the ASTM D5465 - 93:

Determining Microbial Colony Counts from Water Analysed by Plating Methods, and APHA 907: Standard Plate Count.

Total microbial colonies were calculated as follows:

$$\text{Plate Count (cfu/ml)} = \text{Vol plated} \times \text{Number of cells} \times \frac{(1)}{\text{dilution}} \times \text{dilution factor}$$

1.7 Quality, Health, Safety and Environment Plan

All aspects of the study were carried out in accordance to FNL Quality, Health, Safety and Environment (QHSE) plan and procedures. This covered the study execution and includes sample collection, handling, laboratory analysis and data (results) management as well as personnel health, safety and environmental protection.

The survey was carried out in a manner that ensured the health and safety of personnel and assets as well as the preservation of the integrity of the ecosystem. This involved carrying out safety briefings prior to commencement of sampling. All personnel wore personal protective equipment during sampling activities. All preservations and tests were carried in the field.

Laboratory Analyses

Quality Assurance and Quality Control (QA/ QC) measures adopted for laboratory analysis were in line with standard practices and included collection and analysis of duplicate samples to establish analytical precision. Other QA/ QC measures adopted include:

- Only adequately trained personnel were used at all phases of the study;
- Written analytical standard operating procedures were followed during analyses;
- Routine auditing and checking of analyses results, were introduced into every batch or five samples collected.

Data Management

Standard data spreadsheets were used for recording and transmitting analytical results. Presentation of results was carried out following written standard operating procedures. Final results were issued only after a general QA/ QC check and validation has been carried out.

APPENDIX 4.2

SOIL PHYSICO-CHEMICAL AND MICROBIOLOGY RESULTS

Table 1: Soil Physico-chemical Results – Dry Season

Sample Stations **Parameters**	**SS1**	**SS2**	**SS3**	**SS4**	**SS5**	**SS6**	**SS7**	**SS8**	**SS9**
pH (H_2O) @ 24.1°C	5.35	4,86	6.20	5.45	7.30	7.15	6.00	6.15	7.00
Moisture Content (%)	23.3	15.9	12.4	13.6	13.1	11.0	12.6	12.0	15.0
THC (mg/kg)	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
PSD Clay (%)	-	13.0	-	14.0	-	-	-	-	-
Silt (%)	-	28.0	-	29.0	-	-	-	-	-
Sand (%)	100	59.0	100	57.0	100	100	100	100	100
Ext. Nitrate (mg/kg)	0.10	0.09	0.10	0.09	0.09	0.17	0.13	0.47	0.19
Ext. Sulphate (mg/kg)	195	163	178	215	205	320	300	275	180
Ext. Phosphate (mg/kg)	33.8	25.1	23.7	23.9	17.5	28.9	21.1	19.1	17.7
Total Iron (mg/kg)	11,100	10,350	10,080	10,020	11,430	11,170	10,590	9,517	9,435
Copper (mg/kg)	2.90	5.10	1.50	9.70	89.2	19.0	18.3	13.9	50.5
Lead (mg/kg)	22.5	22.6	18.3	23.8	54.7	11.5	17.5	34.6	8.10
Nickel (mg/kg)	12.3	8.90	10.2	11.8	29.3	12.6	8.80	7.80	9.60
Zinc (mg/kg)	25.1	26.2	134	33.1	137	96.1	30.5	65.2	698
Vanadium (mg/kg)	44.3	37.0	30.2	28.2	18.3	19.9	24.6	22.2	20.5

Table 1: Soil Physico-chemical Results – Dry Season – cont'd

Sample Stations **Parameters**	**SS10**	**SS11**	**SS12**	**SS13**	**SS14**	**SS15**	**SS Control**
pH (H_2O) @ 24.1°C	6.25	5.65	5.80	5.30	6.85	7.00	7.00
Moisture Content (%)	20.8	14.6	14.7	15.2	15.5	17.3	16.3
THC (mg/kg)	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
PSD Clay (%)	-	-	-	-	-	-	-
Silt (%)	-	-	-	-	-	-	-
Sand (%)	100	100	100	100	100	100	100
Ext. Nitrate (mg/kg)	0.34	0.10	0.13	0.14	0.10	0.10	0.22
Ext. Sulphate (mg/kg)	235	173	188	215	168	145	248
Ext. Phosphate (mg/kg)	24.8	18.5	21.4	21.6	21.8	16.9	19.6
Total Iron (mg/kg)	9,020	10,060	9,436	9,619	8,224	10,760	10,540
Copper (mg/kg)	15.1	12.2	10.6	21.6	54.8	42.4	8.00
Lead (mg/kg)	18.3	56.2	38.7	60.3	34.3	48.8	43.5
Nickel (mg/kg)	10.6	6.30	15.6	7.80	21.0	10.4	8.80
Zinc (mg/kg)	15.1	69.4	68.6	67.8	132	187	305
Vanadium (mg/kg)	42.1	34.8	23.9	14.7	19.0	21.7	7.80

Table 1: Soil Physico-chemical Results – Wet Season

Sample Stations **Parameters**	**SS1**	**SS2**	**SS3**	**SS4**	**SS5**	**SS6**	**SS7**	**SS8**	**SS9**
pH (H_2O) @ 24.1°C	7.27	7.23	6.08	5.32	6.18	5.74	6.88	7.03	7.10
Moisture Content (%)	15.7	32.1	14.0	12.7	14.3	15.8	18.9	18.3	12.5
THC (mg/kg)	<5.00	<5.00	192	<5.00	1,440	<5.00	<5.00	<5.00	1,151
PSD Clay (%)	-	-	-	-	-	-	-	-	-
Silt (%)	20.0	30.0	28.0	20.0	30.0	36.0	28.0	30.0	20.0
Sand (%)	80.0	70.0	72.0	80.0	70.0	64.0	72.0	70.0	80.0
Ext. Nitrate (mg/kg)	13.6	7.49	33.9	4.81	15.1	35.8	25.6	56.1	112
Ext. Sulphate (mg/kg)	148	70.0	108	210	67.5	270	180	220	118
Ext. Phosphate (mg/kg)	49.9	163	23.6	33.3	37.6	2.45	1,056	2,865	14.9
Total Iron (mg/kg)	8,037	9,999	11,010	10,150	10,800	10,540	10,829	10,220	9,445
Copper (mg/kg)	1.30	2.50	12.1	1.20	8.10	15.1	14.0	4.00	2.80
Lead (mg/kg)	11.4	30.8	25.9	4.80	21.2	<1.00	17.6	7.60	21.6
Nickel (mg/kg)	2.50	9.20	14.3	7.40	7.90	22.0	16.5	8.60	7.70
Zinc (mg/kg)	71.4	371	42.2	33.6	87.9	36.4	91.9	102	163
Vanadium (mg/kg)	<1.00	14.4	19.4	8.70	18.0	35.9	18.0	18.0	4.80

Table 1: Soil Physico-chemical Results – Wet Season – cont'd

Sample Stations **Parameters**	**SS10**	**SS11**	**SS12**	**SS13**	**SS14**	**SS15**	**SS Control**
pH (H_2O) @ 24.1°C	6.64	5.92	5.73	5.77	5.45	5.42	5.55
Moisture Content (%)	17.5	19.4	16.2	18.1	14.8	15.7	14.6
THC (mg/kg)	220	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
PSD Clay (%)	-	-	-	-	-	-	-
Silt (%)	20.0	30.0	10.0	19.0	22.0	20.0	18.0
Sand (%)	80.0	70.0	90.0	81.0	78.0	80.0	82.0
Ext. Nitrate (mg/kg)	49.5	54.9	61.5	64.6	113	73.9	79.0
Ext. Sulphate (mg/kg)	105	92.5	92.5	100	125	138	148
Ext. Phosphate (mg/kg)	18.5	8.34	52.9	3.58	1.94	<0.02	5.60
Total Iron (mg/kg)	10,270	9,838	9,337	9,321	9,761	9,750	8,887
Copper (mg/kg)	3.10	1.80	2.50	12.1	1.70	1.60	10.9
Lead (mg/kg)	13.3	85.5	48.5	9.30	42.7	43.0	155
Nickel (mg/kg)	10.6	6.90	4.20	12.4	3.70	5.10	10.9
Zinc (mg/kg)	410	245	136	140	112	113	61.0
Vanadium (mg/kg)	8.00	15.9	8.90	14.1	13.9	11.5	13.3

Table 2: Soil Microbiology Results- Dry Season

Parameters Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SS 1	*Proteus sp* *Pseudomonas sp* *Actinomyces sp* *Bacillus sp*	$2.00x10^5$	*Pseudomonas sp* *Bacillus sp*	$2.30x10^4$	*Penicillium sp* *Candida sp* *Aspergillus sp* *Fusarium sp* *Mucor sp*	$4.40x10^2$	*Fusarium sp* *Penicillium sp* *Mucor sp* *Aspergillus sp* *Candida sp*	$3.80x10^2$
SS 2	*Pseudomonas sp* *Bacillus sp* *Staphylococcus sp* *Proteus sp*	$1.63x10^5$	*Pseudomonas sp* *Bacillus sp*	$8.50x10^3$	*Trichoderma sp* *Penicillium sp* *Aspergillus sp* *Candida sp*	$4.80x10^2$	*Rhodotorula sp* *Candida sp* *Penicillium sp* *Aspergillus sp*	$3.50x10^2$
SS 3	*Actinomyces sp* *Proteus sp* *Pseudomonas sp* *Bacillus sp* *Staphylococcus sp*	$2.90x10^5$	*Staphylococcus sp* *Pseudomonas sp* *Bacillus sp*	$3.10x10^4$	*Rhizopus sp* *Aspergillus sp* *Candida sp* *Penicilium sp* *Mucor sp*	$5.00x10^2$	*Candida sp* *Mucor sp* *Aspergillus sp* *Rhizopus sp* *Penicillium sp*	$4.00x10^2$
SS 4	*Pseudomonas sp* *Bacillus sp* *Proteus sp* *Alcaligenes sp* *Staphylococcus sp*	$2.74x10^5$	*Staphylococcus sp* *Pseudomonas sp* *Bacillus sp*	$5.30x10^4$	*Aspergillus sp* *Mucor sp* *Chaetomium sp* *Pleurotus sp* *Candida sp* *Penicillium sp*	$6.00x10^2$	*Penicillium sp* *Pleurotus sp* *Aspergillus sp* *Mucor sp* *Candida sp*	$5.50x10^2$
SS 5	*Proteus sp* *Streptococcus sp* *Bacillus sp* *Pseudomonas sp* *Dactylosporangium sp* *Enterobacter sp* *Streptomyces sp* *Klebsiella sp*	$1.78x10^5$	*Pseudomonas sp* *Bacillus sp*	$1.91x10^4$	*Aspergillus sp* *Pleurotus sp* *Sporothrix sp* *Penicillium sp* *Candida sp*	$5.10x10^2$	*Aspergillus sp* *Pleurotus sp* *Candida sp* *Penicillium sp*	$4.20x10^2$
SS 6	*Bacillus sp* *Pseudomonas sp* *Proteus sp* *Dactylosporangium sp* *Staphylococcus sp*	$4.50x10^4$	*Bacillus sp* *Staphylococcus sp* *Pseudomonas sp*	$1.24x10^4$	*Candida sp* *Mucor sp* *Sporothrix sp* *Aspergillus sp* *Penicillium sp*	$7.00x10^2$	*Mucor sp* *Penicillium sp* *Candida sp*	$5.90x10^2$

Table 2: Soil Microbiology Results Dry Season- Cont'd

Parameters Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SS 7	*Proteus sp* *Actinomyces sp* *Bacillus sp* *Pseudomonas sp*	$6.00x10^4$	*Pseudomonas sp* *Bacillus sp*	$2.86x10^4$	*Trichoderma sp* *Penicilliumsp* *Candida sp* *Mucor sp*	$1.90x10^2$	*Penicillium sp* *Mucor sp* *Candida sp*	$1.50x10^2$
SS 8	*Proteus sp* *Pseudomonas sp* *Bacillus sp*	$1.90x10^5$	*Pseudomonas sp* *Bacillus sp*	$3.60x10^4$	*Candida sp* *Rhodotorula sp* *Rhizopus sp* *Mucor sp* *Aspergillus sp* *Penicillium sp*	$6.00x10^2$	*Aspergillus sp* *Candida sp* *Rhodotorula sp* *Mucor sp*	$5.00x10^2$
SS 9	*Bacillus sp* *Streptomyces sp* *Staphylococcus sp* *Pseudomonas sp* *Actinomyces sp*	$3.80x10^5$	*Pseudomonas sp* *Bacillus sp*	$2.20x10^4$	*Aspergillus sp* *Penicilliumsp* *Candida sp* *Mucor sp*	$7.60x10^2$	*Aspergillus sp* *Mucor sp* *Candida sp*	$3.70x10^2$
SS 10	*Streptomyces sp* *Arthrobacter sp* *Bacillus sp* *Nocardia sp* *Pseudomonas sp* *Proteus sp* *Staphylococcus sp*	$1.67x10^5$	*Pseudomonas sp* *Bacillus sp* *Staphylococcus sp* *Proteus sp*	$1.19x10^4$	*Fusarium sp* *Penicillium sp* *Mucor sp* *Aspergillus sp* *Candida sp*	$2.30x10^2$	*Aspergillus sp* *Mucor sp* *Penicillium sp* *Candida sp*	$1.50x10^2$
SS 11	*Proteus sp* *Actinomyces sp* *Bacillus sp* *Streptomyces sp*	$1.48x10^5$	*Pseudomonas sp* *Bacillus sp*	$2.44x10^4$	*Trichoderma sp* *Penicillium sp* *Ulocladium sp* *Fusarium sp* *Aspergillus sp* *Candida sp*	$4.60x10^2$	*Fusarium sp* *Aspergillus sp* *Penicillium sp* *Candida sp*	$4.00x10^2$
SS 12	*Pseudomonas sp* *Bacillus sp* *Alcaligenes sp* *Micrococcus sp*	$1.36x10^5$	*Bacillus sp* *Pseudomonas sp*	$3.40x10^4$	*Rhodotorula sp* *Candida sp* *Aspergillus sp* *Penicillium sp* *Mucor sp*	$4.20x10^2$	*Aspergillus sp* *Rhodotorula sp* *Penicillium sp* *Mucor sp*	$3.40x10^2$

Table 2: Soil Microbiology Results Dry Season- Cont'd

Parameters / Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SS 13	Bacillus sp Streptomyces sp Actinomyces sp Pseudomonas sp	$1.70x10^5$	Bacillus sp Pseudomonas sp	$2.70x10^4$	Fusarium sp Mucor sp Aspergillus sp Candida sp Penicillium sp	$4.80x10^2$	Mucor sp Fusrium sp Candida sp Aspergillus sp Penicilliumsp	$3.60x10^2$
SS 14	Staphylococcus sp Actinomyces sp Bacillus sp Pseudomonas sp Micrococcus sp	$2.60x10^5$	Staphylococcus sp Pseudomonas sp Bacillus sp	$2.51x10^4$	Aspergillus sp Mucor sp Candida sp Penicillium sp	$6.30x10^2$	Aspergillus sp Penicilium sp Mucor sp Candida sp	$5.30x10^2$
SS 15	Dactylosporangium sp Actinomyces sp Bacillus sp Pseudomonas sp Staphylococcus sp Micrococcus sp	$7.50x10^5$	Micrococcus sp Pseudomonas sp Bacillus sp	$3.70x10^4$	Trichoderma sp Mucor sp Aspergillus sp Candida sp Penicillium sp	$2.24x10^3$	Candida sp Penicillium sp Mucor sp Aspergillus sp	$1.98x10^3$
SS Control	Pseudomonas sp Bacillus sp Actinomyces sp Proteus sp	$3.40x10^5$	Bacillus sp Pseudomonas sp	$4.00x10^4$	Rhizopus sp Mucor sp Aspergillus sp Penicillium sp Candida sp	$1.80x10^3$	Rhizopus sp Candida sp Penicilium sp Aspergillus sp Mucor sp	$1.60x10^3$

Table 2: Soil Microbiology Results- Wet Season

Parameters / Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SS 1	*Pseudomonas sp* *Proteus sp* *Bacillus sp* *Staphylococcus sp* *Actinomyces sp* *Micrococcus sp*	$2.99x10^5$	*Pseudomonas sp* *Bacillus sp*	$2.80x10^3$	*Fusarium sp* *Aspergillus sp* *Candida sp* *Mucor sp*	$3.50x10^2$	*Aspergillus sp* *Mucor sp*	$1.70x10^2$
SS 2	*Pseudomonas sp* *Proteus sp* *Bacillus sp* *Staphylococcus sp* *Micrococcus sp*	$3.40x10^5$	*Pseudomonas sp* *Bacillus sp*	$1.00x10^3$	*Trichoderma sp* *Fusarium sp* *Aspergillus sp* *Candida sp*	$3.00x10^2$	*Aspergillus sp*	30
SS 3	*Bacillus sp* *Pseudomonas sp* *Staphylococcus sp*	$1.62x10^5$	*Bacillus sp* *Pseudomonas sp* *Staphylococcus sp*	$2.04x10^4$	*Aspergillus sp* *Mucor sp* *Candida sp* *Rhizopus sp* *Penicillium sp*	$6.00x10^2$	*Candida sp* *Aspergillus sp* *Mucor sp*	50
SS 4	*Bacillus sp* *Actinomyces sp* *Proteus sp* *Pseudomonas sp*	$5.60x10^4$	*Pseudomonas sp* *Bacillus sp*	$1.90x10^4$	*Candida sp* *Fusarium sp* *Mucor sp* *Aspergillus sp*	$1.10x10^2$	*Fusarium sp* *Mucor sp*	60
SS 5	*Bacillus sp* *Actinomyces sp* *Proteus sp* *Pseudomonas sp*	$7.10x10^4$	*Pseudomonas sp* *Bacillus sp*	$4.70x10^3$	*Candida sp* *Penicillium sp* *Aspergillus sp* *Rhizopus sp* *Mucor sp*	$5.60x10^2$	*Candida sp* *Mucor sp* *Aspergillus sp*	$2.50x10^2$
SS 6	*Pseudomonas sp* *Bacillus sp* *Micrococcus sp* *Staphylococcus sp*	$4.60x10^5$	*Micrococcus sp* *Pseudomonas sp* *Bacillus sp*	$1.15x10^4$	*Rhizopus sp* *Penicillium sp* *Aspergillus sp* *Candida sp* *Mucor sp* *Pleurotus sp*	$6.40x10^2$	*Penicillium sp* *Candida sp* *Mucor sp*	$1.00x10^2$

Table 2: Soil Microbiology Results Wet Season- Cont'd

Parameters / Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SS 7	*Pseudomonas sp* *Bacillus sp* *Actinomyces sp* *Staphylococcus sp* *Proteus sp*	$3.20x10^5$	*Pseudomonas sp* *Bacillus sp*	$1.40x10^3$	*Aspergillus sp* *Penicillium sp* *Candida sp* *Mucor sp*	$2.80x10^2$	*Candida sp* *Mucor sp* *Aspergillus sp*	$2.20x10^2$
SS 8	*Proteus sp* *Bacillus sp* *Pseudomonas sp* *Micrococcus sp*	$2.91x10^5$	*Micrococcus sp* *Pseudomonas sp* *Bacillus sp*	$2.00x10^3$	*Candida sp* *Aspergillus sp* *Fusarium sp* *Mucor sp*	$7.60x10^2$	*Aspergillus sp* *Candida sp*	$1.00x10^2$
SS 9	*Proteus sp* *Bacillus sp* *Staphylococcus sp* *Micrococcus sp* *Pseudomonas sp*	$3.10x10^5$	*Pseudomonas sp* *Micrococcus sp*	$1.10x10^3$	*Mucor sp* *Penicillium sp* *Aspergillus sp* *Candida sp*	$4.50x10^2$	*Aspergillus sp* *Mucor sp*	$2.40x10^2$
SS 10	*Bacillus sp* *Chromobacterium sp* *Proteus sp* *Actinomyces sp* *Flavorbacterium sp* *Pseudomonas sp*	$2.50x10^5$	*Flavobacterium sp* *Bacillus sp* *Pseudomonas sp*	$2.20x10^3$	*Aspergillus sp* *Candida sp* *Rhizopus sp* *Penicillium sp* *Mucor sp*	$4.20x10^2$	*Rhizopus sp* *Mucor sp* *Candida sp*	$1.80x10^2$
SS 11	*Chromobacterium sp* *Proteus sp* *Bacillus sp* *Staphylococcus sp* *Pseudomonas sp* *Actinomyces sp*	$2.66x10^5$	*Staphylococcus sp* *Pseudomonas sp* *Bacillus sp*	$9.50x10^3$	*Aspergillus sp* *Penicillium sp* *Mucor sp* *Candida sp*	$3.60x10^2$	*Aspergillus sp* *Penicillium sp* *Mucor sp*	$2.40x10^2$
SS 12	*Chromobacterium sp* *Micrococcus sp* *Bacillus sp* *Pseudomonas sp* *Staphylococcus sp* *Proteus sp*	$2.74x10^5$	*Staphylococcus sp* *Pseudomonas sp* *Micrococcus sp*	$6.10x10^3$	*Aspergillus sp* *Penicillium sp* *Mucor sp* *Candida sp* *Fusarium sp*	$9.90x10^2$	*Candida sp* *Mucor sp* *Aspergillus sp*	$2.70x10^2$

Table 2: Soil Microbiology Results Wet Season- Cont'd

Parameters / Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SS 13	*Proteus sp* *Pseudomonas sp* *Bacillus sp* *Actinomyces sp* *Chromobacterium sp* *Micrococcus sp* *Staphylococcus sp*	$2.80x10^5$	*Staphylococcus sp* *Micrococcus sp* *Bacillus sp* *Pseudomonas sp*	$7.00x10^3$	*Aspergillus sp* *Mucor sp* *Penicillium sp* *Candida sp*	$6.00x10^2$	*Aspergillus sp* *Mucor sp*	$3.50x10^2$
SS 14	*Chromobacterium sp* *Micrococcus sp* *Staphylococcus sp* *Proteus sp* *Pseudomonas sp* *Bacillus sp*	$3.30x10^5$	*Staphylococcus sp* *Pseudomonas sp* *Bacillus sp*	$3.00x10^3$	*Aspergillus sp* *Fusarium sp* *Penicillium sp* *Candida sp* *Mucor sp*	$8.00x10^2$	*Mucor sp* *Aspergillus sp* *Fusarium sp*	$2.00x10^2$
SS 15	*Paenibacillus sp* *Micrococcus sp* *Bacillus sp* *Chromobacterium sp* *Proteus sp* *Pseudomonas sp* *Staphylococcus sp*	$4.40x10^5$	*Micrococcus sp* *Pseudomonas sp* *Bacillus sp* *Staphylococcus sp*	$7.60x10^3$	*Aspergillus sp* *Fusarium sp* *Penicillium sp* *Candida sp* *Mucor sp*	$4.60x10^2$	*Mucor sp* *Aspergillus sp* *Fusarium sp*	$3.00x10^2$
SS Control	*Chromobacterium sp* *Proteus sp* *Bacillus sp* *Staphylococcus sp* *Pseudomonas sp*	$3.50x10^5$	*Pseudomonas sp* *Bacillus sp*	$6.00x10^3$	*Aspergillus sp* *Penicillium sp* *Candida sp* *Mucor sp*	$7.50x10^2$	*Aspergillus sp* *Mucor sp*	$3.30x10^2$

Table 3: Soil Microbiology Results -Dry Season

Sample Station	Anaerobic Bacteria	Count (cfu/g)
SS 1	Proteus sp, Bacillus sp, Clostridium sp	$2.21x10^3$
SS 2	Clostridium sp, Proteus sp, Bacteriodes sp	$2.34x10^3$
SS 3	Bacillus sp, Clostridium sp	$3.60x10^3$
SS 4	Proteus sp, Bacillus sp, Clostridium sp, Prevotella sp	$2.54x10^3$
SS 5	Bacteriodes sp, Klebsiella sp, Peptostreptococcus sp	$2.00x10^3$
SS 6	Proteus sp, Clostridium sp, Prevotella sp	$2.08x10^3$
SS 7	Fusobacterium sp, Bacillus sp, Clostridium sp	$2.53x10^3$
SS 8	Butyrivibrio sp, Bacillus sp, Clostridium sp	$5.00x10^3$
SS 9	Butyrivibrio sp, Bacillus sp, Clostridium sp	$4.00x10^3$
SS 10	Staphylococcus sp, Bacillus sp, Clostridium sp	$1.81x10^3$
SS 11	Bacillus sp, Clostridium sp, Proteus sp	$2.50x10^3$
SS 12	Bacillus sp, Proteus sp, Clostridium sp	$3.00x10^3$
SS 13	Veillonella sp, Proteus sp, Bacillus sp, Clostridium sp	$3.50x10^3$
SS 14	Peptococcus sp, Clostridium sp, Bacillus sp	$3.60x10^3$
SS 15	Bacteroides sp, Bacillus sp, Clostridium sp	$2.93x10^3$
SS Control	Prevotella sp, Bacillus sp	$2.18x10^3$

Table 3: Soil Microbiology Results -Wet Season

Sample Station	Anaerobic Bacteria	Count (cfu/g)
SS 1	Bacillus sp, Clostridium sp, Bacteriodes sp	$1.12x10^3$
SS 2	Bacillus sp, Clostridium sp, Prevotella sp	$8.50x10^2$
SS 3	Staphylococcus sp, Bacillus sp, Clostridium sp	$9.40x10^2$
SS 4	Clostridium sp, Bacillus sp, Proteus sp, Fusobacterium sp	$4.20x10^2$
SS 5	Staphylococcus sp, Bacillus sp, Clostridium sp	$9.50x10^2$
SS 6	Bacillus sp, Peptococcus sp, Proteus sp	$6.30x10^2$
SS 7	Bacillus sp, Prevotells sp, Fusobacterium sp	$8.60x10^2$
SS 8	Bacillus sp, Clostridium sp, Staphylococcus sp, Bacteriodes sp	$8.90x10^2$
SS 9	Bacteriodes sp, Bacillus sp, Staphylococcus sp, Clostridium sp	$9.60x10^2$
SS 10	Staphylococcus sp, Clostridium sp, Bacillus sp	$1.01x10^3$
SS 11	Actinomyces sp, Bacillus sp, Clostridium sp	$1.10x10^3$
SS 12	Veillonella sp, Proteus sp, Bacillus sp, Clostridium sp	$8.10x10^2$
SS 13	Bacillus sp, Clostridium sp, Prevotella sp, Staphylococcus sp	$7.00x10^2$
SS 14	Peptococcus sp, Clostridium sp, Bacillus sp, Fusobacterium sp	$7.30x10^2$
SS 15	Bacteriodes sp, Bacillus sp, Clostridium sp	$5.50x10^2$
SS Control	Bacillus sp, Prevotella sp, Staphylococcus sp	$4.80x10^2$

APPENDIX 4.3

SEDIMENT PHYSICO-CHEMICAL AND MICROBIOLOGY RESULTS

Table 1: Sediment Physico-chemical Results – Dry Season

Parameters	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9
pH (H_2O) @ 24.2ºC	4.16	4.24	4.25	4.14	3.55	3.60	4.10	4.21	4.15
Elect. Conductivity (µS/cm)	199	77.2	97.0	254	572	412	82.0	95.0	62.0
THC (mg/kg)	<5.00	<5.00	1,347	207	<5.00	<5.00	202	1,149	3,058
PSD									
Clay (%)	-	-	-	-	8.00	4.00	-	-	-
Silt (%)	-	-	-	-	37.0	36.0	-	-	-
Sand (%)	100	100	100	100	55.0	60.0	100	100	100
Ext. Nitrate (mg/kg)	0.08	0.12	0.10	0.27	0.17	0.16	0.10	0.24	0.19
Ext. Sulphate (mg/kg)	248	128	183	183	193	223	90.0	173	100
Ext. Phosphate (mg/kg)	23.0	18.5	10.0	13.9	18.4	16.0	11.3	35.1	76.4
Magnesium (mg/kg)	1,570	1,570	1,570	595	2,144	1,920	1,290	1,570	1,570
Sodium (mg/kg)	980	586	1,037	2,450	2,920	2,080	251	744	1,180
PotaSWium (mg/kg)	2,470	2,540	2,655	2,033	2,244	2,254	2,037	2,005	1,963
Calcium (mg/kg)	1,370	371	1,222	315	617	654	543	1,287	463
Total Chromium (mg/kg)	41.4	30.1	39.3	47.1	18.6	17.3	41.0	45.3	31.6
Total Iron (mg/kg)	8,572	8,313	8,028	8,961	10,480	10,680	8,268	8,149	8,096
Copper (mg/kg)	60.5	1.00	0.90	1.90	28.4	44.4	18.9	3.50	14.7
Lead (mg/kg)	57.9	22.6	18.3	23.6	3.50	28.6	50.7	45.4	36.8
Nickel (mg/kg)	8.90	6.60	6.00	9.10	16.7	20.4	13.2	8.70	11.4
Zinc (mg/kg)	37.5	36.0	23.5	2.10	36.1	41.9	49.3	59.3	35.8
Silver (mg/kg)	<2.00	<2.00	<2.00	<2.00	5.90	6.20	3.40	<2.00	<2.00
Cobalt (mg/kg)	<3.00	<3.00	<3.00	<3.00	19.0	22.5	<3.00	<3.00	<3.00
Barium (mg/kg)	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00
Manganese (mg/kg)	59.6	63.0	45.7	38.3	130	142	64.4	46.1	36.2
Cadmium (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	1.20	<0.10	<0.10

Table 1: Sediment Physico-chemical Results – Dry Season – cont'd

Parameters	SW10	SW11	SW12	SW13	SW14	SW15	SW Control 1	SW Control 2
pH (H_2O) @ 24.2ºC	4.05	4.00	4.00	4.05	4.15	4.00	4.24	4.03
Elect. Conductivity (µS/cm)	56.0	97.3	128	66.0	59.0	71.2	109	121
THC (mg/kg)	617	2,133	790	2,376	3,990	3,014	<5.00	<5.00
PSD								
Clay (%)	-	-	-	-	-	-	-	-
Silt (%)	-	-	-	-	-	-	-	-
Sand (%)	100	100	100	100	100	100	100	100
Ext. Nitrate (mg/kg)	0.29	0.19	0.20	0.19	0.18	0.22	0.21	0.19
Ext. Sulphate (mg/kg)	105	38.0	72.5	52.5	174	108	148	185
Ext. Phosphate (mg/kg)	35.2	26.5	18.2	45.6	25.0	25.7	24.1	47.
Magnesium (mg/kg)	700	620	637	485	538	1,569	510	347
Sodium (mg/kg)	2,130	1,750	2,290	2,080	2,260	2,520	2,000	1,940
PotaSWium (mg/kg)	1,970	1,926	1,975	2,017	1,795	1,263	1,892	1,159
Calcium (mg/kg)	324	344	306	1,076	1,071	1,450	357	106
Total Chromium (mg/kg)	<1.00	<1.00	<1.00	24.2	47.1	15.3	29.2	20.6
Total Iron (mg/kg)	8,193	8,137	8,005	5,078	7,847	10,760	8,108	4,848
Copper (mg/kg)	1.60	1.30	1.60	12.3	10.2	21.6	7.20	6.10
Lead (mg/kg)	<1.00	<1.00	<1.00	32.0	23.6	35.2	35.4	16.2
Nickel (mg/kg)	3.50	6.10	3.20	9.10	13.9	10.4	8.80	8.60
Zinc (mg/kg)	43.1	44.6	39.4	28.7	32.0	187	26.7	18.6
Silver (mg/kg)	<2.00	<2.00	<2.00	<2.00	<2.00	2.70	<2.00	<2.00
Cobalt (mg/kg)	<3.00	<3.00	<3.00	<3.00	<3.00	<3.00	<3.00	<3.00
Barium (mg/kg)	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00
Manganese (mg/kg)	46.8	32.7	32.4	42.3	33.4	144	45.5	60.3
Cadmium (mg/kg)	<0.10	<0.10	<0.10	1.00	<0.10	<0.10	<0.10	<0.10

Table 1: Sediment Physico-chemical Results – Wet Season

Parameters	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9
pH (H_2O) @ 24.2ºC	5.00	5.16	5.12	5.28	5.36	5.44	5.56	5.88	5.23
Elect. Conductivity (µS/cm)	336	91.3	372	170	182	160	98.0	282	228
THC (mg/kg)	2,383	2,618	1,791	1,027	733	801	2,568	517	889
PSD									
Clay (%)	2.00	4.00	5.00	4.00	-	-	-	-	5.00
Silt (%)	78.0	76.0	65.0	70.0	70.0	60.0	70.0	50.0	75.0
Sand (%)	20.0	20.0	30.0	26.0	30.0	40.0	30.0	50.0	20.0
Ext. Nitrate (mg/kg)	21.3	22.5	12.1	26.1	15.7	32.5	25.6	24.5	28.7
Ext. Sulphate (mg/kg)	373	173	528	429	238	190	185	365	180
Ext. Phosphate (mg/kg)	<0.02	2.25	<0.02	<0.02	1.88	<0.02	<0.02	<0.02	<0.02
Magnesium (mg/kg)	214	238	218	1,370	238	265	1,350	358	1,384
Sodium (mg/kg)	245	241	233	126	241	197	126	147	124
PotaSWium (mg/kg)	926	991	995	2,264	991	4,940	2,278	907	2,250
Calcium (mg/kg)	70.4	247	232	410	247	218	235	252	362
Total Chromium (mg/kg)	63.5	56.3	56.6	37.2	56.3	135	39.8	29.2	37.7
Total Iron (mg/kg)	12,620	14,170	16,500	12,210	14,170	27,680	12,170	2,886	11,480
Copper (mg/kg)	20.9	22.1	23.0	49.6	22.1	29.5	49.2	17.4	35.4
Lead (mg/kg)	35.8	26.8	29.2	49.9	26.8	49.0	28.9	8.80	27.1
Nickel (mg/kg)	33.6	31.7	32.0	27.4	31.7	58.1	28.6	23.0	24.7
Zinc (mg/kg)	56.4	51.4	53.4	83.7	51.4	68.3	81.8	41.7	24.3
Silver (mg/kg)	5.90	5.40	6.70	6.00	5.40	5.00	5.20	4.90	83.3
Cobalt (mg/kg)	22.6	23.0	28.6	25.2	23.0	21.1	25.0	16.4	17.5
Barium (mg/kg)	158	168	159	129	168	164	115	206	116
Manganese (mg/kg)	142	156	159	161	156	194	119	135	110
Cadmium (mg/kg)	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00

Table 1: Sediment Physico-chemical Results – Wet Season – cont'd

Parameters	SW10	SW11	SW12	SW13	SW14	SW15	SW Control 1	SW Control 2
pH (H_2O) @ 24.2ºC	5.29	5.63	5.90	5.33	5.60	5.10	5.49	5.58
Elect. Conductivity (µS/cm)	125	179	166	209	212	130	115	285
THC (mg/kg)	2,554	2,150	1,668	2,283	776	<5.00	2,543	307
PSD								
Clay (%)	-	-	-	-	6.00	-	4.00	-
Silt (%)	80.0	80.0	40.0	46.0	20.0	40.0	76.0	60.0
Sand (%)	20.0	20.0	60.0	54.0	74.0	60.0	20.0	40.0
Ext. Nitrate (mg/kg)	17.8	13.0	4.02	6.35	10.5	9.39	15.8	23.1
Ext. Sulphate (mg/kg)	245	303	305	385	315	183	240	395
Ext. Phosphate (mg/kg)	<0.02	<0.02	<0.02	4.50	<0.02	<0.02	<0.02	<0.02
Magnesium (mg/kg)	186	272	513	1,462	493	672	211	485
Sodium (mg/kg)	265	264	243	120	193	232	221	280
Potassium (mg/kg)	1,066	1,062	1,090	2,296	1,040	993	984	1,361
Calcium (mg/kg)	47.0	162	331	462	516	365	85.8	544
Total Chromium (mg/kg)	142	55.9	16.4	12.1	21.4	<1.00	53.5	44.2
Total Iron (mg/kg)	13,380	18,360	3,428	11,590	7,722	8,612	11,320	19,640
Copper (mg/kg)	27.0	26.2	19.0	50.0	17.6	9.40	24.5	28.4
Lead (mg/kg)	34.5	43.2	7.90	36.7	21.2	<1.00	32.9	29.9
Nickel (mg/kg)	32.0	32.0	21.5	21.7	21.6	16.7	31.1	30.8
Zinc (mg/kg)	51.4	64.1	53.7	59.7	49.5	25.2	48.4	96.3
Silver (mg/kg)	6.40	7.90	7.70	10.8	6.60	5.80	6.80	8.00
Cobalt (mg/kg)	20.3	28.3	17.0	25.4	23.1	13.4	19.7	28.8
Barium (mg/kg)	190	168	167	112	199	259	170	230
Manganese (mg/kg)	146	148	140	129	145	140	138	161
Cadmium (mg/kg)	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00

Table 2: Sediment Microbiology Results- Dry Season

Parameters / Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SW 1	*Pseudomonas sp* *Dactylosporangium sp* *Staphylococcus sp* *Bacillus sp* *Micrococcus sp* *Actinomyces sp*	$2.46x10^5$	*Micrococcus sp* *Pseudomonas sp* *Bacillus sp* *Staphylococcus sp*	$1.50x10^4$	*Aspergillus sp* *Penicillium sp* *Fusarium sp* *Mucor sp* *Candida sp*	$2.60x10^2$	*Aspergillus sp* *Mucor sp*	$2.00x10^2$
SW 2	*Proteus sp* *Bacillus sp* *Micrococcus sp* *Pseudomonas sp* *Staphylococcus sp*	$1.48x10^5$	*Staphylococcus sp* *Pseudomonas sp* *Bacillus sp* *Micrococcus sp*	$1.53x10^4$	*Ulocadium sp* *Candida sp* *Penicillium sp* *Aspergillus sp*	$2.00x10^2$	*Aspergillus sp* *Candida sp* *Penicillium sp*	$1.20x10^2$
SW 3	*Proteus sp* *Bacillus sp* *Pseudomonas sp* *Staphylococcus sp*	$2.43x10^5$	*Bacillus sp* *Pseudomonas sp*	$7.80x10^3$	*Rhodotorula sp* *Candida sp* *Aspergillus sp* *Penicillium sp* *Mucor sp*	$2.40x10^2$	*Rhodotorula sp* *Candida sp* *Penicillium sp*	60
SW 4	*Pseudomonas sp* *Bacillus sp*	$1.72x10^5$	*Bacillus sp* *Pseudomonas sp*	$1.54x10^4$	*Rhodotorula sp* *Candida sp*	$1.21x10^3$	*Rhodotorula sp* *Candida sp*	40
SW 5	*Micrococcus sp* *Bacillus sp* *Staphylococcus sp* *Pseudomonas sp*	$1.02x10^5$	*Staphylococcus sp* *Bacillus sp* *Pseudomonas sp*	$3.90x10^4$	Penicillium sp Candida sp Aspergillus sp	$1.30x10^2$	*Penicillium sp* *Aspergillus sp*	90
SW 6	*Flavobacterium sp* *Micrococcus sp* *Staphylococcus sp* *Pseudomonas sp* *Bacillus sp* *Proteus sp*	$2.16x10^5$	*Micrococcus sp* *Bacillus sp* *Pseudomonas sp*	$1.02x10^4$	Trichoderma sp Fusarium sp Aspergillus sp Penicillium sp Mucor sp Candida sp	$2.00x10^2$	*Mucor sp* *Aspergillus sp*	40

Table 2: Sediment Microbiology Results Dry Season- Cont'd

Parameters / Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SW 7	*Bacillus sp* *Pseudomonas sp* *Actinomyces sp*	$1.52x10^5$	*Staphylococcus sp* *Pseudomonas sp*	$1.35x10^4$	*Penicillium sp* *Fusarium sp*	90	*Penicillium sp* *Fusarium sp*	60
SW 8	*Proteus sp* *Bacillus sp* *Actinomyces sp* *Pseudomonas sp*	$6.50x10^5$	*Pseudomonas sp*	10	*Penicillium sp* *Mucor sp* *Rhodotorula sp*	$1.30x10^2$	*Mucor sp*	40
SW 9	*Actinomyces sp* *Proteus sp* *Bacillus sp* *Pseudomonas sp*	$3.40x10^5$	*Bacillus sp*	$3.00x10^2$	*Candida sp* *Aspergillus sp* *Mucor sp*	$9.30x10^2$	*Candida sp* *Mucor sp* *Aspergillus sp*	$8.90x10^2$
SW 10	*Proteus sp* *Actinomyces sp* *Bacillus sp* *Pseudomonas sp*	$5.60x10^4$	*Pseudomonas sp*	$6.00x10^2$	*Candida sp* *Mucor sp*	$1.50x10^2$	*Aspergillus sp* *Mucor sp*	$1.40x10^2$
SW 11	*Pseudomonas sp* *Proteus sp* *Bacillus sp*	$4.50x10^4$	*Pseudomonas sp* *Bacillus sp*	$2.60x10^3$	*Aspergillus sp* *Rhizopus sp* *Mucor sp*	$1.30x10^2$	*Aspergillus sp* *Rhizopus sp* *Mucor sp*	$1.10x10^2$
SW 12	*Bacillus sp* *Actinomyces sp* *Pseudomonas sp*	$1.70x10^4$	*Pseudomonas sp* *Bacillus sp*	$1.57x10^4$	*Candida sp* *Penicillium sp* *Mucor sp* *Aspergillus sp*	$1.00x10^2$	*Aspergillus sp* *Mucor sp*	90
SW 13	*Staphylococcus sp* *Bacillus sp* *Pseudomonas sp*	$1.18x10^5$	*Pseudomonas sp* *Bacillus sp*	$9.00x10^3$	*Candida sp* *Penicillium sp* *Mucor sp* *Aspergillus sp*	$2.60x10^2$	*Aspergillus sp* *Mucor sp* *Candida sp*	$2.50x10^2$
SW 14	*Bacillus sp* *Proteus sp* *Pseudomonas sp*	$1.04x10^5$	*Pseudomonas sp*	$9.00x10^2$	*Rhodotorula sp* *Aspergillus sp* *Fusarium sp* *Candida sp* *Mucor sp*	$4.00x10^2$	*Mucor sp* *Fusarium sp* *Aspergillus sp*	$3.70x10^2$

Table 2: Sediment Microbiology Results Dry Season- Cont'd

Parameters Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SW 15	*Bacillus sp* *Proteus sp* *Pseudomonas sp*	$1.04x10^5$	*Pseudomonas sp*	$9.00x10^2$	*Rhodotorula sp* *Aspergillus sp* *Fusarium sp* *Candida sp* *Mucor sp*	$4.00x10^2$	*Mucor sp* *Fusarium sp* *Aspergillus sp*	$3.70x10^2$
SW Control 1	*Proteus sp* *Pseudomonas sp* *Bacillus sp* *Actinomyces sp*	$1.25x10^5$	*Staphylococcus sp* *Bacillus sp* *Pseudomonas sp*	$9.00x10^3$	*Rhodotorula sp* *Candida sp* *Aspergillus sp* *Penicillium sp* *Mucor sp*	$3.10x10^2$	*Aspergillus sp* *Mucor sp* *Candida sp*	80
SW Control 2	*Chromobacterium sp* *Staphylococcus sp* *Pseudomonas sp* *Bacillus sp*	$1.90x10^5$	*Pseudomonas sp* *Bacillus sp*	$1.17x10^4$	*Candida sp* *Penicillium sp* *Aspergillus sp*	$5.40x10^2$	*Candida sp* *Penicillium sp* *Aspergillus sp*	$4.00x10^2$

Table 2: Sediment Microbiology Results- Wet Season

Parameters Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SW 1	*Pseudomonas sp* *Bacillus sp* *Proteus sp*	2.10×10^4	*Pseudomonas sp*	3.00×10^2	*Fusarium sp* *Aspergillus sp* *Candida sp*	60	*Fusarium sp* *Aspergillus sp*	30
SW 2	*Pseudomonas sp* *Bacillus sp* *Proteus sp*	8.00×10^3	*Pseudomonas sp*	10	*Penicillium sp* *Rhizopus sp* *Mucor sp*	40	*Mucor sp*	10
SW 3	*Pseudomonas sp* *Bacillus sp* *Proteus sp* *Staphylococcus sp*	3.80×10^5	*Pseudomonas sp*	20	*Rhodotorula sp* *Candida sp* *Mucor sp*	70	*Mucor sp*	10
SW 4	*Pseudomonas sp* *Bacillus sp* *Proteus sp* *Micrococcus sp* *Staphylococcus sp*	3.60×10^5	*Pseudomonas sp*	10	*Penicillium sp* *Candida sp* *Mucor sp* *Fusarium sp* *Aspergillus sp*	50	*Mucor sp* *Fusarium sp* *Aspergillus sp*	40
SW 5	*Pseudomonas sp* *Bacillus sp* *Proteus sp* *Staphylococcus sp*	2.08×10^5	*Pseudomonas sp* *Bacillus sp*	9.00×10^2	*Fusarium sp* *Mucor sp* *Aspergillus sp*	60	*Fusarium sp* *Aspergillus sp*	40
SW 6	*Bacillus sp* *Pseudomonas sp*	1.51×10^5	*Pseudomonas sp*	10	*Fusarium sp* *Aspergillus sp* *Mucor sp*	50	*Aspergillus sp*	20
SW 7	*Pseudomonas sp* *Proteus sp* *Bacillus sp* *Staphylococcus sp* *Actinomyces sp*	1.70×10^4	*Pseudomonas sp*	20	*Penicillium sp* *Fusarium sp* *Mucor sp*	30	*Fusarium sp* *Mucor sp*	20
SW 8	*Pseudomonas sp* *Bacillus sp* *Proteus sp*	2.33×10^4	*Pseudomonas sp*	10	*Mucor sp* *Aspergillus sp*	40	*Aspergillus sp* *Mucor sp*	30
SW 9	*Proteus sp* *Bacillus sp* *Pseudomonas sp* *Micrococcus sp*	1.04×10^5	*Pseudomonas sp*	10	*Mucor sp*	10	*Nil*	0

Table 2: Sediment Microbiology Results Wet Season- Cont'd

Parameters Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SW 10	Actinomyces sp Pseudomonas sp Staphylococcus sp Micrococcus sp	$1.26x10^5$	Pseudomonas sp Bacillus sp	20	Penicillium sp Fusarium sp Candida sp	40	Penicillium sp	10
SW 11	Proteus sp Bacillus sp Pseudomonas sp Staphylococcus sp	$1.80x10^5$	Pseudomonas sp Bacillus sp	10	Mucor sp	10	Nil	0
SW 12	Actinobacillus sp Staphylococcus sp Pseudomonas sp Bacillus sp Proteus sp	$2.10x10^5$	Pseudomonas sp	30	Mucor sp Fusarium sp	20	Mucor sp	10
SW 13	Actinomyces sp Proteus sp Bacillus sp Pseudomonas sp	$4.60x10^4$	Pseudomonas sp Bacillus sp	$6.00x10^2$	Aspergillus sp Candida sp	$1.00x10^2$	Aspergillus sp Candida sp	20
SW 14	Staphylococcus sp Proteus sp Bacillus sp Pseudomonas sp	$6.00x10^4$	Pseudomonas sp Bacillus sp	$3.00x10^2$	Alternaria sp Penicillium sp	50	Penicillium sp	10
SW 15	Staphylococcus sp Proteus sp Bacillus sp Pseudomonas sp	$8.40x10^5$	Pseudomonas sp	10	Candida sp Penicillium sp	$4.50x10^2$	Penicillium sp Candida sp	50
SW Control 1	Actinomyces sp Staphylococcus sp Proteus sp Bacillus sp Pseudomonas sp	$1.38x10^5$	Pseudomonas sp	10	Candida sp	$9.00x10^2$	Candida sp	$7.70x10^2$
SW Control 2	Staphylococcus sp Pseudomonas sp Bacillus sp Proteus sp	$1.23x10^5$	Pseudomonas sp Staphylococcus sp	20	Candida sp	$2.50x10^2$	Candida sp	50

Table 3: Sediment Microbiology Results Dry Season

Sample Station	Anaerobic Bacteria	Count (cfu/g)
SW 1	Bacteriodes sp, Bacillus sp, Clostridium sp	$2.31x10^3$
SW 2	Veillonella sp, Bacillus sp, Clostridium sp	$1.90x10^3$
SW 3	Prevotella sp, Bacillus sp, Staphylococcus sp	$3.90x10^2$
SW 4	Prevotella sp, Bacillus sp, Clostridium sp	$5.10x10^2$
SW 5	Prevotella sp, Clostridium sp, Bacillus	$4.90x10^2$
SW 6	Bacillus sp, Staphylococcus sp, Clostridium sp	$1.03x10^3$
SW 7	Bacillus sp, Staphylococcus sp, Clostridium sp	$1.24x10^3$
SW 8	Actinomyces sp, Staphylococcus sp, Clostridium sp	$1.12x10^3$
SW 9	Actinomyces sp, Clostridium sp	$2.01x10^2$
SW 10	Bacillus sp, Prevotella sp, Candida sp	$9.90x10^2$
SW 11	Bacillus sp, Proteus sp	$1.03x10^3$
SW 12	Bacillus sp, Staphylococcus sp, Bacteriodes sp	$2.14x10^3$
SW 13	Bacillus sp, Staphylococcus sp, Clostridium sp Bacteriodes sp	$1.84x10^3$
SW 14	Bacillus sp, Staphylococcus sp, Prevotella sp	$9.80x10^2$
SW 15	Bacillus sp, Staphylococcus sp, Clostridium sp	$1.00x10^3$
SW Control 1	Bacillus sp, Staphylococcus sp, Clostridium sp	$1.21x10^3$
SW Control 2	Actinomyces sp, Clostridium sp	$2.08x10^2$

Table 3: Sediment Microbiology Results Wet Season

Sample Station	Anaerobic Bacteria	Count (cfu/g)
SW 1	Proteus sp, Bacillus sp, Clostridium sp	$3.40x10^2$
SW 2	Proteus sp, Bacillus sp, Clostridium sp	$2.33x10^3$
SW 3	Prevotella sp, Bacillus sp, Clostridium sp	$1.55x10^3$
SW 4	Proteus sp, Clostridium sp, Bacillus sp	$2.05x10^3$
SW 5	Bacteriodes sp, Proteus sp, Clostridium sp, Bacillus sp	$1.94x10^3$
SW 6	Peptococcus sp, Bacillus sp, Clostridium sp	$2.78x10^3$
SW 7	Proteus sp, Staphylococcus sp, Clostridium sp, Bacillus sp	$2.52x10^3$
SW 8	Proteus sp, Clostridium sp	$3.60x10^2$
SW 9	Clostridium sp, Bacillus sp, Proteus sp	$3.60x10^2$
SW 10	Proteus sp, Peptococcus sp, Clostridium sp, Bacillus sp	$2.60x10^3$
SW 11	Bacteriodes sp, Clostridium sp, Bacillus sp	$2.42x10^3$
SW 12	Staphylococcus sp, Bacillus sp, Clostridium sp	$2.10x10^3$
SW 13	Bacillus sp, Bacteriodes sp, Clostridium sp, Actinomyces sp	$2.25x10^3$
SW 14	Staphylococcus sp, Clostridium sp, Bacillus sp, Prevotella sp Proteus sp	$1.70x10^3$
SW 15	Prevotella sp, Proteus sp, Bacillus sp	$8.00x10^2$
SW Control 1	Bacillus sp, Clostridium sp, Proteus sp	$2.41x10^3$
SW Control 2	Bacillus sp, Clostridium sp, Proteus sp	$2.16x10^3$

APPENDIX 4.4

SURFACE WATER PHYSICO-CHEMICAL AND MICROBIOLOGY RESULTS

Table 1: Surface water Physico-chemical Results – Dry Season

Sample Stations Parameters	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9
pH	5.02	5.52	5.82	5.48	5.38	5.36	5.44	5.55	5.46
Temperature (ºC)	22.1	21.1	22.1	23.7	21.9	22.1	22.1	25.4	23.4
Conductivity (µS/cm)	13.6	13.2	13.2	12.8	13.5	13.7	13.1	13.0	13.6
Salinity (g/l)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
DO (mg/l)	4.28	5.21	4.05	4.44	4.48	4.62	4.37	4.29	4.70
Turbidity (NTU)	6.00	7.00	2.00	3.00	5.00	2.00	3.00	1.00	5.00
TSW (mg/l)	3.00	1.00	1.00	3.00	3.00	2.00	2.00	1.00	2.00
TDS(mg/l)	7.80	7.92	7.86	7.68	8.10	8.22	7.86	7.80	8.16
Oil & Grease (mg/l)	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
Bicarbonate (mg/l)	6.00	4.00	6.00	4.00	8.00	6.00	2.00	10.0	4.00
BOD (mg/l)	30.0	20.0	30.0	8.00	10.0	12.0	12.0	13.0	12.2
COD (mg/l)	50.8	36.0	46.4	12.5	19.6	19.2	18.6	19.6	18.4
Lead (mg/l)	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Zinc (mg/l)	0.07	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Copper (mg/l)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Iron (mg/l)	0.30	0.73	0.43	0.45	0.27	0.27	0.29	0.35	0.46
Nickel (mg/l)	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Vanadium (mg/l)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20

Table 1: Surface water Physico-chemical Results – Dry Season – cont'd

Sample Stations Parameters	SW10	SW11	SW12	SW13	SW14	SW15	SW Control 1	SW Control 2
pH	5.20	5.82	5.57	5.34	5.61	5.64	4.25	4.46
Temperature (^{0}C)	22.0	22.6	23.9	24.9	23.3	22.7	23.8	22.8
Conductivity (µS/cm)	13.9	12.7	13.4	12.8	12.5	13.5	13.3	13.5
Salinity (g/l)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
DO (mg/l)	4.82	4.91	4.96	4.84	4.89	5.30	4.19	4.16
Turbidity (NTU)	2.00	7.00	5.00	2.00	5.00	3.00	5.00	4.00
TSW (mg/l)	3.00	2.00	7.00	5.00	6.00	2.00	2.00	1.00
TDS(mg/l)	8.34	7.62	8.04	7.68	7.50	8.10	7.98	8.10
Oil & Grease (mg/l)	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
Bicarbonate (mg/l)	4.00	6.00	14.0	4.00	4.00	4.00	8.00	6.00
BOD (mg/l)	10.0	8.00	20.0	8.00	10.0	12.4	14.0	8.00
COD (mg/l)	17.6	12.8	36.8	13.4	17.6	18.6	21.2	12.7
Lead (mg/l)	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Zinc (mg/l)	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	0.02
Copper (mg/l)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Iron (mg/l)	0.61	0.34	0.63	0.28	0.33	0.30	0.26	0.26
Nickel (mg/l)	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Vanadium (mg/l)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20

Table 1: Surface water Physico-chemical Results – Wet Season

Sample Stations Parameters	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9
pH	5.46	5.53	5.33	5.41	5.62	5.39	5.55	5.79	5.60
Temperature (^{0}C)	27.2	27.2	27.2	27.4	27.5	27.2	27.2	27.3	27.1
Conductivity (µS/cm)	14.0	13.0	12.5	14.8	15.3	53.2	12.5	12.7	12.9
Salinity (g/l)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
DO (mg/l)	6.24	6.31	6.42	6.39	6.52	6.56	6.58	6.60	6.62
Turbidity (NTU)	6.00	6.00	7.00	5.00	7.00	8.00	8.00	4.00	7.00
TSW (mg/l)	2.00	1.00	3.00	10.0	20.0	10.0	10.0	5.00	10.0
TDS(mg/l)	8.40	7.80	7.50	8.88	9.18	31.9	7.50	7.62	7.74
Oil & Grease (mg/l)	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
Bicarbonate (mg/l)	8.94	8.65	5.46	3.81	8.39	7.31	13.7	14.3	13.4
BOD (mg/l)	20.0	10.0	10.0	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
COD (mg/l)	35.1	20.1	26.0	6.51	6.38	4.50	3.83	10.2	3.83
Lead (mg/l)	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Zinc (mg/l)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Copper (mg/l)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Iron (mg/l)	0.21	0.13	0.13	0.10	0.16	0.22	0.19	0.22	0.17
Nickel (mg/l)	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Vanadium (mg/l)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20

Table 1: Surface water Physico-chemical Results – Wet Season – cont'd

Sample Stations Parameters	SW10	SW11	SW12	SW13	SW14	SW15	SW Control 1	SW Control 2
pH	5.49	5.37	5.72	5.93	5.50	5.83	5.30	5.58
Temperature (^{0}C)	24.3	24.3	24.4	27.3	27.3	27.5	27.2	27.5
Conductivity (µS/cm)	13.4	19.6	20.8	12.4	23.1	16.5	20.5	13.6
Salinity (g/l)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
DO (mg/l)	6.59	6.56	6.63	6.64	6.63	6.65	6.61	6.63
Turbidity (NTU)	7.00	8.00	9.00	8.00	8.00	8.00	4.00	7.50
TSW (mg/l)	5.00	10.0	5.00	10.0	10.0	40.0	5.00	10.0
TDS(mg/l)	8.04	11.8	12.5	7.44	13.9	9.90	12.3	8.16
Oil & Grease (mg/l)	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
Bicarbonate (mg/l)	3.89	4.18	6.38	6.54	3.51	7.52	3.59	3.43
BOD (mg/l)	5.50	<0.50	<0.50	4.30	<0.50	<0.50	7.00	<0.50
COD (mg/l)	9.57	6.38	3.83	6.38	7.66	12.8	10.5	<0.80
Lead (mg/l)	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Zinc (mg/l)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Copper (mg/l)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Iron (mg/l)	0.20	0.15	0.19	0.16	0.18	0.24	0.36	0.19
Nickel (mg/l)	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Vanadium (mg/l)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20

Table 2: Surface water Microbiology Results- Dry Season

Parameters / Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SW 1	*Bacillus sp* *Pseudomonas sp* *Proteus sp* *Staphylococcus sp* *Micrococcus sp*	$4.40x10^2$	*Pseudomonas sp* *Bacillus sp*	*7*	*Mucor sp* *Fusarium sp* *Aspergillus sp* *Rhodotorula sp* *Candida sp*	21	*Mucor sp* *Candida sp*	10
SW 2	*Actinomyces sp* *Bacillus sp* *Pseudomonas sp* *Micrococcus sp* *Dactylosporangium sp* *Staphylococcus sp*	$1.50x10^3$	*Pseudomonas sp* *Bacillus sp*	*5*	*Aspergillus sp* *Penicillium sp* *Acremonium sp* *Candida sp* *Mucor sp*	28	*Candida sp* *Mucor sp* *Aspergillus sp*	23
SW 3	*Proteus sp* *Pseudomonas sp* *Paenibacillus sp* *Bacillus sp* *Staphylococcus sp* *Micrococcus sp*	$1.24x10^3$	*Bacillus sp* *Pseudomonas sp* *Staphylococcus sp*	*35*	*Fusarium sp* *Rhodotorula sp* *Candida sp* *Penicillium sp*	11	*Candida sp* *Mucor sp* *Fusarium sp*	8
SW 4	*Bacillus sp* *Proteus sp* *Staphylococcus sp* *Actinomyces sp* *Flavobacterium sp* *Micrococcus sp* *Pseudomonas sp*	$3.10x10^3$	*Staphylococcus sp* *Micrococcus sp* *Pseudomonas sp* *Flavobacterium sp*	*32*	*Trichoderma sp* *Rhodotorula sp* *Mucor sp* *Aspergillus sp*	19	*Mucor sp* *Aspergillus sp*	14
SW 5	*Proteus sp* *Pseudomonas sp* *Bacillus sp* *Staphylococcus sp* *Streptococcus sp*	$2.87x10^3$	*Pseudomonas sp* *Bacillus sp*	*$3.40x10^2$*	*Penicillium sp* *Rhodotorula sp* *Candida sp* *Fusarium sp* *Aspergillus sp* *Mucor sp*	40	*Mucor sp* *Aspergillus sp* *Candida sp*	29
SW 6	*Arthrobacter sp* *Pseudomonas sp* *Klebsiella sp* *Micrococcus sp* *Staphylococcus sp* *Bacillus sp*	$2.27x10^3$	*Staphylococcus sp* *Micrococcus sp* *Pseudomonas sp* *Bacillus sp*	67	*Rhodotorula sp* *Penicillium sp* *Mucor sp* *Candida sp* *Aspergillus sp*	30	*Mucor sp* *Candida sp* *Aspergillus sp*	17

Table 2: Surface water Microbiology Results Dry Season- Cont'd

Parameters Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SW 7	*Pseudomonas sp* *Bacillus sp* *Staphylococcus sp* *Dactylosporangium sp* *Flavobacterium sp* *Proteus sp* *Arthrobacter sp*	$1.69x10^3$	*Pseudomonas sp* *Staphylococcus sp* *Bacillus sp*	20	*Fusarium sp* *Rhodotorula sp* *Rhizopus sp* *Mucor sp* *Aspergillus sp* *Penicillium sp*	11	*Rhizopus sp* *Mucor sp* *Aspergillus sp*	3
SW 8	*Proteus sp* *Pseudomonas sp* *Bacillus sp* *Alcaligenes sp* *Staphylococcus sp*	$6.10x10^2$	*Bacillus sp* *Staphylococcus sp* *Pseudomonas sp*	21	*Aspergillus sp* *Candida sp* *Rhodotorula sp* *Mucor sp* *Rhizopus sp* *Fusarium sp*	30	*Aspergillus sp* *Candida sp* *Rhizopus sp* *Mucor sp*	24
SW 9	*Actinomyces sp* *Pseudomonas sp* *Bacillus sp* *Micrococcus sp* *Staphylococcus sp* *Dactylosporangium sp* *Flavobacterium sp*	$2.55X10^3$	*Bacillus sp* *Proteus sp* *Pseudomonas sp* *Staphylococcus sp*	66	*Aspergillus sp* *Candida sp* *Rhisopus sp* *Rhodotorula sp* *Mucor sp*	31	*Aspergillus sp* *Candida sp* *Rhizopus sp* *Mucor sp*	23
SW 10	*Proteus sp* *Pseudomonas sp* *Bacillus sp* *Klebsiella sp* *Staphylococcus sp*	$7.10X10^2$	*Bacillus sp* *Pseudomonas sp* *Staphylococcus sp* *Proteus sp*	$2.64X10^2$	*Rhodotorula sp* *Aspergillus sp* *Mucor sp* *Candida sp*	12	*Mucor sp* *Candida sp*	7
SW 11	*Proteus sp* *Bacillus sp* *Pseudomonas sp* *Actinomyces sp* *Staphylococcus sp* *Micrococcus sp*	$1.38x10^3$	*Staphylococcus sp* *Pseudomonas sp* *Bacillus sp*	33	*Fusarium sp* *Penicillium sp* *Aspergillus sp* *Mucor sp*	14	*Mucor sp* *Aspergillus sp*	8
SW 12	*Proteus sp* *Bacillus sp* *Pseudomonas sp* *Actinomyces sp* *Staphylococcus sp* *Micrococcus sp*	$6.10x10^3$	*Staphylococcus sp* *Pseudomonas sp* *Bacillus sp*	$1.82x10^2$	*Rhizopus sp* *Rhodotorula sp* *Mucor sp* *Candida sp*	18	*Rhizopus sp* *Candida sp* *Mucor sp*	4

Table 2: Surface water Microbiology Results Dry Season- Cont'd

Parameters Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SW 13	*Arthrobacter sp* *Micrococcus sp* *Actinomyces sp* *Proteus sp* *Pseudomonas sp* *Staphylococcus sp*	$2.90x10^3$	*Pseudomonas sp* *Micrococcus sp* *Bacillus sp* *Arthrobacter sp* *Proteus sp*	$1.10x10^2$	*Rhodotorula sp* *Rhizopus sp* *Candida sp* *Mucor sp* *Aspergillus sp*	17	*Rhizopus sp* *Candida sp* *Mucor sp* *Aspergillus sp* *Rhodotorula sp*	12
SW 14	*Staphylococcus sp* *Alcaligenes sp* *Bacillus sp* *Bacillus sp* *Arthrobacter sp* *Pseudomonas sp*	$1.40x10^3$	*Pseudomonas sp* *Staphylococcus sp* *Bacillus sp* *Arthrobacter sp*	$1.10x10^2$	*Penicillium sp* *Aspergillus sp* *Rhodotorula sp* *Mucor sp* *Candida sp*	79	*Penicillium sp* *Rhodotorula sp* *Mucor sp* *Candida sp*	61
SW 15	*Flavobacterium sp* *Bacillus sp* *Micrococcus sp* *Pseudomonas sp* *Staphylococcus sp*	$1.32x10^3$	*Staphylococcus sp* *Pseudomonas sp* *Bacillus sp*	46	*Rhodotorula sp* *Penicilium sp* *Mucor sp* *Aspergillus sp* *Rhizopus sp*	25	*Rhodotorula sp* *Candida sp* *Mucoor sp* *Rhizopus sp*	14
SW Control 1	*Staphylococcus sp* *Pseudomonas sp* *Bacillus sp* *Micrococcus sp*	$9.80x10^2$	*Bacillus sp* *Pseudomonas sp*	16	*Penicillium sp* *Aspergillus sp* *Candida sp* *Mucor sp*	12	*Aspergillus sp* *Mucor sp* *Candida sp*	7
SW Control 2	*Proteus sp* *Pseudomonas sp* *Bacillus sp* *Staphylococcus sp*	$6.80x10^2$	*Pseudomonas sp* *Bacillus sp* *Staphylococcus sp*	$1.32x10^2$	*Fusarium sp* *Rhodotorula sp* *Candida sp* *Penicillium sp*	19	*Mucor sp* *Candida sp* *Fusarium sp*	12

Table 2: Surface water Microbiology Results- Wet Season

Parameters / Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SW 1	*Bacillus sp* *Proteus sp* *Pseudomonas sp* *Staphylococcus sp*	$3.30x10^3$	*Pseudomonas sp* *Bacillus sp* *Staphylococcus sp*	55	*Fusarium sp* *Candida sp* *Aspergillus sp*	$2.80x10^2$	*Candida sp*	$1.20x10^2$
SW 2	*Proteus sp* *Bacillus sp* *Pseudomonas sp*	$1.80x10^2$	*Pseudomonas sp* *Bacillus sp*	40	*Penicillium sp* *Mucor sp*	17	*Penicillium sp* *Mucor sp*	4
SW 3	*Chromobacterium sp* *Bacillus sp* *Pseudomonas sp* *Micrococcus sp* *Proteus sp*	$3.90x10^3$	*Pseudomonas sp*	20	*Candida sp* *Aspergillus sp* *Mucor sp* *Penicillium sp*	$1.50x10^2$	*Aspergillus sp* *Mucor sp*	3
SW 4	*Pseudomonas sp* *Bacillus sp* *Micrococcus sp* *Staphylococcus sp*	$3.80x10^3$	*Pseudomonas sp* *Staphylococcus sp*	23	*Candida sp* *Mucor sp* *Penicillium sp* *Fusarium sp*	10	*Penicillium sp*	6
SW 5	*Pseudomonas sp* *Proteus sp* *Chromobacterium sp* *Bacillus sp* *Staphylococcus sp*	$1.77x10^3$	*Pseudomonas sp* *Bacillus sp*	$3.40x10^2$	*Aspergillus sp* *Mucor sp*	41	*Mucor sp* *Aspergillus sp*	35
SW 6	*Proteus sp* *Bacillus sp* *Pseudomonas sp* *Staphylococcus sp*	$1.06x10^3$	*Bacillus sp* *Pseudomonas sp*	77	*Aspergillus sp* *Mucor sp* *Rhodotorula sp*	6	*Mucor sp* *Aspergillus sp*	4
SW 7	*Pseudomonas sp* *Bacillus sp* *Micrococcus sp*	$1.56x10^3$	*Micrococcus sp* *Pseudomonas sp*	42	*Candida sp* *Fusarium sp* *Mucor sp*	3	*Mucor sp*	1
SW 8	*Proteus sp* *Chromobacterium sp* *Pseudomonas sp* *Bacillus sp*	$1.47x10^3$	*Pseudomonas sp* *Bacillus sp*	18	*Candida sp* *Fusarium sp* *Mucor sp*	4	*Candida sp* *Mucor sp*	2

Table 2: Surface water Microbiology Results Wet Season- Cont'd

Parameters Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SW 9	*Bacillus sp* *Pseudomonas sp* *Staphylococcus sp*	$2.25x10^3$	*Pseudomonas sp* *Bacillus sp* *Staphylococcus sp*	$4.40x10^2$	*Rhodotorula sp* *Aspergillus sp*	13	*Aspergillus sp*	8
SW 10	*Bacillus sp* *Proteus sp* *Pseudomonas sp* *Chromobacterium sp* *Staphylococcus sp*	$4.40x10^3$	*Pseudomonas sp* *Bacillus sp*	$1.36x10^2$	*Fusarium sp* *Rhodotorula sp* *Candida sp*	4	*Candida sp*	2
SW 11	*Pseudomonas sp* *Staphylococcus sp* *Bacillus sp* *Micrococcus sp*	$2.24x10^3$	*Micrococcus sp* *Pseudomonas sp* *Bacillus sp*	84	*Rhodotorula sp* *Mucor sp*	2	*Nil*	0
SW 12	*Bacillus sp* *Pseudomonas sp* *Staphylococcus sp* *Chromobacterium sp* *Micrococcus sp*	$3.80x10^3$	*Pseudomonas sp*	14	*Rhizopus sp* *Mucor sp* *Candida sp*	3	*Mucor sp*	1
SW 13	*Bacillus sp* *Pseudomonas sp* *Staphylococcus sp* *Micrococcus sp*	$2.40x10^3$	*Pseudomonas sp* *Staphylococcus sp* *Bacillus sp*	$3.60x10^2$	*Candida sp*	1	*Nil*	0
SW 14	*Proteus sp* *Bacillus sp* *Pseudomonas sp* *Micrococcus sp*	$1.53x10^3$	*Pseudomonas sp* *Micrococcus sp*	5	*Candida sp* *Fusarium sp* *Mucor sp* *Penicillium sp*	4	*Penicillium sp*	1
SW 15	*Pseudomonas sp* *Bacillus sp* *Staphylococcus sp* *Chromobacterium sp* *Micrococcus sp*	$3.70x10^3$	*Micrococcus sp* *Pseudomonas sp* *Bacillus sp*	$2.20x10^2$	*Mucor sp*	1	*Mucor sp*	1

Table 2: Surface water Microbiology Results Wet Season- Cont'd

Parameters / Sample Stations	Total Heterotrophic Bacteria	Count (cfu/ml)	Hydrocarbon Utilising Bacteria	Count (cfu/ml)	Total Heterotrophic Fungi	Count (cfu/ml)	Hydrocarbon Utilising Fungi	Count (cfu/ml)
SW Control 1	*Bacillus sp* *Pseudomonas sp* *Staphylococcus sp*	1.95×10^3	*Pseudomonas sp* *Bacillus sp* *Staphylococcus sp*	6.00×10^2	*Fusarium sp* *Candida sp* *Aspergillus sp*	10	*Aspergillus sp*	4
SW Control 2	*Micrococcus sp* *Bacillus sp* *Staphylococcus sp* *Pseudomonas sp* *Proteus sp*	4.30×10^3	*Pseudomonas sp*	5.00×10^2	*Rhodotorula sp* *Fusarium sp* *Candida sp* *Aspergillus sp*	5	*Fusarium sp* *Candida sp* *Aspergillus sp*	3

Table 3: Surface water Microbiology Results - Dry Season

Sample Station	Anaerobic Bacteria	Count (cfu/g)
SW 1	Proteus sp, Clostridium sp	5
SW 2	Staphylococcus sp, Proteus sp, Clostridium sp	24
SW 3	Proteus sp, Bacillus sp, Prevotella sp	34
SW 4	Actinomyces sp, Proteus sp, Peptococcus sp	13
SW 5	Peptostreptococcus sp, Proteus sp	40
SW 6	Bacillus sp, Bacteriodes sp	12
SW 7	Bacillus sp, Proteus sp, Peptococcus sp	45
SW 8	Proteus sp, Bacillus sp, Clostridium sp	$1.00x10^2$
SW 9	Proteus sp, Clostridium sp	35
SW 10	Bacteriodes sp Proteus sp, Clostridium sp	28
SW 11	Actinomyces sp, Proteus sp, Clostridium sp, Fusobacterium sp	96
SW 12	Peptococcus sp, Actinomyces sp, Proteus sp Clostridium sp	72
SW 13	Clostridium sp, Proteus sp	$1.80x10^2$
SW 14	Prevotella sp, Proteus sp	$1.45x10^2$
SW 15	Bacillus sp, Clostridium sp	56
SW Control 1	Proteus sp, Clostridium sp	3
SW Control 2	Proteus sp, Prevotella sp	8

Table 3: Surface water Microbiology Results - Wet Season

Sample Station	Anaerobic Bacteria	Count (cfu/g)
SW 1	Prevotella sp, Bacillus sp, Proteus sp	$2.00x10^2$
SW 2	Proteus sp, Peptococcus sp	$1.76x10^2$
SW 3	Proteus sp, Clostridium sp	$1.50x10^2$
SW 4	Clostridium sp, Bacillus sp, Peptococcus sp	$1.05x10^2$
SW 5	Clostridium sp, Proteus sp	6
SW 6	Bacteriodes sp, Proteus sp, Bacillus sp	$1.64x10^2$
SW 7	Bacillus sp	40
SW 8	Clostridium sp, Proteus sp	44
SW 9	Proteus sp, Clostridium sp	60
SW 10	Proteus sp, Bacillus sp, Clostridium sp	31
SW 11	Staphylococcus sp, Clostridium sp, Bacillus sp	42
SW 12	Clostridium sp, Bacillus sp	$1.20x10^2$
SW 13	Clostridium sp, Proteus sp	32
SW 14	Clostridium sp, Bacillus sp	40
SW 15	Proteus sp, prevotella sp	28
SW Control 1	Proteus sp, Bacillus sp	42
SW Control 2	Bacillus sp, Proteus sp, Prevotella sp	$1.50x10^2$

APPENDIX 4.5

HYDROBIOLOGY CHARACTERISTICS

Table 1a: Diversity, Abundance and Distribution of Phytoplankton-Dry Season

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW1	Algae	Diatom	Melosiraceae	Melosira granulata	204
SW1	Algae	Diatom	Melosiraceae	Melosira granulata var. angustissima	52
SW1	Algae	Blue-green algae	Chroococcaceae	Microcystis aeruginosa	12
SW1	Algae	Blue-green algae	Nostocaceae	Anabaena spiroides	25
SW1	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya limnetica	15
SW1	Algae	Green algae	Desmidiaceae	Closterium moniliferum	4
SW1	Algae	Blue-green algae	Oscillatoriaceae	Spirulina sp	40
SW1	Algae	Green algae	Desmidiaceae	Staurastrum asterias	4
SW1	Algae	Diatom	Thalassionemataceae	Synedra ulna	80
SW1	Algae	Diatom	Bacillariaceae	Nitzschia sp	6
SW1	Algae	Diatom	Melosiraceae	Melosira varians	8
SW1	Algae	Diatom	Bacillariaceae	Nitzschia palea	4
SW1	Algae	Diatom	Coscinodiscaceae	Coscinodiscus eccentricus	2
SW1	Algae	Green algae	Desmidiaceae	Staurastrum asterias	6
SW1	Algae	Diatom	Surirellaceae	Surirella sp	4
SW1	Algae	Diatom	Thalassiosiraceae	Cyclotella striata	10
Total Count					**476**
Number of Species					**16**
Margalef Species Index					**2.43**
SW-control 1	Algae	Diatom	Melosiraceae	Melosira granulata	206
SW-control 1	Algae	Diatom	Melosiraceae	Melosira granulata var. angustissima	52
SW-control 1	Algae	Blue-green algae	Chroococcaceae	Microcystis aeruginosa	15
SW-control 1	Algae	Blue-green algae	Nostocaceae	Anabaena spiroides	28
SW-control 1	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya limnetica	10
SW-control 1	Algae	Green algae	Desmidiaceae	Closterium moniliferum	4
SW-control 1	Algae	Green algae	Desmidiaceae	Staurastrum asterias	4
SW-control 1	Algae	Diatom	Thalassionemataceae	Synedra ulna	75
SW-control 1	Algae	Blue-green algae	Oscillatoriaceae	Spirulina sp	34
SW-control 1	Algae	Green algae	Desmidiaceae	Staurastrum fragile	4
SW-control 1	Algae	Diatom	Cymbellaceae	Cymbella sp	4
SW-control 1	Algae	Diatom	Bacillariaceae	Nitzschia closterium	10
SW-control 1	Algae	Green algae	Volvocaceae	Eudorina elegans	4
SW-control 1	Algae	Diatom	Thalassiosiraceae	Cyclotella striata	10

Table 1a: Diversity, Abundance and Distribution of Phytoplankton-Dry Season –cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW-control 1	Algae	Green algae	Desmidiaceae	Closterium moniliferum	25
SW-control 1	Algae	Blue-green algae	Oscillatoriaceae	Oscillatoria limnetica	12
SW2	Algae	Diatom	Melosiraceae	Melosira granulata	200
SW2	Algae	Diatom	Melosiraceae	Melosira granulata var. angustissima	52
SW2	Algae	Blue-green algae	Chroococcaceae	Microcystis aeruginosa	12
SW2	Algae	Blue-green algae	Nostocaceae	Anabaena spiroides	25
SW2	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya limnetica	15
SW2	Algae	Green algae	Desmidiaceae	Closterium moniliferum	4
SW2	Algae	Blue-green algae	Oscillatoriaceae	Spirulina sp	40
SW2	Algae	Green algae	Desmidiaceae	Staurastrum asterias	4
SW2	Algae	Diatom	Thalassionemataceae	Synedra ulna	72
SW2	Algae	Diatom	Bacillariaceae	Nitzschia sp	6
SW2	Algae	Diatom	Melosiraceae	Melosira varians	12
SW2	Algae	Diatom	Bacillariaceae	Nitzschia closterium	15
SW2	Algae	Green algae	Desmidiaceae	Staurastrum asterias	6
SW2	Algae	Blue-green algae	Nostocaceae	Anabaena sp	8
SW2	Algae	Dinoflagellate	Peridiniaceae	Peridinium balticum	4
Total Count					**475**
Number of Species					**15**
Margalef Species Index					**2.27**
SW-Control 2	Algae	Diatom	Thalassiosiraceae	Cyclotella sp	4
SW-Control 2	Algae	Diatom	Melosiraceae	Melosira granulata	165
SW-Control 2	Algae	Diatom	Bacillariaceae	Nitzschia closterium	6
SW-Control 2	Algae	Diatom	Thalassionemataceae	Synedra ulna	44
SW-Control 2	Algae	Diatom	Melosiraceae	Melosira granulata var. angustissima	12
SW-Control 2	Algae	Diatom	Fragilariaceae	Fragilaria construens	10
SW-Control 2	Algae	Diatom	Naviculaceae	Gomphonema accuminatum	4
SW-Control 2	Algae	Diatom	Naviculaceae	Navicula radiosa	10
SW-Control 2	Algae	Diatom	Bacillariaceae	Nitzschia sp	10
SW-Control 2	Algae	Green algae	Hydrodictyaceae	Pediastrum duplex	8
SW-Control 2	Algae	Green algae	Desmidiaceae	Staurastrum asterias	8
SW-Control 2	Algae	Blue-green algae	Oscillatoriaceae	Phormidium tenue	6
SW-Control 2	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya contorta	8

Table 1a: Diversity, Abundance and Distribution of Phytoplankton-Dry Season –cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
Total Count					**295**
Number of Species					**13**
Margalef Species Index					**2.11**
SW3	Algae	Diatom	Bacillariaceae	Nitzschia palea	6
SW3	Algae	Blue-green algae	Oscillatoriaceae	Oscillatoria limosa	6
SW3	Algae	Diatom	Melosiraceae	Melosira granulata	155
SW3	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya contorta	8
SW3	Algae	Diatom	Naviculaceae	Navicula oblonga	12
SW3	Algae	Blue-green algae	Oscillatoriaceae	Phormidium tenue	6
SW3	Algae	Diatom	Thalassionemataceae	Synedra ulna	50
SW3	Algae	Green algae	Desmidiaceae	Closterium moniliferum	12
SW3	Algae	Green algae	Desmidiaceae	Staurastrum asterias	15
SW3	Algae	Blue-green algae	Oscillatoriaceae	Oscillatoria limnetica	8
SW3	Algae	Diatom	Melosiraceae	Melosira granulata var. angustissima	12
Total Count					**290**
Number of Species					**11**
Margalef Species Index					**1.76**
SW4	Algae	Green algae	Desmidiaceae	Staurastrum asterias	8
SW4	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya cylindricum	8
SW4	Algae	Dinoflagellate	Peridiniaceae	Peridinium balticum	2
SW4	Algae	Diatom	Melosiraceae	Melosira granulata	215
SW4	Algae	Diatom	Thalassionemataceae	Synedra ulna	28
SW4	Algae	Diatom	Thalassionemataceae	Synedra delicatissima	10
SW4	Algae	Blue-green algae	Chroococcaceae	Microcystis aeruginosa	10
SW4	Algae	Blue-green algae	Nostocaceae	Anabaena spiroides	10
SW4	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya limnetica	15
SW4	Algae	Diatom	Naviculaceae	Gomphonema accuminatum	8
SW4	Algae	Diatom	Melosiraceae	Melosira granulata var. angustissima	15
SW4	Algae	Green algae	Zygnemataceae	Zygnema sp	10
Total Count					**347**
Number of Species					**13**
Margalef Species Index					**2.05**

Table 1a: Diversity, Abundance and Distribution of Phytoplankton-Dry Season –cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW5	Algae	Diatom	Bacillariaceae	Nitzschia palea	4
SW5	Algae	Diatom	Bacillariaceae	Nitzschia closterium	12
SW5	Algae	Diatom	Naviculaceae	Navicula radiosa	8
SW5	Algae	Diatom	Thalassionemataceae	Synedra ulna	45
SW5	Algae	Diatom	Melosiraceae	Melosira granulata	240
SW5	Algae	Diatom	Eunotiaceae	Eunotia gracilis	12
SW5	Algae	Green algae	Desmidiaceae	Staurastrum asterias	8
SW5	Algae	Blue-green algae	Oscillatoriaceae	Oscillatoria sp	10
SW5	Algae	Green algae	Volvocaceae	Eudorina elegans	8
SW5	Algae	Diatom	Melosiraceae	Melosira granulata var. angustissima	8
SW5	Algae	Blue-green algae	Oscillatoriaceae	Phormidium tenue	12
SW5	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya contorta	8
SW5	Algae	Blue-green algae	Chroococcaceae	Merismopedia elegans	6
Total Count					**381**
Number of Species					**13**
Margalef Species Index					**2.02**
SW6	Algae	Diatom	Melosiraceae	Melosira granulata var. angustissima	4
SW6	Algae	Blue-green algae	Oscillatoriaceae	Spirulina major	2
SW6	Algae	Diatom	Eunotiaceae	Eunotia gracilis	6
SW6	Algae	Diatom	Bacillariaceae	Nitzschia closterium	4
SW6	Algae	Diatom	Melosiraceae	Melosira granulata	200
SW6	Algae	Green algae	Desmidiaceae	Staurastrum asterias	4
SW6	Algae	Green algae	Desmidiaceae	Closterium moniliferum	4
SW6	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya limnetica	4
SW6	Algae	Green algae	Hydrodictyaceae	Pediastrum simplex	6
SW6	Algae	Blue-green algae	Oscillatoriaceae	Phormidium fragile	8
SW6	Algae	Green algae	Desmidiaceae	Micrasterias echinulata	8
SW6	Algae	Diatom	Thalassionemataceae	Synedra ulna	55
Total Count					**305**
Number of Species					**12**
Margalef Species Index					**1.92**

Table 1a: Diversity, Abundance and Distribution of Phytoplankton-Dry Season –cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW7	Algae	Green algae	Hydrodictyaceae	Pediastrum simplex	3
SW7	Algae	Diatom	Melosiraceae	Melosira granulata	295
SW7	Algae	Diatom	Melosiraceae	Melosira granulata var. angustissima	58
SW7	Algae	Green algae	Desmidiaceae	Closterium gracile	25
SW7	Algae	Green algae	Desmidiaceae	Closterium moniliferum	15
SW7	Algae	Diatom	Melosiraceae	Melosira sp	12
SW7	Algae	Diatom	Bacillariaceae	Nitzschia palea	6
SW7	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya contorta	6
SW7	Algae	Blue-green algae	Oscillatoriaceae	Phormidium tenue	4
SW7	Algae	Diatom	Thalassionemataceae	Synedra ulna	100
SW7	Algae	Blue-green algae	Chroococcaceae	Microcystis aeruginosa	6
SW7	Algae	Blue-green algae	Oscillatoriaceae	Spirulina sp	45
SW7	Algae	Green algae	Desmidiaceae	Staurastrum fragile	4
SW7	Algae	Diatom	Cymbellaceae	Cymbella sp	4
SW7	Algae	Diatom	Bacillariaceae	Nitzschia closterium	15
SW7	Algae	Green algae	Desmidiaceae	Staurastrum asterias	6
SW7	Algae	Green algae	Volvocaceae	Eudorina elegans	8
SW7	Algae	Dinoflagellate	Peridiniaceae	Peridinium balticum	4
Total Count					**616**
Number of Species					**18**
Margalef Species Index					**2.65**
SW8	Algae	Diatom	Thalassionemataceae	Synedra ulna	45
SW8	Algae	Diatom	Melosiraceae	Melosira granulata	160
SW8	Algae	Diatom	Melosiraceae	Melosira monilliformis	15
SW8	Algae	Diatom	Naviculaceae	Navicula sp	8
SW8	Algae	Diatom	Bacillariaceae	Nitzschia acicularis	8
SW8	Algae	Green algae	Desmidiaceae	Closterium gracile	8
SW8	Algae	Green algae	Zygnemataceae	Zygnema sp	8
SW8	Algae	Diatom	Cymbellaceae	Cymbella sp	12

Table 1a: Diversity, Abundance and Distribution of Phytoplankton-Dry Season –cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW8	Algae	Green algae	Desmidiaceae	Staurastrum fragile	6
SW8	Algae	Blue-green algae	Oscillatoriaceae	Oscillatoria limosa	6
SW8	Algae	Blue-green algae	Oscillatoriaceae	Phormidium fragile	10
Total Count					**286**
Number of Species					**11**
Margalef Species Index					**1.77**
SW9	Algae	Diatom	Thalassiosiraceae	Cyclotella meneghiniana	8
SW9	Algae	Diatom	Melosiraceae	Melosira granulata	260
SW9	Algae	Diatom	Melosiraceae	Melosira varians	15
SW9	Algae	Diatom	Bacillariaceae	Nitzschia palea	4
SW9	Algae	Diatom	Thalassionemataceae	Synedra ulna	75
SW9	Algae	Diatom	Bacillariaceae	Nitzschia closterium	6
SW9	Algae	Diatom	Fragilariaceae	Fragilaria construens	6
SW9	Algae	Blue-green algae	Oscillatoriaceae	Phormidium tenue	10
SW9	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya limnetica	2
SW9	Algae	Diatom	Eupodiscaceae	Odontella laevis	10
SW9	Algae	Green algae	Hydrodictyaceae	Pediastrum simplex	4
SW9	Algae	Blue-green algae	Oscillatoriaceae	Oscillatoria limosa	4
SW9	Algae	Blue-green algae	Oscillatoriaceae	Oscillatoria sp	4
SW9	Algae	Green algae	Desmidiaceae	Closterium moniliferum	2
SW9	Algae	Euglenoid	Euglenaceae	Trachelomonas hispida	2
Total Count					**412**
Number of Species					**15**
Margalef Species Index					**2.33**
SW10	Algae	Diatom	Melosiraceae	Melosira granulata	230
SW10	Algae	Diatom	Bacillariaceae	Nitzschia acicularis	8
SW10	Algae	Diatom	Thalassionemataceae	Synedra ulna	60
SW10	Algae	Diatom	Naviculaceae	Navicula radiosa	15
SW10	Algae	Diatom	Eunotiaceae	Eunotia gracilis	10
SW10	Algae	Diatom	Thalassiosiraceae	Cyclotella meneghiniana	6
SW10	Algae	Diatom	Thalassionemataceae	Synedra delicatissima	12
SW10	Algae	Green algae	Hydrodictyaceae	Pediastrum simplex	12

Table 1a: Diversity, Abundance and Distribution of Phytoplankton-Dry Season –cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW10	Algae	Green algae	Desmidiaceae	Staurastrum asterias	18
SW10	Algae	Diatom	Cymbellaceae	Cymbella sp	8
SW10	Algae	Dinoflagellate	Peridiniaceae	Peridinium balticum	2
SW10	Algae	Blue-green algae	Oscillatoriaceae	Oscillatoria sp	16
SW10	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya circumcreta	8
Total Count					**405**
Number of Species					**13**
Margalef Species Index					**2.00**
SW11	Algae	Diatom	Eunotiaceae	Eunotia sp	8
SW11	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya cylindricum	8
SW11	Algae	Dinoflagellate	Peridiniaceae	Peridinium balticum	12
SW11	Algae	Diatom	Melosiraceae	Melosira granulata	185
SW11	Algae	Diatom	Thalassionemataceae	Synedra ulna	70
SW11	Algae	Diatom	Thalassionemataceae	Synedra delicatissima	10
SW11	Algae	Diatom	Bacillariaceae	Nitzschia closterium	10
SW11	Algae	Diatom	Eunotiaceae	Eunotia lunaris	10
SW11	Algae	Diatom	Naviculaceae	Navicula radiosa	15
SW11	Algae	Diatom	Naviculaceae	Gomphonema accuminatum	8
SW11	Algae	Green algae	Desmidiaceae	Staurastrum asterias	15
SW11	Algae	Green algae	Zygnemataceae	Zygnema sp	10
Total Count					**369**
Number of Species					**13**
Margalef Species Index					**2.03**
SW12	Algae	Diatom	Melosiraceae	Melosira granulata	260
SW12	Algae	Diatom	Melosiraceae	Melosira granulata var. angustissima	25
SW12	Algae	Blue-green algae	Chroococcaceae	Microcystis aeruginosa	15
SW12	Algae	Green algae	Desmidiaceae	Micrasterias sp	10
SW12	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya limnetica	6
SW12	Algae	Green algae	Desmidiaceae	Closterium moniliferum	15
SW12	Algae	Diatom	Thalassionemataceae	Synedra sp	80
SW12	Algae	Diatom	Bacillariaceae	Nitzschia sp	6
SW12	Algae	Diatom	Melosiraceae	Melosira sp	8

Table 1a: Diversity, Abundance and Distribution of Phytoplankton-Dry Season –cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW12	Algae	Diatom	Bacillariaceae	Nitzschia palea	4
SW12	Algae	Green algae	Zygnemataceae	Zygnema sp	12
SW12	Algae	Green algae	Desmidiaceae	Staurastrum sp	6
SW12	Algae	Blue-green algae	Oscillatoriaceae	Oscillatoria sp	10
SW12	Algae	Diatom	Thalassiosiraceae	Cyclotella striata	10
Total Count					**479**
Number of Species					**15**
Margalef Species Index					**2.27**
SW13	Algae	Diatom	Melosiraceae	Melosira granulata	290
SW13	Algae	Diatom	Melosiraceae	Melosira granulata var. angustissima	15
SW13	Algae	Blue-green algae	Chroococcaceae	Microcystis aeruginosa	6
SW13	Algae	Green algae	Desmidiaceae	Micrasterias sp	4
SW13	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya limnetica	6
SW13	Algae	Green algae	Desmidiaceae	Closterium moniliferum	15
SW13	Algae	Diatom	Fraglariaceae	Fragilaria sp	12
SW13	Algae	Diatom	Thalassionemataceae	Synedra sp	70
SW13	Algae	Diatom	Bacillariaceae	Nitzschia sp	6
SW13	Algae	Diatom	Melosiraceae	Melosira varians	8
SW13	Algae	Diatom	Bacillariaceae	Nitzschia palea	4
SW13	Algae	Green algae	Zygnemataceae	Zygnema sp	12
SW13	Algae	Diatom	Fraglariaceae	Fragilaria construens	6
SW13	Algae	Diatom	Bacillariaceae	Nitzschia sp	4
Total Count					**468**
Number of Species					**15**
Margalef Species Index					**2.28**
SW14	Algae	Green algae	Desmidiaceae	Staurastrum fragile	8
SW14	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya cylindricum	8
SW14	Algae	Diatom	Melosiraceae	Melosira granulata var. angustissima	30
SW14	Algae	Diatom	Melosiraceae	Melosira granulata	170
SW14	Algae	Diatom	Thalassionemataceae	Synedra ulna	65
SW14	Algae	Diatom	Thalassionemataceae	Synedra delicatissima	10
SW14	Algae	Diatom	Bacillariaceae	Nitzschia closterium	10

Table 1a: Diversity, Abundance and Distribution of Phytoplankton-Dry Season –cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW14	Algae	Diatom	Eunotiaceae	Eunotia lunaris	10
SW14	Algae	Diatom	Naviculaceae	Navicula radiosa	15
SW14	Algae	Diatom	Naviculaceae	Gomphonema accuminatum	15
SW14	Algae	Green algae	Desmidiaceae	Staurastrum asterias	8
SW14	Algae	Green algae	Zygnemataceae	Zygnema sp	8
SW14	Algae	Diatom	Fraglariaceae	Fragilaria construens	10
Total Count					**367**
Number of Species					**13**
Margalef Species Index					**2.03**
SW15	Algae	Diatom	Melosiraceae	Melosira granulata	240
SW15	Algae	Diatom	Melosiraceae	Melosira granulata var. angustissima	35
SW15	Algae	Blue-green algae	Chroococcaceae	Microcystis aeruginosa	12
SW15	Algae	Green algae	Desmidiaceae	Micrasterias sp	4
SW15	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya limnetica	6
SW15	Algae	Green algae	Desmidiaceae	Closterium moniliferum	5
SW15	Algae	Green algae	Desmidiaceae	Staurastrum asterias	6
SW15	Algae	Diatom	Thalassionemataceae	Synedra sp	80
SW15	Algae	Diatom	Bacillariaceae	Nitzschia sp	12
SW15	Algae	Diatom	Melosiraceae	Melosira varians	8
SW15	Algae	Diatom	Bacillariaceae	Nitzschia palea	4
SW15	Algae	Green algae	Zygnemataceae	Zygnema sp	12
SW15	Algae	Green algae	Desmidiaceae	Staurastrum sp	4
SW15	Algae	Blue-green algae	Oscillatoriaceae	Oscillatoria limnetica	6
SW15	Algae	Diatom	Thalassiosiraceae	Cyclotella striata	10
Total Count					**444**
Number of Species					**15**
Margalef Species Index					**2.30**

Table 1b: Diversity, Abundance and Distribution of Phytoplankton-Wet Season

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW 1	Algae	Green algae	Oocystaceae	Ankistrodesmus sp	4
SW 1	Algae	Green algae	Hydrodictyaceae	Eudorina elegans	2
SW 1	Algae	Diatom	Eunotiaceae	Eunotia gracilis	6
SW 1	Algae	Diatom	Bacillariaceae	Nitzschia closterium	4
SW 1	Algae	Diatom	Melosiraceae	Melosira granulata	78
SW 1	Algae	Green algae	Desmidiaceae	Staurastrum asterias	4
SW 1	Algae	Green algae	Desmidiaceae	Closterium moniliferum	4
SW 1	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya limnetica	4
SW 1	Algae	Green algae	Hydrodictyaceae	Pediastrum simplex	6
SW 1	Algae	Blue-green algae	Oscillatoriaceae	Phormidium fragile	8
SW 1	Algae	Green algae	Desmidiaceae	Micrasterias echinulata	8
SW 1	Algae	Diatom	Thalassionemataceae	Synedra ulna	30
Total Count					**158**
Number of Species					**12**
Margalef Species Index					**2.17**
SW-Control-1	Algae	Blue-green algae	Nostocaceae	Anabaena spiroides	6
SW-Control-1	Algae	Green algae	Desmidiaceae	Closterium gracile	10
SW-Control-1	Algae	Euglenoid	Euglenaceae	Trachelomonas hispida	2
SW-Control-1	Algae	Diatom	Melosiraceae	Melosira granulata	65
SW-Control-1	Algae	Diatom	Thalassionemataceae	Synedra ulna	25
SW-Control-1	Algae	Diatom	Thalassionemataceae	Synedra delicatissima	10
SW-Control-1	Algae	Diatom	Bacillariaceae	Nitzschia closterium	10
SW-Control-1	Algae	Diatom	Eunotiaceae	Eunotia lunaris	10
SW-Control-1	Algae	Diatom	Naviculaceae	Navicula radiosa	15
SW-Control-1	Algae	Diatom	Naviculaceae	Gomphonema accuminatum	8
SW-Control-1	Algae	Green algae	Desmidiaceae	Staurastrum asterias	15
SW-Control-1	Algae	Green algae	Zygnemataceae	Zygnema sp	10
SW-Control-1	Algae	Green algae	Volvocaceae	Eudorina elegans	6
Total Count					**192**
Number of Species					**13**
Margalef Species Index					**2.28**

Table 1b: Diversity, Abundance and Distribution of Phytoplankton-Wet Season –cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW 2	Algae	Diatom	Naviculaceae	Navicula sp	8
SW 2	Algae	Diatom	Melosiraceae	Melosira granulata	60
SW 2	Algae	Diatom	Bacillariaceae	Nitzschia closterium	6
SW 2	Algae	Diatom	Thalassionemataceae	Synedra ulna	20
SW 2	Algae	Diatom	Eunotiaceae	Eunotia lunaris	8
SW 2	Algae	Diatom	Fragilariaceae	Fragilaria sp	6
SW 2	Algae	Diatom	Naviculaceae	Gomphonema accuminatum	4
SW 2	Algae	Diatom	Naviculaceae	Navicula radiosa	10
SW 2	Algae	Green algae	Volvocaceae	Volvox aureus	10
SW 2	Algae	Green algae	Hydrodictyaceae	Pediastrum duplex	8
SW 2	Algae	Green algae	Desmidiaceae	Staurastrum asterias	8
SW 2	Algae	Blue-green algae	Oscillatoriaceae	Phormidium tenue	6
SW 2	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya contorta	8
Total Count					**162**
Number of Species					**13**
Margalef Species Index					**2.36**
SW-Control-2	Algae	Diatom	Thalassionemataceae	Synedra ulna	32
SW-Control-2	Algae	Diatom	Melosiraceae	Melosira granulata	75
SW-Control-2	Algae	Diatom	Melosiraceae	Melosira monilliformis	15
SW-Control-2	Algae	Diatom	Naviculaceae	Navicula sp	8
SW-Control-2	Algae	Diatom	Bacillariaceae	Nitzschia acicularis	8
SW-Control-2	Algae	Green algae	Desmidiaceae	Closterium gracile	8
SW-Control-2	Algae	Green algae	Zygnemataceae	Zygnema sp	12
SW-Control-2	Algae	Green algae	Hydrodictyaceae	Pediastrum simplex	8
SW-Control-2	Algae	Green algae	Desmidiaceae	Staurastrum fragile	6
SW-Control-2	Algae	Blue-green algae	Oscillatoriaceae	Oscillatoria sp	4
SW-Control-2	Algae	Blue-green algae	Oscillatoriaceae	Phormidium fragile	10
Total Count					**186**
Number of Species					**11**
Margalef Species Index					**1.91**

Table 1b: Diversity, Abundance and Distribution of Phytoplankton-Wet Season – cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW 3	Algae	Green algae	Oocystaceae	Ankistrodesmus sp	4
SW 3	Algae	Diatom	Diatomataceae	Tabellaria floculosa	6
SW 3	Algae	Diatom	Bacillariaceae	Nitzschia palea	8
SW 3	Algae	Blue-green algae	Oscillatoriaceae	Oscillatoria limnetica	4
SW 3	Algae	Blue-green algae	Oscillatoriaceae	Phormidium fragile	12
SW 3	Algae	Green algae	Volvocaceae	Eudorina elegans	10
SW 3	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya limnetica	4
SW 3	Algae	Diatom	Thalassionemataceae	Synedra ulna	20
SW 3	Algae	Diatom	Melosiraceae	Melosira grannulata	65
SW 3	Algae	Green algae	Desmidiaceae	Closterium gracile	12
SW 3	Algae	Diatom	Bacillariaceae	Nitzschia closterium	2
SW 3	Algae	Dinoflagellate	Peridiniaceae	Peridinium cintum	2
Total Count					**149**
Number of Species					**12**
Margalef Species Index					**2.2**
SW 4	Algae	Green algae	Desmidiaceae	Closterium gracile	6
SW 4	Algae	Diatom	Melosiraceae	Melosira granulata	80
SW 4	Algae	Diatom	Bacillariaceae	Nitzschia closterium	6
SW 4	Algae	Green algae	Desmidiaceae	Closterium sp	10
SW 4	Algae	Diatom	Eunotiaceae	Eunotia lunaris	12
SW 4	Algae	Diatom	Fragilariaceae	Fragilaria construens	10
SW 4	Algae	Diatom	Naviculaceae	Gomphonema accuminatum	4
SW 4	Algae	Diatom	Naviculaceae	Navicula radiosa	10
SW 4	Algae	Green algae	Volvocaceae	Volvox aureus	10
SW 4	Algae	Green algae	Hydrodictyaceae	Pediastrum duplex	8
SW 4	Algae	Green algae	Desmidiaceae	Staurastrum asterias	8
SW 4	Algae	Blue-green algae	Oscillatoriaceae	Phormidium tenue	6
SW 4	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya contorta	8
Total Count					**178**
Number of Species					**13**
Margalef Species Index					**2.32**

Table 1b: Diversity, Abundance and Distribution of Phytoplankton-Wet Season – cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW 5	Algae	Green algae	Oocystaceae	Ankistrodesmus sp	2
SW 5	Algae	Green algae	Hydrodictyaceae	Eudorina elegans	4
SW 5	Algae	Diatom	Eunotiaceae	Eunotia gracilis	6
SW 5	Algae	Diatom	Bacillariaceae	Nitzschia closterium	4
SW 5	Algae	Diatom	Melosiraceae	Melosira granulata	78
SW 5	Algae	Diatom	Coscinodiscaceae	Coscinodiscus sp	4
SW 5	Algae	Diatom	Fragilariaceae	Fragilaria construens	4
SW 5	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya limnetica	4
SW 5	Algae	Green algae	Desmidiaceae	Closterium moniliferum	6
SW 5	Algae	Blue-green algae	Oscillatoriaceae	Phormidium fragile	8
SW 5	Algae	Green algae	Desmidiaceae	Closterium gracile	8
SW 5	Algae	Diatom	Thalassionemataceae	Synedra ulna	20
Total Count					**148**
Number of Species					**12**
Margalef Species Index					**2.2**
SW 6	Algae	Diatom	Bacillariaceae	Nitzschia sp	8
SW 6	Algae	Green algae	Desmidiaceae	Micrasterias sp	6
SW 6	Algae	Diatom	Melosiraceae	Melosira granulata	54
SW 6	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya contorta	8
SW 6	Algae	Diatom	Naviculaceae	Navicula oblonga	12
SW 6	Algae	Blue-green algae	Oscillatoriaceae	Phormidium tenue	6
SW 6	Algae	Diatom	Thalassionemataceae	Synedra ulna	18
SW 6	Algae	Green algae	Desmidiaceae	Closterium moniliferum	12
SW 6	Algae	Green algae	Desmidiaceae	Staurastrum asterias	8
SW 6	Algae	Green algae	Zygnemataceae	Zygnema sp	8
SW 6	Algae	Green algae	Volvocaceae	Eudorina elegans	12
Total Count					**152**
Number of Species					**11**
Margalef Species Index					**1.99**
SW 7	Algae	Diatom	Thalassionemataceae	Synedra ulna	25
SW 7	Algae	Diatom	Melosiraceae	Melosira granulata	70
SW 7	Algae	Diatom	Melosiraceae	Melosira granulata var. angustissima	15

Table 1b: Diversity, Abundance and Distribution of Phytoplankton-Wet Season – cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW 7	Algae	Diatom	Bacillariaceae	Nitzschia acicularis	8
SW 7	Algae	Euglenoid	Euglenaceae	Trachelomonas hispida	3
SW 7	Algae	Green algae	Zygnemataceae	Zygnema sp	12
SW 7	Algae	Green algae	Hydrodictyaceae	Pediastrum simplex	8
SW 7	Algae	Green algae	Desmidiaceae	Staurastrum gracile	6
SW 7	Algae	Green algae	Desmidiaceae	Closterium moniliferum	6
Total Count					**167**
Number of Species					**11**
Margalef Species Index					**1.95**
SW 8	Algae	Diatom	Thalassionemataceae	Synedra ulna	25
SW 8	Algae	Diatom	Bacillariaceae	Nitzschia vermicularis	10
SW 8	Algae	Diatom	Bacillariaceae	Nitzschia closterium	15
SW 8	Algae	Diatom	Melosiraceae	Melosira granulata	60
SW 8	Algae	Green algae	Volvocaceae	Eudorina elegans	8
SW 8	Algae	Green algae	Desmidiaceae	Closterium moniliferum	4
SW 8	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya limnetica	8
SW 8	Algae	Green algae	Desmidiaceae	Closterium gracile	6
SW 8	Algae	Diatom	Melosiraceae	Melosira granulata var. angustissima	14
SW 8	Algae	Dinoflagellate	Peridiniaceae	Peridinium cintum	2
SW 8	Algae	Green algae	Desmidiaceae	Micrasterias echinulata	4
Total Count					**156**
Number of Species					**11**
Margalef Species Index					**1.98**
SW 9	Algae	Diatom	Naviculaceae	Navicula radiosa	10
SW 9	Algae	Diatom	Melosiraceae	Melosira granulata	73
SW 9	Algae	Diatom	Diatomataceae	Tabellaria fenestrata	2
SW 9	Algae	Diatom	Eunotiaceae	Eunotia gracilis	2
SW 9	Algae	Diatom	Thalassionemataceae	Synedra ulna	25
SW 9	Algae	Green algae	Desmidiaceae	Staurastrum asterias	8
SW 9	Algae	Green algae	Desmidiaceae	Micrasterias echinulata	6
SW 9	Algae	Green algae	Desmidiaceae	Closterium moniliferum	6
SW 9	Algae	Blue-green algae	Nostocaceae	Anabaena spiroides	8

Table 1b: Diversity, Abundance and Distribution of Phytoplankton-Wet Season – cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW 9	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya limnetica	4
Total Count					**144**
Number of Species					**10**
Margalef Species Index					**1.81**
SW 10	Algae	Diatom	Naviculaceae	Navicula sp	4
SW 10	Algae	Diatom	Melosiraceae	Melosira granulata	60
SW 10	Algae	Diatom	Bacillariaceae	Nitzschia closterium	6
SW 10	Algae	Diatom	Thalassionemataceae	Synedra ulna	28
SW 10	Algae	Diatom	Eunotiaceae	Eunotia lunaris	12
SW 10	Algae	Diatom	Naviculaceae	Gomphonema accuminatum	4
SW 10	Algae	Diatom	Naviculaceae	Navicula radiosa	10
SW 10	Algae	Green algae	Volvocaceae	Volvox aureus	10
SW 10	Algae	Green algae	Hydrodictyaceae	Pediastrum duplex	8
SW 10	Algae	Green algae	Desmidiaceae	Staurastrum asterias	8
SW 10	Algae	Blue-green algae	Oscillatoriaceae	Phormidium tenue	6
SW 10	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya contorta	8
Total Count					**174**
Number of Species					**13**
Margalef Species Index					**2.33**
SW 11	Algae	Diatom	Bacillariaceae	Nitzschia palea	6
SW 11	Algae	Diatom	Melosiraceae	Melosira granulata	48
SW 11	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya contorta	8
SW 11	Algae	Diatom	Naviculaceae	Navicula oblonga	12
SW 11	Algae	Blue-green algae	Oscillatoriaceae	Phormidium tenue	6
SW 11	Algae	Diatom	Thalassionemataceae	Synedra ulna	18
SW 11	Algae	Green algae	Desmidiaceae	Closterium moniliferum	12
SW 11	Algae	Green algae	Desmidiaceae	Staurastrum asterias	15
SW 11	Algae	Green algae	Zygnemataceae	Zygnema sp	8
SW 11	Algae	Green algae	Volvocaceae	Eudorina elegans	12
Total Count					**151**
Number of Species					**11**
Margalef Species Index					**1.99**

Table 1b: Diversity, Abundance and Distribution of Phytoplankton-Wet Season – cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW 12	Algae	Diatom	Melosiraceae	Melosira granulata	45
SW 12	Algae	Diatom	Melosiraceae	Melosira granulata var.spiroides	10
SW 12	Algae	Diatom	Thalassionemataceae	Synedra ulna	20
SW 12	Algae	Diatom	Thalassionemataceae	Synedra delicatissima	10
SW 12	Algae	Diatom	Bacillariaceae	Nitzschia closterium	6
SW 12	Algae	Green algae	Desmidiaceae	Closterium moniliferum	10
SW 12	Algae	Green algae	Hydrodictyaceae	Pediastrum duplex	6
SW 12	Algae	Green algae	Zygnemataceae	Zygnema sp	8
SW 12	Algae	Green algae	Desmidiaceae	Closterium moniliferum	8
Total Count					**123**
Number of Species					**9**
Margalef Species Index					**1.66**
SW 13	Algae	Diatom	Eunotiaceae	Eunotia gracilis	8
SW 13	Algae	Diatom	Melosiraceae	Melosira granulata	40
SW 13	Algae	Diatom	Bacillariaceae	Nitzschia acicularis	6
SW 13	Algae	Diatom	Naviculaceae	Navicula radiosa	10
SW 13	Algae	Diatom	Thalassionemataceae	Synedra ulna	24
SW 13	Algae	Green algae	Volvocaceae	Eudorina elegans	12
SW 13	Algae	Green algae	Hydrodictyaceae	Pediastrum simplex	8
SW 13	Algae	Green algae	Desmidiaceae	Micrasterias sp	10
SW 13	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya contorta	4
SW 13	Algae	Green algae	Desmidiaceae	Staurastrum asterias	8
Total Count					**130**
Number of Species					**10**
Margalef Species Index					**1.85**
SW 14	Algae	Diatom	Thalassionemataceae	Synedra ulna	12
SW 14	Algae	Diatom	Bacillariaceae	Nitzschia vermicularis	8
SW 14	Algae	Diatom	Bacillariaceae	Nitzschia closterium	15
SW 14	Algae	Diatom	Melosiraceae	Melosira granulata	65
SW 14	Algae	Green algae	Volvocaceae	Eudorina elegans	8
SW 14	Algae	Blue-green algae	Chroococcaceae	Microcystis sp	4
SW 14	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya limnetica	8

Table 1b: Diversity, Abundance and Distribution of Phytoplankton-Wet Season – cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW 14	Algae	Diatom	Melosiraceae	Melosira granulata var. angustissima	14
SW 14	Algae	Dinoflagellate	Peridiniaceae	Peridinium cintum	2
SW 14	Algae	Euglenoid	Euglenaceae	Trachelomonas hispida	2
Total Count					**144**
Number of Species					**11**
Margalef Species Index					**2.01**
SW 15	Algae	Diatom	Eunotiaceae	Eunotia gracilis	8
SW 15	Algae	Diatom	Melosiraceae	Melosira granulata	45
SW 15	Algae	Diatom	Bacillariaceae	Nitzschia acicularis	6
SW 15	Algae	Diatom	Naviculaceae	Navicula radiosa	10
SW 15	Algae	Diatom	Thalassionemataceae	Synedra ulna	25
SW 15	Algae	Green algae	Volvocaceae	Eudorina elegans	12
SW 15	Algae	Green algae	Hydrodictyaceae	Pediastrum simplex	8
SW 15	Algae	Green algae	Desmidiaceae	Micrasterias sp	10
SW 15	Algae	Blue-green algae	Oscillatoriaceae	Lyngbya contorta	4
SW 15	Algae	Blue-green algae	Nostocaceae	Anabaena flos-aqua	6
Total Count					**134**
Number of Species					**10**
Margalef Species Index					**1.84**

Table 2a: Diversity, Abundance and Distribution of Zooplankton-Dry Season

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW1	Arthropoda/Crustacea	Copepoda	Temoridae	Eurytemora lacustris	2
SW1	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	16
SW1	Chordata	Pisces	--------	Fish larvae	6
SW1	Rotifer	Monogononta	Branchionidae	Keratella valga	4
SW1	Arthropoda/Crustacea	Copepoda	Temoridae	Temora sp	4
SW1	Rotifer	Monogononta	Branchionidae	Branchionus angularis	10
SW1	Rotifer	Monogononta	Branchionidae	Branchionus sp	4
Total Count					**46**
Number of Species					**7**
Margalef Species Index					**1.57**
SW-Control 1	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	20
SW-Control 1	Arthropoda/Crustacea	Copepoda	Temoridae	Eurytemora affinis	6
SW-Control 1	Arthropoda/Crustacea	Copepoda	Oithonidae	Oithona sp	4
SW-Control 1	Rotifer	Monogononta	Branchionidae	Keratella quadrata	8
SW-Control 1	Arthropoda/Crustacea	Copepoda	----------	Nitocra lacustris	6
SW-Control 1	Arthropoda/Crustacea	Copepoda	Cyclopidae	Cyclopina longicornis	6
SW-Control 1	Nematoda	--------	--------	Nematode larvae	6
Total Count					**62**
Number of Species					**8**
Margalef Species Index					**1.70**
SW2	Arthropoda/Crustacea	Copepoda	--------	Copepod nauplius	12
SW2	Arthropoda/Crustacea	Cladocera	Polyphemidae	Evadne spinifera	6
SW2	Arthropoda/Crustacea	Cladocera	Bosmidae	Bosmia sp	4
SW2	Arthropoda/Crustacea	Copepoda	Cyclopidae	Mesocyclops sp	8
SW2	Arthropoda/Crustacea	Copepoda	Cyclopidae	Cyclops strenuus	6
Total Count					**36**
Number of Species					**5**
Margalef Species Index					**1.12**
SW-Control 2	Rotifer	Monogononta	Branchionidae	Keratella valga	3
SW-Control 2	Arthropoda/Crustacea	Copepoda	Temoridae	Temora sp	2
SW-Control 2	Rotifer	Monogononta	Branchionidae	Branchionus angularis	8
SW-Control 2	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	12
SW-Control 2	Rotifer	Monogononta	Branchionidae	Branchionus falcutus	6

Table 2b: Diversity, Abundance and Distribution of Zooplankton-Dry Season – cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
Total Count					**37**
Number of Species					**6**
Margalef species index					**1.39**
SW3	Arthropoda/Crustacea	Copepoda	Temoridae	Eurytemora lacustris	2
SW3	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	16
SW3	Chordata	Pisces	--------	Fish larvae	6
SW3	Rotifer	Monogononta	Branchionidae	Keratella valga	4
SW3	Arthropoda/Crustacea	Copepoda	Temoridae	Temora sp	4
SW3	Rotifer	Monogononta	Branchionidae	Branchionus angularis	10
SW3	Rotifer	Monogononta	Branchionidae	Branchionus sp	4
Total Count					**46**
Number of Species					**7**
Margalef Species Index					**1.57**
SW4	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	16
SW4	Rotifer	Monogononta	Branchionidae	Branchionus falcutus	6
SW4	Arthropoda/Crustacea	Copepoda	Cyclopidae	Cyclops strenuus	6
SW4	Arthropoda/Crustacea	Copepoda	Cyclopidae	Eucyclops serrutalus	2
SW4	Arthropoda/Crustacea	Cladocera	Polyphemidae	Evadne spinifera	6
SW4	Arthropoda/Crustacea	Copepoda	----------	Nitocra lacustris	4
Total Count					**40**
Number of Species					**6**
Margalef Species Index					**1.36**
SW5	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	8
SW5	Rotifer	Monogononta	Branchionidae	Branchionus angularis	6
SW5	Arthropoda/Crustacea	Copepoda	Oithonidae	Oithona sp	4
SW5	Rotifer	Monogononta	Branchionidae	Keratella quadrata	8
SW5	Rotifer	Monogononta	Branchionidae	Keratella valga	6
Total Count					**32**
Number of Species					**5**
Margalef Species Index					**1.15**
SW6	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	14
SW6	Arthropoda/Crustacea	Copepoda	Cyclopidae	Eucyclops serrutalus	2

Table 2b: Diversity, Abundance and Distribution of Zooplankton-Dry Season – cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW6	Arthropoda/Crustacea	Cladocera	Polyphemidae	Evadne spinifera	6
SW6	Arthropoda/Crustacea	Copepoda	----------	Nitocra lacustris	4
Total Count					**32**
Number of Species					**5**
Margalef Species Index					**1.15**
SW7	Arthropoda/Crustacea	Copepoda	--------	Copepod nauplius	17
SW7	Arthropoda/Crustacea	Cladocera	Polyphemidae	Evadne spinifera	6
SW7	Arthropoda/Crustacea	Cladocera	Bosmidae	Bosmia sp	4
SW7	Arthropoda/Crustacea	Copepoda	Cyclopidae	Mesocyclops sp	8
SW7	Arthropoda/Crustacea	Copepoda	Cyclopidae	Cyclops strenuus	12
SW7	Arthropoda/Crustacea	Copepoda	Cyclopidae	Cyclops vicinus	6
SW7	Arthropoda/Crustacea	Copepoda	Calanidae	Sinocalanus dorrii	6
SW7	Arthropoda/Crustacea	Copepoda	Cyclopidae	Macrocyclops distintus	4
Total Count					**63**
Number of Species					**8**
Margalef Species Index					**1.69**
SW8	Arthropoda/Crustacea	Copepoda	Cyclopidae	Macrocyclops distintus	5
SW8	Arthropoda/Crustacea	Copepoda	Temoridae	Eurytemora lacustris	4
SW8	Arthropoda/Crustacea	Copepoda	Temoridae	Eurytemora affinis	2
SW8	Rotifer	Monogononta	Branchionidae	Keratella sp	4
SW8	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	8
SW8	Arthropoda/Crustacea	Cladocera	Bosmidae	Bosmia sp	4
SW8	Arthropoda/Crustacea	Cladocera	--------	Leptodora sp	2
Total Count					**33**
Number of Species					**8**
Margalef Species Index					**2.00**
SW9	Arthropoda/Crustacea	Cladocera	Sidiidae	Penilia aviroris	3
SW9	Nematoda	--------	--------	Polychaete larvae	4
SW9	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	14
SW9	Mollusca	Gastropoda	----------	Gastropod larvae	4
SW9	Arthropoda/Crustacea	Cladocera	Polyphemidae	Evadne tergestina	4
SW9	Arthropoda/Crustacea	Cladocera	Polyphemidae	Evadne spinifera	2

Table 2b: Diversity, Abundance and Distribution of Zooplankton-DrySeason – cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
Total Count					**31**
Number of Species					**6**
Margalef Species Index					**1.46**
SW10	Mollusca	Gastropoda	----------	Gastropod larvae	4
SW10	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	16
SW10	Rotifer	Monogononta	Branchionidae	Branchionus falcutus	8
SW10	Rotifer	Monogononta	Branchionidae	Branchionus sp	8
SW10	Arthropoda/Crustacea	Cladocera	Bosmidae	Bosmia sp	6
SW10	Arthropoda/Crustacea	Copepoda	Cyclopidae	Eucyclops serrutalus	4
Total Count					**46**
Number of Species					**6**
Margalef Species Index					**1.31**
SW11	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	16
SW11	Rotifer	Monogononta	Branchionidae	Branchionus falcutus	6
SW11	Arthropoda/Crustacea	Copepoda	Cyclopidae	Cyclops strenuus	6
SW11	Arthropoda/Crustacea	Copepoda	Cyclopidae	Eucyclops serrutalus	2
SW11	Arthropoda/Crustacea	Cladocera	Polyphemidae	Evadne spinifera	6
SW11	Arthropoda/Crustacea	Copepoda	----------	Nitocra lacustris	4
Total Count					**40**
Number of Species					**6**
Margalef Species Index					**1.36**
SW12	Mollusca	Gastropoda	----------	Gastropod larvae	2
SW12	Arthropoda/Crustacea	Cladocera	Bosmidae	Bosmia sp	8
SW12	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	15
SW12	Arthropoda/Crustacea	Copepoda	Oithonidae	Limnoithona sinensis	8
SW12	Arthropoda/Crustacea	Copepoda	Temoridae	Eurytemora lacustris	8
SW12	Arthropoda/Crustacea	Copepoda	Cyclopidae	Eucyclops serrutalus	6
SW12	Rotifer	Monogononta	Branchionidae	Branchionus falcutus	4
Total Count					**51**
Number of Species					**7**
Margalef Species Index					**1.53**

Table 2b: Diversity, Abundance and Distribution of Zooplankton-Dry Season- cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW13	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	16
SW13	Rotifer	Monogononta	Branchionidae	Branchionus falcutus	6
SW13	Arthropoda/Crustacea	Copepoda	Cyclopidae	Cyclops strenuus	6
SW13	Arthropoda/Crustacea	Copepoda	Cyclopidae	Eucyclops serrutalus	2
SW13	Arthropoda/Crustacea	Cladocera	Polyphemidae	Evadne spinifera	6
SW13	Arthropoda/Crustacea	Copepoda	----------	Nitocra lacustris	4
Total Count					**40**
Number of Species					**6**
Margalef Species Index					**1.36**
SW15	Arthropoda/Crustacea	Copepoda	Temoridae	Eurytemora lacustris	2
SW15	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	16
SW15	Chordata	Pisces	--------	Fish larvae	6
SW15	Rotifer	Monogononta	Branchionidae	Keratella valga	4
SW15	Arthropoda/Crustacea	Copepoda	Temoridae	Temora sp	4
SW15	Rotifer	Monogononta	Branchionidae	Branchionus angularis	10
SW15	Rotifer	Monogononta	Branchionidae	Branchionus sp	4
Total Count					**46**
Number of Species					**7**
Margalef Species Index					**1.57**

Table 2b: Diversity, Abundance and Distribution of Zooplankton- Wet Season

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW 1	Arthropoda/Crustacea	Copepoda	Cyclopidae	Mesocyclops sp	6
SW 1	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	15
SW 1	Rotifer	Monogononta	Branchionidae	Keratella quadrata	10
SW 1	Rotifer	Monogononta	Branchionidae	Keratella valga	6
Total Count					**37**
Number of Species					**4**
Margalef Species Index					**0.83**
SW-Control-1	Arthropoda/Crustacea	Copepoda	Cyclopidae	Cyclops strenuus	6
SW-Control-1	Arthropoda/Crustacea	Copepoda	Oithonidae	Limnoithona sinensis	14
SW-Control-1	Arthropoda/Crustacea	Copepoda	Cyclopoidae	Cyclops sp	6
SW-Control-1	Arthropoda/Crustacea	Copepoda	Cyclopidae	Eucyclops serrutalus	4
SW-control-1	Rotifer	Monogononta	Branchionidae	Branchionus falcutus	8
Total Count					**58**
Number of Species					**6**
Margalef Species Index					**1.23**
SW 2	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	16
SW 2	Rotifer	Monogononta	Branchionidae	Branchionus falcutus	6
SW 2	Arthropoda/Crustacea	Copepoda	Cyclopidae	Cyclops strenuus	6
SW 2	Arthropoda/Crustacea	Copepoda	Cyclopidae	Eucyclops serrutalus	2
SW 2	Arthropoda/Crustacea	Cladocera	Polyphemidae	Evadne spinifera	6
SW 2	Arthropoda/Crustacea	Copepoda	----------	Nitocra lacustris	4
Total Count					**40**
Number of Species					**6**
Margalef Species Index					**1.36**
SW-Control-2	Arthropoda/Crustacea	Copepoda	Temoridae	Eurytemora lacustris	2
SW-Control-2	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	16
SW-Control-2	Rotifer	Monogononta	Branchionidae	Keratella valga	4
SW-Control-2	Arthropoda/Crustacea	Copepoda	Temoridae	Temora sp	4
SW-Control-2	Rotifer	Monogononta	Branchionidae	Branchionus angularis	10
SW-Control-2	Rotifer	Monogononta	Branchionidae	Branchionus sp	4
Total Count					**46**
Number of Species					**7**
Margalef Species Index					**1.57**

Table 2b: Diversity, Abundance and Distribution of Zooplankton-Wet Season – cont'd

Station ID	Phylum/Division	Group/Class	Family	Species	Count/ml
SW 3	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	12
SW 3	Rotifer	Monogononta	Branchionidae	Branchionus angularis	4
SW 3	Arthropoda/Crustacea	Copepoda	Cyclopidae	Eucyclops sp	4
SW 3	Rotifer	Monogononta	Branchionidae	Keratella quadrata	6
SW 3	Rotifer	Monogononta	Branchionidae	Keratella valga	6
Total Count					**32**
Number of Species					**5**
Margalef species index					**1.15**
SW 4	Mollusca	Gastropoda	----------	Gastropod larvae	4
SW 4	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	16
SW 4	Rotifer	Monogononta	Branchionidae	Branchionus falcutus	8
SW 4	Rotifer	Monogononta	Branchionidae	Branchionus sp	8
SW 4	Arthropoda/Crustacea	Cladocera	Bosmidae	Bosmia sp	6
SW 4	Arthropoda/Crustacea	Copepoda	Cyclopidae	Eucyclops serrutalus	4
Total Count					**46**
Number of Species					**6**
Margalef species index					**1.31**
SW 5	Arthropoda/Crustacea	Copepoda	Temoridae	Eurytemora lacustris	2
SW 5	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	16
SW 5	Chordata	Pisces	--------	Fish larvae	6
SW 5	Rotifer	Monogononta	Branchionidae	Keratella valga	4
SW 5	Arthropoda/Crustacea	Copepoda	Temoridae	Temora sp	4
SW 5	Rotifer	Monogononta	Branchionidae	Branchionus angularis	10
SW 5	Rotifer	Monogononta	Branchionidae	Branchionus sp	4
Total Count					**46**
Number of Species					**7**
Margalef species index					**1.57**
SW 6	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	15
SW 6	Arthropoda/Crustacea	Copepoda	Oithonidae	Oithona sp	4
SW 6	Rotifer	Monogononta	Branchionidae	Branchionus angularis	8
SW 6	Arthropoda/Crustacea	Copepoda	Temoridae	Eurytemora lacustris	6
SW 6	Arthropoda/Crustacea	Copepoda	Cyclopidae	Eucyclops serrutalus	4

Table 2b: Diversity, Abundance and Distribution of Zooplankton-Wet Season – cont'd

SW 6	Arthropoda/Crustacea	Copepoda	Acartidae	Acartia tonsa	2
Total Count					**39**
Number of Species					**6**
Margalef species Index					**1.37**
SW 7	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	14
SW 7	Rotifer	Monogononta	Branchionidae	Branchionus angularis	8
SW 7	Arthropoda/Crustacea	Copepoda	Cyclopidae	Cyclops strenuus	6
SW 7	Arthropoda/Crustacea	Copepoda	Cyclopidae	Eucyclops serrutalus	2
SW 7	Arthropoda/Crustacea	Cladocera	Polyphemidae	Evadne spinifera	6
SW 7	Mollusca	Gastropoda	----------	Gastropod larvae	4
Total Count					**40**
Number of Species					**6**
Margalef species Index					**1.36**
SW 8	Arthropoda/Crustacea	Copepoda	Cyclopidae	Cyclops strenuus	6
SW 8	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	20
SW 8	Arthropoda/Crustacea	Copepoda	Cyclopidae	Eucyclops serrutalus	4
SW 8	Rotifer	Monogononta	Branchionidae	Branchionus falcutus	8
Total Count					**38**
Number of Species					**4**
Margalef species Index					**0.82**
SW 9	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	8
SW 9	Rotifer	Monogononta	Branchionidae	Branchionus angularis	6
SW 9	Arthropoda/Crustacea	Copepoda	Oithonidae	Oithona sp	4
SW 9	Rotifer	Monogononta	Branchionidae	Keratella quadrata	8
SW 9	Rotifer	Monogononta	Branchionidae	Keratella valga	6
Total Count					**32**
Number of Species					**5**
Margalef species Index					**1.15**
SW 10	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	16
SW 10	Rotifer	Monogononta	Branchionidae	Branchionus falcutus	6
SW 10	Arthropoda/Crustacea	Copepoda	Cyclopidae	Cyclops strenuus	6
SW 10	Arthropoda/Crustacea	Copepoda	Cyclopidae	Eucyclops serrutalus	2
SW 10	Arthropoda/Crustacea	Cladocera	Polyphemidae	Evadne spinifera	6
SW 10	Arthropoda/Crustacea	Copepoda	----------	Nitocra lacustris	4

Table 2b: Diversity, Abundance and Distribution of Zooplankton-Wet Season – cont'd

Total Count					**40**
Number of Species					**6**
Margalef species Index					**1.36**
SW 11	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	12
SW 11	Rotifer	Monogononta	Branchionidae	Branchionus angularis	6
SW 11	Arthropoda/Crustacea	Copepoda	Oithonidae	Oithona sp	4
SW 11	Rotifer	Monogononta	Branchionidae	Keratella quadrata	4
SW 11	Rotifer	Monogononta	Branchionidae	Keratella valga	6
Total Count					**32**
Number of Species					**5**
Margalef species Index					**1.15**
SW 12	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	8
SW 12	Arthropoda/Crustacea	Copepoda	Temoridae	Eurytemora affinis	6
SW 12	Arthropoda/Crustacea	Copepoda	Oithonidae	Oithona sp	2
SW 12	Rotifer	Monogononta	Branchionidae	Keratella quadrata	6
SW 12	Arthropoda/Crustacea	Copepoda	Cyclopidae	Cyclopina longicornis	6
Total Count					**28**
Number of Species					**5**
Margalef species Index					**1.20**
SW 13	Arthropoda/Crustacea	Copepoda	Cyclopidae	Macrocyclops distintus	5
SW 13	Arthropoda/Crustacea	Copepoda	Cyclopoidae	Cyclops sp	4
SW 13	Arthropoda/Crustacea	Copepoda	Temoridae	Eurytemora affinis	2
SW 13	Rotifer	Monogononta	Branchionidae	Keratella sp	4
SW 13	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	8
SW 13	Arthropoda/Crustacea	Cladocera	Bosmidae	Bosmia sp	4
SW 13	Arthropoda/Crustacea	Cladocera	--------	Leptodora sp	2
Total Count					**29**
Number of Species					**7**
Margalef species Index					**1.78**
SW 14	Mollusca	Gastropoda	----------	Gastropod larvae	4
SW 14	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	8
SW 14	Rotifer	Monogononta	Branchionidae	Branchionus falcutus	8
SW 14	Rotifer	Monogononta	Branchionidae	Branchionus sp	6
SW 14	Arthropoda/Crustacea	Cladocera	Bosmidae	Bosmia sp	6

Table 2b: Diversity, Abundance and Distribution of Zooplankton-Wet Season – cont'd

Total Count					**34**
Number of Species					**6**
Margalef species Index					**1.42**
SW 15	Arthropoda/Crustacea	Cladocera	Sidiidae	Penilia aviroris	3
SW 15	Arthropoda/Crustacea	Copepoda	--------	Meta-nauplius larvae	4
SW 15	Arthropoda/Crustacea	Copepoda	----------	Copepod nauplius	14
SW 15	Mollusca	Gastropoda	----------	Gastropod larvae	4
SW 15	Arthropoda/Crustacea	Cladocera	Polyphemidae	Evadne tergestina	4
SW 15	Arthropoda/Crustacea	Cladocera	Polyphemidae	Evadne spinifera	2
Total Count					**31**
Number of Species					**6**
Margalef species Index					**1.46**

Table 1c: Diversity, Abundance and Distribution of Macro Benthos-Dry Season

SW 1	No Benthos				
SW 2	No Benthos				
SW Control 2	Annelida	Polychaeta	Glyceridae	Glycera convulata	3
SW Control 2	Annelida	Oligochaeta	Tubificidae	Tubifex sp	1
SW Control 2	Mollusca	Gastropoda	Hydrobiidae	Hydrobia minuta	2
Total Abundance					**6**
Number of Species					**3**
Margalef Index					**1.12**
Shannon Weiner Index					**1.46**
SW 3	Annelida	Polychaeta	Nereidae	Nereis sp	2
Total Abundance					**2**
Number of Species					**1**
Margalef Index					**0**
Shannon Weiner Index					**0**
SW 4	No Benthos				
SW 5	No Benthos				
Total Abundance					
Number of Species					
Margalef Index					
Shannon Weiner Index					
SW 6	Annelida	Polychaeta	Glyceridae	Glycera convulata	2
SW 6	Annelida	Oligochaeta	Tubificidae	Tubifex sp	2
SW 6	Mollusca	Gastropoda	Hydrobiidae	Hydrobia minuta	2
Total Abundance					**6**
Number of Species					**3**
Margalef Index					**1.12**
Shannon Weiner Index					**1.46**
SW 7	Annelida	Polychaeta	Glyceridae	Glycera convoluta	1
SW 7	Annelida	Oligochaeta	Tubificidae	Tubifex sp	4
SW 7	Annelida	Polychaeta	Spionidae	Polydora ciliiata	1
Total Abundance					**6**
Number of Species					**3**
Margalef Index					**1.12**
Shannon Weiner Index					**1.26**

Table 1c: Diversity, Abundance and Distribution of Macro Benthos-Dry Season- cont'd

SW 8	No Benthos				
SW 9	No Benthos				
SW10	No Benthos				
SW 11	No Benthos				
SW 12	No Benthos				
SW 13	No Benthos				
SW 14	Annelida	Polychaeta	Glyceridae	Glycera convulata	6
SW 14	Annelida	Polychaeta	Nereidae	Nereis sp	2
Total Abundance					**8**
Number of Species					**2**
Margalef Index					**0.48**
Shannon Weiner Index					**0.80**
SW 15	No Benthos				

Table 2c: Diversity, Abundance and Distribution of Macro Benthos-Wet Season

SW 1	No Benthos				
SW Control 1	Annelida	Polychaeta	Glyceridae	*Glycera convoluta*	1
SW Control 1	Annelida	Polychaeta	Nereidae	Nereis sp	2
Total Abundance					**3**
Number of Species					**2**
Margalef Index					**0.91**
Shannon Weiner Index					**0.87**
SW 2	No Benthos				
SW Control 2	Annelida	Polychaeta	Glyceridae	*Glycera convoluta*	1
SW Control 2	-	Polychaeta	Nereidae	Nereis sp	1
Total Abundance					**2**
Number of Species					**2**
Margalef Index					**1.45**
Shannon Weiner Index					**0.97**
SW 3	No Benthos				
SW 4	Annelida	Polychaeta	Spionidae	*Polydora ciliata*	1
Total Abundance					1
Number of Species					1
Margalef Index					0
Shannon Weiner Index					0
SW 5	No Benthos				
SW 6	No Benthos				
SW 7	No Benthos				
SW 8	No Benthos				
SW 9	No Benthos				
SW 10	No Benthos				
SW 11	No Benthos				
SW 12	No Benthos				
SW 13	No Benthos				
SW 14	No Benthos				
SW 15	No Benthos				

APPENDIX 4.6

EVIDENCES OF CONSULTATION

PROTON ENERGY LIMITED
PROPOSED INDEPENDENT POWER PLANT
ENVIRONMENTAL IMPACT ASSESSMENT

ATTENDANCE LIST DURING COMMUNITY CONSULTATION

Date: 04/12/13

S/N	NAMES	TELEPHONE NO.	SIGN
1	Ajulasemo Israel	08022104937	
2	Christian Temiagiri	08039314474	
3	Temiagin Tina Nkechi	08057568855	
4	Oshevine Temiagin	08028626632	Temiagin
5	Eyinsam Patience	08063435399	Patience
6	Charles Godfrey	—	
7	Victoria Temiagiri	08051292166	
8	Theresa Temiagin	08035686727	
9	Christiana Ubi	08037727146	
10	OLA JOSEPH		
11	Apigi Mudingha	—	
12	Otikpeme Dennis	—	
13	Joseph Temiagiri	08032598939	
14	Lois Temiagire	08060928249	
15	Izeagwe Deborah	08025355257	
16	ANINI AKOKO	—	
17	Emmanuel Ayami	—	
18	Odogwu Michael		Michael
19	Amukaya Sunday	07069523855	
20	Vicky Temiagiri	—	Vicky
21	Monday Almuna	—	
22	Richard Umann	08087071366	
23	Otikpeme Robison	—	
24	Mrs. Iyiboh Joseph		
25	Otikpeme moses	—	
26	Abednego Michael	—	Michael
27	Otikpeme moses	—	moses
28	Ben Eyetsenitan	08028083337	Ben
29	Alfred Mozimo		
30	Waide Kennedy. P	07037551080	
31	Imughemi Joseph	—	Joseph
32	Blessing Nobel	—	Nobel
33	Ogbaru Daniel	08033429890	
34	Johnathan Ebibi	08063435998	
35	Godfrey Azuka	08039207532	Azuka
36	Ibinadu Beresima	08037892699	
37	Ozdau FRED	07037559080	
38	Ogbemi Sunday	—	
39	Maye Roland	—	

Meeting at the Residence of Ogbe of Olepe Kingdom
Proton Energy Limited – Energy Power Plant ESIA (05/12/13)

S/N	Names	Designation / organisation	Tel No
1	Onyeteru Joseph Emeka	Fed. Min. of Env. Warri	07084191775 08088023747
2.	Chief (Dr) O.E. Temiagin	Principal member: Ijighare family of Sapele.	08033923443
3	Agbude Omuba		08068044353
4	Okusor Emeka A.	Fugro Nigeria Limited	07031004071
5	Adebule Oluwafemi	Proton Energy	08182661580
6	Uche Allanah	Fugro Nig. Ltd.	08036767627
7.	Chief J.O. Onomor (JP)	Rep: Sapele Olepe Community	08035498337
8.	Mr. Ojegba Okpako	Sapele Olepe Community.	08034816353

FEDERAL MINISTRY OF ENVIRONMENT

PANEL REVIEW MEETING ON THE ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF THE PROPOSED 500MW INDEPENDENT POWER PLANT IN OGHORODE, SAPELE LOCAL GOVERNMENT AREA, DELTA STATE BY PROTON ENERGY LIMITED HELD AT WELLINGTON HOTEL, WARRI ON 16TH MAY, 2015.

ATTENDANCE LIST

(GENERAL)

S/NO	NAME	TEL. NO	ADDRESS	SIGN.
1	UKAEGBU K.P.S	08038553657	Emeyan Ntaka	
2	Onyetenu J. Emeka	07081191775	Emeyan Warri	
3	Victoria Temiagin	08051292666	80 Olch rd	
4	Joseph Temiagin	08932598939	11 Ikomi Rd, Sapele	
5	Vicky Temiagin	Sapele.	80 Olch rd Sapele	
6	Christian Temiagin	08039304174	80 Olch rd. Sapele	
7	Johnbull O. Temiagin	08039365906	80 OLCH RD	Sapele
8	Temiagin Tina Nkechi	08037568855	5B Ikomi Rd, Sapele	
9	Chief S.A. Temiagin	07064935710	80 Olch rd	Sapele
10	Lois Temiagin	08660928249	117 Olohro Ogharefe	
11	Theresa Temiagin	08035686727	117 Olohro Ogharefe	
12	Oshevire A. Temiagin	08028626632	76 Ugbegiji Rd Sap	
13	ISAAC. A. TEMIAGIN	08036600087	7 NEBRASKO STREET	
14	John-Godfrey	07057285121	Proton energy	
15	Otoru John	08155094386	Prot. ENTY	
16.	OTI IKOMI	08034022749	PROTON ENERGY, SAPELE	
17.	AMUK OMOIKHUDU	08038336367	PROTON ENERGY, SAPELE	

ATTENDANCE LIST contd.

S/NO	NAME	TEL. NO	ADDRESS	SIGN.
18	Okusor Emeka A	07031004071	Fugro (PH)	
19	KAINE DIKE NWUGUMI	08035736363	Fugro Nig Ltd, PHC	
20	Ojeifo Omozuanfo	08037058052	Proton Energy Ltd	
21	ALUYA STANLEY	08033749061	Proton Energy Ltd	
22	Engr. Mukoro Daniel	07033940228	Proton Energy Ltd	
23	ONYEACHONAM IKE	08065689112	PROTON ENERGY LTD	
24	Lucky-O-Hope	08053023578	Proton Energy	
25	Blessing Agwuas	08028391786	Proton Energy	
26	Christiana Uji	08037727146	Sapele	
27	Richard Omarin	08087071366	Sapele	
28	Mr. E. S. Akoko	08022104937	Sapele	
29	AJUYA JOHN ISRAEL	08137133152 08080712323	SAPELE	
30	Goodness Eyefran	08035812965	Sapele	
31	Victoria Tegeri	—	Sapele	
32	Anini AKOKU	—	Sapele	
33	Madina Doris OGOR	—	Sapele	
34	Madam Regina Udi	—	Sapele	
35	Emmanuel Iyanu	—	Benin	
36	BEN EYETSEMIAN	08028808337	NNPC H/Comp	
37	MUDE-O-OGOR	08039572605	Sapele	
38	Roselyn Akpo	07033246807	Sapele	
39	Muhammed Malam	08068325873	FMEN Abuja	

ATTENDANCE LIST contd.

S/NO	NAME	TEL. NO	ADDRESS	SIGN.
40	ONOKURHEFE JUDITH	08066536785	OSMENO – ASABA	
41	Agim Ken A.	07069418274	FMENV – ABUJA	

FEDERAL MINISTRY OF ENVIRONMENT

PANEL REVIEW MEETING ON THE ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF THE PROPOSED 500MW INDEPENDENT POWER PLANT IN OGHORODE, SAPELE LOCAL GOVERNMENT AREA, DELTA STATE BY PROTON ENERGY LIMITED HELD AT WELLINGTON HOTEL, WARRI ON 16TH MAY, 2015.

ATTENDANCE LIST

(PANEL MEMBERS ONLY)

S/NO	NAME	TEL. NO	ADDRESS	SIGN.
1	Prof A. OGIDIOLU	08034988215	K.S.U Anyigba	
2	Engr J.O. OBAFISOYE	08034530537	ABUJA	
3	Jehwe Stephen	08087484456	SLG Sapele	
4	Ufiofio Isaac	07031635632	DSM Env Asaba	
5	Smith Ajibola	08023139111	Abuja	
6	ONOTAKE O.O	08065485024	FMEnv ABUJA	

APPENDIX 4.7

QUESTIONNAIRES SAMPLE

ENVIRONMENTAL IMPACT ASSESSMENT OF PROTON ENERGY POWER PLANT PROJECT

Household Questionnaire

INTRODUCTION

Proton Energy Ltd. has proposed to build an Independent Power Plant in Ogorode community. This study is aimed at generating information and data that will be utilized in developing the Environmental Impact Assessment (EIA) document. We therefore, request your participation in this study by responding to the questions below in a sincere and appropriate manner. Your responses will be treated as confidential. Thank you for your cooperation.

SECTION A: Respondents' Bio-data/Household Characteristics

1. Community…… LGA…… House No. …….
2. Sex: (a) Male (b) Female
3. Age: (a) 15-24years (b) 25-64years (c) 65years and above
4. Marital Status: (a) Single (b) Married (c) Divorced/Separated (d) widow/widower
5. Age and Sex structure. How many members of your household, including yourself, fall into the following age and sex categories? Please indicate numbers in the Table below.

Age Categories	Male	Female	Total
0-4 years			
5-9 years			
10-14			
15-19			
20-24			
25-29			
30-34			
35-39			
40-44			
45-49			
50-54			
55-59			
60-64			
65 and above			
Total			

SECTION B: Human Capital

6. How many members of your household aged 15-64 years, including yourself, have been continuously unemployed in the last 6 months? Please tick from the following.

Males		**Females**	
15-24 years	**25-64 years**	**15-24 years**	**25-64 years**
0	0	0	0
1-2	1-2	1-2	1-2
3-4	3-4	3-4	3-4
5 and above	5 and above	5 and above	5 and above

7. How many members of your household, including yourself, have acquired training in the following skills? Please indicate number.

Skills	**Males**			**Females**		
	15-24 years	**25-64 years**	**Total**	**15-24 years**	**25-64 years**	**Total**
No Skills						
Carpentry/Furniture making						
Electrical/Electronic installation and repairs						
Plumbing						
Metal works (machining/smiths)						
Welding/Fabrication						
Masonry						
Tailoring/Fashion design/Textile works						
Auto repairs (mechanic, electrical, panel beating, vulcanizing, painting)						
ICT (computer works)						
Catering						
Hat making/bending						
Instrumentation/Calibration						
Safety/Security						
Teaching						
Administration						
Building (architecture, quantity surveying, estate management)						
Engineering						
Land Surveying						
Health services						
Managing micro/small business						
Leadership skills						

8. How many child births have you had in your household in the last 5 years?

   (a) None (b) 1 (c) 2 (d) 3 (e) 4 (f) 5

9. Where did the mothers receive ante-natal care?

   (a) None (b) Traditional birth attendant(TBA) (c) Hospital/Clinic/Health Centre (d) Maternity Home (e) Church/Prayer House

10. Where is the place of child delivery?

    (a) Home (b)TBA (c) Hospital/Clinic/Health Centre (d) Maternity (e) Church/Prayer House

11. Where was the birth registered?

    (a) None (b)Government Agency (c)Community (d)Church

12. How many members of your household aged 0-5years have been immunized?

13. How many deaths occurred in your household in the last one year?

    (a)None (b) 1 (c) 2 (d) 3 (e) 4 (f) 5

14. Do members of your household use any of these against mosquito bites and malaria?

    (a) Ordinary mosquito nets (b) Insecticide treated mosquito nets (c) Preventive drugs

15. In the past four weeks, how often were you sick enough to seek help?

    (a) None (b) 1-2 times (c) 3-4 times (d) 5 times (e) More than 5 times

16. Where did you seek help?

    (a) Hospital/Clinic/Health Centre (b) Drug Store (Chemist) (c) Traditional healers

    (d) Self medication (e) Church/Prayer House (f) nowhere

17. What time does it take for members of your household to get to the nearest health facility to your residence?

18. What is the cost of transportation to your nearest health facility?

    (a) 0-₦50 (b)₦50-₦100 (c) ₦100-₦200 (d) ₦300-₦500 (e) More than ₦500

19. Did any member of your household (including yourself) suffer from any of these symptoms/diseases in the last six months? How frequently, please tick?

Symptoms/Diseases	Always	Sometimes	Never
Cough			
Catarrh			
Malaria			
Typhoid			
Difficulty in breathing			
Diarrhea			
Asthma			
Hypertension			
Diabetes			
Pile			
Impaired vision			
Impaired hearing			
Arthritis			
Rashes			
Epilepsy			
Mental disorder			
Ulcer			
Anemia			
Sleeping disorder			
Sickle cell disease			
Sexually transmitted disease (STDs)			
Miscarriage			
Cancer			
Others (please specify)			

How often in the past one year did you have problems satisfying the food needs of your household?

(a) None (b) Seldom (c) Sometimes (d) Often (e) Always

20. How many meals is your household able to provide daily? Please tick.

(a) None (b) 1 (c) 2 (d) 3 (e) More than 3

21. What time does it take for members of your household to get to the nearest public school to your residence?

(a) 0-10 mins. (b) 10-30 mins. (c) 30 mins- 1hr. (d) 1-2hrs. (e) More than 2hrs.

22. What is the cost of transportation to your nearest school?

(b) 0-₦50 (b)₦50-₦100 (c) ₦100-₦200 (d) ₦300-₦500 (e) More than ₦500

23. Does the school members of your household attend have equipped and functional laboratory?

(a) Yes (b) No

24. Does the school members of your household attend have an equipped and functional library?

    (a) Yes (b) No

25. How many members of your household are currently in school? Indicate numbers.

School	Male	Female	Total
Nursery			
Primary			
Secondary			
Vocational/Technical			
Tertiary			
Total			

26. What is the highest level of education attained by all members of your household aged 15 years and above, including yourself? Please indicate numbers in the Table below.

Education Category	Male	Female
No formal education		
Attempted primary school		
Completed primary school		
Attempted secondary school		
Completed secondary school		
Attempted tertiary school		
Completed tertiary school		

27. Estimate the time taken to get to the nearest ICT centre that is nearest to your household?

    (a) Zero (there is in house facility) (b) Less than 10mins. (c) 10-30mins. (d) 30mins.-1hr.

    (e) More than 1hr. (f) No ICT facility in my community

28. How many members of your household are computer literate? Please tick from Table below.

Male	Female
0	0
1-2	1-2
3-4	3-4
5 and above	5 and above

SECTION C: Social/Political Capital

29. How many members of your household aged 15-64 years are engaged in the following economic activities? Indicate numbers in Table below.

Economic Activity	Males	Females
Farming		
Collection of forest products (fruits, firewood, etc.)		
Livestock farming		
Fishing		
Collection of sea products (shell fish, etc.)		
Aquaculture (fish ponds)		
Trading (wholesale, distributorship)		
Trading (petty trading)		
Civil/Public Service		
Food Processing (garri, palm oil milling, fish smoking, local gin, etc.)		
Hunting		
Lumbering		
Company Employment		
Artisanship (carpentry, canoe carving, welding, etc.)		
Handicraft (pottery, weaving, tailoring, etc.)		
Contracts		
Apprenticeship/Training		

30. What is the approximate monthly income of your household?

    (a) Less than N1000 (b) N1000-N5000 (c) N5100-N10,000 (d) N10,100-N20,000 (e) N20,100-N35,000 (f)N35,100-N50,000 (g)N50,100-N100,000 (h) More than N100,000

31. Does your household own any of these assets? Please tick from list below (only those working)

Livestock (chicken, goats, pigs, etc.) (a) 1-20 (b) 21-50 (c) 51-100 (d) More than 100	Other assets (a) Electric fan (b) Refrigerator/freezer (c) Television (d) Video/DVD (e) Radio (f) Mattress (g) Watch/Clock (h) Sewing machine (i) Bicycle (j) Motor cycle (k) Canoe (l) Speed boat (m) Car/truck (n) Commercial Store
Agric Equipment/Input (a) Fertilizer (b) Improved seedling (c) Fish fingerlings (d) Hooks/Nets (e) Herbicides	

32. Do any NGOs operate in your community? What are their names and what do they do?

    (a)

    (b)

    (c)

33. Who inherits family assets in your community?

    (a) First male child (b) First female child (c) Male children (d) Female children (e) All children

    (f) Male relatives (g) Female relatives

34. Who is responsible for taking final decisions on household matters in your household?

    (a) Father (b) Mother (c) Parents jointly (d) Children (e)Everybody jointly

35. Who are responsible for taking decisions about the community?

    (a) Traditional Ruler (b) Community Elders (c)Community Development Committee/Trust(e)Men only (f) Women only (g) Youth only (h) All recognized stakeholders/groups

SECTION E: Financial Capital

36. Are there any operational micro credit schemes in your community? (a) Yes (b) No

37. Has any member of your household ever benefited from a micro credit loan? (a) Yes (b) No

38. How many members of your household belong to cooperative societies? (a)None (b) 1 (c)2 (d)3 (e)4 (f)5 and above

SECTION D: Natural Capital

39. How do you dispose your household waste?

    (a) Burning (b) Burying (c) Composting (d) Dumping (gutters, creeks, bush)

    (e) Government refuse collection (f) Private commercial refuse collection

40. How do you dispose your household sewage?

    (a) Bush (b) Covered Pit toilet (c) Open Pit toilet (d) Water closet (e) Pier System(water side)

41. What is your main source of water supply?

    (a) Rain (b) River/pond (c) Covered well (d) Open well (e) Private/commercial bore hole

    (f) Public pipe borne water

42. What is your source of energy for cooking?

    (a) Firewood (b) Kerosene (c) Cooking gas (d) Electricity (e) Coal

43. What is your source of energy for lighting?

    (a) Kerosene lamp (b) Electricity (c) Community generator (d) Private generator

44. Has there been any encroachment on your community reserved forests, farm lands, fishing sites in the last 10years?

    (a) Yes (b) No

45. What two reasons are responsible for this encroachment?

    (a) Housing development (b) Government acquisition for infrastructural development

    (c) Farming (d) Industrial activities (e.g. oil & gas) (e) Fetching firewood/lumbering

    (f) Environmental factors (erosion, flooding, silting)

46. Estimate the extent of land loss. (a) None (no loss) (b) 1-5% (c) 5-10% (d) 10-20% (d) 20-30% (e) 30-50% (f) More than 50%

47. How is land acquired in your community?(a) Inheritance (b) Purchase (c) Lease/hire

    (d) Pledge/collateral

48. If you farm, how did you acquire your farm land? (a) Inheritance (b) Purchase (c) Lease/hire

    (d) Pledge/collateral

49. Who owns land in your community? (a) The community (b) Families/Individuals (c)Both a & b

50. Who can acquire land in your community? (a) Males only (b) Females only (c) Indigenes only (d)Males/Female (e) Indigenes and none indigenes

51. If you fish where do you carry out your fishing activities? (a)Rivers/Creeks (b) Ponds (c)Wetlands

52. Does your community have any historical/archeological sites? (a) Yes (b)No (c)Do not know

SECTION F: Physical Capital

53. Does your community have any of the following facilities? Please tick. (a)Tarred roads (b)Untarred earth roads (c) Bridges (d) Public primary school (e)Public secondary school (f) Public electricity (g) Public water supply (h)Market (i)Community hall

54. What mode of transport do your household members use for distances more than 3km? (a)Trekking (b)Bicycle (c)Motor cycle (d)Canoe (e)Speed boats (f)Buses/Taxis (g)Private cars

55. What is the travel time by public transport to your LGA headquarters? (a) 1-10mins. (b) 10-30mins. (c) 30mins-1hr. (d) 1-2hrs. (e)More than 2hrs.

56. Which of the following house types do you live in? (a)Bungalow (a) Duplex (c) Tenement (d) Storey building (e)Block of flats.

57. Who owns the house your household lives in? (a)Family house (b)Father (c) Mother (d)Self owned (e)Rented

58. How many bedrooms are in your house? (a)1 (b)2 (c)3 (d)4 (e)5 and above

59. How many people sleep in one room? (a)1 (b)2 (c)3 (d)4 (e)5 and above

60. What is the construction material (wall)? (a)Thatch (b)Plank/Wood /Straw (c)Corrugated iron sheets (zinc) (d)Cement blocks (e)Bricks

61. What is the roofing material? (a)Thatch (b) Asbestos (c)Corrugated iron sheets (zinc) (c)Aluminum (d)Slate

62. How many members of your household have access to telephone lines? (a)None (b)1 (c)2 (d)3 (e)4 (f)5 and above

63. How many telephone services do you receive in your community? (a)None (b)1 (c)2 (d)3 (e)4 (f)5 and above

GENERAL QUESTIONS

1. What language do you speak?

2. What is the hierarchy of traditional/community administration? (e.g. king-please give local title, chiefs/elders, CDC, youth, women, etc.)

3. What are the names and locations of deities/shrines in the community (2-3 names will be enough)? Will any be trespassed by the project?

4. Does the community celebrate any festivals? What are their names (2-3 will do)? How often (e.g. yearly)? Is participation restricted (e.g. to indigene alone, members of the group alone, etc.)?

5. Are there any forbidden foods, animals, practices, etc. (please name them)?

6. Do you have the following facilities? Who provided each one and when?

   a. Schools; Primary School & Secondary School (Nos.)

      -Classes (1-6)

      -Enrolment (students-No., teachers-No., more girls or more boys)

      -Facilities (desks/chairs for students, library/laboratory, toilets, water, fence, etc.)

   b. Public water supply (e.g. borehole)

   c. Public electricity (e.g. community generator)

   d. Health facilities; including Drug stores, TBAs & Herbalist (types, nos., capacity, personnel)

   e. Market (when does it hold, any built stalls)

   f. Telecommunication (e.g. MTN, Glo, Airtel, Etisalat)

   g. Access and Internal link roads/streets (paved or untarred, estimate length)

7. Major occupations (please list them)

   a. Farming (seasons, crops)

   b. Fishing (equipment, types of fish, seasons)

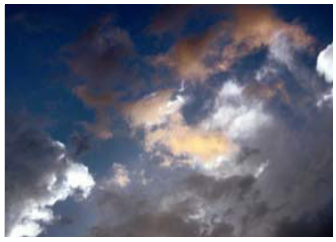
8. How much does it cost to get to the nearest (1) community (2) your Local Government headquarters by public transport?

9. What are your concerns, fears and expectations about the proposed project?

10. What are your community needs?

APPENDIX 5.1

AIR AND NOISE MODELLING REPORT



Proton Energy

Air Dispersion Modeling
FINAL Report

22 March 2016
Environmental Resources Management
75 Valley Stream Parkway,
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FINAL Report

22 March 2016
Project No. 0339085

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TABLE OF CONTENTS

1.0	***INTRODUCTION***	***1***
	1.1 Ambient Air Quality Standards	1
2.0	***PROJECT DESCRIPTION***	***2***
	2.1 Facility Location	2
	2.2 Modeling Parameters	2
3.0	***MODEL SELECTION & MODEL METHODOLOGY***	***6***
	3.1 Good Engineering Practice (GEP) Stack Height Analysis	7
	3.2 Meteorological Data	7
	3.3 Receptors	9
4.0	***DISPERSION MODELING RESULTS***	***9***

LIST OF TABLES

Table 1: Summary of Ambient Air Quality Standards (µg/m³)

Table 2: Modeling Scenarios

Table 3: Emission Rates and Stack Parameters by Source

Table 4: Maximum Offsite Concentrations –Scenario#1

Table 5: Maximum Offsite Concentrations –Scenario#2

Table 6: Maximum Offsite Concentrations –Scenario#3

LIST OF FIGURES

Figure 1: Project Location

Figure 2: Source Locations and Building Layout (Close-up)

Figure 3: Wind Roses

Figure 4: Extended Boundary and Receptors Grid

LIST OF ATTACHMENTS

ATTACHMENT A CONTOUR PLOTS

LIST OF ACRONYMS

WHO	World Health Organization
AQG	Air Quality Guidelines
BPIP	Building Profile Input Program
DEM	Global Digital Elevation Model
EPA	Environmental Protection Agency
GEP	Good Engineering Practice
WRF	Weather Research Forecasting
NAAQS	U.S. National Ambient Air Quality Standards
UTM	Universal Transverse Mercator

1. INTRODUCTION

Air emissions from the proposed Proton Energy power plant, to be located in the City of Sapele, Delta State, were modeled to determine maximum air quality concentration and associated impacts at locations outside of the power plant. In addition, cumulative impacts were evaluated by modeling emissions from nearby power plants. Maximum predicted concentrations are compared to World Health Organization (WHO) guideline concentrations and U.S. National Ambient Air Quality Standards (NAAQS), both of which are recommended in International Finance Corporation (IFC) guidance[1] as potentially relevant standards in countries, such as Nigeria, where nationally legislated standards do not exist. This report presents the methodology and results of air dispersion modeling conducted for the proposed Proton power plant to assess compliance with ambient air quality guidelines and standards.

1.1 Ambient Air Quality Standards

ERM has identified that the ambient air quality standards used by the IFC and USEPA NAAQS should be used as benchmarks for the modeling analysis of the proposed project. These ambient standards considered in this modeling evaluation are summarized in Table 1.

Table 1: Summary of Ambient Air Quality Standards (µg/m³)

Pollutant	Averaging Period	NAAQS USEPA	WHO Guidelines
		(µg/m3)	(µg/m3)
NO_2	1-hour	188	200
	Annual	100	40
SO_2	1-hour	196	-
	10-min	-	500
	24-hour	-	20
PM_{10}	24-hour	150	50
	Annual	-	20
$PM_{2.5}$	24-hour	35	25
	Annual	12	10
CO	1-hour	40000	30000
	8-hour	10000	10000

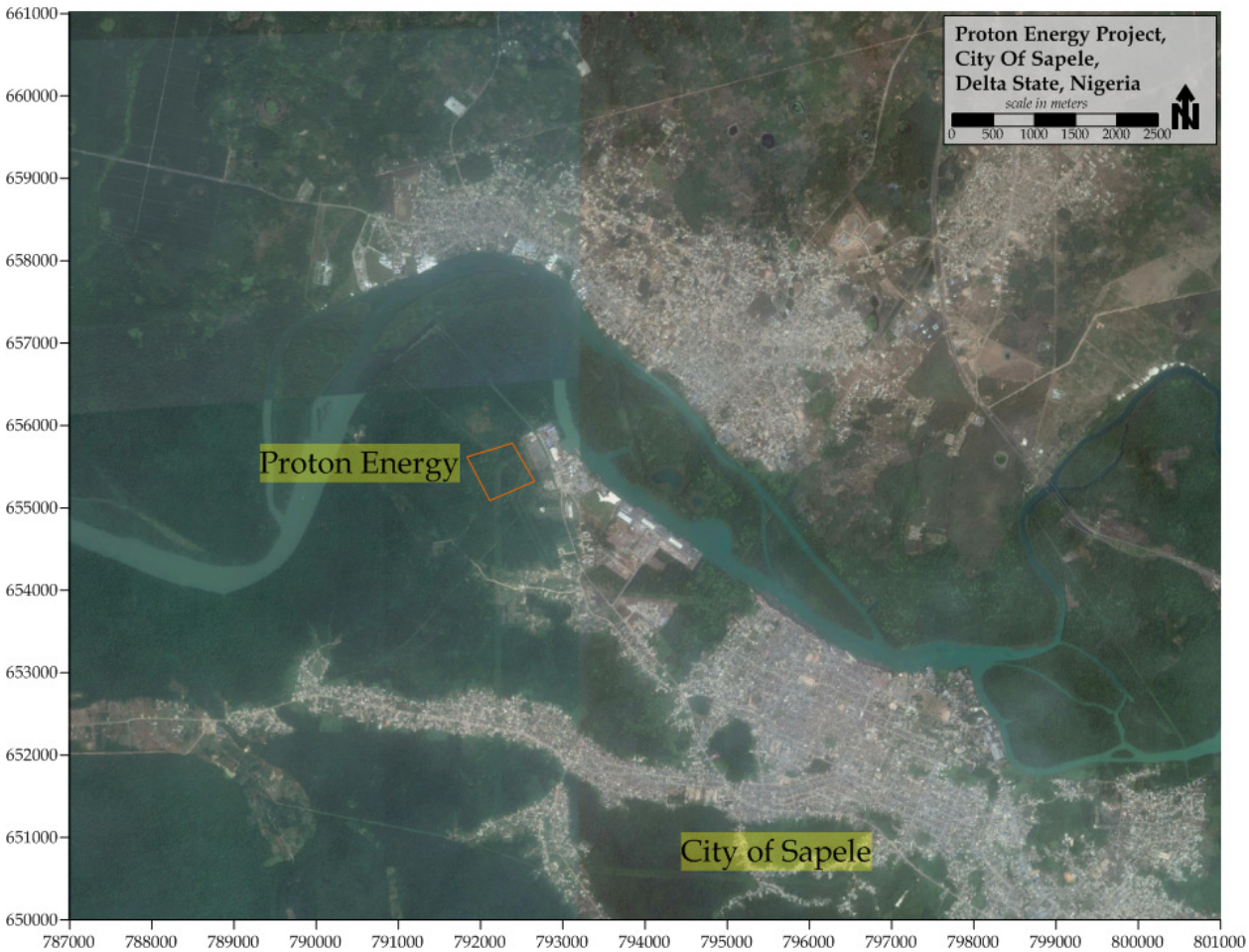
[1] IFC - Environmental, Health, and Safety General Guidelines. April 2007.

2.0 PROJECT DESCRIPTION

2.1 Facility Location

The proposed Proton Energy facility is located in City of Sapele, Delta State, Nigeria and Figure 1 shows the contextual location of the proposed Proton Energy site within the close proximity of City of Sapele.

Figure 1: Project Location



2.2 Modeling Parameters

To the extent they were available, project-specific and site-specific data were utilized in the modeling. However, assumptions were used in some cases where project-specific or site-specific data were not available. The data used as inputs to the model are summarized below.

Emission Sources

For the cumulative modeling, in addition to the emission units from Proton Energy, power generating turbines from all nearby power plants are also included. These nearby power plants include power generating turbines at CMEC/Eurafric and NIPP. CMEC/Eurafric has six gas turbines each with maximum generating capacity of 170 MW, while NIPP has four gas turbines with total generating capacity of 450 MW. All of these emissions sources are vented through a dedicated stack for each unit. For modeling purposes, all stacks are assumed to have a vertical orientation.

Modeling Scenarios

The modeling scenarios include a total of three different setups. The emission units included under each scenario are shown in Table 2 and the description for each of the modeling scenarios are as follow:

- **Scenario #1**: All three power generating turbines at Proton Energy are assumed to operate at maximum capacity generating the maximum output of 150MW.

- **Scenario #2**: In addition to the Proton Energy maximum output, both CMEC/Eurafric and NIPP are assumed to operate at maximum generating capacity. (ie, 1020 MW for CMEC/Eurafric and 450 MW for NIPP). This modelling analysis considers the emissions from the turbines operating simultaneously. This scenario is not anticipated to occur; however it was modeled to provide a conservative upper bound on predicted concentrations.

- **Scenario #3**: Under Scenario #3, while the turbines at Proton Energy operate at maximum capacity, turbines at CMEC /Eurafric and NIPP are assumed at more realistic five year generation levels set by Nigerian Electricity Regulatory Commission (NERC). (ie, 400 MW for CMEC/Eurafric and 250 MW for NIPP).

Table 2: Modeling Scenarios

Scenarios:	Power Generation (MW)	Units under each scenario					
Scenario 1	141.0	PROTN_1	PROTN_2	PROTN_3			
Scenario 2	141.0	PROTN_1	PROTN_2	PROTN_3			
	1020.0	CMECP_1	CMECP_2	CMECP_3	CMECP_4	CMECP_5	CMECP_6
	450.0	NIPP2_1	NIPP2_2	NIPP1_1	NIPP1_2		
Scenario 3	141.0	PROTN_1	PROTN_2	PROTN_3			
	400.0	CMECP_1x	CMECP_2x	CMECP_3x	CMECP_4x	CMECP_5x	CMECP_6x
	250.0	NIPP2_1x	NIPP2_2x	NIPP1_1x	NIPP1_2x		

Emission Rates and Stack Parameters

The power-generating turbines are primary source of emissions at the above mentioned power plants. The emissions from each turbine were determined based on the maximum generating capacity, operating parameters and equipment manufacturer information provided by Proton Energy.

Source parameters used in the modeling were based on equipment manufacturer information, engineering inputs of the power plant, data provided by Proton Energy, and formulated assumptions.

Emissions Estimates

The emissions were prepared for each turbine at all three power plants. Natural gas is the only fuel used by these turbines for combustion. The emissions associated with the turbines were based on AP-42 emission factors for natural gas fired combustion turbines. The emissions associated with these sources were then assigned to specific stacks for input into the model.

Maximum hourly emissions reflect each source operating continuously (i.e. 8760 hours per year) at full capacity. The maximum hourly emissions were then used in the model to predict maximum concentrations for comparison to short-term (up to 24 hours) and annual average air quality guidelines and standards. Emission rates, in grams per second (g/s), by source are presented in Table 3 for normal operations, continuous sources (for short-term and long-term modeling).

Stack Parameter Development

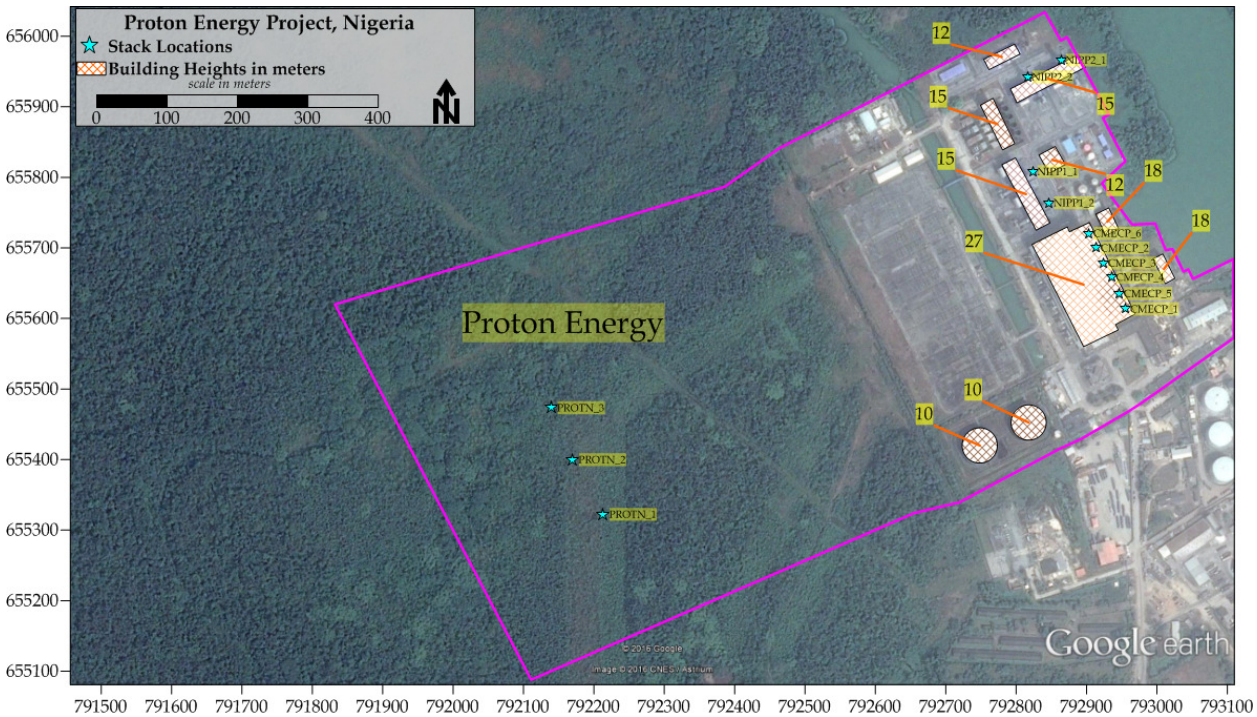
The AERMOD model requires detailed information representing how each source releases emissions into the atmosphere (i.e., 'stack parameters'). Required stack parameters include height of the release, stack diameter, stack gas exit temperature and stack gas exit velocity. A list of the stack parameters used in the AERMOD model is provided in Table 3

Table . As noted previously, all stacks were assumed to be oriented vertically with an unobstructed release. Source locations were identified using the Universal Transverse Mercator (UTM) coordinate system. Source locations are illustrated in Figure 2.

Table 3: Emission Rates and Stack Parameters by Source

Source ID	Capacity	Fuel	UTM Easting	UTM Northing	Base Elev	Stack Diameter	Stack Height	Exit Velocity	Exhaust Flow Rate	Exit Temperature	NOx	SO2	CO	PM
	MW		m	m	m	m	m	m/s	m^3/s	K	g/s	g/s	g/s	g/s
CMECP_1	170.0	Gas	792956	655614	4.57	3.5	67.0	39.0	375.0	364.2	12.31	0.78	18.79	1.51
CMECP_2	170.0	Gas	792914	655700	4.57	3.5	67.0	39.0	375.0	364.2	12.31	0.78	18.79	1.51
CMECP_3	170.0	Gas	792924	655679	4.57	3.5	67.0	39.0	375.0	364.2	12.31	0.78	18.79	1.51
CMECP_4	170.0	Gas	792935	655658	4.57	3.5	67.0	39.0	375.0	364.2	12.31	0.78	18.79	1.51
CMECP_5	170.0	Gas	792946	655635	4.57	3.5	67.0	39.0	375.0	364.2	12.31	0.78	18.79	1.51
CMECP_6	170.0	Gas	792903	655721	4.57	3.5	67.0	39.0	375.0	364.2	12.31	0.78	18.79	1.51
NIPP2_1	112.5	Gas	792864	655966	4.57	6.0	35.0	35.2	995.0	817.2	8.14	0.52	12.44	1.00
NIPP2_2	112.5	Gas	792816	655942	4.57	6.0	35.0	35.2	995.0	817.2	8.14	0.52	12.44	1.00
NIPP1_1	112.5	Gas	792824	655808	4.57	6.0	35.0	35.2	995.0	817.2	8.14	0.52	12.44	1.00
NIPP1_2	112.5	Gas	792847	655764	4.57	6.0	35.0	35.2	995.0	817.2	8.14	0.52	12.44	1.00
CMECP_1x	66.7	Gas	792956	655614	4.57	3.5	67.0	39.0	375.0	364.2	4.83	0.31	7.37	0.59
CMECP_2x	66.7	Gas	792914	655700	4.57	3.5	67.0	39.0	375.0	364.2	4.83	0.31	7.37	0.59
CMECP_3x	66.7	Gas	792924	655679	4.57	3.5	67.0	39.0	375.0	364.2	4.83	0.31	7.37	0.59
CMECP_4x	66.7	Gas	792935	655658	4.57	3.5	67.0	39.0	375.0	364.2	4.83	0.31	7.37	0.59
CMECP_5x	66.7	Gas	792946	655635	4.57	3.5	67.0	39.0	375.0	364.2	4.83	0.31	7.37	0.59
CMECP_6x	66.7	Gas	792903	655721	4.57	3.5	67.0	39.0	375.0	364.2	4.83	0.31	7.37	0.59
NIPP2_1x	62.5	Gas	792864	655966	4.57	6.0	35.0	35.2	995.0	817.2	4.52	0.29	6.91	0.56
NIPP2_2x	62.5	Gas	792816	655942	4.57	6.0	35.0	35.2	995.0	817.2	4.52	0.29	6.91	0.56
NIPP1_1x	62.5	Gas	792824	655808	4.57	6.0	35.0	35.2	995.0	817.2	4.52	0.29	6.91	0.56
NIPP1_2x	62.5	Gas	792847	655764	4.57	6.0	35.0	35.2	995.0	817.2	4.52	0.29	6.91	0.56
PROTN_1	47.0	Gas	792213	655322	4.57	3.2	18.0	39.3	315.8	817.2	3.40	0.22	5.20	0.42
PROTN_2	47.0	Gas	792170	655400	4.57	3.2	18.0	39.3	315.8	817.2	3.40	0.22	5.20	0.42
PROTN_3	47.0	Gas	792140	655473	4.57	3.2	18.0	39.3	315.8	817.2	3.40	0.22	5.20	0.42

Figure 2: Source Locations and Building Layout (Close-up)



3.0 *MODEL SELECTION & MODEL METHODOLOGY*

The US EPA regulatory dispersion model AERMOD was selected for use in this analysis. The latest version of AERMOD (version 15181) was used in this analysis.

The principal steps involved in this modelling analysis can be summarized as follows:

- Processing five years (2010-2014) of representative meteorological data from WRF data using MMIF and AERMET (see the description below);
- Developing a comprehensive receptor grid extending up to twenty kilometers from the facility;
- Conducting modelling analysis using AERMOD; and
- Comparing the model predicted impacts to various air quality standards including the WHO guidelines[2,3] for CO, SO_2, NO_2, PM_{10} and $PM_{2.5}$ where applicable.

[2] WHO. 2005. *WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide, Global update 2005*.

The maximum predicted concentrations, as well as the spatial distribution of predicted concentrations of the model analysis, are reported and documented in the results section.

3.1 *Good Engineering Practice (GEP) Stack Height Analysis*

Aerodynamic downwash has the potential to increase ground-level concentrations from stack sources over concentrations than would be predicted in the absence of these effects. Downwash is handled in air quality models through the use of arrays of direction-specific building dimensions, determined through the use of the US EPA's Building Profile Input Program (BPIP). BPIP generates direction-specific building heights and widths for a given stack. BPIP also calculates a Good Engineering Practice (GEP) stack height above which the downwash from the buildings do not have any impact on the emissions from the stack. A BPIP analysis was performed for the area surrounding each source involved in this project. If the stack height is greater than 2.5 times the height of the tallest building adjacent to the stack, the emissions from the stack are not impacted by downwash effects from the building. The direction-specific building dimensions generated by BPIP were used as input to AERMOD. Figure 2 depicts the buildings and their outlines that were considered for the building downwash evaluation.

3.2 *Meteorological Data*

Meteorological Data Development: WRF

The primary source of input meteorological data was the 3-dimensional meteorological data sets produced by the WRF prognostic meteorological model. WRF is a widely-used three-dimensional numerical meteorological model which contains non-hydrostatic dynamics, a variety of physics options for parameterizing cumulus clouds, microphysics, the planetary boundary layer and atmospheric radiation. WRF model runs were conducted for five years from 2010 through 2014. WRF was also used to generate three-dimensional gridded meteorological data (such as hourly wind and temperature fields) in the modeling domain through treatment and assimilation of available surface/upper air/precipitation observations. WRF provides surface level and vertical profiles of parameters that can be used within the AERMOD modeling system, as input to the AERMET processor. The horizontal grid spacing of the WRF data was 12 km.

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http://whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf, accessed February 2013.

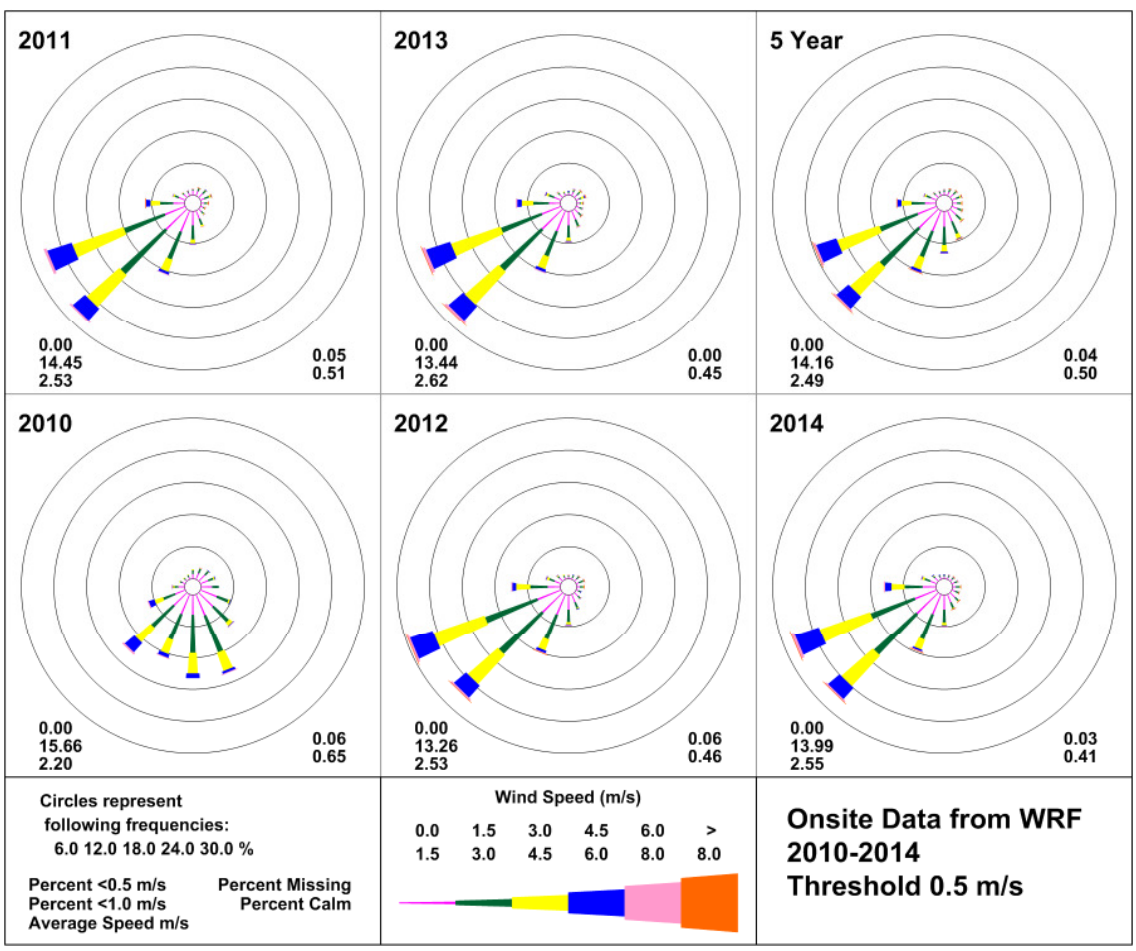
[3] WHO. 1999. *Environmental Health Criteria 213, Carbon Monoxide (Second Edition)*. http://whqlibdoc.who.int/ehc/WHO_EHC_213.pdf, accessed February 2013.

MMIF

The Mesoscale Model Interface Program (MMIF), Version 3.2, was used to develop meteorological inputs to AERMOD. MMIF utilizes the output from prognostic meteorological models such as MM5 and WRF and processes them to provide the required parameters for direct input into dispersion models including AERMOD. The meteorological pre-processor, AERMET, which is part of the AERMOD suite, was used to develop meteorological inputs to AERMOD. AERMET requires hourly surface data and once-daily upper air sounding profiles at a minimum; both of these file types are produced by the MMIF processor. The processing program produces surface and profile meteorological data files for input to AERMOD containing wind, temperature, micrometeorological parameters, and mixing heights. The meteorological data used in this analysis were based on WRF data developed for the years 2010 through 2014.

The data sets produced by MMIF were also presented in wind rose format in Figure 3. Wind roses were created to illustrate the prominent wind pattern. These wind roses for project site were extracted for 10m from the ground level. This wind rose also provides summaries of average wind speed and percent of calm wind on an annual basis s. These patterns accurately reflect expected patterns at the project site.

Figure 3: Wind Roses

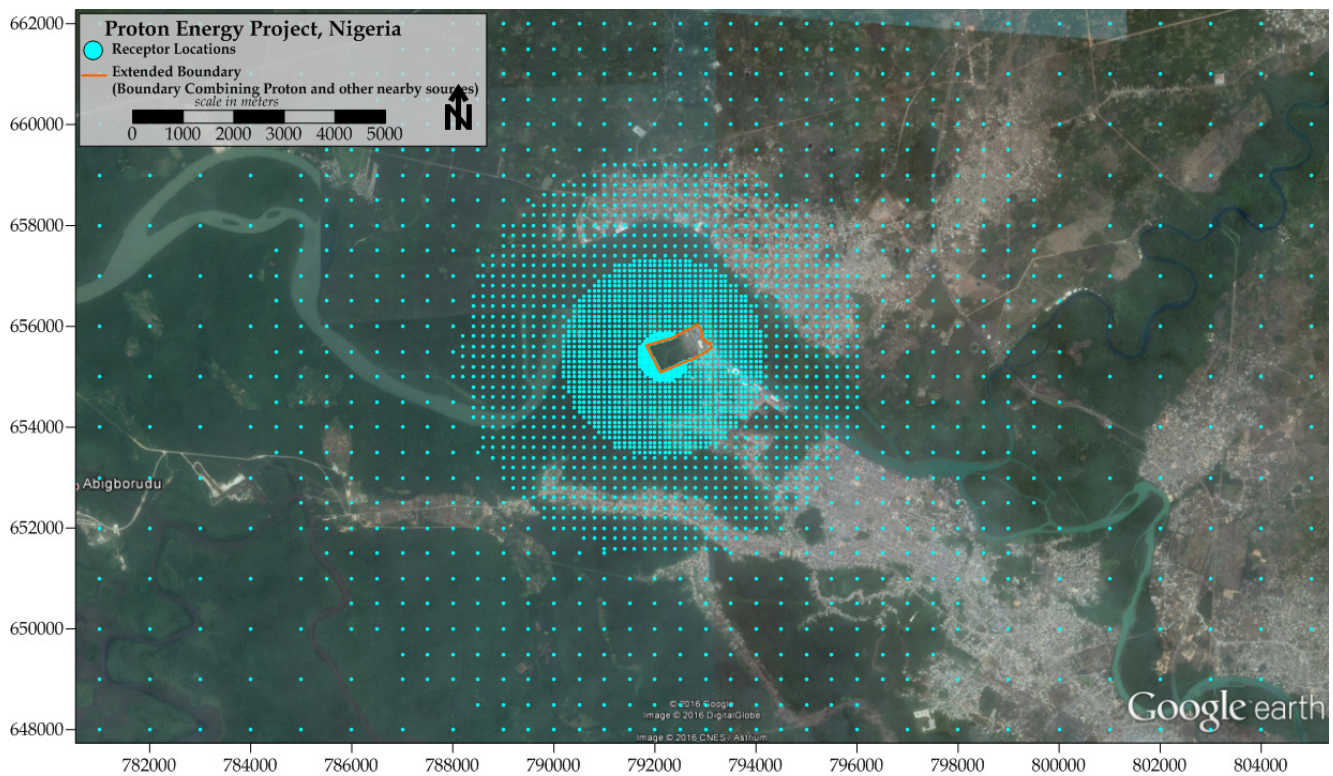


3.3 Receptors

A comprehensive receptor grid was developed centered on the proposed location as shown in Figure 4. Receptor spacing varied from 50 to 500 meters from the facility fence line out to a distance of 5 km, and a polar arrangement was used from 5 km to 20 km from the facility. For the purpose of modeling, a receptor grid was established for points at which concentrations of various emissions would be calculated in the vicinity of the facility.

Terrain elevations were assumed to be flat for all of the receptors since the terrain in the immediate vicinity of the facility is relatively flat.

Figure 4: Extended Boundary and Receptors Grid



4.0 DISPERSION MODELING RESULTS

The results from the AERMOD model were analyzed and the maximum concentrations for each receptor were identified. Overall maximum concentrations were also identified as well as concentrations for all modeled scenario were presented. The results of these analyses are provided and discussed in this section.

Scenario #1 (Only Proton Energy)

Table 4 summarizes the overall modeling results for Scenario #1 (i.e. continuous sources). For each pollutant modeled, maximum concentrations were predicted over various averaging periods (e.g., 1-hour, 8-hour, annual, etc.). The averaging periods were selected to match the averaging periods specified by the WHO AQGs and the U.S. National Ambient Air Quality Standards (NAAQS). Background ambient air quality data are not available for this region; therefore, modeled concentrations have been directly compared to the WHO AQGs and the NAAQS. The WHO AQGs do not specify whether predicted concentrations for short-term averages should be compared to guideline values for the absolute maximum or at various percentile levels as is frequently the case with air quality threshold levels. For example, the NAAQS for NO_2 (1-hour) is compared at the 98th percentile level; and the NAAQS for SO_2 (1-hour) is compared at the 99th percentile level. The results presented here include both the maximum concentration and the percentile levels appropriate for comparison to the NAAQS.

Table 4: Maximum Offsite Concentrations –Scenario#1

Ambient Air Quality Standards and Guidelines (µg/m3)

Pollutant	Averaging Period	NAAQS USEPA	WHO Guidelines	Modeled Concentrations (µg/m3)			Percent of Relevant Guideline/Standard(%)		
		(µg/m3)	(µg/m3)	Max Concentration	99th Percentile	98th Percentile	Max Concentration	99th Percentile	98th Percentile
NO_2	1-hour	188	200	11.1	-	3.6	5.5%	-	2%
	Annual	100	40	0.2	-	-	0.5%	-	-
SO_2	1-hour	196	-	0.9	0.4	-	-	0%	-
	10-min	-	500	1.3		-	0.3%	0%	-
	24-hour	-	20	0.1	-	-	0.4%	-	-
PM_{10}	24-hour	150	50	0.1	-	-	0.3%	-	-
	Annual	-	20	0.0	-	-	0.2%	-	-
$PM_{2.5}$	24-hour	35	25	0.1	-	-	0.6%	-	-
	Annual	12	10	0.0	-	-	0.3%	-	-
CO	1-hour	40000	30000	21.2	-	-	0.1%	-	-
	8-hour	10000	10000	5.5	-	-	0.1%	-	-

Note:

10-min is calculated using the 1/5th power law

ARM approach has been applied for the conversion of NO to NO2 (80%)

Predicted values greater than 25% shaded in yellow; greater than 100% shaded in pink

Short-term maximum concentrations predicted to occur in the vicinity of the facility and occur typically for a small subset of worst-case meteorological conditions, for specific wind directions that transport plumes from source to receptor. However, the predicted concentrations are not found in excess of 10% for any pollutant and averaging period. The predicted annual NO_2 concentrations in excess of 5% occur only in a small area adjacent to the power plant property. The IFC guidelines discussed previously recommend that new development sources consume no more than 25% of relevant guidelines or standards, in order to preserve a margin for future growth in an airshed. As illustrated in Table 4, predicted concentrations for new development (i.e. Proton Energy) are well under the 25% guideline for all pollutants and averaging periods.

Scenario #2 (All Three Power Plants Operating at Maximum Capacity)

Table 5 summarizes the overall modeling results for Scenario #2. The table also shows that predicted concentrations at all receptors are within applicable guidelines/ standards. Also, the predicted 1-hour NO_2 concentrations are within the NAAQS at the 98th percentile level as specified in the NAAQS standard. As noted previously, this scenario is not anticipated to occur; however it was modeled to provide a conservative upper bound on predicted concentrations.

Table 5: Maximum Offsite Concentrations – Scenario #2

Ambient Air Quality Standards and Guidelines (µg/m3)									
Pollutant	**Averaging Period**	**NAAQS USEPA**	**WHO Guidelines**	**Modeled Concentrations (µg/m3)**			**Percent of Relevant Guideline/Standard(%)**		
		(µg/m3)	**(µg/m3)**	**Max Concentration**	**99th Percentile**	**98th Percentile**	**Max Concentration**	**99th Percentile**	**98th Percentile**
NO_2	1-hour	188	200	91.0	-	44.5	45.5%	-	24%
	Annual	100	40	3.0	-	-	7.6%	-	-
SO_2	1-hour	196	-	7.2	5.1	-	-	3%	-
	10-min	-	500	10.3		-	2.1%	0%	-
	24-hour	-	20	1.0	-	-	4.9%	-	-
PM_{10}	24-hour	150	50	1.9	-	-	3.8%	-	-
	Annual	-	20	0.5	-	-	2.5%	-	-
$PM_{2.5}$	24-hour	35	25	1.9	-	-	7.7%	-	-
	Annual	12	10	0.5	-	-	4.9%	-	-
CO	1-hour	40000	30000	173.6	-	-	0.6%	-	-
	8-hour	10000	10000	67.2	-	-	0.7%	-	-
Note:									
10-min is calculated using the 1/5th power law									
ARM approach has been applied for the conversion of NO to NO2 (80%)									
Predicted values greater than 25% shaded in yellow; greater than 100% shaded in pink									

Scenario #3 (Power Generation as Defined by NERC)

These results reflect continuous, simultaneous operation of each of the turbines at the level prescribed by NERC. Table 6**Error! Reference source not found.** summarizes the overall modeling results for Scenario #3. The table also shows that predicted concentrations at all receptors are met for all pollutant and averaging periods.

Table 6: Maximum Offsite Concentrations – Scenario #3

Ambient Air Quality Standards and Guidelines (µg/m3)									
Pollutant	**Averaging Period**	**NAAQS USEPA**	**WHO Guidelines**	**Modeled Concentrations (µg/m3)**			**Percent of Relevant Guideline/Standard(%)**		
		(µg/m3)	**(µg/m3)**	**Max Concentration**	**99th Percentile**	**98th Percentile**	**Max Concentration**	**99th Percentile**	**98th Percentile**
NO_2	1-hour	188	200	37.5	-	18.1	18.7%	-	10%
	Annual	100	40	1.3	-	-	3.2%	-	-
SO_2	1-hour	196	-	3.0	2.1	-	-	1%	-
	10-min	-	500	4.3		-	0.9%	0%	-
	24-hour	-	20	0.4	-	-	2.1%	-	-
PM_{10}	24-hour	150	50	0.8	-	-	1.6%	-	-
	Annual	-	20	0.2	-	-	1.1%	-	-
$PM_{2.5}$	24-hour	35	25	0.8	-	-	3.2%	-	-
	Annual	12	10	0.2	-	-	2.1%	-	-
CO	1-hour	40000	30000	71.5	-	-	0.2%	-	-
	8-hour	10000	10000	27.2	-	-	0.3%	-	-
Note:									
10-min is calculated using the 1/5th power law									
ARM approach has been applied for the conversion of NO to NO2 (80%)									
Predicted values greater than 25% shaded in yellow; greater than 100% shaded in pink									

Modeling results are also displayed in a series of isopleth (constant concentration contour) plots that are displayed in Attachment A. It should be noted that these plots are presented to illustrate the spatial distribution of predicted concentrations, but since maximum concentrations are all within applicable guidelines the appearance of any contours does not indicate that air quality impacts are unhealthy.

5.0 SUMMARY AND CONCLUSIONS

This air quality modeling analysis demonstrates that the Proton Energy power plant will not cause or contribute to a violation of any applicable guideline or standard. Maximum impacts from the Proton Energy combustion turbines are less than 10% of applicable guidelines and standards for all pollutants and averaging times. Cumulative impacts, even with all power plants operating at maximum capacity, are less than 50% of applicable guidelines and standards for all pollutants and averaging times. Measured background concentrations have not been added to the modeled impacts; however, the most likely contributors to cumulative impacts are the nearby power plants. Since these plants were explicitly modeled, and since maximum impacts overall are a fraction of the standards, it is not necessary to define background concentrations for this study.

Proton Energy

Air Dispersion Modeling

Attachment A
Contour Plots

Figure A-1: Contour Plot for NOx 1-hour Averaging Period - Scenario#1

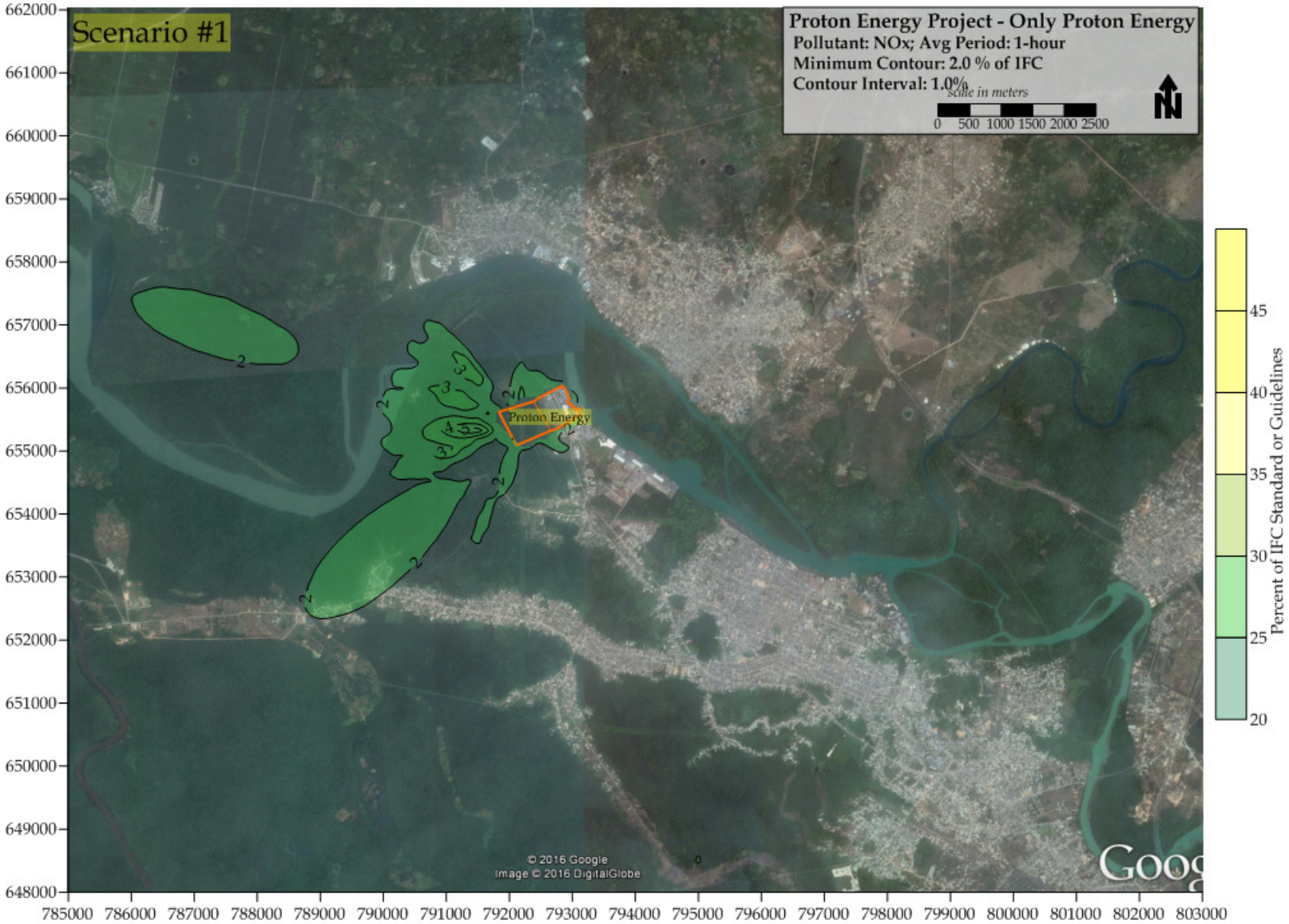


Figure A-2: Contour Plot for NO_2 1-hour Averaging Period - Scenario#2

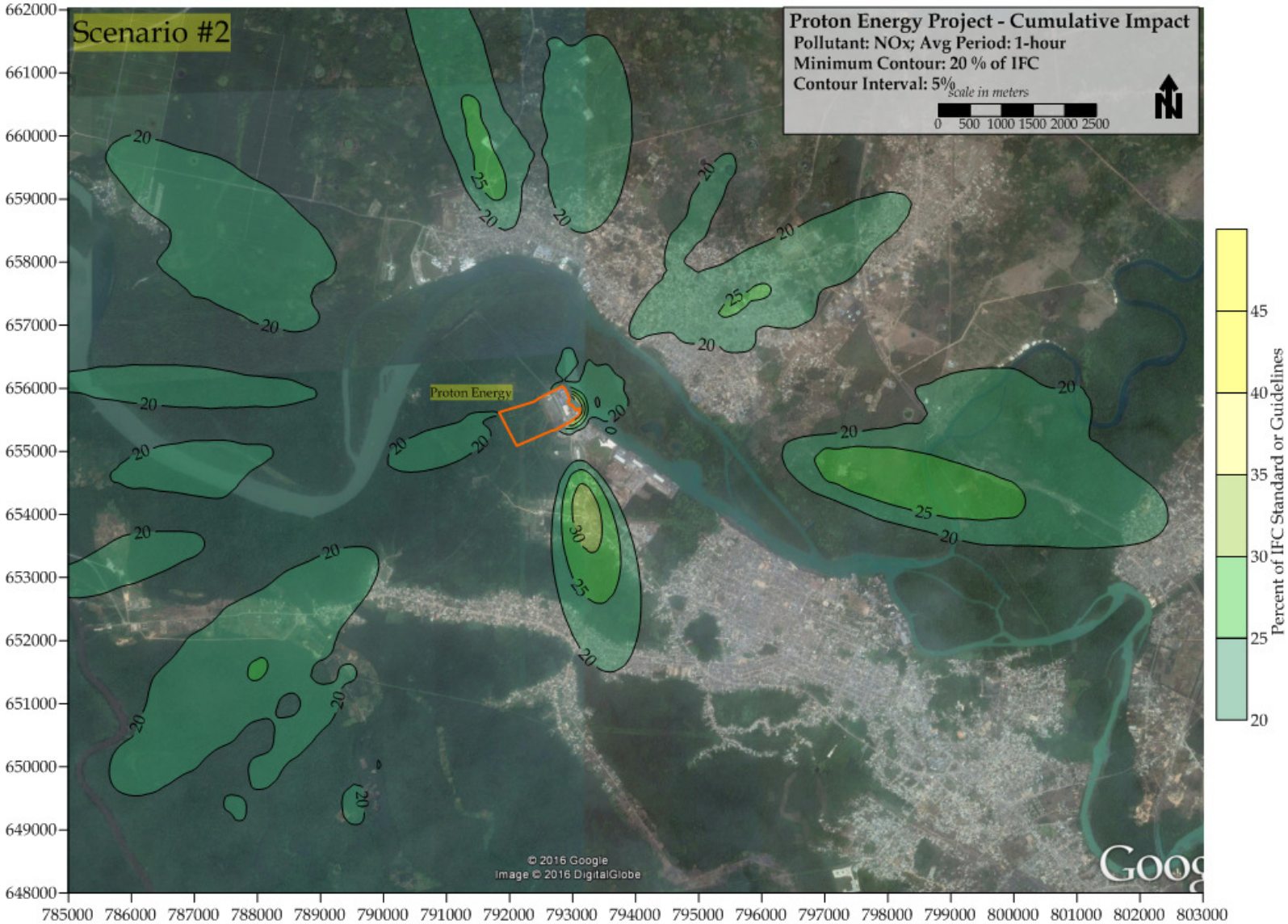


Figure A-3: Contour Plot for PM_{10} 24-hour Averaging Period - Scenario#2

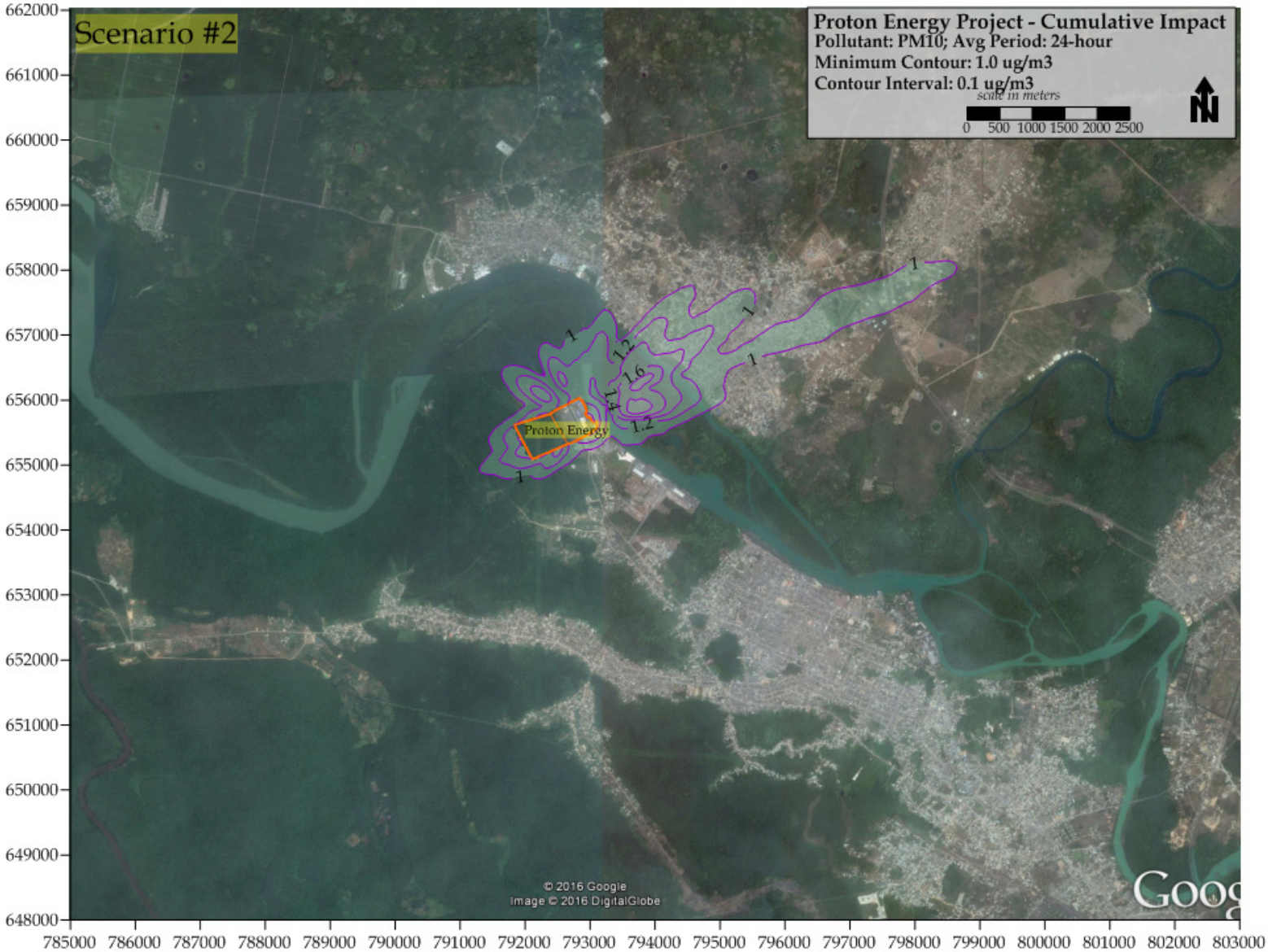


Figure A-4: Contour Plot for CO 8-hour Averaging Period - Scenario#2

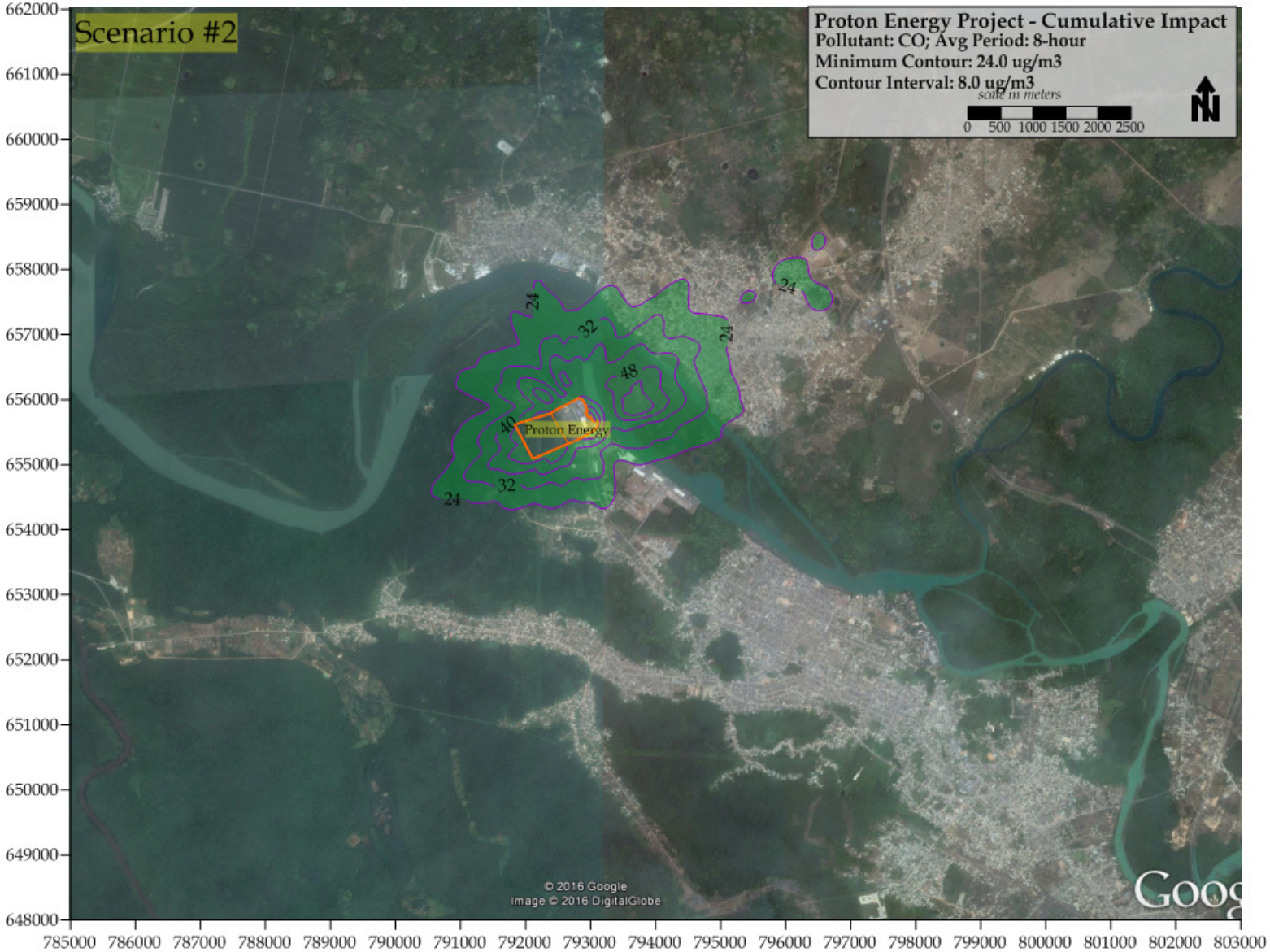


Figure A-5: Contour Plot for SO2 Annual Averaging Period - Scenario#2

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Noise Modelling Report

Proton Delta Sunrise Project

ERM Document: 0324235

Rev 0 DRAFT 21 March 2016

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Noise Modelling Report

Proton Delta Sunrise Project

ERM Document: 0339085

Prepared by: Adeyinka Afon P.E.

For and on behalf of Environmental Resources Management	
Approved by:	DRAFT FOR CLIENT REVIEW
Signed:	
Position:	
Date:	21 March 2016

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CONTENTS

1 INTRODUCTION 1

1.1 Background 1

1.2 Report Structure 2

2 MAJOR NOISE SOURCE DESCRIPTION AND SOUND POWER LEVELS 3

3 RECEPTORS AFFECTED BY NOISE 9

4 NOISE CRITERIA 11

5 NOISE PREDICTION METHODOLOGY 12

6 NOISE MODELLING RESULTS 13

7 CONCLUSIONS AND RECOMMENDATIONS 15

8 REFERENCES 17

TABLES

TABLE 1 MAJOR NOISE SOURCE DESCRIPTION AND SOUND POWER LEVELS FOR SCENARIO 1 3

TABLE 2 MAJOR NOISE SOURCE DESCRIPTION AND SOUND POWER LEVELS FOR SCENARIO 2 4

TABLE 3 MAJOR NOISE SOURCE DESCRIPTION AND SOUND POWER LEVELS FOR SCENARIO 3 7

TABLE 4 DISTANCE AND DIRECTION OF RECEPTOR LOCATIONS FROM CLOSEST PROJECT BOUNDARY 9

TABLE 5 IFC NOISE LEVEL GUIDELINES 11

TABLE 6 PREDICTED NIGHT-TIME POWER GENERATION NOISE LEVELS FOR ALL PROJECT SCENARIOS AND COMPARISON TO PROJECT NOISE CRITERIA 14

FIGURE

FIGURE 1 – PROPOSED PROJECT BOUNDARY AND NEAREST NOISE SENSITIVE AREAS 10

APPENDEX

APPENDIX A NOISE CONTOUR RESULTS

APPENDIX B TABULAR NOISE RESULTS FOR SCENARIO 1

APPENDIX C TABULAR NOISE RESULTS FOR SCENARIO 2

APPENDIX D TABULAR NOISE RESULTS FOR SCENARIO 3

1 INTRODUCTION

1.1 BACKGROUND

This Noise Modelling Report presents an assessment of noise effects on nearby communities during operation of the proposed Proton Delta Sunrise Project (Proton DSP) in Sapele, Delta State, Nigeria. The Proton DSP will be located on 27.4 hectares, owned by Proton Energy Limited, and would be adjacent to two existing power plants (NIPP gas turbine power plant and CMEC/Eurafric gas and steam turbine power plants) with associated gas pipeline and grid transmission infrastructure and access to river supply for cooling and transport. Installed (nameplate) capacity for the Proton DSP and the two existing power plants are as follows:

- Proton DSP: 150 megawatts[1] (MW) (3 x 47 MW SGT-800 Siemens, simple cycle gas turbine);
- NIPP: 450 MW (4 x 112.5 MW GE Frame 9, simple cycle gas turbines); and
- CMEC/Eurafric: 1020 MW (6 x 120 MW ABB steam turbines, 4 x 75 MW simple cycle gas turbines).

The objective of the report is to predict noise levels from project operations to assess impacts and risks on the surrounding community. The report also compares these levels to applicable regulatory limits. Scenarios to be modelled for the noise impact assessment are as follows:

- Scenario 1: Proton Energy's proposed power plant (DSP) at maximum output (150 MW).
- Scenario 2: In addition to Proton Energy maximum output, both NIPP and CMEC/Eurafric are assumed to operate at maximum nameplate capacity (450 MW for NIPP and 1020 MW for CMEC/Eurafric, as listed above). This scenario is not anticipated to occur; however it was modeled to provide a conservative upper bound on predicted noise levels.
- Scenario 3: All three power plants operating at the more realistic 5-year generation levels (i.e., by Year 2020) set by the Nigerian Electricity Regulatory Commission (NERC), which are:
    - Proton DSP still operating at maximum output of 150 MW by Year 2020 (3 x 47 MW simple cycle gas turbines);
    - NIPP operating at 250 MW by Year 2020, assuming a plant load factor of approximately 56 percent (4 x 62.5 MW simple cycle gas turbines); and
    - CMEC/Eurafric operating at 400 MW by Year 2020, assuming a plant load factor of approximately 56 percent (6 x 66.7 MW steam

[1] Initial installed capacity for the Proton Delta Sunrise Project is 150 MW (Phase 1), expanding to 500 MW in Phase 2 (http://protonenergyafrica.com/delta%20SunisеProject.html). However, this report focuses only on 150 MW (Phase 1).

turbines).[2]

1.2 REPORT STRUCTURE

The report includes the following elements:

- project site description and receptor location;
- major noise sources;
- impact criteria;
- prediction methodology;
- modelling results; and
- conclusions and recommendations.

Annex A contains the predicted noise contour results. *Annex B, C,* and *D* contains the predicted noise results (including individual source contributions) in tabular format for Scenario 1, 2, and 3, respectively.

[2] For the 5-Year NERC projection, the four gas turbine units associated with the CMEC/Eurafric plant were assumed to be non-functional as they currently are.

2 MAJOR NOISE SOURCE DESCRIPTION AND SOUND POWER LEVELS

Table 1, 2, and 3 provide information on the major noise sources and overall A-weighted sound power level (L_{WA}) for Scenario 1, 2, and 3, respectively.

Table 1 Major Noise Source Description and Sound Power Levels for Scenario 1

Noise Source Description	Source Location and Type	Source Dimensions (m) L	W	H	Source Surface Area, S (m^2)	Operational Capacity Per Unit, 100% Load (MW)	# of Units	Overall A-weighted L_{WA} Per Unit (dBA)[2]
Proton DSP (3 x 47 MW Siemens SGT-800 Gas Turbines at Nameplate Capacity, Simple Cycle)[1]								
Gas turbine (GT) enclosure - double skin cladding or equivalent (façades, doors, silenced HVAC system)	Enclosed (emitting façades)	15.8	7.29	6.83	589	47.0	3	99
GT generator enclosure - double skin cladding or equivalent (façades, doors, silenced HVAC system)	Enclosed (emitting façades)	5.26	3.65	6.83	243	47.0	3	101
GT air intake with air filters and silencers	Outdoor (point source)	NA	NA	13.4	NA	47.0	3	105
GT exhaust system (diffuser extension duct, elbow casing, and stack) with silencers and exhaust duct acoustic enclosure/barrier wall	Outdoor (point source)	NA	NA	18.0	NA	47.0	3	110
Transformer	Outdoor (point source)	NA	NA	5.0	NA	47.0	3	105
Fuel gas system (FG reducing station, FG preheating metering & filtering skids, and FG gas pipes)	Outdoor (point source)	NA	NA	3.0	NA	47.0	1	105
Fin fan cooler (including all fans, motors and drives)	Outdoor (point source)	NA	NA	3.0	NA	47.0	3	109

[1]Overall A-weighted sound power level (L_{WA}) represent per equipment unit. In the absence of publicly available L_{WA} for the proposed Proton DSP gas turbine units, the L_{WA} per equipment unit was calculated using Siemens data for similar open cycle gas turbine units *ie*, 3 x 150 MW SGT5-2000E at nameplate capacity (see Azura-Edo Independent Power Project ESIA Addendum - Air Quality and Noise Modelling and Impact Assessment Update, October 2013). For the proposed Proton DSP (3 x 47 MW SGT-800 at nameplate capacity), the L_{WA} per equipment unit was estimated based on the logarithmic ratio of the power ratings. The dimensions for the GT units were based on specifications for Siemens SGT-800 gas turbines. The dimensions for other noise sources were assumed based on similar units.

[2]Overall L_{WA} per unit is in dBA for all sources, except for emitting facades, which are in dBA per m^2.

Table 2 Major Noise Source Description and Sound Power Levels for Scenario 2

Noise Source Description	Source Location and Type	Source Dimensions (m) L	W	H	Source Surface Area, S (m^2)	Operational Capacity Per Unit, 100% Load (MW)	# of Units	Overall A-weighted L_{WA} Per Unit (dBA)[5]
Proton DSP (3 x 47 MW Siemens SGT-800 Gas Turbines at Nameplate Capacity, Simple Cycle)[1]								
Gas turbine (GT) enclosure - double skin cladding or equivalent (façades, doors, silenced HVAC system)	Enclosed (emitting façades)	15.8	7.29	6.83	589	47.0	3	99
GT generator enclosure - double skin cladding or equivalent (façades, doors, silenced HVAC system)	Enclosed (emitting façades)	5.26	3.65	6.83	243	47.0	3	101
GT air intake with air filters and silencers	Outdoor (point source)	NA	NA	13.4	NA	47.0	3	105
GT exhaust system (diffuser extension duct, elbow casing, and stack) with silencers and exhaust duct acoustic enclosure/barrier wall	Outdoor (point source)	NA	NA	18.0	NA	47.0	3	110
Transformer	Outdoor (point source)	NA	NA	5.0	NA	47.0	3	105
Fuel gas system (FG reducing station, FG preheating metering & filtering skids, and FG gas pipes)	Outdoor (point source)	NA	NA	3.0	NA	47.0	1	105
Fin fan cooler (including all fans, motors and drives)	Outdoor (point source)	NA	NA	3.0	NA	47.0	3	109
NIPP Power House 1& 2 (4 x 112.5 MW GE Frame 9 Gas Turbines at Nameplate Capacity, Simple Cycle)[2]								
GT and generator enclosure for each power house (two units per power house) - double skin cladding or equivalent (facades, doors, silenced HVAC system)	Enclosed (emitting façades)	40.0	30.0	15.0	3,712	112.5	4	107
GT air intake with air filters and silencers	Outdoor (point source)	NA	NA	20.0	NA	112.5	4	109
GT exhaust system (diffuser extension duct, elbow casing, and stack) with silencers and exhaust duct acoustic enclosure/barrier wall	Outdoor (point source)	NA	NA	35.0	NA	112.5	4	114
Transformer	Outdoor (point source)	NA	NA	5.0	NA	112.5	4	109
Fuel gas system (FG reducing station, FG preheating metering & filtering skids, and FG gas pipes)	Outdoor (point source)	NA	NA	3.0	NA	112.5	1	109
Fin fan cooler (including all	Outdoor	NA	NA	3.0	NA	112.5	4	113

Noise Source Description	Source Location and Type	Source Dimensions (m)			Source Surface Area, S (m^2)	Operational Capacity Per Unit, 100% Load (MW)	# of Units	Overall A-weighted L_{WA} Per Unit (dBA)[5]
		L	W	H				
fans, motors and drives)	(point source)							
CMEC/Eurafric (6 x 120 MW ABB Steam Turbines and 4 x 75 MW Gas Turbines at Nameplate Capacity, Simple Cycle)[3, 4]								
Steam turbine (ST) and generator enclosure (includes contributions from high and low-pressure turbines, generators, and shaft-driven exciters)	Enclosed (emitting façades)	125	45.0	27.0	15,713	120	1	93
ST exhaust system (diffuser extension duct, elbow casing, and stack) with silencers and exhaust duct acoustic enclosure/barrier wall	Outdoor (point source)	NA	NA	52.0	NA	120	6	114
Pump house (circulating pumps and motors)	Outdoor (point source)	NA	NA	3.0	NA	No data	1	105
GT and generator enclosure - double skin cladding or equivalent (facades, doors, silenced HVAC system)	Enclosed (emitting façades)	70.0	15.0	15.0	4,072	75	1	105
GT air intake with air filters and silencers	Outdoor (point source)	NA	NA	13.4	NA	75	4	105
GT exhaust system (diffuser extension duct, elbow casing, and stack) with silencers and exhaust duct acoustic enclosure/barrier wall	Outdoor (point source)	NA	NA	18.0	NA	75.0	4	112
Transformer	Outdoor (point source)	NA	NA	5.0	NA	75	4	107
Fuel gas system (FG reducing station, FG preheating metering & filtering skids, and FG gas pipes)	Outdoor (point source)	NA	NA	3.0	NA	75	1	107
Fin fan cooler (including all fans, motors and drives)	Outdoor (point source)	NA	NA	3.0	NA	75	4	111

[1]Overall A-weighted sound power level (L_{WA}) represent per equipment unit. In the absence of publicly available L_{WA} for the proposed Proton DSP gas turbine units, the L_{WA} per equipment unit was calculated using Siemens data for similar open cycle gas turbine units *ie*, 3 x 150 MW SGT5-2000E at nameplate capacity (see Azura-Edo Independent Power Project ESIA Addendum - Air Quality and Noise Modelling and Impact Assessment Update, October 2013). For the proposed Proton DSP (3 x 47 MW SGT-800 at nameplate capacity), the L_{WA} per equipment unit was estimated based on the logarithmic ratio of the power ratings. The dimensions for the GT units were based on specifications for Siemens SGT-800 gas turbines. The dimensions for other noise sources were assumed based on similar units.

[2] Overall L_{WA} represent per equipment unit but dimensions for the gas turbine and generator enclosure at each power house is for two units (ie, two units for NIPP Power Hour 1 and two units for NIPP Power House 2). In the absence of publicly available L_{WA} for the existing NIPP gas turbine units, the L_{WA} per equipment unit was calculated using Siemens data for similar open cycle gas turbine units ie, 3 x 150 MW SGT5-2000E at 100% load

Noise Source Description	Source Location and Type	Source Dimensions (m)			Source Surface Area, S (m^2)	Operational Capacity Per Unit, 100% Load (MW)	# of Units	Overall A-weighted L_{WA} Per Unit (dBA)[5]
		L	W	H				

(see Azura-Edo Independent Power Project ESIA Addendum - Air Quality and Noise Modelling and Impact Assessment Update, October 2013). For the existing NIPP Power House 1 (2 x 112.5 MW GE Frame 9 at nameplate capacity) and Power House 2 (2 x 112.5 MW GE Frame 9 at nameplate capacity), the L_{WA} per equipment unit was estimated based on the logarithmic ratio of the power ratings. Enclosure and source dimensions were estimated from aerial photos and similar equipment types.

[3] Overall L_{WA} represent per equipment unit but dimensions for the steam turbine and generator enclosure at each power house is for six units. In the absence of publicly available L_{WA} for existing CMEC/Eurafric steam turbine units, the overall A-weighted sound pressure level (L_{PA}) for the ST and generator enclosure was assumed to be 85 dBA at 1 meter from the enclosure, which is equivalent to an L_{WA} of 93 dBA per m^2. The L_{WA} for the ST exhaust system was calculated using Siemens data for an open cycle gas turbine exhaust system ie, 3 x 150 MW SGT5-2000E at nameplate capacity (see Azura-Edo Independent Power Project ESIA Addendum - Air Quality and Noise Modelling and Impact Assessment Update, October 2013). For the existing CMEC/Eurafric (6 x 120 MW ABB STs at nameplate capacity), the L_{WA} per equipment unit was estimated based on the logarithmic ratio of the power ratings. Operational capacity of the pump house (MW) is currently unavailable. The L_{WA} for the power house was obtained based on data from a similar pump house operating at 25% of capacity.

[4] Overall L_{WA} represent per equipment unit but dimensions for the gas turbine and generator enclosure at each power house is for four units. In the absence of publicly available LWA for the existing CMEC/Eurafric gas turbine units, the L_{WA} per equipment unit was calculated using Siemens data for similar open cycle gas turbine units ie, 3 x 150 MW SGT5-2000E at nameplate capacity (see Azura-Edo Independent Power Project ESIA Addendum - Air Quality and Noise Modelling and Impact Assessment Update, October 2013). For the existing CMEC/Eurafric GT Plant (4 x 75 MW simple cycle GTs at nameplate capacity), the L_{WA} per equipment unit was estimated based on the logarithmic ratio of the power ratings. Manufacturer and model type for the CMEC/Eurafric GT Plant was unavailable. Building and source dimensions were estimated from aerial photos and similar equipment types.

[5]Overall L_{WA} per unit is in dBA for all sources, except for emitting facades, which are in dBA per m^2.

Table 3 Major Noise Source Description and Sound Power Levels for Scenario 3

Noise Source Description	Source Location and Type	Source Dimensions (m) L	W	H	Source Surface Area, S (m^2)	Operational Capacity Per Unit, 100% Load (MW)	# of Units	Overall A-weighted L_{WA} Per Unit (dBA)[4]
Proton DSP (3 x 47 MW Siemens SGT-800 Gas Turbines at Nameplate Capacity, Simple Cycle)[1]								
Gas turbine (GT) enclosure - double skin cladding or equivalent (façades, doors, silenced HVAC system)	Enclosed (emitting façades)	15.8	7.29	6.83	589	47.0	3	99
GT generator enclosure - double skin cladding or equivalent (façades, doors, silenced HVAC system)	Enclosed (emitting façades)	5.26	3.65	6.83	243	47.0	3	101
GT air intake with air filters and silencers	Outdoor (point source)	NA	NA	13.4	NA	47.0	3	105
GT exhaust system (diffuser extension duct, elbow casing, and stack) with silencers and exhaust duct acoustic enclosure/barrier wall	Outdoor (point source)	NA	NA	18.0	NA	47.0	3	110
Transformer	Outdoor (point source)	NA	NA	5.0	NA	47.0	3	105
Fuel gas system (FG reducing station, FG preheating metering & filtering skids, and FG gas pipes)	Outdoor (point source)	NA	NA	3.0	NA	47.0	1	105
Fin fan cooler (including all fans, motors and drives)	Outdoor (point source)	NA	NA	3.0	NA	47.0	3	109
NIPP Power House 1& 2 (4 x 112.5 MW GE Frame 9 Gas Turbines at NERC 5-Year Projection, Simple Cycle)[2]								
GT and generator enclosure for each power house (two units per power house) - double skin cladding or equivalent (façades, doors, silenced HVAC system)	Enclosed (emitting façades)	40.0	30.0	15.0	3,712	62.5	4	104
GT air intake with air filters and silencers	Outdoor (point source)	NA	NA	20.0	NA	62.5	4	106
GT exhaust system (diffuser extension duct, elbow casing, and stack) with silencers and exhaust duct acoustic enclosure/barrier wall	Outdoor (point source)	NA	NA	35.0	NA	62.5	4	111
Transformer	Outdoor (point source)	NA	NA	5.0	NA	62.5	4	106
Fuel gas system (FG reducing station, FG preheating metering & filtering skids, and FG gas pipes)	Outdoor (point source)	NA	NA	3.0	NA	62.5	1	106

Noise Source Description	Source Location and Type	Source Dimensions (m)			Source Surface Area, S (m^2)	Operational Capacity Per Unit, 100% Load (MW)	# of Units	Overall A-weighted L_{WA} Per Unit (dBA)[4]
		L	W	H				
Fin fan cooler (including all fans, motors and drives)	Outdoor (point source)	NA	NA	3.0	NA	62.5	4	110
CMEC/Eurafric (6 x 120 MW ABB Steam Turbines and 4 x 75 MW Gas Turbines at NERC 5-Year Projection, Simple Cycle)[3]								
Steam turbine (ST) and generator enclosure (includes contributions from high and low-pressure turbines, generators, and shaft-driven exciters)	Enclosed (emitting façades)	125	45.0	27.0	15,713	66.7	1	93
ST exhaust system (diffuser extension duct, elbow casing, and stack) with silencers and exhaust duct acoustic enclosure/barrier wall	Outdoor (point source)	NA	NA	52.0	NA	66.7	6	111
Pump house (circulating pumps and motors)	Outdoor (point source)	NA	NA	3.0	NA	No data	1	105

[1]Overall A-weighted sound power level (L_{WA}) represent per equipment unit. In the absence of publicly available L_{WA} for the proposed Proton DSP gas turbine units, the L_{WA} per equipment unit was calculated using Siemens data for similar open cycle gas turbine units *ie*, 3 x 150 MW SGT5-2000E at nameplate capacity (see Azura-Edo Independent Power Project ESIA Addendum - Air Quality and Noise Modelling and Impact Assessment Update, October 2013). For the proposed Proton DSP (3 x 47 MW SGT-800 at nameplate capacity), the L_{WA} per equipment unit was estimated based on the logarithmic ratio of the power ratings. The dimensions for the GT units were based on specifications for Siemens SGT-800 gas turbines. The dimensions for other noise sources were assumed based on similar units.

[2] Overall L_{WA} represent per equipment unit but dimensions for the gas turbine and generator enclosure at each power house is for two units (ie, two units for NIPP Power Hour 1 and two units for NIPP Power House 2). In the absence of publicly available L_{WA} for the existing NIPP gas turbine units, the L_{WA} per equipment unit was calculated using Siemens data for similar open cycle gas turbine units ie, 3 x 150 MW SGT5-2000E at 100% load (see Azura-Edo Independent Power Project ESIA Addendum - Air Quality and Noise Modelling and Impact Assessment Update, October 2013). For the existing NIPP Power House 1 (2 x 112.5 MW GE Frame 9 at nameplate capacity) and Power House 2 (2 x 112.5 MW GE Frame 9 at nameplate capacity), the L_{WA} per equipment unit was estimated based on the logarithmic ratio of the power ratings. Enclosure and source dimensions were estimated from aerial photos and similar equipment types.

[3] Overall L_{WA} represent per equipment unit but dimensions for the steam turbine and generator enclosure at each power house is for six units. In the absence of publicly available L_{WA} for existing CMEC/Eurafric steam turbine units, the overall A-weighted sound pressure level (L_{PA}) for the ST and generator enclosure was assumed to be 85 dBA at 1 meter from the enclosure, which is equivalent to an L_{WA} of 93 dBA per m^2. The L_{WA} for the ST exhaust system was calculated using Siemens data for an open cycle gas turbine exhaust system ie, 3 x 150 MW SGT5-2000E at nameplate capacity (see Azura-Edo Independent Power Project ESIA Addendum - Air Quality and Noise Modelling and Impact Assessment Update, October 2013). Operational capacity of the pump house (MW) is currently unavailable. The L_{WA} for the power house was obtained based on data from a similar pump house operating at 25% of capacity. For the NERC 5-Year projection, the 4 x 75 MW gas turbine units were assumed to be non-functional (defunct) as they currently are.

[4]Overall L_{WA} per unit is in dBA for all sources, except for emitting facades, which are in dBA per m^2.

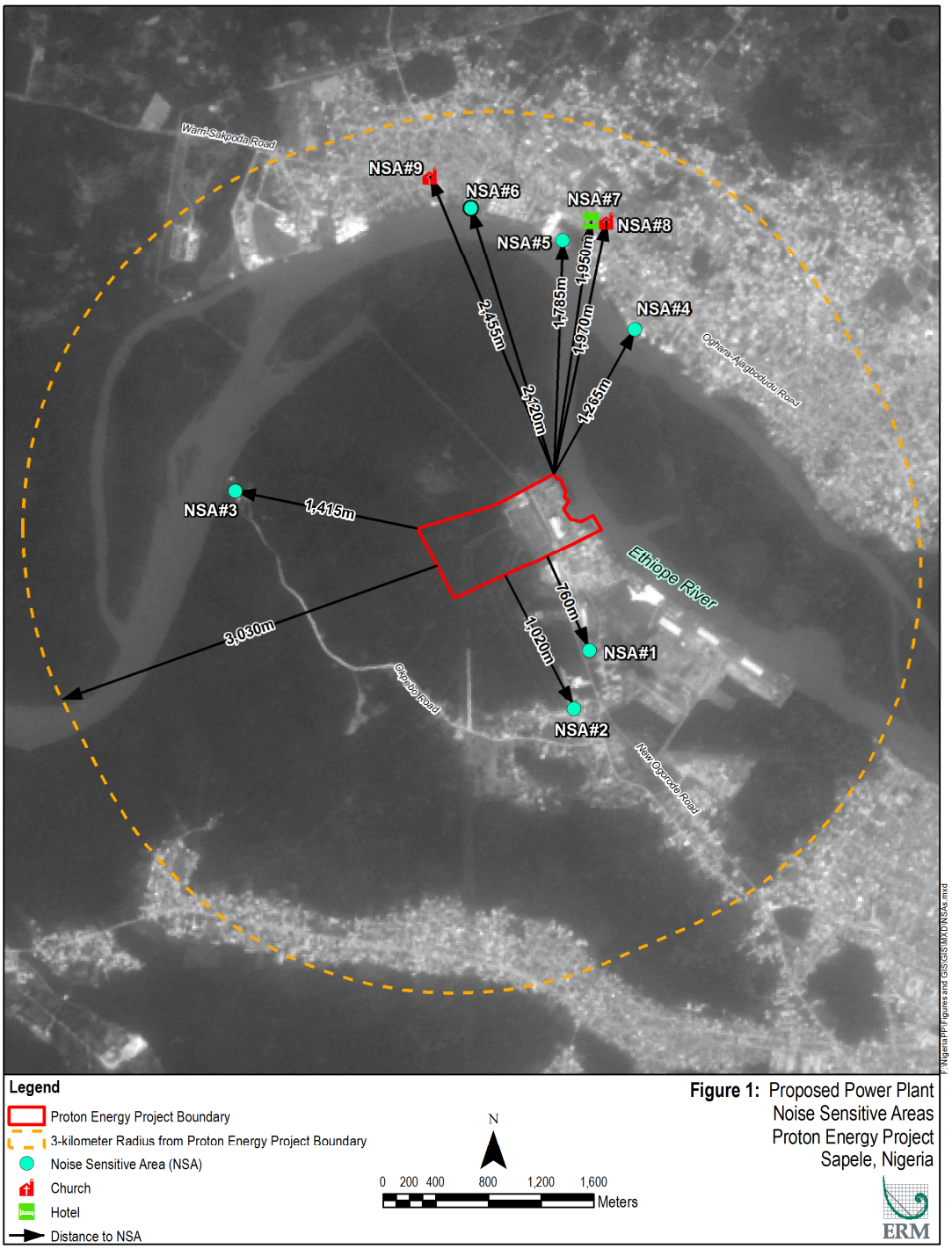
3 RECEPTORS AFFECTED BY NOISE

The Project site will be located at Sapele, Delta State in the Southern Region of Nigeria. A total of nine noise sensitive areas (NSAs), including seven residential areas (multiple residences to the north, north-northeast, northeast, south, and west), two churches (Apostolic Church Mission to the north-northeast and Felix Church to the north), and a hotel (Amena Hotels and Resorts to the north-northeast) were identified within a 3 km radius of the Project boundary (see *Figure 1*). A description of the nine NSAs and approximate distance and direction from the closest Project boundary are provided in *Table 4*.

Table 4 Distance and Direction of Receptor Locations from Closest Project Boundary

Receptor ID	Description	Approximate Distance and Direction from Closest Project Boundary (meters)
NSA#1	Residences	760 m south of Project boundary
NSA#2	Residences	1,020 m south of Project boundary
NSA#3	Residence	1,415 m west of Project boundary
NSA#4	Residences	1,265 m northeast of Project boundary
NSA#5	Residences	1,785 m north-northeast of Project boundary
NSA#6	Residences	2,120 m north of Project boundary
NSA#7	Hotel	1,950 m north-northeast of Project boundary
NSA#8	Church	1,970 m north-northeast of Project boundary
NSA#9	Church	2,455 m north of Project boundary

Figure 1 – Proposed Project Boundary and Nearest Noise Sensitive Areas



4 NOISE CRITERIA

Table 5 presents noise guidelines that should not be exceeded at the nearest NSAs offsite, from potential lenders (International Finance Corporation (IFC). For this Project, the more stringent IFC night-time noise limit of 45 dB(A) would be used to assess impacts at the closest NSAs. In addition to the absolute values provided in *Table 5*, the IFC also requires that noise increase above existing levels should not exceed 3 dB.

Table 5 IFC Noise Level Guidelines

Receptor	**One Hour LAeq (dB(A))**	
	Daytime (07:00 – 22:00)	Night (22:00 – 07:00)
Residential; institutional; educational	55	45
Industrial; commercial	70	70

L_{Aeq} (or L_{eq}) = A-weighted equivalent sound levels over a measurement period, dB(A) = A-weighted decibel

Source: General Environmental, Health, and Safety (EHS) Guidelines, IFC 2007

5 NOISE PREDICTION METHODOLOGY

Bruel & Kjaer's Predictor Version 10.10 noise modelling software was used to calculate noise emissions from Project operations following the methods identified within ISO 9613 Part 2 for the propagation of noise. The computer model incorporates identifiable noise source data, meteorological data, surrounding terrain characteristics, and barrier effects of nearby buildings and structures.

The model accounted for atmospheric absorption (assumed a temperature of 30 degree Celsius and 90 percent relative humidity) and assumed meteorological conditions favourable to sound propagation per ISO 9613 Part 2 (ISO 1996) *i.e.*, downwind propagation with wind speeds between 1 and 5 meters per second. A ground absorption coefficient of 1.0 was assumed for hard ground/reflective surfaces such as Ethiope River and 0.5 (*i.e.* 50 percent hard ground and 50 percent soft ground) for the remaining modelled areas. The model accounts for attenuation due to an industrial site adjacent to the south-southwestern Project boundary. The model also accounts for attenuation due to dense foliage (average height of the trees were assumed to be 18.3 m) between the noise sources and most NSAs.

The L_{WA} for each major noise source associated with Scenario 1, 2, and 3 are provided in *Table 1, 2, and 3* (see Section 2). The gas turbine and generator building walls and steam turbine building walls were modelled as emitting façades. The model accounts for surface area for each emitting façade or source using dimensions from available turbine manufacturer specifications and aerial imagery. All outdoors sources such as air intakes, exhaust system, transformers, fuel gas system, fin fan coolers, and pump house were modelled as point sources.

6 NOISE MODELLING RESULTS

The predicted noise contribution at the closest NSAs due to continuous operation of the Project (all three scenarios) is summarised in *Table 6.* The table also includes a comparison of the predicted noise levels to the IFC night-time noise guidelines for residential, institutional, and educational areas.

As shown in the table, the predicted power generation noise levels for Scenario 1 (25.2 to 35.7 dB(A)) at the closest NSAs are below the IFC night-time noise level of 45 dB(A). The predicted noise levels due to power generation for Scenario 2 (34.6 to 53.9 dB(A)) are below the IFC night-time noise levels for all identified NSAs, except at NSA#1 (50.9 dB(A)), NSA#4 (53.9 dB(A)), NSA#5 (46.8 dB(A)), NSA#7 (46.8 dB(A)) and NSA#8 (46.5 dB(A)) where the noise limits are exceeded. For Scenario 3, the predicted noise levels due to power generation (31.7 to 50.2 dB(A)) are below the IFC night-time noise levels for all identified NSAs, except at NSA#1 (47.4 dB(A)) and NSA#4 (50.2 dB(A)) where the noise limits are exceeded.

The power generation noise model results in contour format for all scenarios are provided in *Annex A.* Noise model results in tabular format showing individual noise source contribution at each NSA for Scenario 1, 2, and 3 are provided in *Annex B, C, and D*, respectively.

Table 6 *Predicted Night-time Power Generation Noise Levels for all Project Scenarios and Comparison to Project Noise Criteria*

Receptor ID	Closest Noise Sensitive Areas to Project Boundary	Distance to Project Boundary (meter)	Predicted Noise Levels, dB(A)	IFC Night-time Noise Limit for Residential, Institutional, and Educational Areas, dB(A)	Comply with IFC Night-time Noise Limit? (Yes/No)
Scenario 1: Proton Energy's proposed power plant (DSP) at maximum output (150 MW).					
NSA#1	Residences (South)	760	35.7	45	Yes
NSA#2	Residences (South)	1,020	38.2	45	Yes
NSA#3	Residences (West)	3,030	27.8	45	Yes
NSA#4	Residences (Southwest)	1,265	31.9	45	Yes
NSA#5	Residences (North-northeast)	1,785	26.7	45	Yes
NSA#6	Residences (North)	2,120	25.7	45	Yes
NSA#7	Hotel (North-northeast)	1,950	28.4	45	Yes
NSA#8	Church (North-northeast)	1,970	27.6	45	Yes
NSA#9	Church (North)	2,455	25.2	45	Yes
Scenario 2: Proton Energy's power plant at 150 MW and the two nearby existing power plants at nameplate capacity (450 MW for NIPP and 1020 MW for CMEC/Eurafric)					
NSA#1	Residences (South)	760	50.9	45	No
NSA#2	Residences (South)	1,020	43.2	45	Yes
NSA#3	Residences (West)	3,030	34.6	45	Yes
NSA#4	Residences (Southwest)	1,265	53.9	45	No
NSA#5	Residences (North-northeast)	1,785	46.8	45	No
NSA#6	Residences (North)	2,120	44.3	45	Yes
NSA#7	Hotel (North-northeast)	1,950	46.8	45	No
NSA#8	Church (North-northeast)	1,970	46.5	45	No
NSA#9	Church (North)	2,455	39.8	45	Yes
Scenario 3: Proton Energy's power plant at 150 MW and the two nearby existing power plants operating at NERC 5-Year Projection capacity (250 MW for NIPP and 400 MW for CMEC/Eurafric)					
NSA#1	Residences (South)	760	47.4	45	No
NSA#2	Residences (South)	1,020	40.9	45	Yes
NSA#3	Residences (West)	3,030	31.7	45	Yes
NSA#4	Residences (Southwest)	1,265	50.2	45	No
NSA#5	Residences (North-northeast)	1,785	42.3	45	Yes
NSA#6	Residences (North)	2,120	40.5	45	Yes
NSA#7	Hotel (North-northeast)	1,950	42.9	45	Yes
NSA#8	Church (North-northeast)	1,970	42.7	45	Yes
NSA#9	Church (North)	2,455	35.8	45	Yes

7 CONCLUSIONS AND RECOMMENDATIONS

The noise modelling assessment for the Project has determined the effects of noise emission on closest NSAs. Sources with the highest potential noise generation capacity were used to estimate maximum potential noise levels from the Project.

Scenario 1 Noise

For Scenario 1, the assessment estimated that all nine NSAs would comply with the IFC night-time noise guideline of 45 dB(A), provided the specified sound power levels and design criteria (including enclosed gas turbine and generators, mufflers for enclosure ventilation, turbine air intakes, and exhausts) are successfully implemented (see *Table 1*).

Scenario 2 Noise

The assessment estimated that power generation noise from Scenario 2 would be within the IFC night-time noise guidelines of 45 dB(A) at all NSAs, except at NSA#1, NSA#4, NSA#5, NSA#7, and NSA#8, which are projected to exceed the night-time noise limits by 1.5 to 8.9 dB.

Scenario 3 Noise

This Scenario is the likely scenario situation. The assessment estimated that power generation noise from Scenario 3 would be within the IFC night-time noise guidelines of 45 dB(A) at all NSAs, except at NSA#1 and NSA#4, which are projected to exceed the night-time noise limits by 2.4 and 5.2 dB.

Recommended Mitigation Measures

To reduce noise impacts on the closest NSAs for Scenario 2 and 3, the following mitigation measures are recommended.

- Implement a 24-hour pre-construction noise monitoring program at the affected NSAs to determine if existing noise levels are within the IFC limits. If pre-construction noise levels show that the regulatory limits are currently being exceeded (particularly existing night-time levels), the Project noise impacts would be determined based on an increase above existing levels (ie IFC requires that noise increase above existing levels should not exceed 3 dB).

- If the baseline plus 3 dB(A) result is less than 45 dB(A) and compliance with the 45 dB(A) limit is required, engineering noise control measures such as installation of barriers and/ or silencer upgrades on exhaust stacks and air intakes may be required for the two existing power plants (since the noise exceedance is due to the existing power plants).

However, Proton Energy has no influence or control over the existing power plants to implement any noise control measures.

- To maintain positive community relations, keep the public informed about the construction and operation plans and efforts to minimise noise, and establish procedures for prompt response and corrective action with regard to noise complaints.

8 REFERENCES

Environmental Resources Management (ERM), 2013. Azura-Edo Independent Power Project ESIA Addendum - Air Quality and Noise Modelling and Impact Assessment Update, October 2013.

International Finance Corporation (IFC) 2007. General Environmental, Health, and Safety (EHS) Guidelines, April 30, 2007.

International Organization for Standardization (ISO) 1996. Acoustics – Attenuation of Sound During Propagation Outdoors, Part 2: General Method of Calculation. ISO 9613-2:1996.

ANNEX A

NOISE CONTOUR RESULTS

ANNEX B

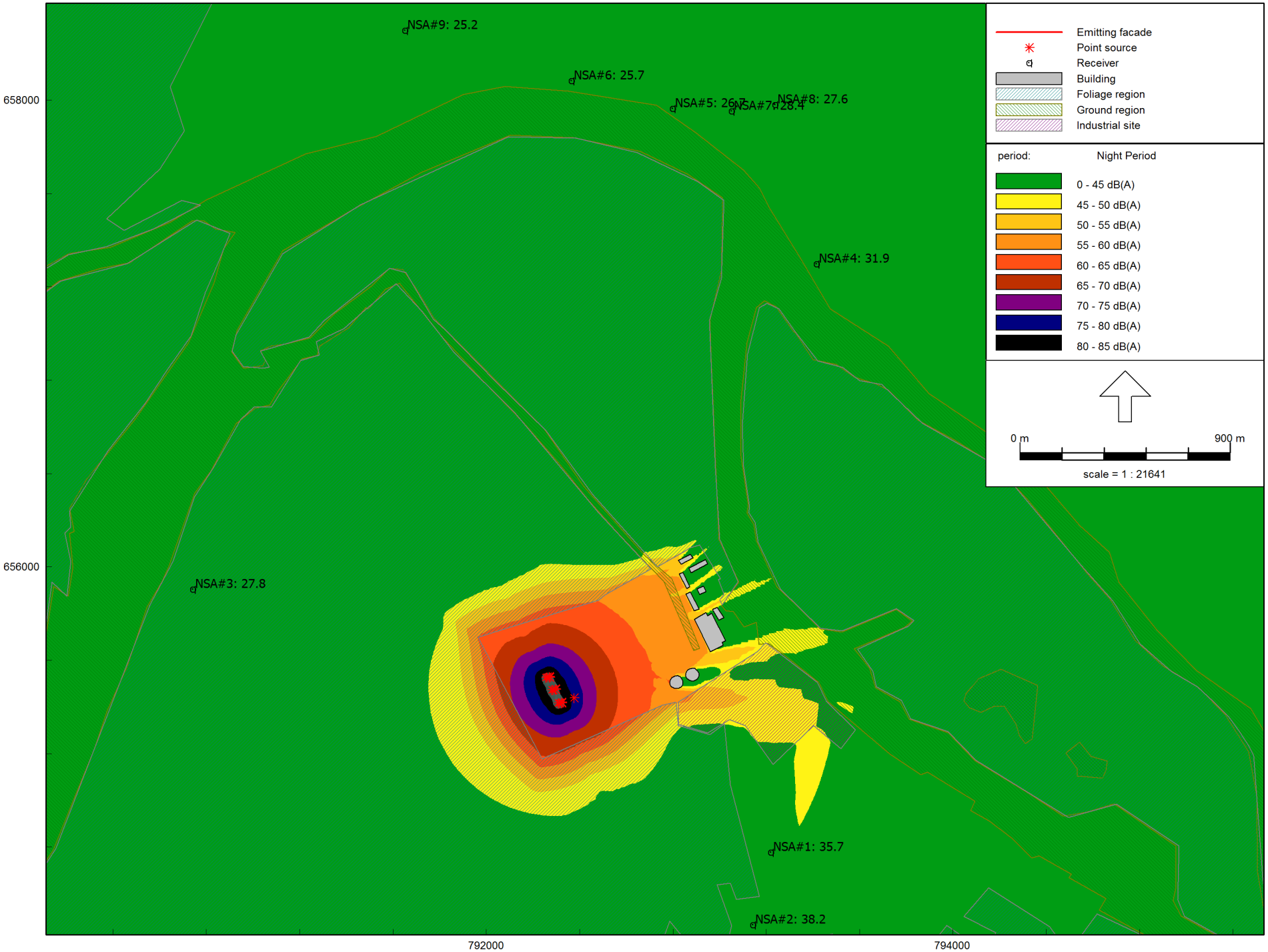
TABULAR NOISE RESULTS FOR SCENARIO 1

ANNEX C

TABULAR NOISE RESULTS FOR SCENARIO 2

ANNEX D

TABULAR NOISE RESULTS FOR SCENARIO 3

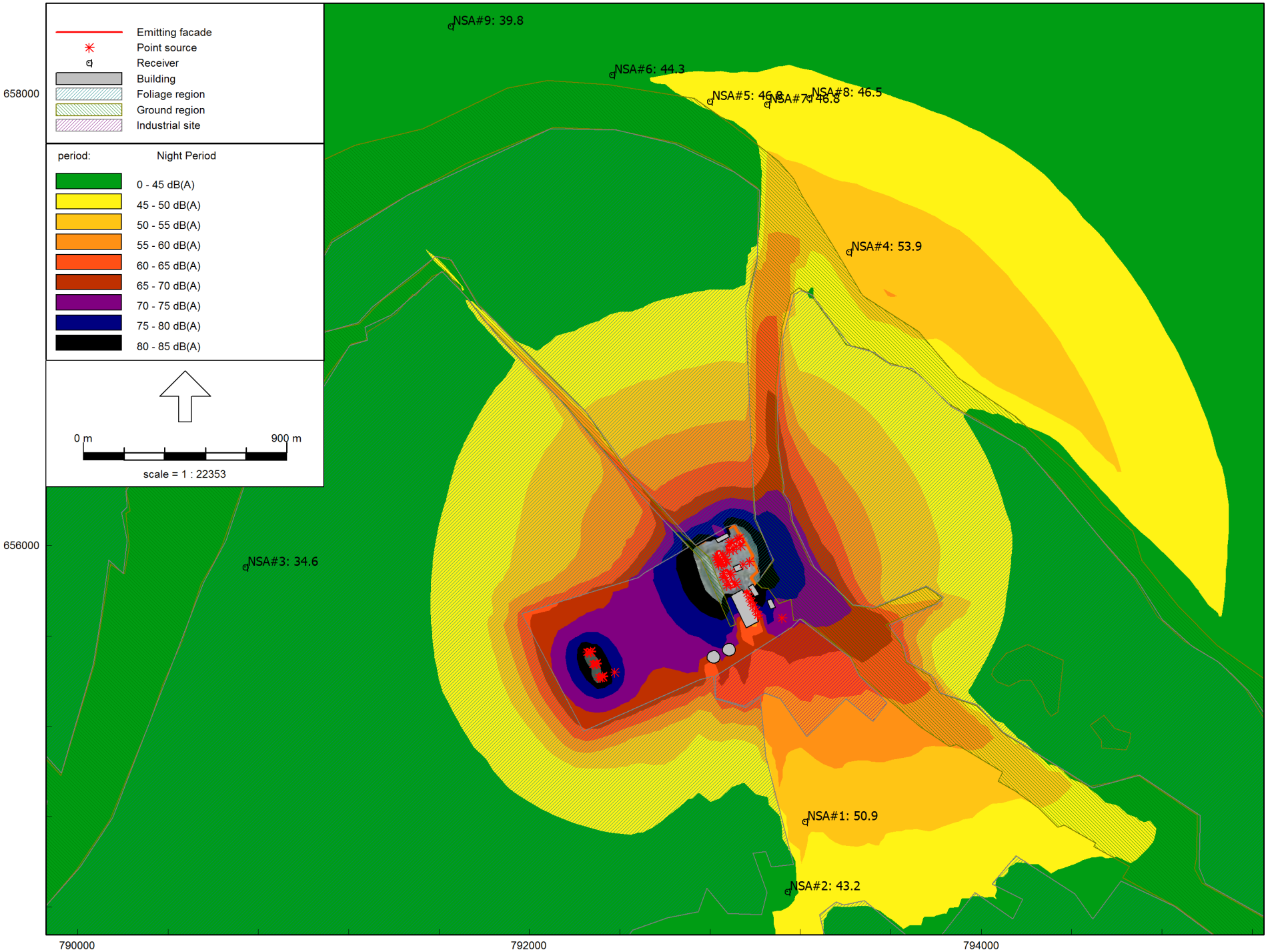


Industrial noise - ISO 9613.1/2, [Operation Phase of Proton Energy Power Plant - Sapele - Copy of Industry] , Predictor V10.10

Proton DSP Noise Contour (100% Load)

Copy of Industry
16 Mar 2016, 15:37

ERM, Annapolis, USA

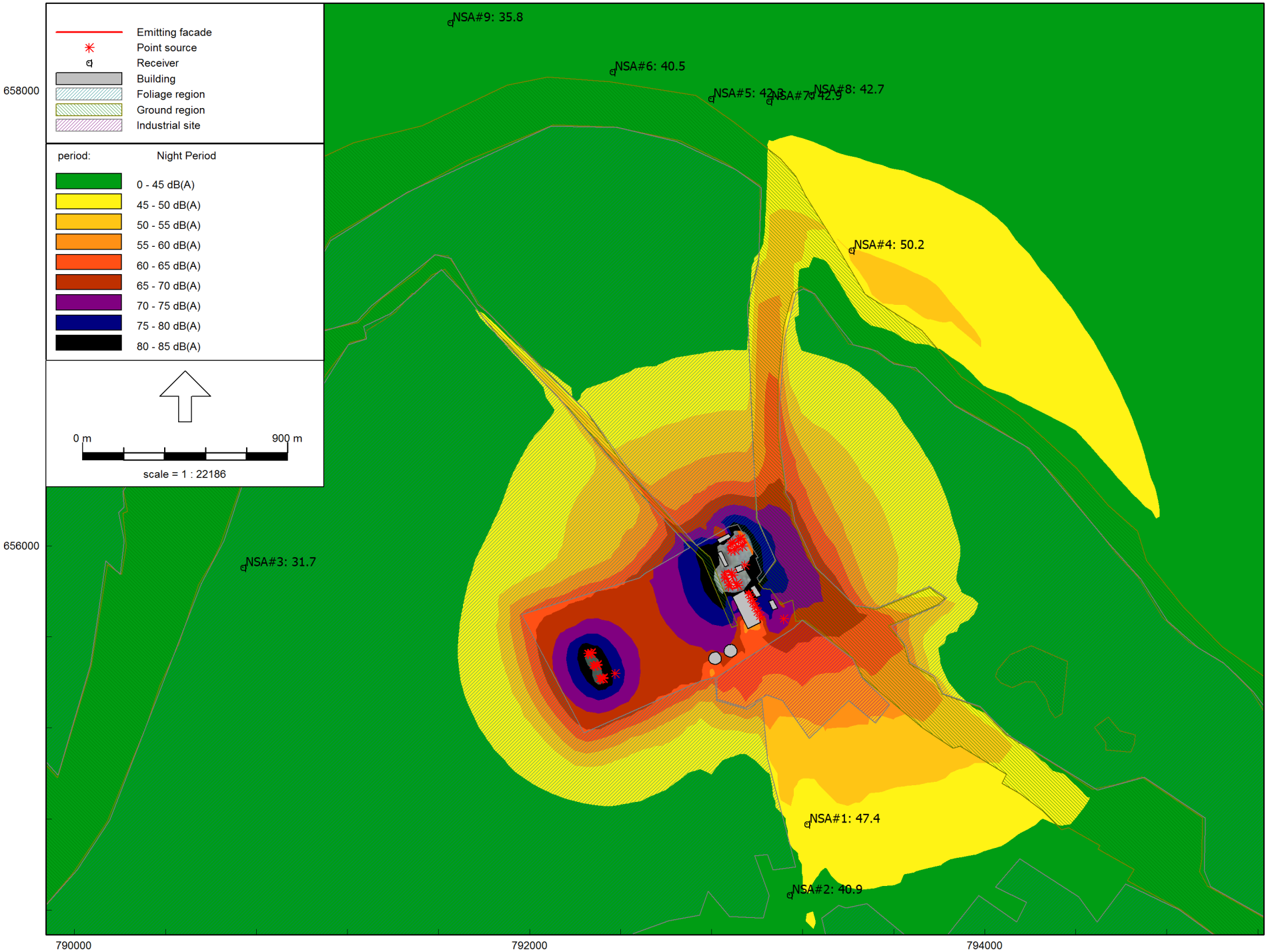


Industrial noise - ISO 9613.1/2, [Operation Phase of Proton Energy Power Plant - Sapele - Copy of Industry] , Predictor V10.10

Proton Energy Project Noise Contours - Maximum Nameplate Capacity

Copy of Industry
16 Mar 2016, 20:18

ERM, Annapolis, USA



Industrial noise - ISO 9613.1/2, [Operation Phase of Proton Energy Power Plant - Sapele - Copy of Industry] , Predictor V10.10

Proton Energy Project Noise Contours - NERC 5-Year Projection

Copy of Industry
16 Mar 2016, 20:52

ERM, Annapolis, USA

Proton DSP Noise Results (100% Load)

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#1_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#1_A	Residences	1.50	35.7	35.7
P_FGS	Proton Fuel Gas System	3.00	11.3	11.3
P1_Air-Int	Proton1 GT Air Intake	13.40	13.8	13.8
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	15.3	15.3
P1_Exh	Proton1 GT Exhaust System	18.00	20.6	20.6
P1_GT_E	Proton1 GT Facade, East	6.83	21.0	21.0
P1_GT_N	Proton1 GT Facade, North	6.83	24.7	24.7
P1_GT_S	Proton1 GT Facade, South	6.83	24.5	24.5
P1_GT_W	Proton1 GT Facade, West	6.83	18.0	18.0
P1_GTG_N	Proton1 GTG Facade, North	6.83	21.4	21.4
P1_GTG_S	Proton1 GTG Facade, South	6.83	21.2	21.2
P1_GTG_W	Proton1 GTG Facade, West	6.83	19.1	19.1
P1_Trans	Proton1 GT Transformer	5.00	-7.9	-7.9
P2_Air-Int	Proton2 GT Air Intake	13.40	13.4	13.4
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	14.5	14.5
P2_Exh	Proton2 GT Exhaust System	18.00	20.1	20.1
P2_GT_E	Proton2 GT Facade, East	6.83	21.4	21.4
P2_GT_N	Proton2 GT Facade, North	6.83	24.5	24.5
P2_GT_S	Proton2 GT Facade, South	6.83	24.4	24.4
P2_GT_W	Proton2 GT Facade, West	6.83	16.2	16.2
P2_GTG_N	Proton2 GT Facade, North	6.83	20.9	20.9
P2_GTG_S	Proton2 GT Facade, South	6.83	21.2	21.2
P2_GTG_W	Proton2 GT Facade, West	6.83	19.6	19.6
P2_Trans	Proton2 GT Transformer	5.00	-6.1	-6.1
P3_Air-Int	Proton3 GT Air Intake	13.40	13.0	13.0
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	13.7	13.7
P3_Exh	Proton3 GT Exhaust System	18.00	19.6	19.6
P3_GT_E	Proton3 GT Facade, East	6.83	21.2	21.2
P3_GT_N	Proton3 GT Facade, North	6.83	24.2	24.2
P3_GT_S	Proton3 GT Facade, South	6.83	24.4	24.4
P3_GT_W	Proton3 GT Facade, West	6.83	16.0	16.0
P3_GTG_N	Proton3 GT Facade, North	6.83	20.7	20.7
P3_GTG_S	Proton3 GT Facade, South	6.83	20.4	20.4
P3_GTG_W	Proton3 GT Facade, West	6.83	18.5	18.5
P3_Trans	Proton3 GT Transformer	5.00	-7.1	-7.1

All shown dB values are A-weighted

Proton DSP Noise Results (100% Load)

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#2_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#2_A	Residences	1.50	38.2	38.2
P_FGS	Proton Fuel Gas System	3.00	8.8	8.8
P1_Air-Int	Proton1 GT Air Intake	13.40	16.7	16.7
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	13.0	13.0
P1_Exh	Proton1 GT Exhaust System	18.00	23.0	23.0
P1_GT_E	Proton1 GT Facade, East	6.83	24.2	24.2
P1_GT_N	Proton1 GT Facade, North	6.83	28.0	28.0
P1_GT_S	Proton1 GT Facade, South	6.83	27.7	27.7
P1_GT_W	Proton1 GT Facade, West	6.83	21.5	21.5
P1_GTG_N	Proton1 GTG Facade, North	6.83	24.9	24.9
P1_GTG_S	Proton1 GTG Facade, South	6.83	24.7	24.7
P1_GTG_W	Proton1 GTG Facade, West	6.83	22.6	22.6
P1_Trans	Proton1 GT Transformer	5.00	-8.4	-8.4
P2_Air-Int	Proton2 GT Air Intake	13.40	15.8	15.8
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	9.6	9.6
P2_Exh	Proton2 GT Exhaust System	18.00	22.1	22.1
P2_GT_E	Proton2 GT Facade, East	6.83	24.0	24.0
P2_GT_N	Proton2 GT Facade, North	6.83	27.2	27.2
P2_GT_S	Proton2 GT Facade, South	6.83	27.2	27.2
P2_GT_W	Proton2 GT Facade, West	6.83	19.1	19.1
P2_GTG_N	Proton2 GT Facade, North	6.83	21.6	21.6
P2_GTG_S	Proton2 GT Facade, South	6.83	24.1	24.1
P2_GTG_W	Proton2 GT Facade, West	6.83	19.7	19.7
P2_Trans	Proton2 GT Transformer	5.00	-3.0	-3.0
P3_Air-Int	Proton3 GT Air Intake	13.40	14.9	14.9
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	12.6	12.6
P3_Exh	Proton3 GT Exhaust System	18.00	21.2	21.2
P3_GT_E	Proton3 GT Facade, East	6.83	23.3	23.3
P3_GT_N	Proton3 GT Facade, North	6.83	26.5	26.5
P3_GT_S	Proton3 GT Facade, South	6.83	26.7	26.7
P3_GT_W	Proton3 GT Facade, West	6.83	18.5	18.5
P3_GTG_N	Proton3 GT Facade, North	6.83	20.8	20.8
P3_GTG_S	Proton3 GT Facade, South	6.83	22.9	22.9
P3_GTG_W	Proton3 GT Facade, West	6.83	21.0	21.0
P3_Trans	Proton3 GT Transformer	5.00	-4.4	-4.4

All shown dB values are A-weighted

Proton DSP Noise Results (100% Load)

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#3_A - Residence
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#3_A	Residence	1.50	27.8	27.8
P_FGS	Proton Fuel Gas System	3.00	-1.5	-1.5
P1_Air-Int	Proton1 GT Air Intake	13.40	3.4	3.4
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	5.2	5.2
P1_Exh	Proton1 GT Exhaust System	18.00	8.3	8.3
P1_GT_E	Proton1 GT Facade, East	6.83	12.3	12.3
P1_GT_N	Proton1 GT Facade, North	6.83	16.2	16.2
P1_GT_S	Proton1 GT Facade, South	6.83	15.9	15.9
P1_GT_W	Proton1 GT Facade, West	6.83	9.6	9.6
P1_GTG_N	Proton1 GTG Facade, North	6.83	13.1	13.1
P1_GTG_S	Proton1 GTG Facade, South	6.83	12.8	12.8
P1_GTG_W	Proton1 GTG Facade, West	6.83	10.8	10.8
P1_Trans	Proton1 GT Transformer	5.00	6.0	6.0
P2_Air-Int	Proton2 GT Air Intake	13.40	3.9	3.9
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	5.8	5.8
P2_Exh	Proton2 GT Exhaust System	18.00	8.8	8.8
P2_GT_E	Proton2 GT Facade, East	6.83	13.4	13.4
P2_GT_N	Proton2 GT Facade, North	6.83	16.7	16.7
P2_GT_S	Proton2 GT Facade, South	6.83	16.5	16.5
P2_GT_W	Proton2 GT Facade, West	6.83	8.5	8.5
P2_GTG_N	Proton2 GT Facade, North	6.83	13.4	13.4
P2_GTG_S	Proton2 GT Facade, South	6.83	13.6	13.6
P2_GTG_W	Proton2 GT Facade, West	6.83	12.1	12.1
P2_Trans	Proton2 GT Transformer	5.00	6.5	6.5
P3_Air-Int	Proton3 GT Air Intake	13.40	4.4	4.4
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	6.3	6.3
P3_Exh	Proton3 GT Exhaust System	18.00	9.3	9.3
P3_GT_E	Proton3 GT Facade, East	6.83	13.9	13.9
P3_GT_N	Proton3 GT Facade, North	6.83	17.2	17.2
P3_GT_S	Proton3 GT Facade, South	6.83	17.3	17.3
P3_GT_W	Proton3 GT Facade, West	6.83	9.1	9.1
P3_GTG_N	Proton3 GT Facade, North	6.83	13.9	13.9
P3_GTG_S	Proton3 GT Facade, South	6.83	13.6	13.6
P3_GTG_W	Proton3 GT Facade, West	6.83	11.8	11.8
P3_Trans	Proton3 GT Transformer	5.00	7.0	7.0

All shown dB values are A-weighted

Proton DSP Noise Results (100% Load)

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#4_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#4_A	Residences	1.50	31.9	31.9
P_FGS	Proton Fuel Gas System	3.00	7.3	7.3
P1_Air-Int	Proton1 GT Air Intake	13.40	8.3	8.3
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	8.8	8.8
P1_Exh	Proton1 GT Exhaust System	18.00	14.4	14.4
P1_GT_E	Proton1 GT Facade, East	6.83	16.9	16.9
P1_GT_N	Proton1 GT Facade, North	6.83	20.6	20.6
P1_GT_S	Proton1 GT Facade, South	6.83	20.4	20.4
P1_GT_W	Proton1 GT Facade, West	6.83	13.9	13.9
P1_GTG_N	Proton1 GTG Facade, North	6.83	17.4	17.4
P1_GTG_S	Proton1 GTG Facade, South	6.83	17.1	17.1
P1_GTG_W	Proton1 GTG Facade, West	6.83	15.0	15.0
P1_Trans	Proton1 GT Transformer	5.00	9.5	9.5
P2_Air-Int	Proton2 GT Air Intake	13.40	8.7	8.7
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	9.0	9.0
P2_Exh	Proton2 GT Exhaust System	18.00	14.8	14.8
P2_GT_E	Proton2 GT Facade, East	6.83	17.7	17.7
P2_GT_N	Proton2 GT Facade, North	6.83	20.8	20.8
P2_GT_S	Proton2 GT Facade, South	6.83	20.7	20.7
P2_GT_W	Proton2 GT Facade, West	6.83	12.5	12.5
P2_GTG_N	Proton2 GT Facade, North	6.83	17.3	17.3
P2_GTG_S	Proton2 GT Facade, South	6.83	17.5	17.5
P2_GTG_W	Proton2 GT Facade, West	6.83	16.0	16.0
P2_Trans	Proton2 GT Transformer	5.00	9.7	9.7
P3_Air-Int	Proton3 GT Air Intake	13.40	8.8	8.8
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	9.1	9.1
P3_Exh	Proton3 GT Exhaust System	18.00	15.2	15.2
P3_GT_E	Proton3 GT Facade, East	6.83	17.9	17.9
P3_GT_N	Proton3 GT Facade, North	6.83	21.0	21.0
P3_GT_S	Proton3 GT Facade, South	6.83	21.1	21.1
P3_GT_W	Proton3 GT Facade, West	6.83	12.8	12.8
P3_GTG_N	Proton3 GT Facade, North	6.83	17.5	17.5
P3_GTG_S	Proton3 GT Facade, South	6.83	17.2	17.2
P3_GTG_W	Proton3 GT Facade, West	6.83	15.3	15.3
P3_Trans	Proton3 GT Transformer	5.00	9.9	9.9

All shown dB values are A-weighted

Proton DSP Noise Results (100% Load)

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#5_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#5_A	Residences	1.50	26.7	26.7
P_FGS	Proton Fuel Gas System	3.00	1.9	1.9
P1_Air-Int	Proton1 GT Air Intake	13.40	2.9	2.9
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	3.5	3.5
P1_Exh	Proton1 GT Exhaust System	18.00	8.4	8.4
P1_GT_E	Proton1 GT Facade, East	6.83	11.4	11.4
P1_GT_N	Proton1 GT Facade, North	6.83	15.2	15.2
P1_GT_S	Proton1 GT Facade, South	6.83	14.9	14.9
P1_GT_W	Proton1 GT Facade, West	6.83	8.5	8.5
P1_GTG_N	Proton1 GTG Facade, North	6.83	11.9	11.9
P1_GTG_S	Proton1 GTG Facade, South	6.83	11.7	11.7
P1_GTG_W	Proton1 GTG Facade, West	6.83	9.6	9.6
P1_Trans	Proton1 GT Transformer	5.00	4.3	4.3
P2_Air-Int	Proton2 GT Air Intake	13.40	3.3	3.3
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	4.0	4.0
P2_Exh	Proton2 GT Exhaust System	18.00	8.9	8.9
P2_GT_E	Proton2 GT Facade, East	6.83	12.5	12.5
P2_GT_N	Proton2 GT Facade, North	6.83	15.6	15.6
P2_GT_S	Proton2 GT Facade, South	6.83	15.5	15.5
P2_GT_W	Proton2 GT Facade, West	6.83	7.3	7.3
P2_GTG_N	Proton2 GT Facade, North	6.83	12.2	12.2
P2_GTG_S	Proton2 GT Facade, South	6.83	12.4	12.4
P2_GTG_W	Proton2 GT Facade, West	6.83	10.8	10.8
P2_Trans	Proton2 GT Transformer	5.00	4.7	4.7
P3_Air-Int	Proton3 GT Air Intake	13.40	3.8	3.8
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	4.4	4.4
P3_Exh	Proton3 GT Exhaust System	18.00	9.4	9.4
P3_GT_E	Proton3 GT Facade, East	6.83	12.9	12.9
P3_GT_N	Proton3 GT Facade, North	6.83	16.1	16.1
P3_GT_S	Proton3 GT Facade, South	6.83	16.2	16.2
P3_GT_W	Proton3 GT Facade, West	6.83	7.8	7.8
P3_GTG_N	Proton3 GT Facade, North	6.83	12.6	12.6
P3_GTG_S	Proton3 GT Facade, South	6.83	12.3	12.3
P3_GTG_W	Proton3 GT Facade, West	6.83	10.4	10.4
P3_Trans	Proton3 GT Transformer	5.00	5.1	5.1

All shown dB values are A-weighted

Proton DSP Noise Results (100% Load)

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#6_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#6_A	Residences	1.50	25.7	25.7
P_FGS	Proton Fuel Gas System	3.00	0.7	0.7
P1_Air-Int	Proton1 GT Air Intake	13.40	1.8	1.8
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	2.5	2.5
P1_Exh	Proton1 GT Exhaust System	18.00	7.3	7.3
P1_GT_E	Proton1 GT Facade, East	6.83	10.4	10.4
P1_GT_N	Proton1 GT Facade, North	6.83	14.1	14.1
P1_GT_S	Proton1 GT Facade, South	6.83	13.8	13.8
P1_GT_W	Proton1 GT Facade, West	6.83	7.4	7.4
P1_GTG_N	Proton1 GTG Facade, North	6.83	10.9	10.9
P1_GTG_S	Proton1 GTG Facade, South	6.83	10.6	10.6
P1_GTG_W	Proton1 GTG Facade, West	6.83	8.6	8.6
P1_Trans	Proton1 GT Transformer	5.00	3.2	3.2
P2_Air-Int	Proton2 GT Air Intake	13.40	2.4	2.4
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	3.0	3.0
P2_Exh	Proton2 GT Exhaust System	18.00	7.9	7.9
P2_GT_E	Proton2 GT Facade, East	6.83	11.5	11.5
P2_GT_N	Proton2 GT Facade, North	6.83	14.7	14.7
P2_GT_S	Proton2 GT Facade, South	6.83	14.5	14.5
P2_GT_W	Proton2 GT Facade, West	6.83	6.4	6.4
P2_GTG_N	Proton2 GT Facade, North	6.83	11.2	11.2
P2_GTG_S	Proton2 GT Facade, South	6.83	11.5	11.5
P2_GTG_W	Proton2 GT Facade, West	6.83	9.9	9.9
P2_Trans	Proton2 GT Transformer	5.00	3.8	3.8
P3_Air-Int	Proton3 GT Air Intake	13.40	2.9	2.9
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	2.6	2.6
P3_Exh	Proton3 GT Exhaust System	18.00	8.5	8.5
P3_GT_E	Proton3 GT Facade, East	6.83	12.0	12.0
P3_GT_N	Proton3 GT Facade, North	6.83	15.2	15.2
P3_GT_S	Proton3 GT Facade, South	6.83	15.3	15.3
P3_GT_W	Proton3 GT Facade, West	6.83	7.0	7.0
P3_GTG_N	Proton3 GT Facade, North	6.83	11.8	11.8
P3_GTG_S	Proton3 GT Facade, South	6.83	11.4	11.4
P3_GTG_W	Proton3 GT Facade, West	6.83	9.6	9.6
P3_Trans	Proton3 GT Transformer	5.00	4.3	4.3

All shown dB values are A-weighted

Proton DSP Noise Results (100% Load)

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#7_A - Amena Hotels and Resorts
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#7_A	Amena Hotels and Resorts	1.50	28.4	28.4
P_FGS	Proton Fuel Gas System	3.00	4.4	4.4
P1_Air-Int	Proton1 GT Air Intake	13.40	4.1	4.1
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	6.1	6.1
P1_Exh	Proton1 GT Exhaust System	18.00	9.1	9.1
P1_GT_E	Proton1 GT Facade, East	6.83	13.2	13.2
P1_GT_N	Proton1 GT Facade, North	6.83	16.9	16.9
P1_GT_S	Proton1 GT Facade, South	6.83	16.6	16.6
P1_GT_W	Proton1 GT Facade, West	6.83	10.2	10.2
P1_GTG_N	Proton1 GTG Facade, North	6.83	13.6	13.6
P1_GTG_S	Proton1 GTG Facade, South	6.83	13.4	13.4
P1_GTG_W	Proton1 GTG Facade, West	6.83	11.3	11.3
P1_Trans	Proton1 GT Transformer	5.00	6.6	6.6
P2_Air-Int	Proton2 GT Air Intake	13.40	4.6	4.6
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	6.6	6.6
P2_Exh	Proton2 GT Exhaust System	18.00	9.6	9.6
P2_GT_E	Proton2 GT Facade, East	6.83	14.2	14.2
P2_GT_N	Proton2 GT Facade, North	6.83	17.4	17.4
P2_GT_S	Proton2 GT Facade, South	6.83	17.2	17.2
P2_GT_W	Proton2 GT Facade, West	6.83	9.1	9.1
P2_GTG_N	Proton2 GT Facade, North	6.83	13.9	13.9
P2_GTG_S	Proton2 GT Facade, South	6.83	14.1	14.1
P2_GTG_W	Proton2 GT Facade, West	6.83	12.6	12.6
P2_Trans	Proton2 GT Transformer	5.00	7.1	7.1
P3_Air-Int	Proton3 GT Air Intake	13.40	5.0	5.0
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	7.1	7.1
P3_Exh	Proton3 GT Exhaust System	18.00	10.1	10.1
P3_GT_E	Proton3 GT Facade, East	6.83	14.7	14.7
P3_GT_N	Proton3 GT Facade, North	6.83	17.8	17.8
P3_GT_S	Proton3 GT Facade, South	6.83	17.9	17.9
P3_GT_W	Proton3 GT Facade, West	6.83	9.6	9.6
P3_GTG_N	Proton3 GT Facade, North	6.83	14.4	14.4
P3_GTG_S	Proton3 GT Facade, South	6.83	14.0	14.0
P3_GTG_W	Proton3 GT Facade, West	6.83	12.2	12.2
P3_Trans	Proton3 GT Transformer	5.00	7.5	7.5

All shown dB values are A-weighted

Proton DSP Noise Results (100% Load)

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#8_A - Apostolic Church Miission
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#8_A	Apostolic Church Miission	1.50	27.6	27.6
P_FGS	Proton Fuel Gas System	3.00	3.7	3.7
P1_Air-Int	Proton1 GT Air Intake	13.40	3.3	3.3
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	5.3	5.3
P1_Exh	Proton1 GT Exhaust System	18.00	8.3	8.3
P1_GT_E	Proton1 GT Facade, East	6.83	12.4	12.4
P1_GT_N	Proton1 GT Facade, North	6.83	16.1	16.1
P1_GT_S	Proton1 GT Facade, South	6.83	15.8	15.8
P1_GT_W	Proton1 GT Facade, West	6.83	9.4	9.4
P1_GTG_N	Proton1 GTG Facade, North	6.83	12.9	12.9
P1_GTG_S	Proton1 GTG Facade, South	6.83	12.6	12.6
P1_GTG_W	Proton1 GTG Facade, West	6.83	10.5	10.5
P1_Trans	Proton1 GT Transformer	5.00	5.8	5.8
P2_Air-Int	Proton2 GT Air Intake	13.40	3.7	3.7
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	5.8	5.8
P2_Exh	Proton2 GT Exhaust System	18.00	8.8	8.8
P2_GT_E	Proton2 GT Facade, East	6.83	13.4	13.4
P2_GT_N	Proton2 GT Facade, North	6.83	16.5	16.5
P2_GT_S	Proton2 GT Facade, South	6.83	16.4	16.4
P2_GT_W	Proton2 GT Facade, West	6.83	8.2	8.2
P2_GTG_N	Proton2 GT Facade, North	6.83	13.0	13.0
P2_GTG_S	Proton2 GT Facade, South	6.83	13.3	13.3
P2_GTG_W	Proton2 GT Facade, West	6.83	11.7	11.7
P2_Trans	Proton2 GT Transformer	5.00	6.2	6.2
P3_Air-Int	Proton3 GT Air Intake	13.40	4.1	4.1
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	6.2	6.2
P3_Exh	Proton3 GT Exhaust System	18.00	9.2	9.2
P3_GT_E	Proton3 GT Facade, East	6.83	13.8	13.8
P3_GT_N	Proton3 GT Facade, North	6.83	17.0	17.0
P3_GT_S	Proton3 GT Facade, South	6.83	17.0	17.0
P3_GT_W	Proton3 GT Facade, West	6.83	8.7	8.7
P3_GTG_N	Proton3 GT Facade, North	6.83	13.5	13.5
P3_GTG_S	Proton3 GT Facade, South	6.83	13.1	13.1
P3_GTG_W	Proton3 GT Facade, West	6.83	11.3	11.3
P3_Trans	Proton3 GT Transformer	5.00	6.6	6.6

All shown dB values are A-weighted

Proton DSP Noise Results (100% Load)

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#9_A - Felix Church
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#9_A	Felix Church	1.50	25.2	25.2
P_FGS	Proton Fuel Gas System	3.00	0.9	0.9
P1_Air-Int	Proton1 GT Air Intake	13.40	0.8	0.8
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	2.8	2.8
P1_Exh	Proton1 GT Exhaust System	18.00	5.8	5.8
P1_GT_E	Proton1 GT Facade, East	6.83	9.9	9.9
P1_GT_N	Proton1 GT Facade, North	6.83	13.6	13.6
P1_GT_S	Proton1 GT Facade, South	6.83	13.3	13.3
P1_GT_W	Proton1 GT Facade, West	6.83	6.9	6.9
P1_GTG_N	Proton1 GTG Facade, North	6.83	10.4	10.4
P1_GTG_S	Proton1 GTG Facade, South	6.83	10.2	10.2
P1_GTG_W	Proton1 GTG Facade, West	6.83	8.1	8.1
P1_Trans	Proton1 GT Transformer	5.00	-3.3	-3.3
P2_Air-Int	Proton2 GT Air Intake	13.40	1.5	1.5
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	3.5	3.5
P2_Exh	Proton2 GT Exhaust System	18.00	6.4	6.4
P2_GT_E	Proton2 GT Facade, East	6.83	11.1	11.1
P2_GT_N	Proton2 GT Facade, North	6.83	14.3	14.3
P2_GT_S	Proton2 GT Facade, South	6.83	14.1	14.1
P2_GT_W	Proton2 GT Facade, West	6.83	6.0	6.0
P2_GTG_N	Proton2 GT Facade, North	6.83	10.8	10.8
P2_GTG_S	Proton2 GT Facade, South	6.83	11.1	11.1
P2_GTG_W	Proton2 GT Facade, West	6.83	9.5	9.5
P2_Trans	Proton2 GT Transformer	5.00	-2.3	-2.3
P3_Air-Int	Proton3 GT Air Intake	13.40	2.0	2.0
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	2.7	2.7
P3_Exh	Proton3 GT Exhaust System	18.00	7.0	7.0
P3_GT_E	Proton3 GT Facade, East	6.83	11.6	11.6
P3_GT_N	Proton3 GT Facade, North	6.83	14.9	14.9
P3_GT_S	Proton3 GT Facade, South	6.83	14.9	14.9
P3_GT_W	Proton3 GT Facade, West	6.83	6.7	6.7
P3_GTG_N	Proton3 GT Facade, North	6.83	11.5	11.5
P3_GTG_S	Proton3 GT Facade, South	6.83	11.1	11.1
P3_GTG_W	Proton3 GT Facade, West	6.83	9.3	9.3
P3_Trans	Proton3 GT Transformer	5.00	4.6	4.6

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#1_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#1_A	Residences	1.50	50.9	50.9
C_AirInt1	CMEC/Eurafric GT Air Intake 1	13.40	-2.2	-2.2
C_AirInt2	CMEC/Eurafric GT Air Intake 2	13.40	18.5	18.5
C_AirInt3	CMEC/Eurafric GT Air Intake 3	13.40	18.3	18.3
C_AirInt4	CMEC/Eurafric GT Air Intake 4	13.40	15.6	15.6
C_FGS	CMEC/Eurafric Fuel Gas System	3.00	16.6	16.6
C_GT_E	CMEC/Eurafric GT Facade, East	15.00	39.8	39.8
C_GT_Exh1	CMEC/Eurafric GT Exhaust System 1	18.00	21.2	21.2
C_GT_Exh2	CMEC/Eurafric GT Exhaust System 2	18.00	21.3	21.3
C_GT_Exh3	CMEC/Eurafric GT Exhaust System 3	18.00	21.4	21.4
C_GT_Exh4	CMEC/Eurafric GT Exhaust System 4	18.00	21.5	21.5
C_GT_N	CMEC/Eurafric GT Facade, North	15.00	31.9	31.9
C_GT_S	CMEC/Eurafric GT Facade, South	15.00	33.2	33.2
C_GT_Tran1	CMEC/Eurafric GT Transformer 1	5.00	22.8	22.8
C_GT_Tran2	CMEC/Eurafric GT Transformer 2	5.00	23.0	23.0
C_GT_Tran3	CMEC/Eurafric GT Transformer 3	5.00	23.2	23.2
C_GT_Tran4	CMEC/Eurafric GT Transformer 4	5.00	23.3	23.3
C_GT_W	CMEC/Eurafric GT Facade, West	15.00	40.0	40.0
C_Pump_H	CMEC/Eurafric Pump House	3.00	25.9	25.9
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	37.5	37.5
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	33.7	33.7
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	34.1	34.1
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	34.5	34.5
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	34.9	34.9
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	35.3	35.3
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	35.7	35.7
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	24.7	24.7
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	32.9	32.9
N_FGS	NIPP Fuel Gas System	3.00	17.1	17.1
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	26.1	26.1
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	18.4	18.4
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	12.0	12.0
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	6.0	6.0
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	25.2	25.2
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	26.9	26.9
N1_GT_E	NIPP1 GT Facade, East	15.00	39.4	39.4

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#1_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
N1_GT_N	NIPP1 GT Facade, North	15.00	36.0	36.0
N1_GT_S	NIPP1 GT Facade, South	15.00	25.2	25.2
N1_GT_W	NIPP1 GT Facade, West	15.00	41.9	41.9
N1_Trans1	NIPP1 Transformer 1	5.00	26.2	26.2
N1_Trans2	NIPP1 Transformer 2	5.00	26.8	26.8
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	18.1	18.1
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	18.0	18.0
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	13.4	13.4
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	3.1	3.1
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	23.2	23.2
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	23.1	23.1
N2_GT_E	NIPP2 GT Facade, East	15.00	35.4	35.4
N2_GT_N	NIPP2 GT Facade, North	15.00	41.7	41.7
N2_GT_S	NIPP2 GT Facade, South	15.00	41.9	41.9
N2_GT_W	NIPP2 GT Facade, West	15.00	35.5	35.5
N2_Trans1	NIPP2 Transformer 1	5.00	18.2	18.2
N2_Trans2	NIPP2 Transformer 2	5.00	19.6	19.6
P_FGS	Proton Fuel Gas System	3.00	11.3	11.3
P1_Air-Int	Proton1 GT Air Intake	13.40	13.8	13.8
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	15.3	15.3
P1_Exh	Proton1 GT Exhaust System	18.00	20.6	20.6
P1_GT_E	Proton1 GT Facade, East	6.83	21.0	21.0
P1_GT_N	Proton1 GT Facade, North	6.83	24.7	24.7
P1_GT_S	Proton1 GT Facade, South	6.83	24.5	24.5
P1_GT_W	Proton1 GT Facade, West	6.83	18.0	18.0
P1_GTG_N	Proton1 GTG Facade, North	6.83	21.4	21.4
P1_GTG_S	Proton1 GTG Facade, South	6.83	21.2	21.2
P1_GTG_W	Proton1 GTG Facade, West	6.83	19.1	19.1
P1_Trans	Proton1 GT Transformer	5.00	-7.9	-7.9
P2_Air-Int	Proton2 GT Air Intake	13.40	13.4	13.4
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	14.5	14.5
P2_Exh	Proton2 GT Exhaust System	18.00	20.1	20.1
P2_GT_E	Proton2 GT Facade, East	6.83	21.4	21.4
P2_GT_N	Proton2 GT Facade, North	6.83	24.5	24.5
P2_GT_S	Proton2 GT Facade, South	6.83	24.4	24.4

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#1_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P2_GT_W	Proton2 GT Facade, West	6.83	16.2	16.2
P2_GTG_N	Proton2 GT Facade, North	6.83	20.9	20.9
P2_GTG_S	Proton2 GT Facade, South	6.83	21.2	21.2
P2_GTG_W	Proton2 GT Facade, West	6.83	19.6	19.6
P2_Trans	Proton2 GT Transformer	5.00	-6.1	-6.1
P3_Air-Int	Proton3 GT Air Intake	13.40	13.0	13.0
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	13.7	13.7
P3_Exh	Proton3 GT Exhaust System	18.00	19.6	19.6
P3_GT_E	Proton3 GT Facade, East	6.83	21.2	21.2
P3_GT_N	Proton3 GT Facade, North	6.83	24.2	24.2
P3_GT_S	Proton3 GT Facade, South	6.83	24.4	24.4
P3_GT_W	Proton3 GT Facade, West	6.83	16.0	16.0
P3_GTG_N	Proton3 GT Facade, North	6.83	20.7	20.7
P3_GTG_S	Proton3 GT Facade, South	6.83	20.4	20.4
P3_GTG_W	Proton3 GT Facade, West	6.83	18.5	18.5
P3_Trans	Proton3 GT Transformer	5.00	-7.1	-7.1

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#2_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#2_A	Residences	1.50	43.2	43.2
C_AirInt1	CMEC/Eurafric GT Air Intake 1	13.40	-9.9	-9.9
C_AirInt2	CMEC/Eurafric GT Air Intake 2	13.40	11.7	11.7
C_AirInt3	CMEC/Eurafric GT Air Intake 3	13.40	4.8	4.8
C_AirInt4	CMEC/Eurafric GT Air Intake 4	13.40	4.9	4.9
C_FGS	CMEC/Eurafric Fuel Gas System	3.00	4.1	4.1
C_GT_E	CMEC/Eurafric GT Facade, East	15.00	28.0	28.0
C_GT_Exh1	CMEC/Eurafric GT Exhaust System 1	18.00	8.9	8.9
C_GT_Exh2	CMEC/Eurafric GT Exhaust System 2	18.00	8.3	8.3
C_GT_Exh3	CMEC/Eurafric GT Exhaust System 3	18.00	10.4	10.4
C_GT_Exh4	CMEC/Eurafric GT Exhaust System 4	18.00	10.5	10.5
C_GT_N	CMEC/Eurafric GT Facade, North	15.00	24.3	24.3
C_GT_S	CMEC/Eurafric GT Facade, South	15.00	22.6	22.6
C_GT_Tran1	CMEC/Eurafric GT Transformer 1	5.00	7.2	7.2
C_GT_Tran2	CMEC/Eurafric GT Transformer 2	5.00	7.3	7.3
C_GT_Tran3	CMEC/Eurafric GT Transformer 3	5.00	7.5	7.5
C_GT_Tran4	CMEC/Eurafric GT Transformer 4	5.00	7.6	7.6
C_GT_W	CMEC/Eurafric GT Facade, West	15.00	33.5	33.5
C_Pump_H	CMEC/Eurafric Pump House	3.00	13.7	13.7
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	26.2	26.2
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	25.0	25.0
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	25.4	25.4
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	25.8	25.8
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	26.1	26.1
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	26.5	26.5
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	26.9	26.9
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	13.3	13.3
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	21.7	21.7
N_FGS	NIPP Fuel Gas System	3.00	5.6	5.6
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	13.5	13.5
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	13.9	13.9
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	3.2	3.2
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	-4.8	-4.8
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	21.0	21.0
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	21.7	21.7
N1_GT_E	NIPP1 GT Facade, East	15.00	30.4	30.4

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#2_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
N1_GT_N	NIPP1 GT Facade, North	15.00	29.3	29.3
N1_GT_S	NIPP1 GT Facade, South	15.00	16.3	16.3
N1_GT_W	NIPP1 GT Facade, West	15.00	35.6	35.6
N1_Trans1	NIPP1 Transformer 1	5.00	10.4	10.4
N1_Trans2	NIPP1 Transformer 2	5.00	10.8	10.8
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	5.4	5.4
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	5.2	5.2
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	2.2	2.2
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	-10.6	-10.6
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	12.8	12.8
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	12.5	12.5
N2_GT_E	NIPP2 GT Facade, East	15.00	22.0	22.0
N2_GT_N	NIPP2 GT Facade, North	15.00	28.4	28.4
N2_GT_S	NIPP2 GT Facade, South	15.00	28.6	28.6
N2_GT_W	NIPP2 GT Facade, West	15.00	22.4	22.4
N2_Trans1	NIPP2 Transformer 1	5.00	8.2	8.2
N2_Trans2	NIPP2 Transformer 2	5.00	8.0	8.0
P_FGS	Proton Fuel Gas System	3.00	8.8	8.8
P1_Air-Int	Proton1 GT Air Intake	13.40	16.7	16.7
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	13.0	13.0
P1_Exh	Proton1 GT Exhaust System	18.00	23.0	23.0
P1_GT_E	Proton1 GT Facade, East	6.83	24.2	24.2
P1_GT_N	Proton1 GT Facade, North	6.83	28.0	28.0
P1_GT_S	Proton1 GT Facade, South	6.83	27.7	27.7
P1_GT_W	Proton1 GT Facade, West	6.83	21.5	21.5
P1_GTG_N	Proton1 GTG Facade, North	6.83	24.9	24.9
P1_GTG_S	Proton1 GTG Facade, South	6.83	24.7	24.7
P1_GTG_W	Proton1 GTG Facade, West	6.83	22.6	22.6
P1_Trans	Proton1 GT Transformer	5.00	-8.4	-8.4
P2_Air-Int	Proton2 GT Air Intake	13.40	15.8	15.8
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	9.6	9.6
P2_Exh	Proton2 GT Exhaust System	18.00	22.1	22.1
P2_GT_E	Proton2 GT Facade, East	6.83	24.0	24.0
P2_GT_N	Proton2 GT Facade, North	6.83	27.2	27.2
P2_GT_S	Proton2 GT Facade, South	6.83	27.2	27.2

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#2_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P2_GT_W	Proton2 GT Facade, West	6.83	19.1	19.1
P2_GTG_N	Proton2 GT Facade, North	6.83	21.6	21.6
P2_GTG_S	Proton2 GT Facade, South	6.83	24.1	24.1
P2_GTG_W	Proton2 GT Facade, West	6.83	19.7	19.7
P2_Trans	Proton2 GT Transformer	5.00	-3.0	-3.0
P3_Air-Int	Proton3 GT Air Intake	13.40	14.9	14.9
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	12.6	12.6
P3_Exh	Proton3 GT Exhaust System	18.00	21.2	21.2
P3_GT_E	Proton3 GT Facade, East	6.83	23.3	23.3
P3_GT_N	Proton3 GT Facade, North	6.83	26.5	26.5
P3_GT_S	Proton3 GT Facade, South	6.83	26.7	26.7
P3_GT_W	Proton3 GT Facade, West	6.83	18.5	18.5
P3_GTG_N	Proton3 GT Facade, North	6.83	20.8	20.8
P3_GTG_S	Proton3 GT Facade, South	6.83	22.9	22.9
P3_GTG_W	Proton3 GT Facade, West	6.83	21.0	21.0
P3_Trans	Proton3 GT Transformer	5.00	-4.4	-4.4

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#3_A - Residence
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#3_A	Residence	1.50	34.6	34.6
C_AirInt1	CMEC/Eurafric GT Air Intake 1	13.40	-8.7	-8.7
C_AirInt2	CMEC/Eurafric GT Air Intake 2	13.40	2.6	2.6
C_AirInt3	CMEC/Eurafric GT Air Intake 3	13.40	2.5	2.5
C_AirInt4	CMEC/Eurafric GT Air Intake 4	13.40	2.4	2.4
C_FGS	CMEC/Eurafric Fuel Gas System	3.00	-2.5	-2.5
C_GT_E	CMEC/Eurafric GT Facade, East	15.00	23.3	23.3
C_GT_Exh1	CMEC/Eurafric GT Exhaust System 1	18.00	4.8	4.8
C_GT_Exh2	CMEC/Eurafric GT Exhaust System 2	18.00	4.7	4.7
C_GT_Exh3	CMEC/Eurafric GT Exhaust System 3	18.00	4.7	4.7
C_GT_Exh4	CMEC/Eurafric GT Exhaust System 4	18.00	4.6	4.6
C_GT_N	CMEC/Eurafric GT Facade, North	15.00	16.0	16.0
C_GT_S	CMEC/Eurafric GT Facade, South	15.00	16.4	16.4
C_GT_Tran1	CMEC/Eurafric GT Transformer 1	5.00	2.8	2.8
C_GT_Tran2	CMEC/Eurafric GT Transformer 2	5.00	2.7	2.7
C_GT_Tran3	CMEC/Eurafric GT Transformer 3	5.00	2.6	2.6
C_GT_Tran4	CMEC/Eurafric GT Transformer 4	5.00	2.6	2.6
C_GT_W	CMEC/Eurafric GT Facade, West	15.00	23.4	23.4
C_Pump_H	CMEC/Eurafric Pump House	3.00	-17.2	-17.2
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	7.7	7.7
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	5.6	5.6
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	5.5	5.5
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	5.4	5.4
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	5.3	5.3
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	5.1	5.1
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	5.0	5.0
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	3.8	3.8
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	-2.5	-2.5
N_FGS	NIPP Fuel Gas System	3.00	-13.7	-13.7
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	1.8	1.8
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	1.6	1.6
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	-2.4	-2.4
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	-17.0	-17.0
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	6.5	6.5
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	6.2	6.2
N1_GT_E	NIPP1 GT Facade, East	15.00	25.5	25.5

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#3_A - Residence
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
N1_GT_N	NIPP1 GT Facade, North	15.00	19.2	19.2
N1_GT_S	NIPP1 GT Facade, South	15.00	18.7	18.7
N1_GT_W	NIPP1 GT Facade, West	15.00	25.5	25.5
N1_Trans1	NIPP1 Transformer 1	5.00	4.4	4.4
N1_Trans2	NIPP1 Transformer 2	5.00	4.2	4.2
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	1.5	1.5
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	1.1	1.1
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	5.4	5.4
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	-1.2	-1.2
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	6.5	6.5
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	6.1	6.1
N2_GT_E	NIPP2 GT Facade, East	15.00	18.4	18.4
N2_GT_N	NIPP2 GT Facade, North	15.00	25.3	25.3
N2_GT_S	NIPP2 GT Facade, South	15.00	25.1	25.1
N2_GT_W	NIPP2 GT Facade, West	15.00	19.3	19.3
N2_Trans1	NIPP2 Transformer 1	5.00	-15.7	-15.7
N2_Trans2	NIPP2 Transformer 2	5.00	-17.3	-17.3
P_FGS	Proton Fuel Gas System	3.00	-1.5	-1.5
P1_Air-Int	Proton1 GT Air Intake	13.40	3.4	3.4
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	5.2	5.2
P1_Exh	Proton1 GT Exhaust System	18.00	8.3	8.3
P1_GT_E	Proton1 GT Facade, East	6.83	12.3	12.3
P1_GT_N	Proton1 GT Facade, North	6.83	16.2	16.2
P1_GT_S	Proton1 GT Facade, South	6.83	15.9	15.9
P1_GT_W	Proton1 GT Facade, West	6.83	9.6	9.6
P1_GTG_N	Proton1 GTG Facade, North	6.83	13.1	13.1
P1_GTG_S	Proton1 GTG Facade, South	6.83	12.8	12.8
P1_GTG_W	Proton1 GTG Facade, West	6.83	10.8	10.8
P1_Trans	Proton1 GT Transformer	5.00	6.0	6.0
P2_Air-Int	Proton2 GT Air Intake	13.40	3.9	3.9
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	5.8	5.8
P2_Exh	Proton2 GT Exhaust System	18.00	8.8	8.8
P2_GT_E	Proton2 GT Facade, East	6.83	13.4	13.4
P2_GT_N	Proton2 GT Facade, North	6.83	16.7	16.7
P2_GT_S	Proton2 GT Facade, South	6.83	16.5	16.5

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#3_A - Residence
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P2_GT_W	Proton2 GT Facade, West	6.83	8.5	8.5
P2_GTG_N	Proton2 GT Facade, North	6.83	13.4	13.4
P2_GTG_S	Proton2 GT Facade, South	6.83	13.6	13.6
P2_GTG_W	Proton2 GT Facade, West	6.83	12.1	12.1
P2_Trans	Proton2 GT Transformer	5.00	6.5	6.5
P3_Air-Int	Proton3 GT Air Intake	13.40	4.4	4.4
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	6.3	6.3
P3_Exh	Proton3 GT Exhaust System	18.00	9.3	9.3
P3_GT_E	Proton3 GT Facade, East	6.83	13.9	13.9
P3_GT_N	Proton3 GT Facade, North	6.83	17.2	17.2
P3_GT_S	Proton3 GT Facade, South	6.83	17.3	17.3
P3_GT_W	Proton3 GT Facade, West	6.83	9.1	9.1
P3_GTG_N	Proton3 GT Facade, North	6.83	13.9	13.9
P3_GTG_S	Proton3 GT Facade, South	6.83	13.6	13.6
P3_GTG_W	Proton3 GT Facade, West	6.83	11.8	11.8
P3_Trans	Proton3 GT Transformer	5.00	7.0	7.0

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#4_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#4_A	Residences	1.50	53.9	53.9
C_AirInt1	CMEC/Eurafric GT Air Intake 1	13.40	9.6	9.6
C_AirInt2	CMEC/Eurafric GT Air Intake 2	13.40	2.0	2.0
C_AirInt3	CMEC/Eurafric GT Air Intake 3	13.40	4.8	4.8
C_AirInt4	CMEC/Eurafric GT Air Intake 4	13.40	3.4	3.4
C_FGS	CMEC/Eurafric Fuel Gas System	3.00	11.8	11.8
C_GT_E	CMEC/Eurafric GT Facade, East	15.00	42.2	42.2
C_GT_Exh1	CMEC/Eurafric GT Exhaust System 1	18.00	25.5	25.5
C_GT_Exh2	CMEC/Eurafric GT Exhaust System 2	18.00	25.4	25.4
C_GT_Exh3	CMEC/Eurafric GT Exhaust System 3	18.00	21.8	21.8
C_GT_Exh4	CMEC/Eurafric GT Exhaust System 4	18.00	23.0	23.0
C_GT_N	CMEC/Eurafric GT Facade, North	15.00	36.4	36.4
C_GT_S	CMEC/Eurafric GT Facade, South	15.00	30.7	30.7
C_GT_Tran1	CMEC/Eurafric GT Transformer 1	5.00	4.0	4.0
C_GT_Tran2	CMEC/Eurafric GT Transformer 2	5.00	-1.6	-1.6
C_GT_Tran3	CMEC/Eurafric GT Transformer 3	5.00	-1.7	-1.7
C_GT_Tran4	CMEC/Eurafric GT Transformer 4	5.00	-1.3	-1.3
C_GT_W	CMEC/Eurafric GT Facade, West	15.00	42.1	42.1
C_Pump_H	CMEC/Eurafric Pump House	3.00	16.7	16.7
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	32.5	32.5
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	25.6	25.6
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	25.4	25.4
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	25.2	25.2
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	25.0	25.0
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	24.8	24.8
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	24.6	24.6
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	24.0	24.0
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	22.8	22.8
N_FGS	NIPP Fuel Gas System	3.00	15.9	15.9
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	21.5	21.5
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	16.0	16.0
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	15.9	15.9
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	19.8	19.8
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	26.6	26.6
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	26.1	26.1
N1_GT_E	NIPP1 GT Facade, East	15.00	44.5	44.5

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#4_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
N1_GT_N	NIPP1 GT Facade, North	15.00	32.1	32.1
N1_GT_S	NIPP1 GT Facade, South	15.00	39.3	39.3
N1_GT_W	NIPP1 GT Facade, West	15.00	43.4	43.4
N1_Trans1	NIPP1 Transformer 1	5.00	1.1	1.1
N1_Trans2	NIPP1 Transformer 2	5.00	-2.6	-2.6
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	22.9	22.9
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	23.3	23.3
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	14.8	14.8
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	16.9	16.9
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	28.2	28.2
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	28.6	28.6
N2_GT_E	NIPP2 GT Facade, East	15.00	41.5	41.5
N2_GT_N	NIPP2 GT Facade, North	15.00	47.5	47.5
N2_GT_S	NIPP2 GT Facade, South	15.00	47.2	47.2
N2_GT_W	NIPP2 GT Facade, West	15.00	40.6	40.6
N2_Trans1	NIPP2 Transformer 1	5.00	-2.3	-2.3
N2_Trans2	NIPP2 Transformer 2	5.00	0.7	0.7
P_FGS	Proton Fuel Gas System	3.00	7.3	7.3
P1_Air-Int	Proton1 GT Air Intake	13.40	8.3	8.3
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	8.8	8.8
P1_Exh	Proton1 GT Exhaust System	18.00	14.4	14.4
P1_GT_E	Proton1 GT Facade, East	6.83	16.9	16.9
P1_GT_N	Proton1 GT Facade, North	6.83	20.6	20.6
P1_GT_S	Proton1 GT Facade, South	6.83	20.4	20.4
P1_GT_W	Proton1 GT Facade, West	6.83	13.9	13.9
P1_GTG_N	Proton1 GTG Facade, North	6.83	17.4	17.4
P1_GTG_S	Proton1 GTG Facade, South	6.83	17.1	17.1
P1_GTG_W	Proton1 GTG Facade, West	6.83	15.0	15.0
P1_Trans	Proton1 GT Transformer	5.00	9.5	9.5
P2_Air-Int	Proton2 GT Air Intake	13.40	8.7	8.7
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	9.0	9.0
P2_Exh	Proton2 GT Exhaust System	18.00	14.8	14.8
P2_GT_E	Proton2 GT Facade, East	6.83	17.7	17.7
P2_GT_N	Proton2 GT Facade, North	6.83	20.8	20.8
P2_GT_S	Proton2 GT Facade, South	6.83	20.7	20.7

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#4_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P2_GT_W	Proton2 GT Facade, West	6.83	12.5	12.5
P2_GTG_N	Proton2 GT Facade, North	6.83	17.3	17.3
P2_GTG_S	Proton2 GT Facade, South	6.83	17.5	17.5
P2_GTG_W	Proton2 GT Facade, West	6.83	16.0	16.0
P2_Trans	Proton2 GT Transformer	5.00	9.7	9.7
P3_Air-Int	Proton3 GT Air Intake	13.40	8.8	8.8
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	9.1	9.1
P3_Exh	Proton3 GT Exhaust System	18.00	15.2	15.2
P3_GT_E	Proton3 GT Facade, East	6.83	17.9	17.9
P3_GT_N	Proton3 GT Facade, North	6.83	21.0	21.0
P3_GT_S	Proton3 GT Facade, South	6.83	21.1	21.1
P3_GT_W	Proton3 GT Facade, West	6.83	12.8	12.8
P3_GTG_N	Proton3 GT Facade, North	6.83	17.5	17.5
P3_GTG_S	Proton3 GT Facade, South	6.83	17.2	17.2
P3_GTG_W	Proton3 GT Facade, West	6.83	15.3	15.3
P3_Trans	Proton3 GT Transformer	5.00	9.9	9.9

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#5_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#5_A	Residences	1.50	46.8	46.8
C_AirInt1	CMEC/Eurafric GT Air Intake 1	13.40	6.1	6.1
C_AirInt2	CMEC/Eurafric GT Air Intake 2	13.40	-1.7	-1.7
C_AirInt3	CMEC/Eurafric GT Air Intake 3	13.40	1.9	1.9
C_AirInt4	CMEC/Eurafric GT Air Intake 4	13.40	1.6	1.6
C_FGS	CMEC/Eurafric Fuel Gas System	3.00	2.3	2.3
C_GT_E	CMEC/Eurafric GT Facade, East	15.00	37.4	37.4
C_GT_Exh1	CMEC/Eurafric GT Exhaust System 1	18.00	18.4	18.4
C_GT_Exh2	CMEC/Eurafric GT Exhaust System 2	18.00	18.3	18.3
C_GT_Exh3	CMEC/Eurafric GT Exhaust System 3	18.00	18.2	18.2
C_GT_Exh4	CMEC/Eurafric GT Exhaust System 4	18.00	19.5	19.5
C_GT_N	CMEC/Eurafric GT Facade, North	15.00	29.9	29.9
C_GT_S	CMEC/Eurafric GT Facade, South	15.00	30.6	30.6
C_GT_Tran1	CMEC/Eurafric GT Transformer 1	5.00	0.1	0.1
C_GT_Tran2	CMEC/Eurafric GT Transformer 2	5.00	2.9	2.9
C_GT_Tran3	CMEC/Eurafric GT Transformer 3	5.00	4.6	4.6
C_GT_Tran4	CMEC/Eurafric GT Transformer 4	5.00	4.3	4.3
C_GT_W	CMEC/Eurafric GT Facade, West	15.00	37.6	37.6
C_Pump_H	CMEC/Eurafric Pump House	3.00	7.3	7.3
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	25.0	25.0
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	18.4	18.4
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	18.2	18.2
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	18.0	18.0
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	17.7	17.7
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	17.5	17.5
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	17.3	17.3
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	16.6	16.6
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	15.2	15.2
N_FGS	NIPP Fuel Gas System	3.00	5.3	5.3
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	14.4	14.4
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	15.1	15.1
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	10.5	10.5
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	12.5	12.5
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	19.5	19.5
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	19.0	19.0
N1_GT_E	NIPP1 GT Facade, East	15.00	32.4	32.4

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#5_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
N1_GT_N	NIPP1 GT Facade, North	15.00	32.1	32.1
N1_GT_S	NIPP1 GT Facade, South	15.00	26.7	26.7
N1_GT_W	NIPP1 GT Facade, West	15.00	34.2	34.2
N1_Trans1	NIPP1 Transformer 1	5.00	-0.5	-0.5
N1_Trans2	NIPP1 Transformer 2	5.00	0.0	0.0
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	15.6	15.6
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	16.7	16.7
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	10.5	10.5
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	12.2	12.2
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	21.0	21.0
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	21.2	21.2
N2_GT_E	NIPP2 GT Facade, East	15.00	33.8	33.8
N2_GT_N	NIPP2 GT Facade, North	15.00	40.2	40.2
N2_GT_S	NIPP2 GT Facade, South	15.00	40.0	40.0
N2_GT_W	NIPP2 GT Facade, West	15.00	33.4	33.4
N2_Trans1	NIPP2 Transformer 1	5.00	-9.4	-9.4
N2_Trans2	NIPP2 Transformer 2	5.00	-9.0	-9.0
P_FGS	Proton Fuel Gas System	3.00	1.9	1.9
P1_Air-Int	Proton1 GT Air Intake	13.40	2.9	2.9
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	3.5	3.5
P1_Exh	Proton1 GT Exhaust System	18.00	8.4	8.4
P1_GT_E	Proton1 GT Facade, East	6.83	11.4	11.4
P1_GT_N	Proton1 GT Facade, North	6.83	15.2	15.2
P1_GT_S	Proton1 GT Facade, South	6.83	14.9	14.9
P1_GT_W	Proton1 GT Facade, West	6.83	8.5	8.5
P1_GTG_N	Proton1 GTG Facade, North	6.83	11.9	11.9
P1_GTG_S	Proton1 GTG Facade, South	6.83	11.7	11.7
P1_GTG_W	Proton1 GTG Facade, West	6.83	9.6	9.6
P1_Trans	Proton1 GT Transformer	5.00	4.3	4.3
P2_Air-Int	Proton2 GT Air Intake	13.40	3.3	3.3
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	4.0	4.0
P2_Exh	Proton2 GT Exhaust System	18.00	8.9	8.9
P2_GT_E	Proton2 GT Facade, East	6.83	12.5	12.5
P2_GT_N	Proton2 GT Facade, North	6.83	15.6	15.6
P2_GT_S	Proton2 GT Facade, South	6.83	15.5	15.5

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#5_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P2_GT_W	Proton2 GT Facade, West	6.83	7.3	7.3
P2_GTG_N	Proton2 GT Facade, North	6.83	12.2	12.2
P2_GTG_S	Proton2 GT Facade, South	6.83	12.4	12.4
P2_GTG_W	Proton2 GT Facade, West	6.83	10.8	10.8
P2_Trans	Proton2 GT Transformer	5.00	4.7	4.7
P3_Air-Int	Proton3 GT Air Intake	13.40	3.8	3.8
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	4.4	4.4
P3_Exh	Proton3 GT Exhaust System	18.00	9.4	9.4
P3_GT_E	Proton3 GT Facade, East	6.83	12.9	12.9
P3_GT_N	Proton3 GT Facade, North	6.83	16.1	16.1
P3_GT_S	Proton3 GT Facade, South	6.83	16.2	16.2
P3_GT_W	Proton3 GT Facade, West	6.83	7.8	7.8
P3_GTG_N	Proton3 GT Facade, North	6.83	12.6	12.6
P3_GTG_S	Proton3 GT Facade, South	6.83	12.3	12.3
P3_GTG_W	Proton3 GT Facade, West	6.83	10.4	10.4
P3_Trans	Proton3 GT Transformer	5.00	5.1	5.1

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#6_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#6_A	Residences	1.50	44.3	44.3
C_AirInt1	CMEC/Eurafric GT Air Intake 1	13.40	2.6	2.6
C_AirInt2	CMEC/Eurafric GT Air Intake 2	13.40	-1.5	-1.5
C_AirInt3	CMEC/Eurafric GT Air Intake 3	13.40	4.1	4.1
C_AirInt4	CMEC/Eurafric GT Air Intake 4	13.40	4.6	4.6
C_FGS	CMEC/Eurafric Fuel Gas System	3.00	-1.3	-1.3
C_GT_E	CMEC/Eurafric GT Facade, East	15.00	33.5	33.5
C_GT_Exh1	CMEC/Eurafric GT Exhaust System 1	18.00	16.5	16.5
C_GT_Exh2	CMEC/Eurafric GT Exhaust System 2	18.00	16.1	16.1
C_GT_Exh3	CMEC/Eurafric GT Exhaust System 3	18.00	15.9	15.9
C_GT_Exh4	CMEC/Eurafric GT Exhaust System 4	18.00	15.8	15.8
C_GT_N	CMEC/Eurafric GT Facade, North	15.00	26.3	26.3
C_GT_S	CMEC/Eurafric GT Facade, South	15.00	26.3	26.3
C_GT_Tran1	CMEC/Eurafric GT Transformer 1	5.00	0.6	0.6
C_GT_Tran2	CMEC/Eurafric GT Transformer 2	5.00	3.5	3.5
C_GT_Tran3	CMEC/Eurafric GT Transformer 3	5.00	3.8	3.8
C_GT_Tran4	CMEC/Eurafric GT Transformer 4	5.00	4.1	4.1
C_GT_W	CMEC/Eurafric GT Facade, West	15.00	33.0	33.0
C_Pump_H	CMEC/Eurafric Pump House	3.00	0.5	0.5
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	22.6	22.6
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	16.1	16.1
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	15.8	15.8
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	15.6	15.6
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	15.4	15.4
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	15.1	15.1
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	14.9	14.9
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	14.3	14.3
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	11.9	11.9
N_FGS	NIPP Fuel Gas System	3.00	3.9	3.9
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	13.1	13.1
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	12.5	12.5
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	1.1	1.1
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	8.8	8.8
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	17.3	17.3
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	16.7	16.7
N1_GT_E	NIPP1 GT Facade, East	15.00	36.2	36.2

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#6_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
N1_GT_N	NIPP1 GT Facade, North	15.00	26.2	26.2
N1_GT_S	NIPP1 GT Facade, South	15.00	29.2	29.2
N1_GT_W	NIPP1 GT Facade, West	15.00	31.6	31.6
N1_Trans1	NIPP1 Transformer 1	5.00	1.1	1.1
N1_Trans2	NIPP1 Transformer 2	5.00	4.1	4.1
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	13.3	13.3
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	13.4	13.4
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	8.1	8.1
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	8.2	8.2
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	18.7	18.7
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	18.8	18.8
N2_GT_E	NIPP2 GT Facade, East	15.00	31.3	31.3
N2_GT_N	NIPP2 GT Facade, North	15.00	37.6	37.6
N2_GT_S	NIPP2 GT Facade, South	15.00	37.3	37.3
N2_GT_W	NIPP2 GT Facade, West	15.00	31.1	31.1
N2_Trans1	NIPP2 Transformer 1	5.00	-12.7	-12.7
N2_Trans2	NIPP2 Transformer 2	5.00	-11.0	-11.0
P_FGS	Proton Fuel Gas System	3.00	0.7	0.7
P1_Air-Int	Proton1 GT Air Intake	13.40	1.8	1.8
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	2.5	2.5
P1_Exh	Proton1 GT Exhaust System	18.00	7.3	7.3
P1_GT_E	Proton1 GT Facade, East	6.83	10.4	10.4
P1_GT_N	Proton1 GT Facade, North	6.83	14.1	14.1
P1_GT_S	Proton1 GT Facade, South	6.83	13.8	13.8
P1_GT_W	Proton1 GT Facade, West	6.83	7.4	7.4
P1_GTG_N	Proton1 GTG Facade, North	6.83	10.9	10.9
P1_GTG_S	Proton1 GTG Facade, South	6.83	10.6	10.6
P1_GTG_W	Proton1 GTG Facade, West	6.83	8.6	8.6
P1_Trans	Proton1 GT Transformer	5.00	3.2	3.2
P2_Air-Int	Proton2 GT Air Intake	13.40	2.4	2.4
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	3.0	3.0
P2_Exh	Proton2 GT Exhaust System	18.00	7.9	7.9
P2_GT_E	Proton2 GT Facade, East	6.83	11.5	11.5
P2_GT_N	Proton2 GT Facade, North	6.83	14.7	14.7
P2_GT_S	Proton2 GT Facade, South	6.83	14.5	14.5

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#6_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P2_GT_W	Proton2 GT Facade, West	6.83	6.4	6.4
P2_GTG_N	Proton2 GT Facade, North	6.83	11.2	11.2
P2_GTG_S	Proton2 GT Facade, South	6.83	11.5	11.5
P2_GTG_W	Proton2 GT Facade, West	6.83	9.9	9.9
P2_Trans	Proton2 GT Transformer	5.00	3.8	3.8
P3_Air-Int	Proton3 GT Air Intake	13.40	2.9	2.9
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	2.6	2.6
P3_Exh	Proton3 GT Exhaust System	18.00	8.5	8.5
P3_GT_E	Proton3 GT Facade, East	6.83	12.0	12.0
P3_GT_N	Proton3 GT Facade, North	6.83	15.2	15.2
P3_GT_S	Proton3 GT Facade, South	6.83	15.3	15.3
P3_GT_W	Proton3 GT Facade, West	6.83	7.0	7.0
P3_GTG_N	Proton3 GT Facade, North	6.83	11.8	11.8
P3_GTG_S	Proton3 GT Facade, South	6.83	11.4	11.4
P3_GTG_W	Proton3 GT Facade, West	6.83	9.6	9.6
P3_Trans	Proton3 GT Transformer	5.00	4.3	4.3

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#7_A - Amena Hotels and Resorts
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#7_A	Amena Hotels and Resorts	1.50	46.8	46.8
C_AirInt1	CMEC/Eurafric GT Air Intake 1	13.40	5.8	5.8
C_AirInt2	CMEC/Eurafric GT Air Intake 2	13.40	-4.5	-4.5
C_AirInt3	CMEC/Eurafric GT Air Intake 3	13.40	0.7	0.7
C_AirInt4	CMEC/Eurafric GT Air Intake 4	13.40	3.1	3.1
C_FGS	CMEC/Eurafric Fuel Gas System	3.00	1.8	1.8
C_GT_E	CMEC/Eurafric GT Facade, East	15.00	35.6	35.6
C_GT_Exh1	CMEC/Eurafric GT Exhaust System 1	18.00	18.3	18.3
C_GT_Exh2	CMEC/Eurafric GT Exhaust System 2	18.00	18.2	18.2
C_GT_Exh3	CMEC/Eurafric GT Exhaust System 3	18.00	18.1	18.1
C_GT_Exh4	CMEC/Eurafric GT Exhaust System 4	18.00	18.1	18.1
C_GT_N	CMEC/Eurafric GT Facade, North	15.00	29.2	29.2
C_GT_S	CMEC/Eurafric GT Facade, South	15.00	27.7	27.7
C_GT_Tran1	CMEC/Eurafric GT Transformer 1	5.00	0.3	0.3
C_GT_Tran2	CMEC/Eurafric GT Transformer 2	5.00	-0.7	-0.7
C_GT_Tran3	CMEC/Eurafric GT Transformer 3	5.00	1.2	1.2
C_GT_Tran4	CMEC/Eurafric GT Transformer 4	5.00	6.5	6.5
C_GT_W	CMEC/Eurafric GT Facade, West	15.00	36.9	36.9
C_Pump_H	CMEC/Eurafric Pump House	3.00	9.5	9.5
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	26.0	26.0
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	19.0	19.0
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	18.8	18.8
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	18.6	18.6
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	18.5	18.5
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	18.2	18.2
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	18.0	18.0
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	17.4	17.4
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	16.4	16.4
N_FGS	NIPP Fuel Gas System	3.00	9.1	9.1
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	14.4	14.4
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	14.1	14.1
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	15.0	15.0
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	12.8	12.8
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	19.7	19.7
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	19.4	19.4
N1_GT_E	NIPP1 GT Facade, East	15.00	34.9	34.9

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#7_A - Amena Hotels and Resorts
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
N1_GT_N	NIPP1 GT Facade, North	15.00	30.0	30.0
N1_GT_S	NIPP1 GT Facade, South	15.00	27.3	27.3
N1_GT_W	NIPP1 GT Facade, West	15.00	35.5	35.5
N1_Trans1	NIPP1 Transformer 1	5.00	-2.8	-2.8
N1_Trans2	NIPP1 Transformer 2	5.00	-1.6	-1.6
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	16.8	16.8
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	16.3	16.3
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	10.7	10.7
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	12.6	12.6
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	21.1	21.1
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	21.7	21.7
N2_GT_E	NIPP2 GT Facade, East	15.00	34.5	34.5
N2_GT_N	NIPP2 GT Facade, North	15.00	40.6	40.6
N2_GT_S	NIPP2 GT Facade, South	15.00	40.4	40.4
N2_GT_W	NIPP2 GT Facade, West	15.00	33.4	33.4
N2_Trans1	NIPP2 Transformer 1	5.00	7.0	7.0
N2_Trans2	NIPP2 Transformer 2	5.00	-8.1	-8.1
P_FGS	Proton Fuel Gas System	3.00	4.4	4.4
P1_Air-Int	Proton1 GT Air Intake	13.40	4.1	4.1
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	6.1	6.1
P1_Exh	Proton1 GT Exhaust System	18.00	9.1	9.1
P1_GT_E	Proton1 GT Facade, East	6.83	13.2	13.2
P1_GT_N	Proton1 GT Facade, North	6.83	16.9	16.9
P1_GT_S	Proton1 GT Facade, South	6.83	16.6	16.6
P1_GT_W	Proton1 GT Facade, West	6.83	10.2	10.2
P1_GTG_N	Proton1 GTG Facade, North	6.83	13.6	13.6
P1_GTG_S	Proton1 GTG Facade, South	6.83	13.4	13.4
P1_GTG_W	Proton1 GTG Facade, West	6.83	11.3	11.3
P1_Trans	Proton1 GT Transformer	5.00	6.6	6.6
P2_Air-Int	Proton2 GT Air Intake	13.40	4.6	4.6
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	6.6	6.6
P2_Exh	Proton2 GT Exhaust System	18.00	9.6	9.6
P2_GT_E	Proton2 GT Facade, East	6.83	14.2	14.2
P2_GT_N	Proton2 GT Facade, North	6.83	17.4	17.4
P2_GT_S	Proton2 GT Facade, South	6.83	17.2	17.2

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#7_A - Amena Hotels and Resorts
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P2_GT_W	Proton2 GT Facade, West	6.83	9.1	9.1
P2_GTG_N	Proton2 GT Facade, North	6.83	13.9	13.9
P2_GTG_S	Proton2 GT Facade, South	6.83	14.1	14.1
P2_GTG_W	Proton2 GT Facade, West	6.83	12.6	12.6
P2_Trans	Proton2 GT Transformer	5.00	7.1	7.1
P3_Air-Int	Proton3 GT Air Intake	13.40	5.0	5.0
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	7.1	7.1
P3_Exh	Proton3 GT Exhaust System	18.00	10.1	10.1
P3_GT_E	Proton3 GT Facade, East	6.83	14.7	14.7
P3_GT_N	Proton3 GT Facade, North	6.83	17.8	17.8
P3_GT_S	Proton3 GT Facade, South	6.83	17.9	17.9
P3_GT_W	Proton3 GT Facade, West	6.83	9.6	9.6
P3_GTG_N	Proton3 GT Facade, North	6.83	14.4	14.4
P3_GTG_S	Proton3 GT Facade, South	6.83	14.0	14.0
P3_GTG_W	Proton3 GT Facade, West	6.83	12.2	12.2
P3_Trans	Proton3 GT Transformer	5.00	7.5	7.5

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#8_A - Apostolic Church Miission
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#8_A	Apostolic Church Miission	1.50	46.5	46.5
C_AirInt1	CMEC/Eurafric GT Air Intake 1	13.40	5.2	5.2
C_AirInt2	CMEC/Eurafric GT Air Intake 2	13.40	-5.6	-5.6
C_AirInt3	CMEC/Eurafric GT Air Intake 3	13.40	-2.8	-2.8
C_AirInt4	CMEC/Eurafric GT Air Intake 4	13.40	-0.5	-0.5
C_FGS	CMEC/Eurafric Fuel Gas System	3.00	4.8	4.8
C_GT_E	CMEC/Eurafric GT Facade, East	15.00	35.3	35.3
C_GT_Exh1	CMEC/Eurafric GT Exhaust System 1	18.00	18.2	18.2
C_GT_Exh2	CMEC/Eurafric GT Exhaust System 2	18.00	18.1	18.1
C_GT_Exh3	CMEC/Eurafric GT Exhaust System 3	18.00	18.0	18.0
C_GT_Exh4	CMEC/Eurafric GT Exhaust System 4	18.00	17.9	17.9
C_GT_N	CMEC/Eurafric GT Facade, North	15.00	29.1	29.1
C_GT_S	CMEC/Eurafric GT Facade, South	15.00	23.4	23.4
C_GT_Tran1	CMEC/Eurafric GT Transformer 1	5.00	-2.6	-2.6
C_GT_Tran2	CMEC/Eurafric GT Transformer 2	5.00	-5.0	-5.0
C_GT_Tran3	CMEC/Eurafric GT Transformer 3	5.00	-4.8	-4.8
C_GT_Tran4	CMEC/Eurafric GT Transformer 4	5.00	4.0	4.0
C_GT_W	CMEC/Eurafric GT Facade, West	15.00	36.0	36.0
C_Pump_H	CMEC/Eurafric Pump House	3.00	8.3	8.3
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	25.3	25.3
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	18.5	18.5
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	18.3	18.3
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	18.0	18.0
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	17.7	17.7
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	17.5	17.5
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	17.3	17.3
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	17.0	17.0
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	15.5	15.5
N_FGS	NIPP Fuel Gas System	3.00	4.6	4.6
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	14.2	14.2
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	13.9	13.9
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	11.1	11.1
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	12.5	12.5
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	19.5	19.5
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	19.1	19.1
N1_GT_E	NIPP1 GT Facade, East	15.00	34.7	34.7

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#8_A - Apostolic Church Miission
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
N1_GT_N	NIPP1 GT Facade, North	15.00	30.6	30.6
N1_GT_S	NIPP1 GT Facade, South	15.00	31.9	31.9
N1_GT_W	NIPP1 GT Facade, West	15.00	35.3	35.3
N1_Trans1	NIPP1 Transformer 1	5.00	-4.4	-4.4
N1_Trans2	NIPP1 Transformer 2	5.00	-2.9	-2.9
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	15.6	15.6
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	16.0	16.0
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	10.4	10.4
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	10.8	10.8
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	20.9	20.9
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	21.3	21.3
N2_GT_E	NIPP2 GT Facade, East	15.00	34.1	34.1
N2_GT_N	NIPP2 GT Facade, North	15.00	40.1	40.1
N2_GT_S	NIPP2 GT Facade, South	15.00	39.9	39.9
N2_GT_W	NIPP2 GT Facade, West	15.00	34.1	34.1
N2_Trans1	NIPP2 Transformer 1	5.00	-8.9	-8.9
N2_Trans2	NIPP2 Transformer 2	5.00	-7.9	-7.9
P_FGS	Proton Fuel Gas System	3.00	3.7	3.7
P1_Air-Int	Proton1 GT Air Intake	13.40	3.3	3.3
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	5.3	5.3
P1_Exh	Proton1 GT Exhaust System	18.00	8.3	8.3
P1_GT_E	Proton1 GT Facade, East	6.83	12.4	12.4
P1_GT_N	Proton1 GT Facade, North	6.83	16.1	16.1
P1_GT_S	Proton1 GT Facade, South	6.83	15.8	15.8
P1_GT_W	Proton1 GT Facade, West	6.83	9.4	9.4
P1_GTG_N	Proton1 GTG Facade, North	6.83	12.9	12.9
P1_GTG_S	Proton1 GTG Facade, South	6.83	12.6	12.6
P1_GTG_W	Proton1 GTG Facade, West	6.83	10.5	10.5
P1_Trans	Proton1 GT Transformer	5.00	5.8	5.8
P2_Air-Int	Proton2 GT Air Intake	13.40	3.7	3.7
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	5.8	5.8
P2_Exh	Proton2 GT Exhaust System	18.00	8.8	8.8
P2_GT_E	Proton2 GT Facade, East	6.83	13.4	13.4
P2_GT_N	Proton2 GT Facade, North	6.83	16.5	16.5
P2_GT_S	Proton2 GT Facade, South	6.83	16.4	16.4

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#8_A - Apostolic Church Miission
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P2_GT_W	Proton2 GT Facade, West	6.83	8.2	8.2
P2_GTG_N	Proton2 GT Facade, North	6.83	13.0	13.0
P2_GTG_S	Proton2 GT Facade, South	6.83	13.3	13.3
P2_GTG_W	Proton2 GT Facade, West	6.83	11.7	11.7
P2_Trans	Proton2 GT Transformer	5.00	6.2	6.2
P3_Air-Int	Proton3 GT Air Intake	13.40	4.1	4.1
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	6.2	6.2
P3_Exh	Proton3 GT Exhaust System	18.00	9.2	9.2
P3_GT_E	Proton3 GT Facade, East	6.83	13.8	13.8
P3_GT_N	Proton3 GT Facade, North	6.83	17.0	17.0
P3_GT_S	Proton3 GT Facade, South	6.83	17.0	17.0
P3_GT_W	Proton3 GT Facade, West	6.83	8.7	8.7
P3_GTG_N	Proton3 GT Facade, North	6.83	13.5	13.5
P3_GTG_S	Proton3 GT Facade, South	6.83	13.1	13.1
P3_GTG_W	Proton3 GT Facade, West	6.83	11.3	11.3
P3_Trans	Proton3 GT Transformer	5.00	6.6	6.6

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#9_A - Felix Church
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#9_A	Felix Church	1.50	39.8	39.8
C_AirInt1	CMEC/Eurafric GT Air Intake 1	13.40	1.3	1.3
C_AirInt2	CMEC/Eurafric GT Air Intake 2	13.40	8.4	8.4
C_AirInt3	CMEC/Eurafric GT Air Intake 3	13.40	8.4	8.4
C_AirInt4	CMEC/Eurafric GT Air Intake 4	13.40	8.3	8.3
C_FGS	CMEC/Eurafric Fuel Gas System	3.00	-2.0	-2.0
C_GT_E	CMEC/Eurafric GT Facade, East	15.00	29.3	29.3
C_GT_Exh1	CMEC/Eurafric GT Exhaust System 1	18.00	11.2	11.2
C_GT_Exh2	CMEC/Eurafric GT Exhaust System 2	18.00	11.1	11.1
C_GT_Exh3	CMEC/Eurafric GT Exhaust System 3	18.00	10.9	10.9
C_GT_Exh4	CMEC/Eurafric GT Exhaust System 4	18.00	10.8	10.8
C_GT_N	CMEC/Eurafric GT Facade, North	15.00	22.7	22.7
C_GT_S	CMEC/Eurafric GT Facade, South	15.00	21.6	21.6
C_GT_Tran1	CMEC/Eurafric GT Transformer 1	5.00	0.5	0.5
C_GT_Tran2	CMEC/Eurafric GT Transformer 2	5.00	0.6	0.6
C_GT_Tran3	CMEC/Eurafric GT Transformer 3	5.00	0.0	0.0
C_GT_Tran4	CMEC/Eurafric GT Transformer 4	5.00	0.1	0.1
C_GT_W	CMEC/Eurafric GT Facade, West	15.00	30.4	30.4
C_Pump_H	CMEC/Eurafric Pump House	3.00	-7.7	-7.7
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	17.3	17.3
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	11.1	11.1
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	10.9	10.9
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	10.7	10.7
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	10.5	10.5
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	10.2	10.2
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	10.0	10.0
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	9.3	9.3
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	1.5	1.5
N_FGS	NIPP Fuel Gas System	3.00	1.8	1.8
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	8.4	8.4
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	9.0	9.0
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	10.8	10.8
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	7.8	7.8
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	12.3	12.3
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	11.8	11.8
N1_GT_E	NIPP1 GT Facade, East	15.00	27.5	27.5

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#9_A - Felix Church
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
N1_GT_N	NIPP1 GT Facade, North	15.00	24.5	24.5
N1_GT_S	NIPP1 GT Facade, South	15.00	20.9	20.9
N1_GT_W	NIPP1 GT Facade, West	15.00	31.1	31.1
N1_Trans1	NIPP1 Transformer 1	5.00	5.1	5.1
N1_Trans2	NIPP1 Transformer 2	5.00	8.3	8.3
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	8.2	8.2
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	8.2	8.2
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	0.2	0.2
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	3.0	3.0
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	13.6	13.6
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	13.6	13.6
N2_GT_E	NIPP2 GT Facade, East	15.00	26.0	26.0
N2_GT_N	NIPP2 GT Facade, North	15.00	32.6	32.6
N2_GT_S	NIPP2 GT Facade, South	15.00	32.3	32.3
N2_GT_W	NIPP2 GT Facade, West	15.00	26.0	26.0
N2_Trans1	NIPP2 Transformer 1	5.00	-1.2	-1.2
N2_Trans2	NIPP2 Transformer 2	5.00	-15.1	-15.1
P_FGS	Proton Fuel Gas System	3.00	0.9	0.9
P1_Air-Int	Proton1 GT Air Intake	13.40	0.8	0.8
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	2.8	2.8
P1_Exh	Proton1 GT Exhaust System	18.00	5.8	5.8
P1_GT_E	Proton1 GT Facade, East	6.83	9.9	9.9
P1_GT_N	Proton1 GT Facade, North	6.83	13.6	13.6
P1_GT_S	Proton1 GT Facade, South	6.83	13.3	13.3
P1_GT_W	Proton1 GT Facade, West	6.83	6.9	6.9
P1_GTG_N	Proton1 GTG Facade, North	6.83	10.4	10.4
P1_GTG_S	Proton1 GTG Facade, South	6.83	10.2	10.2
P1_GTG_W	Proton1 GTG Facade, West	6.83	8.1	8.1
P1_Trans	Proton1 GT Transformer	5.00	-3.3	-3.3
P2_Air-Int	Proton2 GT Air Intake	13.40	1.5	1.5
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	3.5	3.5
P2_Exh	Proton2 GT Exhaust System	18.00	6.4	6.4
P2_GT_E	Proton2 GT Facade, East	6.83	11.1	11.1
P2_GT_N	Proton2 GT Facade, North	6.83	14.3	14.3
P2_GT_S	Proton2 GT Facade, South	6.83	14.1	14.1

All shown dB values are A-weighted

Proton Energy Project Noise Results - Maximum Nameplate Capacity

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#9_A - Felix Church
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P2_GT_W	Proton2 GT Facade, West	6.83	6.0	6.0
P2_GTG_N	Proton2 GT Facade, North	6.83	10.8	10.8
P2_GTG_S	Proton2 GT Facade, South	6.83	11.1	11.1
P2_GTG_W	Proton2 GT Facade, West	6.83	9.5	9.5
P2_Trans	Proton2 GT Transformer	5.00	-2.3	-2.3
P3_Air-Int	Proton3 GT Air Intake	13.40	2.0	2.0
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	2.7	2.7
P3_Exh	Proton3 GT Exhaust System	18.00	7.0	7.0
P3_GT_E	Proton3 GT Facade, East	6.83	11.6	11.6
P3_GT_N	Proton3 GT Facade, North	6.83	14.9	14.9
P3_GT_S	Proton3 GT Facade, South	6.83	14.9	14.9
P3_GT_W	Proton3 GT Facade, West	6.83	6.7	6.7
P3_GTG_N	Proton3 GT Facade, North	6.83	11.5	11.5
P3_GTG_S	Proton3 GT Facade, South	6.83	11.1	11.1
P3_GTG_W	Proton3 GT Facade, West	6.83	9.3	9.3
P3_Trans	Proton3 GT Transformer	5.00	4.6	4.6

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#1_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#1_A	Residences	1.50	47.4	47.4
C_Pump_H	CMEC/Eurafric Pump House	3.00	25.9	25.9
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	37.6	37.6
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	30.7	30.7
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	31.1	31.1
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	31.5	31.5
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	31.9	31.9
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	32.3	32.3
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	32.7	32.7
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	24.7	24.7
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	32.8	32.8
N_FGS	NIPP Fuel Gas System	3.00	14.1	14.1
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	23.1	23.1
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	15.4	15.4
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	9.0	9.0
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	3.0	3.0
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	22.2	22.2
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	23.9	23.9
N1_GT_E	NIPP1 GT Facade, East	15.00	36.4	36.4
N1_GT_N	NIPP1 GT Facade, North	15.00	33.1	33.1
N1_GT_S	NIPP1 GT Facade, South	15.00	22.5	22.5
N1_GT_W	NIPP1 GT Facade, West	15.00	38.9	38.9
N1_Trans1	NIPP1 Transformer 1	5.00	23.2	23.2
N1_Trans2	NIPP1 Transformer 2	5.00	23.8	23.8
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	15.1	15.1
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	15.0	15.0
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	10.4	10.4
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	0.1	0.1
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	20.2	20.2
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	20.1	20.1
N2_GT_E	NIPP2 GT Facade, East	15.00	32.4	32.4
N2_GT_N	NIPP2 GT Facade, North	15.00	38.6	38.6
N2_GT_S	NIPP2 GT Facade, South	15.00	38.9	38.9
N2_GT_W	NIPP2 GT Facade, West	15.00	32.5	32.5
N2_Trans1	NIPP2 Transformer 1	5.00	15.2	15.2
N2_Trans2	NIPP2 Transformer 2	5.00	16.6	16.6

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#1_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P_FGS	Proton Fuel Gas System	3.00	11.3	11.3
P1_Air-Int	Proton1 GT Air Intake	13.40	13.8	13.8
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	15.3	15.3
P1_Exh	Proton1 GT Exhaust System	18.00	20.6	20.6
P1_GT_E	Proton1 GT Facade, East	6.83	21.0	21.0
P1_GT_N	Proton1 GT Facade, North	6.83	24.7	24.7
P1_GT_S	Proton1 GT Facade, South	6.83	24.5	24.5
P1_GT_W	Proton1 GT Facade, West	6.83	18.0	18.0
P1_GTG_N	Proton1 GTG Facade, North	6.83	21.4	21.4
P1_GTG_S	Proton1 GTG Facade, South	6.83	21.2	21.2
P1_GTG_W	Proton1 GTG Facade, West	6.83	19.1	19.1
P1_Trans	Proton1 GT Transformer	5.00	-7.9	-7.9
P2_Air-Int	Proton2 GT Air Intake	13.40	13.4	13.4
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	14.5	14.5
P2_Exh	Proton2 GT Exhaust System	18.00	20.1	20.1
P2_GT_E	Proton2 GT Facade, East	6.83	21.4	21.4
P2_GT_N	Proton2 GT Facade, North	6.83	24.5	24.5
P2_GT_S	Proton2 GT Facade, South	6.83	24.4	24.4
P2_GT_W	Proton2 GT Facade, West	6.83	16.2	16.2
P2_GTG_N	Proton2 GT Facade, North	6.83	20.9	20.9
P2_GTG_S	Proton2 GT Facade, South	6.83	21.2	21.2
P2_GTG_W	Proton2 GT Facade, West	6.83	19.6	19.6
P2_Trans	Proton2 GT Transformer	5.00	-6.1	-6.1
P3_Air-Int	Proton3 GT Air Intake	13.40	13.0	13.0
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	13.7	13.7
P3_Exh	Proton3 GT Exhaust System	18.00	19.6	19.6
P3_GT_E	Proton3 GT Facade, East	6.83	21.2	21.2
P3_GT_N	Proton3 GT Facade, North	6.83	24.2	24.2
P3_GT_S	Proton3 GT Facade, South	6.83	24.4	24.4
P3_GT_W	Proton3 GT Facade, West	6.83	16.0	16.0
P3_GTG_N	Proton3 GT Facade, North	6.83	20.7	20.7
P3_GTG_S	Proton3 GT Facade, South	6.83	20.4	20.4
P3_GTG_W	Proton3 GT Facade, West	6.83	18.5	18.5
P3_Trans	Proton3 GT Transformer	5.00	-7.1	-7.1

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#2_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#2_A	Residences	1.50	40.9	40.9
C_Pump_H	CMEC/Eurafric Pump House	3.00	13.7	13.7
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	26.2	26.2
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	22.0	22.0
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	22.4	22.4
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	22.8	22.8
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	23.1	23.1
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	23.5	23.5
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	23.9	23.9
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	13.3	13.3
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	21.6	21.6
N_FGS	NIPP Fuel Gas System	3.00	2.6	2.6
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	10.5	10.5
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	10.9	10.9
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	0.2	0.2
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	-7.8	-7.8
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	18.0	18.0
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	18.7	18.7
N1_GT_E	NIPP1 GT Facade, East	15.00	27.3	27.3
N1_GT_N	NIPP1 GT Facade, North	15.00	26.6	26.6
N1_GT_S	NIPP1 GT Facade, South	15.00	13.6	13.6
N1_GT_W	NIPP1 GT Facade, West	15.00	32.9	32.9
N1_Trans1	NIPP1 Transformer 1	5.00	7.4	7.4
N1_Trans2	NIPP1 Transformer 2	5.00	7.8	7.8
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	2.4	2.4
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	2.2	2.2
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	-0.9	-0.9
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	-13.6	-13.6
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	9.8	9.8
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	9.5	9.5
N2_GT_E	NIPP2 GT Facade, East	15.00	19.0	19.0
N2_GT_N	NIPP2 GT Facade, North	15.00	25.3	25.3
N2_GT_S	NIPP2 GT Facade, South	15.00	25.6	25.6
N2_GT_W	NIPP2 GT Facade, West	15.00	19.4	19.4
N2_Trans1	NIPP2 Transformer 1	5.00	5.2	5.2
N2_Trans2	NIPP2 Transformer 2	5.00	5.0	5.0

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#2_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P_FGS	Proton Fuel Gas System	3.00	8.8	8.8
P1_Air-Int	Proton1 GT Air Intake	13.40	16.7	16.7
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	13.0	13.0
P1_Exh	Proton1 GT Exhaust System	18.00	23.0	23.0
P1_GT_E	Proton1 GT Facade, East	6.83	24.2	24.2
P1_GT_N	Proton1 GT Facade, North	6.83	28.0	28.0
P1_GT_S	Proton1 GT Facade, South	6.83	27.7	27.7
P1_GT_W	Proton1 GT Facade, West	6.83	21.5	21.5
P1_GTG_N	Proton1 GTG Facade, North	6.83	24.9	24.9
P1_GTG_S	Proton1 GTG Facade, South	6.83	24.7	24.7
P1_GTG_W	Proton1 GTG Facade, West	6.83	22.6	22.6
P1_Trans	Proton1 GT Transformer	5.00	-8.4	-8.4
P2_Air-Int	Proton2 GT Air Intake	13.40	15.8	15.8
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	9.6	9.6
P2_Exh	Proton2 GT Exhaust System	18.00	22.1	22.1
P2_GT_E	Proton2 GT Facade, East	6.83	24.0	24.0
P2_GT_N	Proton2 GT Facade, North	6.83	27.2	27.2
P2_GT_S	Proton2 GT Facade, South	6.83	27.2	27.2
P2_GT_W	Proton2 GT Facade, West	6.83	19.1	19.1
P2_GTG_N	Proton2 GT Facade, North	6.83	21.6	21.6
P2_GTG_S	Proton2 GT Facade, South	6.83	24.1	24.1
P2_GTG_W	Proton2 GT Facade, West	6.83	19.7	19.7
P2_Trans	Proton2 GT Transformer	5.00	-3.0	-3.0
P3_Air-Int	Proton3 GT Air Intake	13.40	14.9	14.9
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	12.6	12.6
P3_Exh	Proton3 GT Exhaust System	18.00	21.2	21.2
P3_GT_E	Proton3 GT Facade, East	6.83	23.3	23.3
P3_GT_N	Proton3 GT Facade, North	6.83	26.5	26.5
P3_GT_S	Proton3 GT Facade, South	6.83	26.7	26.7
P3_GT_W	Proton3 GT Facade, West	6.83	18.5	18.5
P3_GTG_N	Proton3 GT Facade, North	6.83	20.8	20.8
P3_GTG_S	Proton3 GT Facade, South	6.83	22.9	22.9
P3_GTG_W	Proton3 GT Facade, West	6.83	21.0	21.0
P3_Trans	Proton3 GT Transformer	5.00	-4.4	-4.4

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#3_A - Residence
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#3_A	Residence	1.50	31.7	31.7
C_Pump_H	CMEC/Eurafric Pump House	3.00	-17.2	-17.2
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	7.6	7.6
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	2.6	2.6
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	2.5	2.5
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	2.4	2.4
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	2.3	2.3
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	2.1	2.1
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	2.0	2.0
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	3.8	3.8
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	-2.6	-2.6
N_FGS	NIPP Fuel Gas System	3.00	-16.7	-16.7
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	-1.2	-1.2
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	-1.4	-1.4
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	-5.4	-5.4
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	-20.0	-20.0
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	3.5	3.5
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	3.2	3.2
N1_GT_E	NIPP1 GT Facade, East	15.00	22.5	22.5
N1_GT_N	NIPP1 GT Facade, North	15.00	16.3	16.3
N1_GT_S	NIPP1 GT Facade, South	15.00	16.3	16.3
N1_GT_W	NIPP1 GT Facade, West	15.00	22.5	22.5
N1_Trans1	NIPP1 Transformer 1	5.00	1.4	1.4
N1_Trans2	NIPP1 Transformer 2	5.00	1.2	1.2
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	-1.5	-1.5
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	-1.9	-1.9
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	2.4	2.4
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	-4.2	-4.2
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	3.5	3.5
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	3.1	3.1
N2_GT_E	NIPP2 GT Facade, East	15.00	15.4	15.4
N2_GT_N	NIPP2 GT Facade, North	15.00	22.2	22.2
N2_GT_S	NIPP2 GT Facade, South	15.00	22.1	22.1
N2_GT_W	NIPP2 GT Facade, West	15.00	16.3	16.3
N2_Trans1	NIPP2 Transformer 1	5.00	-18.7	-18.7
N2_Trans2	NIPP2 Transformer 2	5.00	-20.3	-20.3

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#3_A - Residence
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P_FGS	Proton Fuel Gas System	3.00	-1.5	-1.5
P1_Air-Int	Proton1 GT Air Intake	13.40	3.4	3.4
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	5.2	5.2
P1_Exh	Proton1 GT Exhaust System	18.00	8.3	8.3
P1_GT_E	Proton1 GT Facade, East	6.83	12.3	12.3
P1_GT_N	Proton1 GT Facade, North	6.83	16.2	16.2
P1_GT_S	Proton1 GT Facade, South	6.83	15.9	15.9
P1_GT_W	Proton1 GT Facade, West	6.83	9.6	9.6
P1_GTG_N	Proton1 GTG Facade, North	6.83	13.1	13.1
P1_GTG_S	Proton1 GTG Facade, South	6.83	12.8	12.8
P1_GTG_W	Proton1 GTG Facade, West	6.83	10.8	10.8
P1_Trans	Proton1 GT Transformer	5.00	6.0	6.0
P2_Air-Int	Proton2 GT Air Intake	13.40	3.9	3.9
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	5.8	5.8
P2_Exh	Proton2 GT Exhaust System	18.00	8.8	8.8
P2_GT_E	Proton2 GT Facade, East	6.83	13.4	13.4
P2_GT_N	Proton2 GT Facade, North	6.83	16.7	16.7
P2_GT_S	Proton2 GT Facade, South	6.83	16.5	16.5
P2_GT_W	Proton2 GT Facade, West	6.83	8.5	8.5
P2_GTG_N	Proton2 GT Facade, North	6.83	13.4	13.4
P2_GTG_S	Proton2 GT Facade, South	6.83	13.6	13.6
P2_GTG_W	Proton2 GT Facade, West	6.83	12.1	12.1
P2_Trans	Proton2 GT Transformer	5.00	6.5	6.5
P3_Air-Int	Proton3 GT Air Intake	13.40	4.4	4.4
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	6.3	6.3
P3_Exh	Proton3 GT Exhaust System	18.00	9.3	9.3
P3_GT_E	Proton3 GT Facade, East	6.83	13.9	13.9
P3_GT_N	Proton3 GT Facade, North	6.83	17.2	17.2
P3_GT_S	Proton3 GT Facade, South	6.83	17.3	17.3
P3_GT_W	Proton3 GT Facade, West	6.83	9.1	9.1
P3_GTG_N	Proton3 GT Facade, North	6.83	13.9	13.9
P3_GTG_S	Proton3 GT Facade, South	6.83	13.6	13.6
P3_GTG_W	Proton3 GT Facade, West	6.83	11.8	11.8
P3_Trans	Proton3 GT Transformer	5.00	7.0	7.0

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#4_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#4_A	Residences	1.50	50.2	50.2
C_Pump_H	CMEC/Eurafric Pump House	3.00	16.7	16.7
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	32.4	32.4
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	22.6	22.6
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	22.4	22.4
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	22.2	22.2
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	22.0	22.0
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	21.8	21.8
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	21.6	21.6
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	24.0	24.0
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	22.7	22.7
N_FGS	NIPP Fuel Gas System	3.00	12.9	12.9
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	18.5	18.5
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	13.0	13.0
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	12.9	12.9
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	16.8	16.8
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	23.6	23.6
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	23.1	23.1
N1_GT_E	NIPP1 GT Facade, East	15.00	41.7	41.7
N1_GT_N	NIPP1 GT Facade, North	15.00	29.2	29.2
N1_GT_S	NIPP1 GT Facade, South	15.00	36.9	36.9
N1_GT_W	NIPP1 GT Facade, West	15.00	40.0	40.0
N1_Trans1	NIPP1 Transformer 1	5.00	-1.9	-1.9
N1_Trans2	NIPP1 Transformer 2	5.00	-5.6	-5.6
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	19.9	19.9
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	20.3	20.3
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	11.8	11.8
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	13.9	13.9
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	25.2	25.2
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	25.6	25.6
N2_GT_E	NIPP2 GT Facade, East	15.00	38.5	38.5
N2_GT_N	NIPP2 GT Facade, North	15.00	44.4	44.4
N2_GT_S	NIPP2 GT Facade, South	15.00	44.2	44.2
N2_GT_W	NIPP2 GT Facade, West	15.00	37.6	37.6
N2_Trans1	NIPP2 Transformer 1	5.00	-5.3	-5.3
N2_Trans2	NIPP2 Transformer 2	5.00	-2.3	-2.3

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#4_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P_FGS	Proton Fuel Gas System	3.00	7.3	7.3
P1_Air-Int	Proton1 GT Air Intake	13.40	8.3	8.3
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	8.8	8.8
P1_Exh	Proton1 GT Exhaust System	18.00	14.4	14.4
P1_GT_E	Proton1 GT Facade, East	6.83	16.9	16.9
P1_GT_N	Proton1 GT Facade, North	6.83	20.6	20.6
P1_GT_S	Proton1 GT Facade, South	6.83	20.4	20.4
P1_GT_W	Proton1 GT Facade, West	6.83	13.9	13.9
P1_GTG_N	Proton1 GTG Facade, North	6.83	17.4	17.4
P1_GTG_S	Proton1 GTG Facade, South	6.83	17.1	17.1
P1_GTG_W	Proton1 GTG Facade, West	6.83	15.0	15.0
P1_Trans	Proton1 GT Transformer	5.00	9.5	9.5
P2_Air-Int	Proton2 GT Air Intake	13.40	8.7	8.7
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	9.0	9.0
P2_Exh	Proton2 GT Exhaust System	18.00	14.8	14.8
P2_GT_E	Proton2 GT Facade, East	6.83	17.7	17.7
P2_GT_N	Proton2 GT Facade, North	6.83	20.8	20.8
P2_GT_S	Proton2 GT Facade, South	6.83	20.7	20.7
P2_GT_W	Proton2 GT Facade, West	6.83	12.5	12.5
P2_GTG_N	Proton2 GT Facade, North	6.83	17.3	17.3
P2_GTG_S	Proton2 GT Facade, South	6.83	17.5	17.5
P2_GTG_W	Proton2 GT Facade, West	6.83	16.0	16.0
P2_Trans	Proton2 GT Transformer	5.00	9.7	9.7
P3_Air-Int	Proton3 GT Air Intake	13.40	8.8	8.8
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	9.1	9.1
P3_Exh	Proton3 GT Exhaust System	18.00	15.2	15.2
P3_GT_E	Proton3 GT Facade, East	6.83	17.9	17.9
P3_GT_N	Proton3 GT Facade, North	6.83	21.0	21.0
P3_GT_S	Proton3 GT Facade, South	6.83	21.1	21.1
P3_GT_W	Proton3 GT Facade, West	6.83	12.8	12.8
P3_GTG_N	Proton3 GT Facade, North	6.83	17.5	17.5
P3_GTG_S	Proton3 GT Facade, South	6.83	17.2	17.2
P3_GTG_W	Proton3 GT Facade, West	6.83	15.3	15.3
P3_Trans	Proton3 GT Transformer	5.00	9.9	9.9

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#5_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#5_A	Residences	1.50	42.3	42.3
C_Pump_H	CMEC/Eurafric Pump House	3.00	7.3	7.3
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	24.9	24.9
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	15.4	15.4
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	15.2	15.2
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	15.0	15.0
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	14.7	14.7
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	14.5	14.5
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	14.3	14.3
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	16.6	16.6
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	15.1	15.1
N_FGS	NIPP Fuel Gas System	3.00	2.3	2.3
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	11.4	11.4
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	12.1	12.1
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	7.5	7.5
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	9.5	9.5
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	16.5	16.5
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	16.0	16.0
N1_GT_E	NIPP1 GT Facade, East	15.00	29.3	29.3
N1_GT_N	NIPP1 GT Facade, North	15.00	29.2	29.2
N1_GT_S	NIPP1 GT Facade, South	15.00	24.3	24.3
N1_GT_W	NIPP1 GT Facade, West	15.00	31.1	31.1
N1_Trans1	NIPP1 Transformer 1	5.00	-3.5	-3.5
N1_Trans2	NIPP1 Transformer 2	5.00	-3.0	-3.0
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	12.6	12.6
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	13.7	13.7
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	7.5	7.5
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	9.2	9.2
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	18.0	18.0
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	18.2	18.2
N2_GT_E	NIPP2 GT Facade, East	15.00	30.8	30.8
N2_GT_N	NIPP2 GT Facade, North	15.00	37.2	37.2
N2_GT_S	NIPP2 GT Facade, South	15.00	37.1	37.1
N2_GT_W	NIPP2 GT Facade, West	15.00	30.4	30.4
N2_Trans1	NIPP2 Transformer 1	5.00	-12.4	-12.4
N2_Trans2	NIPP2 Transformer 2	5.00	-12.0	-12.0

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#5_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P_FGS	Proton Fuel Gas System	3.00	1.9	1.9
P1_Air-Int	Proton1 GT Air Intake	13.40	2.9	2.9
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	3.5	3.5
P1_Exh	Proton1 GT Exhaust System	18.00	8.4	8.4
P1_GT_E	Proton1 GT Facade, East	6.83	11.4	11.4
P1_GT_N	Proton1 GT Facade, North	6.83	15.2	15.2
P1_GT_S	Proton1 GT Facade, South	6.83	14.9	14.9
P1_GT_W	Proton1 GT Facade, West	6.83	8.5	8.5
P1_GTG_N	Proton1 GTG Facade, North	6.83	11.9	11.9
P1_GTG_S	Proton1 GTG Facade, South	6.83	11.7	11.7
P1_GTG_W	Proton1 GTG Facade, West	6.83	9.6	9.6
P1_Trans	Proton1 GT Transformer	5.00	4.3	4.3
P2_Air-Int	Proton2 GT Air Intake	13.40	3.3	3.3
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	4.0	4.0
P2_Exh	Proton2 GT Exhaust System	18.00	8.9	8.9
P2_GT_E	Proton2 GT Facade, East	6.83	12.5	12.5
P2_GT_N	Proton2 GT Facade, North	6.83	15.6	15.6
P2_GT_S	Proton2 GT Facade, South	6.83	15.5	15.5
P2_GT_W	Proton2 GT Facade, West	6.83	7.3	7.3
P2_GTG_N	Proton2 GT Facade, North	6.83	12.2	12.2
P2_GTG_S	Proton2 GT Facade, South	6.83	12.4	12.4
P2_GTG_W	Proton2 GT Facade, West	6.83	10.8	10.8
P2_Trans	Proton2 GT Transformer	5.00	4.7	4.7
P3_Air-Int	Proton3 GT Air Intake	13.40	3.8	3.8
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	4.4	4.4
P3_Exh	Proton3 GT Exhaust System	18.00	9.4	9.4
P3_GT_E	Proton3 GT Facade, East	6.83	12.9	12.9
P3_GT_N	Proton3 GT Facade, North	6.83	16.1	16.1
P3_GT_S	Proton3 GT Facade, South	6.83	16.2	16.2
P3_GT_W	Proton3 GT Facade, West	6.83	7.8	7.8
P3_GTG_N	Proton3 GT Facade, North	6.83	12.6	12.6
P3_GTG_S	Proton3 GT Facade, South	6.83	12.3	12.3
P3_GTG_W	Proton3 GT Facade, West	6.83	10.4	10.4
P3_Trans	Proton3 GT Transformer	5.00	5.1	5.1

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#6_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#6_A	Residences	1.50	40.5	40.5
C_Pump_H	CMEC/Eurafric Pump House	3.00	0.5	0.5
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	22.5	22.5
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	13.1	13.1
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	12.8	12.8
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	12.6	12.6
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	12.4	12.4
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	12.1	12.1
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	11.9	11.9
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	14.3	14.3
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	11.8	11.8
N_FGS	NIPP Fuel Gas System	3.00	0.9	0.9
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	10.1	10.1
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	9.5	9.5
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	-1.9	-1.9
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	5.8	5.8
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	14.3	14.3
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	13.7	13.7
N1_GT_E	NIPP1 GT Facade, East	15.00	33.1	33.1
N1_GT_N	NIPP1 GT Facade, North	15.00	21.9	21.9
N1_GT_S	NIPP1 GT Facade, South	15.00	26.1	26.1
N1_GT_W	NIPP1 GT Facade, West	15.00	28.5	28.5
N1_Trans1	NIPP1 Transformer 1	5.00	-1.9	-1.9
N1_Trans2	NIPP1 Transformer 2	5.00	1.1	1.1
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	10.3	10.3
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	10.4	10.4
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	5.1	5.1
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	5.2	5.2
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	15.7	15.7
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	15.8	15.8
N2_GT_E	NIPP2 GT Facade, East	15.00	28.3	28.3
N2_GT_N	NIPP2 GT Facade, North	15.00	34.6	34.6
N2_GT_S	NIPP2 GT Facade, South	15.00	34.3	34.3
N2_GT_W	NIPP2 GT Facade, West	15.00	28.1	28.1
N2_Trans1	NIPP2 Transformer 1	5.00	-15.7	-15.7
N2_Trans2	NIPP2 Transformer 2	5.00	-14.0	-14.0

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#6_A - Residences
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P_FGS	Proton Fuel Gas System	3.00	0.7	0.7
P1_Air-Int	Proton1 GT Air Intake	13.40	1.8	1.8
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	2.5	2.5
P1_Exh	Proton1 GT Exhaust System	18.00	7.3	7.3
P1_GT_E	Proton1 GT Facade, East	6.83	10.4	10.4
P1_GT_N	Proton1 GT Facade, North	6.83	14.1	14.1
P1_GT_S	Proton1 GT Facade, South	6.83	13.8	13.8
P1_GT_W	Proton1 GT Facade, West	6.83	7.4	7.4
P1_GTG_N	Proton1 GTG Facade, North	6.83	10.9	10.9
P1_GTG_S	Proton1 GTG Facade, South	6.83	10.6	10.6
P1_GTG_W	Proton1 GTG Facade, West	6.83	8.6	8.6
P1_Trans	Proton1 GT Transformer	5.00	3.2	3.2
P2_Air-Int	Proton2 GT Air Intake	13.40	2.4	2.4
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	3.0	3.0
P2_Exh	Proton2 GT Exhaust System	18.00	7.9	7.9
P2_GT_E	Proton2 GT Facade, East	6.83	11.5	11.5
P2_GT_N	Proton2 GT Facade, North	6.83	14.7	14.7
P2_GT_S	Proton2 GT Facade, South	6.83	14.5	14.5
P2_GT_W	Proton2 GT Facade, West	6.83	6.4	6.4
P2_GTG_N	Proton2 GT Facade, North	6.83	11.2	11.2
P2_GTG_S	Proton2 GT Facade, South	6.83	11.5	11.5
P2_GTG_W	Proton2 GT Facade, West	6.83	9.9	9.9
P2_Trans	Proton2 GT Transformer	5.00	3.8	3.8
P3_Air-Int	Proton3 GT Air Intake	13.40	2.9	2.9
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	2.6	2.6
P3_Exh	Proton3 GT Exhaust System	18.00	8.5	8.5
P3_GT_E	Proton3 GT Facade, East	6.83	12.0	12.0
P3_GT_N	Proton3 GT Facade, North	6.83	15.2	15.2
P3_GT_S	Proton3 GT Facade, South	6.83	15.3	15.3
P3_GT_W	Proton3 GT Facade, West	6.83	7.0	7.0
P3_GTG_N	Proton3 GT Facade, North	6.83	11.8	11.8
P3_GTG_S	Proton3 GT Facade, South	6.83	11.4	11.4
P3_GTG_W	Proton3 GT Facade, West	6.83	9.6	9.6
P3_Trans	Proton3 GT Transformer	5.00	4.3	4.3

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#7_A - Amena Hotels and Resorts
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#7_A	Amena Hotels and Resorts	1.50	42.9	42.9
C_Pump_H	CMEC/Eurafric Pump House	3.00	9.5	9.5
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	25.9	25.9
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	16.0	16.0
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	15.8	15.8
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	15.6	15.6
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	15.5	15.5
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	15.2	15.2
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	15.0	15.0
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	17.4	17.4
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	16.3	16.3
N_FGS	NIPP Fuel Gas System	3.00	6.1	6.1
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	11.4	11.4
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	11.1	11.1
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	12.0	12.0
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	9.8	9.8
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	16.7	16.7
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	16.4	16.4
N1_GT_E	NIPP1 GT Facade, East	15.00	31.8	31.8
N1_GT_N	NIPP1 GT Facade, North	15.00	25.6	25.6
N1_GT_S	NIPP1 GT Facade, South	15.00	24.8	24.8
N1_GT_W	NIPP1 GT Facade, West	15.00	33.1	33.1
N1_Trans1	NIPP1 Transformer 1	5.00	-5.8	-5.8
N1_Trans2	NIPP1 Transformer 2	5.00	-4.6	-4.6
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	13.8	13.8
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	13.3	13.3
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	7.7	7.7
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	9.6	9.6
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	18.1	18.1
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	18.7	18.7
N2_GT_E	NIPP2 GT Facade, East	15.00	31.4	31.4
N2_GT_N	NIPP2 GT Facade, North	15.00	37.6	37.6
N2_GT_S	NIPP2 GT Facade, South	15.00	37.4	37.4
N2_GT_W	NIPP2 GT Facade, West	15.00	30.4	30.4
N2_Trans1	NIPP2 Transformer 1	5.00	4.0	4.0
N2_Trans2	NIPP2 Transformer 2	5.00	-11.1	-11.1

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#7_A - Amena Hotels and Resorts
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P_FGS	Proton Fuel Gas System	3.00	4.4	4.4
P1_Air-Int	Proton1 GT Air Intake	13.40	4.1	4.1
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	6.1	6.1
P1_Exh	Proton1 GT Exhaust System	18.00	9.1	9.1
P1_GT_E	Proton1 GT Facade, East	6.83	13.2	13.2
P1_GT_N	Proton1 GT Facade, North	6.83	16.9	16.9
P1_GT_S	Proton1 GT Facade, South	6.83	16.6	16.6
P1_GT_W	Proton1 GT Facade, West	6.83	10.2	10.2
P1_GTG_N	Proton1 GTG Facade, North	6.83	13.6	13.6
P1_GTG_S	Proton1 GTG Facade, South	6.83	13.4	13.4
P1_GTG_W	Proton1 GTG Facade, West	6.83	11.3	11.3
P1_Trans	Proton1 GT Transformer	5.00	6.6	6.6
P2_Air-Int	Proton2 GT Air Intake	13.40	4.6	4.6
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	6.6	6.6
P2_Exh	Proton2 GT Exhaust System	18.00	9.6	9.6
P2_GT_E	Proton2 GT Facade, East	6.83	14.2	14.2
P2_GT_N	Proton2 GT Facade, North	6.83	17.4	17.4
P2_GT_S	Proton2 GT Facade, South	6.83	17.2	17.2
P2_GT_W	Proton2 GT Facade, West	6.83	9.1	9.1
P2_GTG_N	Proton2 GT Facade, North	6.83	13.9	13.9
P2_GTG_S	Proton2 GT Facade, South	6.83	14.1	14.1
P2_GTG_W	Proton2 GT Facade, West	6.83	12.6	12.6
P2_Trans	Proton2 GT Transformer	5.00	7.1	7.1
P3_Air-Int	Proton3 GT Air Intake	13.40	5.0	5.0
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	7.1	7.1
P3_Exh	Proton3 GT Exhaust System	18.00	10.1	10.1
P3_GT_E	Proton3 GT Facade, East	6.83	14.7	14.7
P3_GT_N	Proton3 GT Facade, North	6.83	17.8	17.8
P3_GT_S	Proton3 GT Facade, South	6.83	17.9	17.9
P3_GT_W	Proton3 GT Facade, West	6.83	9.6	9.6
P3_GTG_N	Proton3 GT Facade, North	6.83	14.4	14.4
P3_GTG_S	Proton3 GT Facade, South	6.83	14.0	14.0
P3_GTG_W	Proton3 GT Facade, West	6.83	12.2	12.2
P3_Trans	Proton3 GT Transformer	5.00	7.5	7.5

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#8_A - Apostolic Church Miission
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#8_A	Apostolic Church Miission	1.50	42.7	42.7
C_Pump_H	CMEC/Eurafric Pump House	3.00	8.3	8.3
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	25.2	25.2
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	15.5	15.5
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	15.3	15.3
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	15.0	15.0
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	14.7	14.7
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	14.5	14.5
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	14.3	14.3
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	17.0	17.0
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	15.4	15.4
N_FGS	NIPP Fuel Gas System	3.00	1.6	1.6
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	11.2	11.2
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	10.9	10.9
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	8.1	8.1
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	9.5	9.5
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	16.5	16.5
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	16.1	16.1
N1_GT_E	NIPP1 GT Facade, East	15.00	31.7	31.7
N1_GT_N	NIPP1 GT Facade, North	15.00	27.8	27.8
N1_GT_S	NIPP1 GT Facade, South	15.00	29.5	29.5
N1_GT_W	NIPP1 GT Facade, West	15.00	32.5	32.5
N1_Trans1	NIPP1 Transformer 1	5.00	-7.4	-7.4
N1_Trans2	NIPP1 Transformer 2	5.00	-5.9	-5.9
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	12.6	12.6
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	13.0	13.0
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	7.4	7.4
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	7.8	7.8
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	17.9	17.9
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	18.3	18.3
N2_GT_E	NIPP2 GT Facade, East	15.00	31.1	31.1
N2_GT_N	NIPP2 GT Facade, North	15.00	37.0	37.0
N2_GT_S	NIPP2 GT Facade, South	15.00	36.9	36.9
N2_GT_W	NIPP2 GT Facade, West	15.00	31.1	31.1
N2_Trans1	NIPP2 Transformer 1	5.00	-11.9	-11.9
N2_Trans2	NIPP2 Transformer 2	5.00	-10.9	-10.9

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#8_A - Apostolic Church Miission
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P_FGS	Proton Fuel Gas System	3.00	3.7	3.7
P1_Air-Int	Proton1 GT Air Intake	13.40	3.3	3.3
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	5.3	5.3
P1_Exh	Proton1 GT Exhaust System	18.00	8.3	8.3
P1_GT_E	Proton1 GT Facade, East	6.83	12.4	12.4
P1_GT_N	Proton1 GT Facade, North	6.83	16.1	16.1
P1_GT_S	Proton1 GT Facade, South	6.83	15.8	15.8
P1_GT_W	Proton1 GT Facade, West	6.83	9.4	9.4
P1_GTG_N	Proton1 GTG Facade, North	6.83	12.9	12.9
P1_GTG_S	Proton1 GTG Facade, South	6.83	12.6	12.6
P1_GTG_W	Proton1 GTG Facade, West	6.83	10.5	10.5
P1_Trans	Proton1 GT Transformer	5.00	5.8	5.8
P2_Air-Int	Proton2 GT Air Intake	13.40	3.7	3.7
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	5.8	5.8
P2_Exh	Proton2 GT Exhaust System	18.00	8.8	8.8
P2_GT_E	Proton2 GT Facade, East	6.83	13.4	13.4
P2_GT_N	Proton2 GT Facade, North	6.83	16.5	16.5
P2_GT_S	Proton2 GT Facade, South	6.83	16.4	16.4
P2_GT_W	Proton2 GT Facade, West	6.83	8.2	8.2
P2_GTG_N	Proton2 GT Facade, North	6.83	13.0	13.0
P2_GTG_S	Proton2 GT Facade, South	6.83	13.3	13.3
P2_GTG_W	Proton2 GT Facade, West	6.83	11.7	11.7
P2_Trans	Proton2 GT Transformer	5.00	6.2	6.2
P3_Air-Int	Proton3 GT Air Intake	13.40	4.1	4.1
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	6.2	6.2
P3_Exh	Proton3 GT Exhaust System	18.00	9.2	9.2
P3_GT_E	Proton3 GT Facade, East	6.83	13.8	13.8
P3_GT_N	Proton3 GT Facade, North	6.83	17.0	17.0
P3_GT_S	Proton3 GT Facade, South	6.83	17.0	17.0
P3_GT_W	Proton3 GT Facade, West	6.83	8.7	8.7
P3_GTG_N	Proton3 GT Facade, North	6.83	13.5	13.5
P3_GTG_S	Proton3 GT Facade, South	6.83	13.1	13.1
P3_GTG_W	Proton3 GT Facade, West	6.83	11.3	11.3
P3_Trans	Proton3 GT Transformer	5.00	6.6	6.6

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#9_A - Felix Church
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
NSA#9_A	Felix Church	1.50	35.8	35.8
C_Pump_H	CMEC/Eurafric Pump House	3.00	-7.7	-7.7
C_ST_E	CMEC/Eurafric ST Facade, East	27.00	15.6	15.6
C_ST_Exh1	CMEC/Eurafric ST Exhaust System 1	52.00	8.1	8.1
C_ST_Exh2	CMEC/Eurafric ST Exhaust System 2	52.00	7.9	7.9
C_ST_Exh3	CMEC/Eurafric ST Exhaust System 3	52.00	7.7	7.7
C_ST_Exh4	CMEC/Eurafric ST Exhaust System 4	52.00	7.5	7.5
C_ST_Exh5	CMEC/Eurafric ST Exhaust System 5	52.00	7.2	7.2
C_ST_Exh6	CMEC/Eurafric ST Exhaust System 6	52.00	7.0	7.0
C_ST_N	CMEC/Eurafric ST Facade, North	27.00	9.3	9.3
C_ST_S	CMEC/Eurafric ST Facade, South	27.00	1.4	1.4
N_FGS	NIPP Fuel Gas System	3.00	-1.3	-1.3
N1_AirInt1	NIPP1 GT Air Intake 1	20.00	5.4	5.4
N1_AirInt2	NIPP1 GT Air Intake 2	20.00	6.0	6.0
N1_Cooler1	NIPP1 Fin Fan Cooler 1	3.00	7.8	7.8
N1_Cooler2	NIPP1 Fin Fan Cooler 2	3.00	4.8	4.8
N1_Exh1	NIPP1 GT Exhaust System 1	35.00	9.3	9.3
N1_Exh2	NIPP1 GT Exhaust System 2	35.00	8.8	8.8
N1_GT_E	NIPP1 GT Facade, East	15.00	24.5	24.5
N1_GT_N	NIPP1 GT Facade, North	15.00	21.6	21.6
N1_GT_S	NIPP1 GT Facade, South	15.00	18.5	18.5
N1_GT_W	NIPP1 GT Facade, West	15.00	28.4	28.4
N1_Trans1	NIPP1 Transformer 1	5.00	2.1	2.1
N1_Trans2	NIPP1 Transformer 2	5.00	5.3	5.3
N2_AirInt1	NIPP2 GT Air Intake 1	20.00	5.2	5.2
N2_AirInt2	NIPP2 GT Air Intake 2	20.00	5.2	5.2
N2_Cooler1	NIPP2 Fin Fan Cooler 1	3.00	-2.8	-2.8
N2_Cooler2	NIPP2 Fin Fan Cooler 2	3.00	0.0	0.0
N2_Exh1	NIPP2 GT Exhaust System 1	35.00	10.6	10.6
N2_Exh2	NIPP2 GT Exhaust System 2	35.00	10.6	10.6
N2_GT_E	NIPP2 GT Facade, East	15.00	23.0	23.0
N2_GT_N	NIPP2 GT Facade, North	15.00	29.5	29.5
N2_GT_S	NIPP2 GT Facade, South	15.00	29.3	29.3
N2_GT_W	NIPP2 GT Facade, West	15.00	23.0	23.0
N2_Trans1	NIPP2 Transformer 1	5.00	-4.2	-4.2
N2_Trans2	NIPP2 Transformer 2	5.00	-18.1	-18.1

All shown dB values are A-weighted

Proton Energy Project Noise Results - NERC 5-Year Projection

Report: Table of Results
Model: Copy of Industry
LAeq: by Source/Group for receiver NSA#9_A - Felix Church
Group: (main group)
Group Reduction: No

Name Source/Group	Description	Height	Day	Night
P_FGS	Proton Fuel Gas System	3.00	0.9	0.9
P1_Air-Int	Proton1 GT Air Intake	13.40	0.8	0.8
P1_Cooler	Proton1 GT Fin Fan Cooler	3.00	2.8	2.8
P1_Exh	Proton1 GT Exhaust System	18.00	5.8	5.8
P1_GT_E	Proton1 GT Facade, East	6.83	9.9	9.9
P1_GT_N	Proton1 GT Facade, North	6.83	13.6	13.6
P1_GT_S	Proton1 GT Facade, South	6.83	13.3	13.3
P1_GT_W	Proton1 GT Facade, West	6.83	6.9	6.9
P1_GTG_N	Proton1 GTG Facade, North	6.83	10.4	10.4
P1_GTG_S	Proton1 GTG Facade, South	6.83	10.2	10.2
P1_GTG_W	Proton1 GTG Facade, West	6.83	8.1	8.1
P1_Trans	Proton1 GT Transformer	5.00	-3.3	-3.3
P2_Air-Int	Proton2 GT Air Intake	13.40	1.5	1.5
P2_Cooler	Proton2 GT Fin Fan Cooler	3.00	3.5	3.5
P2_Exh	Proton2 GT Exhaust System	18.00	6.4	6.4
P2_GT_E	Proton2 GT Facade, East	6.83	11.1	11.1
P2_GT_N	Proton2 GT Facade, North	6.83	14.3	14.3
P2_GT_S	Proton2 GT Facade, South	6.83	14.1	14.1
P2_GT_W	Proton2 GT Facade, West	6.83	6.0	6.0
P2_GTG_N	Proton2 GT Facade, North	6.83	10.8	10.8
P2_GTG_S	Proton2 GT Facade, South	6.83	11.1	11.1
P2_GTG_W	Proton2 GT Facade, West	6.83	9.5	9.5
P2_Trans	Proton2 GT Transformer	5.00	-2.3	-2.3
P3_Air-Int	Proton3 GT Air Intake	13.40	2.0	2.0
P3_Cooler	Proton3 GT Fin Fan Cooler	3.00	2.7	2.7
P3_Exh	Proton3 GT Exhaust System	18.00	7.0	7.0
P3_GT_E	Proton3 GT Facade, East	6.83	11.6	11.6
P3_GT_N	Proton3 GT Facade, North	6.83	14.9	14.9
P3_GT_S	Proton3 GT Facade, South	6.83	14.9	14.9
P3_GT_W	Proton3 GT Facade, West	6.83	6.7	6.7
P3_GTG_N	Proton3 GT Facade, North	6.83	11.5	11.5
P3_GTG_S	Proton3 GT Facade, South	6.83	11.1	11.1
P3_GTG_W	Proton3 GT Facade, West	6.83	9.3	9.3
P3_Trans	Proton3 GT Transformer	5.00	4.6	4.6

All shown dB values are A-weighted

APPENDIX 5.2

CLIMATE AND DISASTER RISK SCREENING REPORT FOR ENERGY PROJECT IN NIGERIA- PROTON DELTA SUNRISE PROJECT

Climate and Disaster Risk Screening Report for Energy Project in Nigeria: Proton Delta Sunrise Project[1]

[1] This is the output report from applying the World Bank Group's Climate and Disaster Risk Screening Project Level Tool(Global website: climatescreeningtools.worldbank.org; World Bank users: wbclimatescreeningtools.worldbank.org). The findings, interpretations, and conclusions expressed from applying this tool are those of the individual that applied the tool and should be in no way attributed to the World Bank, to its affiliated institutions, to the Executive Directors of The World Bank or the governments they represent. The World Bank does not guarantee the accuracy of the information included in the screening and this associated output report and accepts no liability for any consequence of its use.

1. Introduction

Building resilience to climate and geophysical hazards is a vital step in the fight against poverty and for sustainable development. Screening for risks from these hazards improves the likelihood and longevity of a project's success. The project level **Climate and Disaster Risks Screening Tool** provides due diligence on climate and disaster risks at an early concept stage. The tool uses an **exposure – sensitivity –adaptive capacity framework** to consider and characterize risks from climate and geophysical hazards, based on key components of a project and its broader development context (Annex 1).

This report summarizes the results of the screening process for the "Proton Delta Sunrise Project/Nigeria, which was applied to the following selected sub-sectors/components:

- [x] Oil, Gas and Coal Mining
- [x] Thermal Power Generation
- [ ] Hydropower
- [ ] Other Renewable Energy
- [ ] Energy Efficiency in Heat and Power & End Use
- [x] Transmission and Distribution of Electricity

The potential risks flagged in this report were identified through four screening stages by connecting information on climate and geophysical hazards exposure with the user's subject matter expertise and understanding of the project components and sensitivity to rate the impacts. The tool does not provide detailed risk assessments, rather it flags risks to inform consultations, enhance dialogue with local and other experts, and define further analytical work at the project location.

This early stage due diligence can be used to strengthen the consideration of climate and disaster considerations in key components of the project design, including the physical (e.g., transmission lines, plants/facilities etc.) and non-physical aspects (e.g., capacity building of energy managers, institutional strengthening, early warning systems, maintenance schedules, etc.). The broader sectoral (e.g., backups and system redundancy in place, strategic planning that considers how climate and geophysical hazards may affect key assets, system reliability, and demand, etc.) and development context conditions (e.g., influence on energy demand from population growth,legal enforcement of proper building codes and zoning regulations, etc.), could help modulate the risks to the delivery of the outcome/service level.

The results of the screening are presented below, with supporting narrative to guide their interpretation.

2. Climate and Disaster Risk Screening Results Summary

2.1 Project Information Summary

Table 1 below provides key project information including the location and key project development objectives. This information is provided by the task team. The activities within the components are important as their sensitivity to the climate and geophysical hazards will determine the level of potential impact from these hazards.

Table 1: Project Information

Project Information	
Title	Proton Delta Sunrise Project
Number	1
Region	Sub-Saharan Africa
Country	Nigeria
Type of Assessment	Energy Projects
Purpose of Screening	Screen a Project at the Concept Stage
Current Project Phase	Implementation□Completion
Funding Source	other
Brief Description of Project or Goals/ Objectives	Development of 150 MW power plant
Sub Sectors	Oil, Gas and Coal Mining, Thermal Power Generation, Transmission and Distribution of Electricity
Location	The Project will be located in Ogorode, a town in Sapele Local Government Area of Delta State, Nigeria. It is located near a major river, Ethiope River.
GPS Coordinates	The GPS coordinates of the Project Site are: Latitude: 5.924328° Longitude: 5.639799°
Oil, Gas and Coal Mining	The project will invest in natural gas development through the installation of gas pipelines to convey gas to the power plant
Thermal Power Generation	The project will invest in a gas-fired simple cycle power plant. Key physical investments include three simple-cycle gas turbines, diesel generator for black start, SCADA and control system, switchyard, transmission lines to evacuate power, and gas pipeline.
Transmission and Distribution of Electricity	To evacuate the generated power from the plant, the project will invest in upgrading the existing switchyard owned by the Transmission Company. It will also construct and install transmission tower(s) and a switchyard within the project location to evacuate power to the national grid.
Outcome / Service Delivery	The objective of this project is to promote the provision of reliable and consistent power supply in Nigeria by increasing the generation capacity of the electricity supply industry. The key indicators of the project result include: - 150 MW of generation capacity added to the national grid - net reduction in air pollution by reducing the need for self- generation through privately powered (home) generators - 1,314 GWh of annual electricity output made available for industrial and productive activities to develop the economy. - Socio-economic development withing the project location. Between 400 and 500 workers will be involved plant construction, most of whom will come from the project area. About 60 direct personnel will be employed during plant operation, a good percentage of whom will be local

* Please note that this is based on user inputs and the coverage may not be comprehensive.

2.2 Summary of Exposure to Climate and Geophysical Hazards

Table 2 presents a summary description of exposure to climate and geophysical hazards at the project location for the Historical/Current and Future time frames[1]. Exposure to climate hazards is evaluated in two timeframes, because past records are not necessarily indicative of future conditions.

The descriptions provide a summary of the key characteristics and some indication of the trends in exposure from each hazard, drawing on global, quality controlled data sets from the Climate Change Knowledge Portal (CCKP). It is useful, for example to understand the temperature range and the rate of annual or decadal increase in a region; or precipitation patterns for historical and future time frames and seasonality shifts. Understanding the trends of hazards is important as they act individually and collectively on components/sub-sectors of the project. Because geophysical hazards (such as earthquakes, tsunamis, landslides, and volcano eruptions) do not have associated future projections, exposure for those hazards is assessed only in the Historical/Current timeframe.

Table 2: Summary of Exposure to Climate and Geophysical Hazards at Project Location

HAZARD	TIME FRAME	DESCRIPTION OF HAZARDS FOR YOUR LOCATION
Extreme Temperature	Current	The maximum mean monthly temperature in the area is 33.7 C
	Future	It is projected that annual mean temperature will increase by 0.3 to 0.57 C by 2050.
Extreme Precipitation and Flooding	Current	The project area has witnessed increasing trend of rainfall intensity over the past decade. Average mean monthly rainfall of 240mm and maximum rainfall recorded in July of 532mm. There is no past record of flooding in the project location
	Future	Intensity of rainfall is projected to increase within the peak of rainy season with increased length of season within the project area.
Sea Level Rise	Current	The Niger Delta, particularly coastal region of Delta State is prone to inundation due to climate-induced sea level rise. The project area is generally low-lying with elevation above sea level ranging from 2 to 17 m. However there is no record of areas within the project location which have been inundated by rising sea levels
	Future	The project lifetime is 20 years. The upper range of local sea level rise is estimated at 1cm/year (IPCC, 2007; Awosika et. al., 1992). Given the project life, sea level is estimated to have risen by 0.2 m at project decommissioning.

[1]The Future time frame is based on changes projected to occur between the 1980-1999 average and a future average. This future average is most likely the 2040-2059 average (i.e., the default in the Climate Change Knowledge Portal - CCKP). Users can choose to select another time frame, or choose to use national/local data sets, but if so, this should be reflected in the notes section of the tool (and summarized in Annex 2). The CCKP draws on global, quality-controlled datasets and is continually updated as new data become available. In some cases, the CCKP is supplemented with other sources of information. For more detail on the data used in this step, please refer to the Data Annex. Climate Change Knowledge Portal (http://climateknowledgeportal.worldbank.org).

Insufficient Understanding	Not Exposed No Potential Impact No Risk	Slightly Exposed Low Potential Impact Low Risk	Moderately Exposed Moderate Potential Impact Moderate Risk	Highly Exposed High Potential Impact High Risk

Please note that the colors shown in Table 2 are only for exposure at the project's location. Overall risk to project's outcome/service delivery, taking into account sensitivity of physical investments and adaptive capacity(non-physical components and development context), is depicted in Tables 3A and 3B.

2.3 Summary of Overall Project Risk

Tables 3A and 3B present the same results, with Table 3A highlighting the impact ratings on the project's components/subsectors, and the overall risk to the outcome/service level for both Historical/Current and Future time frames. Table 3B draws attention to how the climate impacts and risks shift from the Historical/Current to the Future time frame.

The ratings are derived on the basis of the hazard information, subject matter expertise, contextual understanding of the project, and modulated on the basis of adaptive capacity and the larger development context of the energy sector and country. The results indicate what components are most at risk. The actual ratings themselves, while instructive, should inform further consultations, dialogue, and future planning processes. Keep in mind that the greatest value of the tool is that it provides a structured and systematic process for understanding climate and disaster risks.

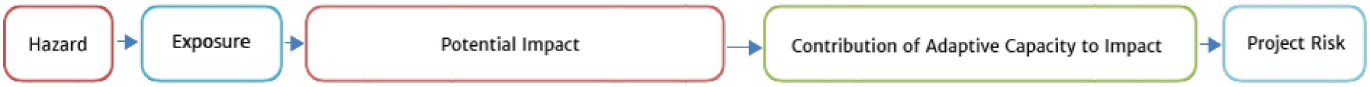
2.3.1 Results Summary - by Component / Subsector

Table 3A provides a characterization of risks caused by climate and geophysical hazard on project subsector/components for both Historical/Current and Future time frames.

The results indicate where risks may exist within one or multiple components and where further work may be required to further understand these climate and geophysical risks. An ongoing process of monitoring risks, refining climate and other information, and regular impact assessment may also be appropriate.

The potential impact on key components due to exposure from hazards is modulated by the project's non-physical components (enabling and capacity building activities). The right kind of capacity building measures could increase preparedness and longer-term resilience and reduce the risks. An understanding of larger sector and development context with respect to key modulating factors helps to assess the climate risks in terms of adaptive capacity.. For example, in the energy sector, a significant system redundancy may help reduce risks; while population growth and increasing peak demand may aggravate the risks.

Table 3A: Results Summary - by Component / Subsector



Hazard	Project Components										Development Context				Outcome / Service Delivery	
	Location		Oil, Gas and Coal Mining		Thermal Power Generation		Transmission and Distribution of Electricity		Non-Physical Components (Overall)		Energy Sector		Broader Context(Overall)			
Time Frame	Current	Future	Current	Future	Current	Future	Current	Future	Current	Future	Current	Future	Current	Future	Current	Future
Extreme Temperature									Data Gathering, Monitoring, and Information Management systems Significantly Reduces Impact Institutional strengthening/ Training/Knowledge Exchange Slightly Reduces Impact Feasibility/Design Studies Significantly Reduces Impact Overall Significantly Reduces Impact		Slightly Reduces Impact		Population growth Significantly Increases Impact Urbanization Significantly Increases Impact Financial resources Slightly Increases Impact Overall Slightly Increases Impact			
Extreme Precipitation and Flooding																
Drought	X	X	X	X	X	X	X	X							X	X
Sea Level Rise																
Storm Surge	X	X													X	X
Strong Winds	X	X	X	X	X	X	X	X							X	X

2.3.2 Results Summary by Time-Frame

The results in Table 3B display the results by time frame. Potential impacts to the components are evaluated separately for the Historical/Current and Future time frames to capture changes in the exposure from climate hazards over time. For example, recent trends may indicate that temperatures are rising in such a way that they may make cooling of electricity generation facilities difficult, significantly escalating the impact on energy production over time.

For investments with long operational lifetimes, such as physical infrastructure, considering future climate variability and change is critical to avoid “locking in” designs and features that are only suited to current climate. For example, coastal energy infrastructure may be more vulnerable if it is located in areas that will be more exposed to sea level rise, storm surge, and coastal flooding in the future, or if the infrastructure is not designed to withstand more frequent or severe flooding.

Table 3B: Results Summary - by Time Frame

Time Frame	Current								Future							
	Project Context					Development Context			Project Context					Development Context		
Hazard	Locat-ion	Oil, -Gas and -Coal -Mining	Thermal - Power - Generat - ion	Transmi - ssion - and - Distrib - ution - of - Electri - city	Non-Physical Components (Overall)	Energy Sector	Broader Context (Overall)	Outcome / Service Delivery	Location	Oil,-Gas and-Coal-Mining	Thermal-Power-Generat-ion	Transmi-ssion-and-Distrib-ution-of-Electri-city	Non-Physical Components (Overall)	Energy Sector	Broader Context (Overall)	Outcome / Service Delivery
Extreme Temperature					Data Gathering, Monitoring, and Information Management systems: Significantly Reduces Impact Institutional strengthening/ Training/Knowledge Exchange: Slightly Reduces Impact Feasibility/Design Studies: Significantly Reduces Impact Overall: Significantly Reduces Impact	Slightly Reduces Impact	Population growth: Significantly Increases Impact Urbanization: Significantly Increases Impact Financial resources: Slightly Increases Impact Overall: Slightly Increases Impact						Data Gathering, Monitoring, and Information Management systems: Significantly Reduces Impact Institutional strengthening/ Training/Knowledge Exchange: Slightly Reduces Impact Feasibility/Design Studies: Significantly Reduces Impact Overall: Significantly Reduces Impact	Slightly Reduces Impact	Population growth: Significantly Increases Impact Urbanization: Significantly Increases Impact Financial resources: Slightly Increases Impact Overall: Slightly Increases Impact	
Extreme Precipitation and Flooding																
Drought	X	X	X	X				X	X	X	X	X				X
Sea Level Rise																
Storm Surge	X							X	X							X
Strong Winds	X	X	X	X				X	X	X	X	X				X

Insufficient Understanding	Not Exposed No Potential Impact No Risk	Slightly Exposed Low Potential Impact Low Risk	Moderately Exposed Moderate Potential Impact Moderate Risk	Highly Exposed High Potential Impact High Risk

2.4 Key Drivers of Risks

Based on the results above, Table 4 highlights the key drivers of risk for each project component/subsector ratings, in terms of hazards that are likely to pose the greatest challenge.

The ratings for the potential impact for each component/subsector reflect the aggregate rating across multiple hazards, drawing on all of the exposure information and their own expert judgment. For example, high temperature may reduce the efficiency of major equipment and cooling in oil, gas, and coal mining, whereas flooding may cause physical damage to mining, drilling, and processing facilities.

Specific consideration should be given to those hazards which have high ratings, or are moving from moderate to high ratings over time. For example, sea-level rise may not be a key risk driver in the Historical/Current time frame; but may emerge as a key driver across multiple sectors in the future time frame. Understanding which hazards are key drivers may help flag follow-on work to manage climate risks within the design and delivery of the project.

Table 4: Key Drivers of Risk

	Historical/Current Drivers	Future Drivers
Hazards and Location	Extreme Precipitation and Flooding	Extreme Precipitation and Flooding
Physical Components	*	Transmission and Distribution of Electricity-Extreme Temperature
Outcome / Service Delivery	*	*

Key: High Risk Moderate Risk

* If a cell is blank it implies there is 'No high or moderate risks' identified for this aspect of the project.

- Overall, the Non-physical Components : **Significantly Reduces Impact**
- The Energy Sector : **Slightly Reduces Impact**
- The Broader Development Context : **Slightly Increases Impact**

3. Next Steps

By understanding which of your energy project components is most at risk from climate change and other natural hazards on the basis of the screening, you can begin to take measures to avoid their impacts by:

- Enhancing the consideration of climate and disaster risks early in the design stage of the project.
- Using your risk screening analysis to inform follow-up feasibility studies and technical assessments.
- Encourage local stakeholder consultations and dialogue to enhance resilience measures and overall success of the project.

Table 5A provides some general guidance based on the risk ratings for the Outcome/Service Delivery, and Table 5B lists some climate risk management measures for your consideration. Visit the "Next steps" page of the tool on the website for guidance and a list of useful resources.

Note: Please recall that that this is a high-level due diligence tool, and the characterization of risks should be complemented with more detailed work.

Table 5A: General Guidance Based on Risk Ratings for Outcome/Service Delivery

Insufficient Understanding	Gather more information to improve your understanding of climate and geophysical hazards and their relationship to your project.
No Risk	If you are confident that climate and geophysical hazards pose no risk to the project, continue with project development. However, keep in mind that this is a high-level risk screening at an early stage of project development. Therefore, you are encouraged to monitor the level of climate and geophysical risks to the project as it is developed and implemented.
Low Risk	If you are confident that climate and geophysical hazards pose low risk to the project, continue with project development. However, keep in mind that this is a high-level risk screening at an early stage of project development. Therefore, you are encouraged to monitor the level of climate and geophysical risks to the project as it is developed and implemented. You may also consider gathering additional information to increase your level of confidence in your rating.
Moderate Risk	For areas of Moderate Risk, you are encouraged to build on this screening through additional studies, consultation, and dialogue. This initial screening may be supplemented with a more detailed risk assessment to better understand the nature of the risk to the project.
High Risk	For areas of High Risk, you are strongly encouraged to conduct a more detailed risk assessment and to explore measures to manage or reduce those risks.

Table 5B: Types of Climate Risk Management Measures for typical Energy Projects

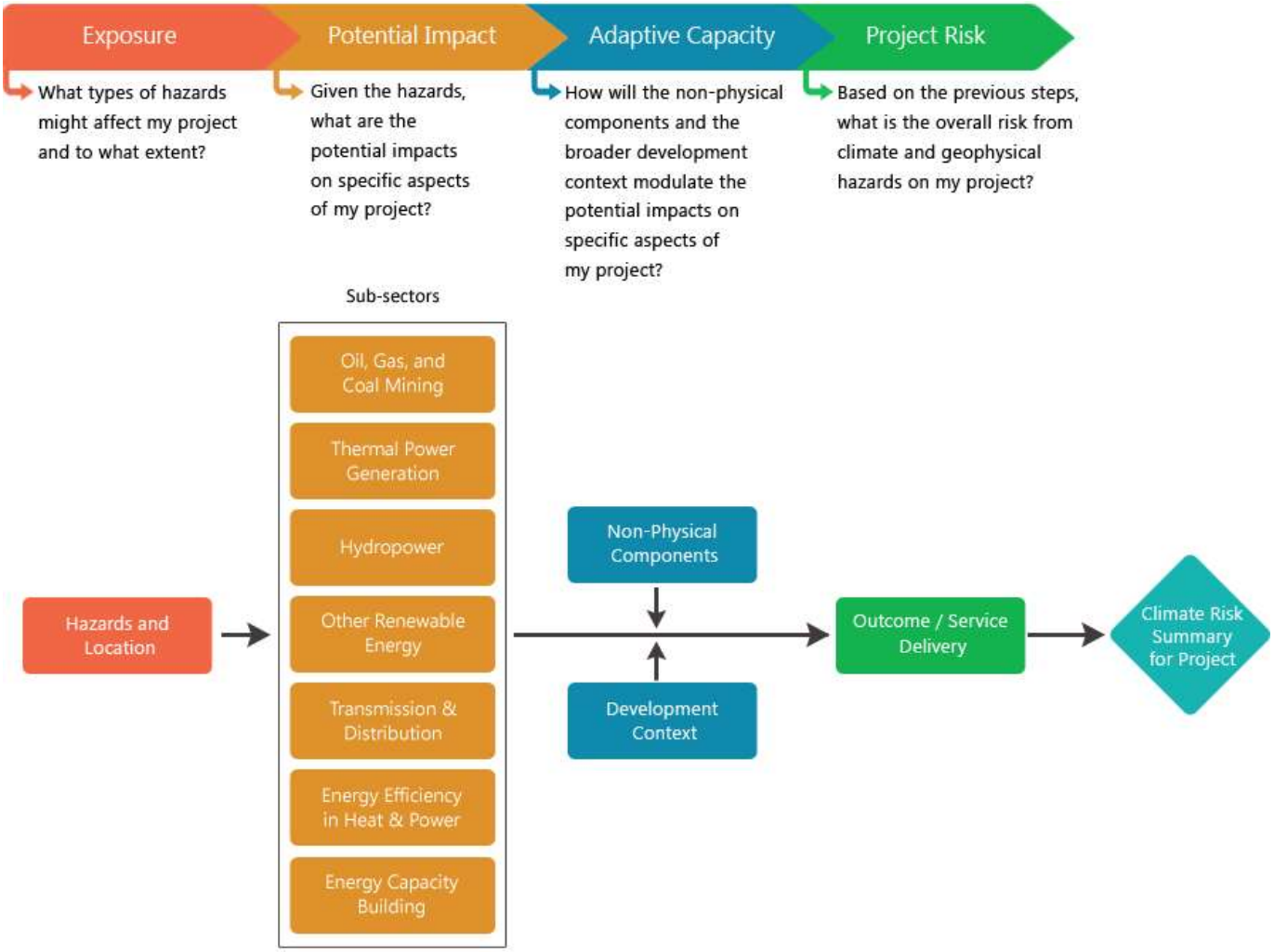
CATEGORY	PROS	CONS	EXAMPLES
Accommodate and Manage	• Flexible • Typically low-cost • Useful when risk is low, but projected to rise in the future	• Temporary solution • Can be insufficient in preventing losses	• Increase repair and maintenance budgets • Consider future fuel and generation demands and costs in planning • Incentivize demand-side management • Conduct monitoring through data collection and analysis
Protect and Harden	• Can be used for existing and new assets • Responds to immediate risks	• High cost • Inflexible • Effectiveness may decrease over time	• Upgrade existing cooling systems • Add reinforcements to walls and roofs • Build dikes to contain flooding • Incorporate structural improvements to transmission • Increase drainage of energy facilities
Retreat and Relocate	• Long-term solution • Responds to immediate risk	• High cost • Inflexible	• Integrate sea level rise projections and storm surge in coastal siting • Move infrastructure further inland or on higher ground

Annex 1: Tool Approach

Tool Approach

The framework below describes the approach taken to screen the project. Climate and natural hazards information used to screen the project is most likely obtained from the World Bank's Climate Change Knowledge Portal, which houses numerous global data sets with historical records and future projections as well as country-specific adaptation profiles.

Figure A1: Project Level Climate and Disaster Risk Screening Tool: Approach for Energy projects



Annex 2: Notes

Table A2-1 summarizes the sub-national locations of high risk noted during the assessment, if the user entered these sub-national locations. Table A2-2 summarizes all the notes entered by user for each section while completing the assessment, if the user elected to enter notes. These notes can help shed light on specific ratings as well as considerations and limitations of the user's expertise.

Table A2-2 Summary of Comments by Section

Section		Notes
Subsectors	Summary	While the project and its subsectors are not immune to the effects of climate change, the project location makes these subsectors and project less susceptible to high impacts from these hazards. For example, effects of extreme temperature will be most felt within the northern part of the country compared with the Niger-Delta region where the project and most of its key infrastructure is sited.
Non-Physical Components	Data Gathering, Monitoring, and Information Management systems	The project as part of its monitoring exercise, shall follow trends of rainfall patterns, and temperature allows for adequate projections to be made which will inform decisions and steps taken to continually make project more resilient to climate change impacts.
	Institutional strengthening/ Training/Knowledge Exchange	By participating in and supporting energy forums, and continuous engagement with relevant government ministries and agencies, the project will promote stronger institutions and knowledge-sharing platforms. This information flow will ensure the project is tune with current mitigation measures and technological tools for reducing impact.
	Feasibility/Design Studies	Adequate feasibility and design studies incorporarted in the Project's planning and development stage, present current baseline status and allow for optimum tolerance limits to be included as part of design and decision-making to forestall/ largely reduce climate change impacts.