JACOBS Consultancy

Ghana Bridge Power Project

Early Power Limited

Environmental and Social Impact Assessment

60K36301

Revision: 3

Date: 07 August 2017

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Volume II: ESIA Study Report

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Project No.	:	60K36301
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Date	Description of Alteration	Rev No
13 Oct 2015	Draft for EPA review	0
17 Dec 2015	Final version following EPA approval of draft	1
24 Jun 2016	Update following design changes	2
08 August 2017	Update following new development site configuration, pipeline route and right of way changes and associated design changes	3

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List of Abbreviations

AAQG	Ambient Air Quality Guideline
AC	Alternating current
ACC	Air Cooled Conditioning
ACEP	African Centre for Energy Policy
ADMS	Atmospheric Dispersion Modelling System
ADT	Average Daily Traffic
AEP	Annual Exceedance Probability
AR	Assessment Report
AZE	Alliance for Zero Extinction
BAT	Best available technique
BGS	British Geological Survey
BMPs	Best Management Practices
BOG	Boil off Gas
BUR	Biennial Update Reports
CBD	1992 Convention of Biological Diversity
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Storage
CDMs	Clean Development Mechanisms
CER	Certified Emission Reduction
CIEEM	Chartered Institute of Ecology and Environmental Management
CEMs	Continuous Emissions Monitoring
CER	Certified Emission Reduction
CFA	Canoe Fishermen Association
CITES	Convention on International Trade in Endangered Species
CO	Carbon monoxide
CO_2	Carbon dioxide
COD	Commercial Operational Date
CPD	Centre of Plant Diversity
CR	Critically Endangered
CWIQ	Core Welfare Indicators Questionnaire
CRU	Climate Research Unit
DA	Degraded Airshed
DC	Direct Current
DCE	District Chief Executive
DCS	Distributed Control System
DD	Data Deficient
DDF	Depth Elevation Frequency
DECC	Department of Energy and Climate Change

DEM	Digital Elevation Model
DFO	Diesel Fuel Oil
DFR	Department of Feeder Roads
DLN	Dry Low NOx
DMRB	Design Manual for Roads and Bridges
DUR	Department of Urban Roads
DWT	Deadweight
EAR Schedule 5	Environmental Assessment Regulations (Regulation 30(2)) of the Ghana Environmental Protection Agency (EPA) regulations
EBA	Endemic Bird Areas
ECG	Energy Company of Ghana
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EHS	Environmental Health and Safety
EN	Endangered
EPA	Environmental Protection Agency
EPC	Engineering Procurement and Construction
ESD	Emergency Shutdown Valves
ERC	Emergency Release Couplings
E&S	Environmental and Social
EIS	Environmental Impact Statement
EMS	Environmental management system
EPC	Engineering, procurement and construction
EPFI	Equator Principle Finance Institutions
ESAP	Environmental and social action plan
ESMP	Environmental and social management plan
ESIA	Environmental and social impact assessment
FSSD	Fisheries Scientific Survey Division
FRA	Flood risk assessment
GCM	Ghana Climate Model
GCLME	Guinea Current Large Marine Ecosystem
GFC	Ghana Forestry Commission
GHG	Greenhouse Gas Emissions
GIIP	Good International Industry Practice
GMA	Ghana Maritime Authority
GFS	Ghana Fire Service
GHAIP	Ghana Italian Petroleum Company
GHEAP	Ghana National Environmental Action Plan
GoG	Government of Ghana
GPHA	Ghana Ports and Harbours Authority

GSS	Ghana Statistical Services
GRIDCo	Ghana Grid Company
GT	Gas Turbine
GWC	Ghana Water Company
GWP	Global Warming Potential
HBWA	High Biodiversity Wilderness Areas
HFC	Hydrofluorocarbons
HGV	Heavy Goods Vehicle
HAT	Highest astronomical tide
HMP	Habitat Management Plan
HP	High Pressure
HRSG	Heat Recovery Steam Generator
HW	High Water
IAS	Integrated Automation System
IBA	Important Bird Area
ICA	Integrated Coastal Management
IDF	Intensity Duration Frequency
IEA	Institute of Environmental Assessment
IFI	International Financial Institution
IFC	International Finance Corporation
IGCC	Integrated Gasification Combined Cycle
ILO	International Labour Organisation
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Project
ITCZ	Inter-tropical Convergence Zone
IUCN	International Union for Conservation of Nature
JDA	Joint Development Agreement
JVA	Joint Venture Agreement
KBA	Key Biodiversity Areas
KIPP	Kpone Independent Power Plant (operated by Cenpower)
KKDA	Kpone-Katamanso District Assembly
KTPP	Kpone Thermal Power Plant (operated by Volta River Authority)
LBED	Local Business and Economic Development
LC	Least Concern
LCA	Landscape Character Area
LCO	Light Crude Oil
LCT	Landscape Character Type
LNG	Liquefied Natural Gas
LNGCs	Liquefied Natural Gas Carriers
LOAEL	Lowest Observed Adverse Effect Level

LP	Low Pressure
MGD	Million Gallons per Day
MMSCFD	Million standard cubic feet per day
MRV	Measurement Reporting and Verification
MSLC	Middle School Leaving Certificate
MW	Mega Watt
NAFAG	National Fisheries Association of Ghana
NC	National Communications
NCCPF	National Climate Change Policy Framework
NDA	Non-degraded air-shed
NFPA	National Fire Protection Association
NG	Natural Gas
NGO	Non-Governmental Organisation
NO_x	Nitrogen oxides
NO_2	Nitrogen dioxide
NTP	Notice to Proceed
OTSG	Once Through Steam Generator
O&M	Operations and Maintenance
OCGT	Open Cycle Gas Turbine
ORPC	Oil Preparedness Response and Co-operation
PAH	Polycyclic Aromatic Hydrocarbons
PC	Process Contribution
PCB	Polychlorinated biphenyl
PEC	Predicted Environmental Concentration
PFC	Perofluorocarbons
PHC	Population and Housing Census
PPE	Personal Protective Equipment
PPS1	Power Plant Site 1
PPS2	Power Plant Site 2
PM	Particular Matter
PS	Performance Standard
PURC	Public Utilities Regulatory Commission
QC/DC-ERS	Quick connect/quick disconnect and emergency release system
RAP	Resettlement Action Plan
RBC	Risk- Based Concentrations
RfDs	Reference Dose intakes
RO	Reverse osmosis
RPT	Rapid Phase Transition
SCS	Soil Conservation Service
SCADA	Supervisory Control and Data Acquisition

SCEP	Stakeholder Consultation and Engagement Plan
SCS	Soil Conservation Service
SEP	Stakeholder Engagement Plan
SEPC	Stakeholder Engagement and Communication Plan
SF_6	Sulfur hexafluoride
SIP	Social Investment Plan
SIS	Social Investment Strategy
SL	Screening Levels (Generic)
SOAEL	Significant Observed Adverse Effect Level
SRTM	Shuttle Radar Topography Mission
STCW	Standards of Training, Certification and Watch Keeping for Seafarers
STP	Sewage Treatment Plant
STS	Ship to shore
SO_x	Sulphur oxide
SO_2	Sulphur dioxide
SOLAS	International Convention for the Safety of Life at Sea" (SOLAS)
TDC	Tema Development Corporation
THIA	Tema Heavy Industrial Area
THQ	Toxicity Hazard Quotient
TOC	Total Organic Carbon
TOR	Tema Oil Refinery
TMA	Tema Metropolitan Assembly
TMP	Traffic Management Plan
TPH	Total Petroleum Hydrocarbons
TTPC	Tema Thermal Power Complex
UAP	Urban all purposes
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
VOC	Volatile Organic Compounds
VU	Vulnerable
VRA	Volta River Authority
WAGP	West African Gas Pipeline
WCR	Wildlife Conservation Regulations
WGS	World Geodetic System
WMP	Waste Management Plan
WRI	World Resources Institute
WHO	World Health Organisation
WWF	World Wildlife Fund

Units

A	-	Ampere (electrical current)
bar	-	bar = 105 Pa (pressure)
cal	-	calorie (energy)
°C	-	degree Centigrade (temperature)
dB	-	decibel (sound pressure)
dS/m		electrical conductivity
g	-	gramme
hr	-	hour (time)
Hz	-	Hertz (frequency)
K	-	Kelvin (temperature)
Kg	-	kilogramme (mass)
Kt	-	kilo tonne per year
J	-	Joule (energy)
l	-	litre
m	-	metre (length)
mg/m^3	-	miliograms per cubic meter
Mm^3	-	million cubic metres = 10^6 m^3
Nm	-	nautical miles
MT	-	metric tonne
ppm	-	parts per million
ppb	-	parts per billion
ppt		parts per trillion
Pa	-	Pascal (pressure)
s	-	second (time)
t	-	tonne = 10^3 kg (mass)
tpy	-	tonne per year
V	-	Volt (electrical potential)
W	-	Watt (power)
Wh	-	Watt hour (energy)

Prefix Symbols and Multiples

G	-	giga	=	x 10^9
M	-	mega	=	x 10^6
k	-	kilo	=	x 10^3
h	-	hecto	=	x 10^2
da	-	deca	=	x 10
d	-	deci	=	x 10^{-1}
c	-	centi	=	x 10^{-2}
m	-	milli	=	x 10^{-3}
μ	-	micro	=	x 10^{-6}
n	-	nano	=	x 10^{-9}
p	-	pico	=	x 10^{-12}

Symbols

CO	-	Carbon monoxide
CO_2	-	Carbon dioxide
Hg	-	Mercury
NaCl		Sodium chloride
NO_x	-	Nitrogen oxides
NO_2	-	Nitrogen dioxide
Nm^3	-	Normal cubic metre
O_2	-	Oxygen
O_3	-	Ozone
PM_{10}	-	Particulate matter with a mean diameter less than 10µm
$PM_{2.5}$	-	Particulate matter with a mean diameter less than 2.5µm
pH	-	A scale of relative acidity/alkalinity
SO_2	-	Sulphur dioxide
SO_x	-	Sulphur oxide

Environmental and Social Impact Assessment - Volume II

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Section 1 – Introduction

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration		Rev No
Sep 2015	First issue		0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency		1
Jun 2016	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating the following changes:		2
	Section No.	***Change***	
	Wherever relevant	Reference to “power plant site” changed to reflect revised plan involving two power plant sites (PPS1 and PPS2).	
	Wherever relevant	Corrections to spelling, grammar and other changes for consistency. Abbreviated terms provided in full at first usage.	
	1	Details of revised project timescale and reason for issue of Revision 2 of the ESIA.	
	1.1	Updated with new project information.	
	1.2	Details of PPS2 added. Update to land use surrounding PPS1 and tank farm. Update to pipeline details. Update to developments in the vicinity.	
	1.5	Update to project phases and schedule.	
	1.7	Update to cumulative impact comments based on additional information about other plants in the area.	
	1.8	Overview of project changes addressed in this ESIA update.	
	Figures	Updated with new project information.	
Aug 2017	ESIA amendment issued to Ghana Environment Protection Agency, incorporating details of further project design changes, including:		3
	Section No.	***Change***	
	1	Details of revised project timescale and reason for issue of Revision 3 of the ESIA.	
	1.1	Updated with new project information including phasing, capacity and unit composition of the two power plant sites.	
	1.2	Details of revised plot locations and surroundings. Updates to developments in the vicinity. Change to the routing of the LPG fuel delivery pipeline and site access route(s).	
	1.5	Update to project development stages and schedule	
	1.7	Update to cumulative impact comments based on additional information about other plants in the area.	
	1.8	Inclusion of text describing the requirement for a third iteration of the ESIA. Extended to include an overview of project changes encapsulated in Version 3 of the ESIA.	
	Figures	Updated with new project information.	

Contents

Figures and Tables

1 Introduction

The Early Power Limited (EPL) Ghana (Emergency) Bridge Power Project ("the project") is to be located on brownfield land within the Tema Heavy Industrial Area (THIA), in the Ghana port town of Tema. The project comprises power plant facilities, a tank farm and associated fuel and water delivery pipelines. The power plant facilities occupy two separate sites, referred to as Power Plant Site 1 (PPS1) and Power Plant Site 2 (PPS2). All project infrastructure features are located within the THIA, a designated industrial zone by Government of Ghana (GoG).

The objective of the project is to deploy electrical energy as quickly as possible to support the GoG short term strategy to increase the power capacity available to the country, with expected Commercial Operational Date (COD) for the first stage in May 2018, and full operation by May 2020.

Jacobs Consultancy was appointed by EPL to undertake an Environmental and Social Impact Assessment (ESIA) for the project. This document presents the findings of the ESIA in the form of an ESIA Study Report. This revision (Revision 3) provides the most recent assessment, incorporating changes to improve the project design. Revision 1 of the report was compiled to satisfy the requirements of the Ghanaian Environmental Protection Agency (EPA) following their review of the Environmental Screening application submitted in March 2015. The ESIA Revision 1 was submitted in December 2015 to the Ghanaian EPA, who subsequently issued an Environmental Permit for the project in January 2016. Modifications to the project design during 2016 were made to improve the energy efficiency, by the incorporation of additional heat recovery. The design change led to the requirement for an additional development plot. An updated assessment (ESIA Revision 2) evaluated these changes and was submitted the EPA in June 2016. Further amendments to the project design and location since then have warranted a further iteration of the ESIA. This updated assessment (ESIA Revision 3) has not identified any substantive adverse environmental or social impacts from the modifications to the Project.

In addition to satisfying the requirements of the EPA, the study is also subject to international standards including the International Finance Corporation (IFC) Performance Standards for Environmental and Social Sustainability ("the Performance Standards" or "PSs"), relevant IFC Environmental, Health and Safety (EHS) Guidelines including the general and sectoral EHS Guidelines, and, relevant IFC Good Practice Notes.

1.1 Project Overview

The project includes the development of power plant facilities, comprising a fuel storage tank farm, and fuel and water delivery pipelines. The power plant facilities are to be constructed across two sites in three Stages. Power Plant Site 1 (PPS1) (Stage 1a and 1b) will comprise mobile Trailer Mounted (TM) turbine units. During Stage 1a the units will operate in open cycle gas turbine (OCGT) mode, with expansion to combined cycle gas turbine (CCGT) generating mode in Stage 1b. Power Plant Site 2 (PPS2) (Stage 2) will comprise sprint turboshaft gas turbines (LM units) operating in CCGT mode. The sites will provide a total generation capacity of 424 MW on completion of Stage 2. The power from PPS1 during

Stage 1a will be via underground connection to the existing Electricity Company of Ghana (ECG) Station H substation, adjacent to the Volta River Authority (VRA) Tema Thermal Power Complex (TTPC). Stage 1b evacuation will initially be via a new 161kV spur into a new double circuit 161kV overhead line to be constructed by GRIDCO by early 2018, which will run adjacent to the existing overhead lines that run east-west along the northern boundary of the Stage 2 site (PPS2). Stage 2 power evacuation will be via a new substation into the new GRIDCO 161kV power lines. The Stage 1b evacuation spur will be transferred to the Stage 2 substation as that switch yard is completed.

Throughout the development, liquefied petroleum gas (LPG) will be used as the primary fuel, though the design allows for operation on diesel fuel oil (DFO) for worst-case scenario operation during a significant disruption to the supply of LPG. It is envisaged that the plant will switch to natural gas (NG) within five years of the start of Stage 2 operation, on condition that NG is made available to the project by the Government of Ghana (GoG).

The regional location of the project is shown on Figure 1-1 and locations of the project infrastructure are shown on Figure 1-2. A detailed project description, which provides full details of the project infrastructure and construction and operational requirements, forms Section 2 of this ESIA.

A consortium of Endeavor Energy, General Electric (GE) and Sage Petroleum (Sage) has been formed under the local company EPL to develop the project and contract with Electricity Company of Ghana (ECG). The project proponent is described in Section 1.4.

1.2 Description of Project Site and Surrounding Area

1.2.1 Project Location and Regional Setting

The project is located in the industrial port town of Tema on the Gulf of Guinea, approximately 27km east of Ghana's capital city, Accra, and 20km south-east of the town of Madina.

The project infrastructure is all located within the Tema Heavy Industrial Area (THIA), between Tema town and the district of Kpone, which has been zoned for industrial / commercial land use by the GoG. The area is located at UTM zone 31N: the centrum of the main infrastructure sites are as follows:

- PPS1: 1502799.7286 635416.1113 metres;
- PPS2 (western): 1502515.1191 635581.2162 metres;
- PPS2 (eastern): 1502787.1491, 635584.3611 metres; and,
- LPG Tank Farm: 1503024.5858, 635719.5899 metres.

The power plant and tank farm sites are located on brownfield land, approximately 3km north of Tema Harbour, one of Ghana's two deep-sea ports and a major container port.

Industrial and/or commercial land use extends for a minimum of approximately 2km in all directions from the power plant and tank farm sites to the nearest residential areas. These are the outskirts of Tema New Town to the south, the district of Kpone to the east, and Tema town to the west. The towns of Prampram and New Ningo lie beyond Kpone to the east. The urban areas of Ashaiman and Sebrepor lie to the north of the industrial area, over 4.5km to the east and north-east of the power plant site, respectively. Farmland and wetland areas occupy land to the north of these urban areas.

The coastal region around Tema is dominated by a mix of residential and industrial areas, interspersed with a series on north-south flowing rivers which drain higher ground to the north. The nearest site of ecological importance is the Sakumo Lagoon Ramsar[1] site, which bounds the western end of Tema, approximately 5.5km west of the project sites. The Sakumo Lagoon is fed by rivers which run from the Ashaman Dam and a smaller dam, approximately 7.5km northwest of the project sites.

Other sites of ecological importance in the surrounding area include the Shai Hills resource reserve, an Important Bird Area[2] approximately 25km north of the project site; and, the Songor Lagoon Ramsar site protected area, approximately 40km east of the site.

The nearest major surface water feature is an artificially straightened drainage channel, which provides the south-west boundaries of both PPS1 and PPS2.

1.2.2 Power Plant Sites and Surrounding Land Use

The proposed plant sites have no permanent existing active use. Both are located within brownfield land within the THIA.

In general, land between the industrial/commercial facilities within the THIA is undeveloped brownfield land either covered in scrub or with various potential uses including current or historical cultivation, informal parking. It was noted during the June 2017 site visit that an increasing number of sites within this part of the THIA are under some form of development.

PPS1

PPS1 is situated within brownfield land, approximately 225m east of the TTPC. The plot is not occupied by any infrastructure or developments, but was under cultivation. The farmers previously cultivating the site have been considered as part of an Abbreviated Resettlement Action Plan (ARAP) for the project.

PPS1 is bounded by the following, as shown on Figure 1-3b:

- A large municipal storm drain (referred to herein as 'the storm drain') is located approximately 5m from the western site boundary. Beyond that, Cirrus Oil Services Limited tank farm is located approximately 50m to the southwest and the Volta River Authority (VRA) Tema thermal Power Complex (TTPC) is located approximately 150m to the west;
- Paper processing and packaging facilities (Tema Paper Limited and JQ Packaging Limited) are located to the east and southeast. These contain warehouses, offices, worker quarters and parking and ancillary buildings;

[1] Ramsar sites are wetlands of international importance designated under the Ramsar convention, 1971.
[2] An Important Bird and Biodiversity Area (IBA) is an area recognised as being globally important habitat for the conservation of bird populations. The sites are identified by BirdLife International following an internationally agreed set of criteria.

- Adjacent to the east (to the north of JQ Packaging) is Kpone Marine Service and Tema Offshore Mooring Ltd. Beyond that is the Quantum Terminals Limited (a subsidiary of Sage Petroleum) tank farm (referred to herein as "the Quantum tank farm"); and,
- Land for the proposed PPS2 to the north, as discussed below.

The TTPC includes various power plants (Trojan Power Limited, VRA and Cenit power plants, VRA Station 3 and Mines Reserve Plants. These are discussed further in Section 1.2.6. The TTPC also includes the Electricity Company of Ghana Station H switchyard which the project will connect into to export power during Stage 1a.

Further west beyond TTPC is the Tema Oil Refinery (TOR). Further South and southwest from the project sites, beyond the Sage Petroleum tank farm, are other large installations including Sentuo Steel, Tema Fuel Trade Company Limited, Ghana Oil Limited (known as GOIL) and Valco Aluminium Limited. The locations of these features are indicated on Figure 1-3b.

PPS2

PPS2 is located immediately north of PPS1, separated by the access road easement. The site is formed of two areas (the 'eastern' and 'western' areas) to be leased from different land owners. There is a small walled portion of land between the western and eastern areas that the project was unable to acquire during negotiations.

The eastern area is rectangular shaped and is currently formed by two parcels of land; one walled and one open:

- The walled parcel contains a small block of rental accommodation close to the western extent of the walled area, one of which is occupied semi-permanently by a 'caretaker' and his family. The central part of the walled area is currently under cultivation and the easternmost portion utilised as a vehicle and fuel storage/resale depot. This area is bare ground with a number of sheds, buildings, above ground fuel tanks and vehicle parking.
- The open portion of the eastern area was under cultivation until recently with the remains of some of the crops still present in a small area close to the access road reserve. However, the crops had been harvested by the time of the survey. The remaining area had been cultivated historically, but had been abandoned by the time of the visit.

The western area of the PPS2 site is a broadly triangular shape and situated adjacent to the storm drain. The land is covered in scrub and appears to have been used as a location for dumping various (potentially construction) waste material. No other uses were identified.

The PPS2 site is bounded by the following, as shown on Figure 1-3b:

- To the north of the eastern area is an undeveloped plot between the PPS2 land and the access road leading to the Blue Ocean Investment Ltd facility and what are understood to be 3 large water treatment ponds;
- To the east is the proposed tank farm site, described below;
- To the south, is PPS1 and surrounding uses as described above; and,

- To the west, the storm drain along the south-west boundary and, beyond that, an area of derelict land, the TTPC and TOR as described above.

1.2.3 Tank Farm Site and Surrounding Features

The tank farm site is ‘L-shaped’, following the addition of a small area of land to the south-eastern extent of the previous configuration. Figure 1-2 shows that the proposed tank farm site is approximately 30m east of PPS2 and 150m north-east of PPS1, and approximately 30m north of the adjacent Quantum tank farm.

The site is predominantly covered by grass, shrubs and small trees. There are significant quantities of construction and other waste which appear to have been illegally dumped. The additional piece of land forming the southeast corner was cultivated historically, but any farming has since been abandoned.

There is a small informal abandoned residential structure on the western boundary close to the proposed entrance to the site. The structure will require removal/relocation by the project, as discussed in Section 20. There are no other structures on the site.

The Quantum tank farm, to the south of the proposed EPL tank farm, has a number of low rise ancillary buildings between the tanks and the road. There is an approximately 20m corridor between the two plots. A large commercial warehouse facility is located approximately 100m further to the east. Remaining land immediately surrounding the tank farm is undeveloped brownfield or commercial facilities. Most plots are walled.

The area surrounding the tank farm site is relatively flat and the drainage direction is towards the south/south-east with prevailing topographic gradient. The road from Valco Road to the site is currently dirt/gravel surfaced. There are storm drains at various stages of construction in the THIA, including on the road opposite the northwest corner of the tank farm site. However, there is no storm drainage immediately adjacent to the tank farm site itself or along the main access road from Valco Road. No information was identified to indicate that formal storm drainage is planned for the access road and therefore this should be considered in the tank farm drainage design, which should therefore require a direct link to the main storm drain (Watercourse 2) adjacent to PPS1 and PPS2.

1.2.4 Pipeline Routes

A detailed description of the LPG pipeline route is provided in Section 2.4. The proposed LPG pipeline route is 11.9km long in total, with four distinct sections as shown on Figure 1-2. The route is described as follows:

- The pipeline runs above ground from TOR jetty at Tema port, along the existing TOR pipeline Right of Way (RoW) to a new booster station close to TOR. The line then enters into TOR above ground and connects into the TOR LPG system.

- The remainder of the pipeline route, from TOR to the tank farm site, is buried within a new RoW along first the north and then crossing to the south side of Valco road up to and beneath the storm drain. Here, the route turns north and runs along the eastern side of the local access road, to the tank farm site. The final sections are separate below ground lines from the tank farm to PPS1 and PPS2. These are 8” lines.

- The entire LPG pipeline route is within industrial/commercial land, with various industrial/commercial facilities located adjacent to the route. No residential properties were identified in the vicinity of the pipeline, apart from the potential dwelling on the tank farm site discussed above. A small number of informal trader kiosks were identified along the section of the pipeline from the storm drain to the tank farm. Impacts to these kiosks have been considered via an Abbreviated Resettlement Action Plan (ARAP), which is discussed further in Section 20.
- A number of other kiosks are located along the south side of Valco road (opposite GOIL and Sentuo Steel). In previous design iterations, the pipeline route would have passed directly through all of these kiosks. However, the project is now intending to avoid the majority of the kiosks by realigning the pipeline route. It is currently intended to keep the pipeline route on the north side of Valco Road until up to the driveway of Sentuo Steel, before crossing to the south side of the road. This will avoid all but approximately 5 kiosks, though is subject to more detailed survey of potential obstacles on this revised route. Associated potential for temporary or permanent relocation of kiosks is discussed in Section 20. The location of the kiosks is shown on Figure 1-4a, and Figure 1-4b.
- The buried section of the pipeline route along the north side of Valco Road passes in front of a number of large industrial installations, with the potential for associated underground infrastructure which will need to be confirmed as discussed above. The area between the road and the various facilities is also utilised in a number of places for informal parking by tankers and other vehicles. Depending on the final design considerations, the use of land above the pipeline may need to be restricted for these vehicles.

Water will be sourced from the Ghana Water Company (GWC) municipal supply at a connection point north of Valco Road. A new water pipeline will be built from this connection, following the RoW of the LPG pipeline, approximately 900m northward to the tank farm and then via a ”Tee” off to water storage tanks within PPS1 and PPS2 which will serve the needs of both power plant sites. The area is covered by brush vegetation and no structures or farmed areas have been identified along this route.

New diesel pipelines are required to transport diesel stored at the Quantum petroleum site to PPS1 and PPS2. The lines will follow the new RoW for the LPG routes between the tank farm and power sites, as described above.

1.2.5 Site Access

The proposed power plant sites lay approximately 3km south-west of the main Accra-Tema motorway (N1) which runs parallel to the coastline in either direction. To the north-west of the TOR site, the N1 links to the north-south running N2 which provides access to towns to the north of Tema, the nearest being Kpong, 50km north.

The Tema railway terminates at Tema port, approximately 5km south of the site on the coast, and provides rail links to Accra, and Kotoka International Airport, located on the eastern side of Accra, approximately 20km west of the development site.

Access to PPS 1 and PPS2 and the tank farm construction, as well as the pipeline construction from TOR to the tank farm and power sites, will be via Harbour Road (from either the port or N1/N2) and Valco Road. The distance from the port via this route is approximately 11 km.

The access roads are generally suitable for heavy loads as required for delivery of the major equipment to the site (i.e. gas turbines, transformers etc.). However, it is possible that during the rainy season, the site access roads after Valco Road may require improvement. Alternatively, it is understood that the EPC contractor is considering a backup route accessed by the main Harbour Road from Tema port, then Tema Aflao Road, before turning south into the main TTPC access road.

It is understood that there are existing municipal protocols in place for construction transport controls within the Tema Metropolitan area and these will be investigated through appropriate consultation by the EPC contractor.

The LPG pipeline pipes have already been sourced and moved to the project area.

1.2.6 Identified Existing and Proposed Developments near to the Power Plant Site

The locations of identified relevant existing and proposed developments in the vicinity of the site are shown on Figure 1-3a and 1-3b. The existing plants in the TTPC and existing or proposed plants or large emitter facilities within 3km of the proposed plant sites, are listed in Table 1-1 and Table 1-2, respectively.

Distances are provided as the closest point between the facility and the nearest project site (PPS1, PPS2, and tank farm).

Table 1-1: Existing and Proposed Power Plants

Plant Details	Part of TTPC	Distance / Direction (from PPS1/PPS2)	Capacity (Existing or proposed)	Fuel	Notes
Trojan Power – Tema I	Yes	110m SW (PPS2)	26 MW	Natural Gas, DFO or biofuel	Sixteen (16) 800kW CAT machines in each building, 32 machines in total. Currently only 6 operating at one time with some being reconditioned. Plants are de-rated due to fuel mix, operating at around 650-685kW. Trojan I is planned to be replaced with 40MW comprising 4 x 10 MW gas engines. Timing unconfirmed
Trojan Power – Tema II	Yes	115m WSW (PPS2)	21 MW	DFO	Trojan II is 20.8MW full capacity with 25 CAT engines. 16 engines are running presently on diesel.
Trojan Power – Tema III (or 'Trojan V Power')	Yes	170m SW (PPS2)	56 MW	Natural Gas	This is a joint venture between Trojan and 'V Power'. Thirty-six (36) x 1.56 MW gas-fired Type 16V 4000 L32 gensets were installed in 2016. It is understood that Trojan will utilise either liquefied

Plant Details	Part of TTPC	Distance / Direction (from PPS1/PPS2)	Capacity (Existing or proposed)	Fuel	Notes
					natural gas or compressed natural gas and is currently building a regasification facility on adjacent land to the south of the new machines.
VRA Station 3 (Siemens)	Yes	210m SW	32 MW	Natural Gas / DFO	Three new Siemens machines installed (12MW, 11MW, and 10MW) and commissioned, but not operating.
VRA Station 3 Expansion (Siemens)	Yes	0.2km W (PPS2)	42 MW	Natural Gas / DFO	Two x 14 MW and one x 13 MW gas & diesel-fired open cycle Siemens plants, currently shut down as gas supply was cut off. Normal fuel is gas, with diesel to be used on an emergency basis only. Only one of the 14 MW plants is currently commissioned, but all are built.
CENIT & VRA Tema Thermal Power Plants	Yes	0.6km SW (PPS2)	220 MW	LCO / Natural Gas	Also referred to as VRA Station 2. 2 plants of 110MW each, GE Frame 9 turbines operate in open cycle mode and there are plans for expansion to combined cycle mode.
Mines Reserve Plant (MRP)	Yes	0.7km W (PPS2)	80 MW	Natural Gas	Also referred to as VRA Station 1
Cenpower Kpone Independent Power Plant (KIPP)	No	1.9km E (tank farm)	350 MW	LCO, DFO and Natural Gas	350 MW CCGT plant with tri-fuel under construction; to be commissioned 2017. Aiming to switch to gas in quarter 2, 2018. Two General Electric Frame 9E Gas Turbines. Two double pass NEM HRSGs, Siemens' Steam Turbine.
Sunon-Asogli Power Plant Phase 1	No	2.7km E (tank farm)	200 MW	Natural Gas	Two x 100 MW gas-fired CCGT GE plants
Sunon-Asogli Power Plant Phase 2	No	2.7km E (tank farm)	360 MW	Natural Gas / LCO	Two x 180 MW gas-fired CCGT GE plants under development, first plant recently commissioned. 2017 consultations indicate that, due to lack of availability of NG, the plant is attempting to convert to using LCO fuel for at least one of the new expansion units. Discussions with Trojan Power indicate that Sunon-Asogli is also planning to use LNG/CNG and has already completed the regasification equipment. However, it was not possible to confirm this with Sunon-Asogli at the time of writing.

Plant Details	Part of TTPC	Distance / Direction (from PPS1/PPS2)	Capacity (Existing or proposed)	Fuel	Notes
VRA KTPP	No	~6.5km N (PPS2)	220 MW	DFO/ Natural Gas	Commissioned in 2016, Expansion in Phase 2 to 330MW capacity[3]
AKSA Heavy Fuel Oil (HFO) Power Plant	No	~0.8km NNW	200 MW	HFO	The plant has a permit for 370 MW - 22 x Wartsilla 17MW reciprocating engines burning HFO. However, only 3 of 4 phases (power houses) were constructed as of May 2017, with 11 units are commissioned, with installed capacity currently at ~200MW.
Karpower Ship	No	5 km SW (PPS1)	225 - 450 MW	HFO	No detailed information has been identified on the Karpower ship. Ghana EPA indicates that the current 225MW capacity ship will be replaced with a 450MW capacity HFO fired ship in late 2017

Notes:
The operation of all existing gas-fired plants is understood to be intermittent at the time of writing due to limitations in availability of gas.

Table 1-2: Other Large Emitter Facilities

Installation Details	Distance / Direction (from project site)	Notes
Tema Oil Refinery (TOR)	0.8km W (PPS2)	Oil refinery and tank farm (multiple fuel) with jetty facilities and delivery pipeline infrastructure
Sentuo Steel	0.6km SW (PPS2)	Steel reprocessing company; smelter.
Tema Fuel Trade Company (TFC)	0.6km SW (PPS1)	Tank farm fuel storage. Second site 1.7km NW.
Valco Aluminium	0.7km S (PPS1)	Smelter; operating intermittently due to lack of power
Tema Steel Company	1.7km NW (PPS2)	Steel production, reduced operation.
Tema Special Steel	1.6km NW (PPS2)	Steel production, reduced operation.

1.3 Project Objectives

The primary objective of the project is to deploy electrical energy as quickly as possible to support GoG's short term strategy for power generation. The project is also required to meet more long term objectives to help meet the increasing energy demand in Ghana and so ensure its continued social and economic development.

[3] Source: VRA, August 2012 – Environmental Impact Assessment of The Kpone Thermal Power Project.

An overview of Ghana's energy supply, its current and future energy requirements and the need and justification for the proposed development is provided in Section 3.

In accordance with these needs, objectives of the project are as follows:

- Provide continuous, reliable, high efficiency and low cost gas-based electric power;
- Provide emergency power to the Tema Industrial zone;
- Provide emergency power to the Ghanaian economy; and,
- Contribute to the long-term national and regional energy requirement to support sustainable development.

1.4 Project Proponents

A consortium of Endeavor Energy, General Electric (GE) and SAGE has been formed under a local company Early Power Limited (EPL) to develop the project and contract with Electricity Company of Ghana (ECG), together forming the "the Proponent". The Early Power consortium has liability/responsibility for both the development and operational phases of the project.

Comments relating to the project and this scoping assessment can be addressed to the following:

Name:	Mr Kingsley Asare
Address:	91 Osu Badu Street West Airport Accra, Ghana
Email:	kingsley.asare@endeavor-energy.com
Telephone Number:	+233 (0) 55.451.3862

1.5 Project Timescales

The estimated timing of the development for each of the project phases is summarised in Table 1-3. The total construction timescale is 34 months. Assuming an August 2017 start date, COD for Stage 2 will be May 2020.

Table 1-3: Proposed Project Construction Timescales

Site / Phase	Net Capacity (MW)	Construction Months																																		Commercial Operation Date
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	
PPS1																																				
1a	145 (OCGT)																																			May 2018
1b	57 (CCGT)																																			August 2019
PPS2																																				
2	222 (CCGT)																																			May 2020
Total	**424**	Operation life: 25 years																																		

OCGT – Open cycle gas turbines
CCGT – Combined cycle gas turbines

1.6 The Preliminary Environmental Report Document Structure

The ESIA includes the following components to meet the environmental impact assessment requirements for the Ghana EPA and the international finance community:

The information is set out as follows:

- Section 1 Introduction and Project Overview.
- Section 2 Project Description.
- Section 3 Project Justification: The Need for the Project.
- Section 4 Analysis of Alternatives and Site Selection.
- Section 5 Policy, Legal and Administrative Framework.
- Section 6 Environmental Impact Assessment Methodology.
- Section 7 Physical Environmental Baseline
    - Land and Water Quality;
    - Climate Profile;
    - Noise;
    - Air Quality;
    - Landscape and Visual;
    - Ecology; and,
    - Transport.
- Section 8 Socio-economic baseline;
- Section 9-20 Impact Assessments and Mitigation
    - Section 9 Land Quality;
    - Section 10 Noise;
    - Section 11 Air Quality;
    - Section 12 Landscape and Visual;
    - Section 13 Flood Risk;
    - Section 14 Climate Change;
    - Section 15 Ecology;
    - Section 16 Water and Wastewater;
    - Section 17 Solid Waste Impacts;
    - Section 18 Greenhouse Gas Emissions;
    - Section 19 Traffic and Transport; and,
    - Section 20 Socio-economic.
- Section 21 Consultation and Disclosure;
- References; and,
- Appendices.

The following assessments have been identified as not required during the project's initial detailed screening phase:

- Cultural Heritage – Construction activities have the potential to impact on areas of cultural heritage. However, previous assessments for the area, along with consultation and searches with the Ghana museum board and Tema Metropolitan Authority have not identified any areas of cultural interest.
- Trans-boundary – The key project components will not have trans-boundary impacts.
- Indigenous People – The socio-economic assessment and on-going project consultation activities have not identified any communities or people who would be considered Indigenous under the IFC definition of Indigenous People.

1.7 Cumulative Impact Assessment

Cumulative impacts may result due to the existing and proposed power plants and developments in the area. Each section within this report provides discussion and impact assessment for cumulative impacts where appropriate.

The key concern from cumulative perspective is associated with the addition of emissions and process contributions to ambient air quality from the other new or expanded power plants described in Table 1-1 above. The following plants are the most significant:

- the operating 200MW AKSA HFO power plant, located 800m to the north-northeast;
- the LCO/diesel/gas fuelled Cenpower KIPP located 1.9km to the east of the tank farm site. Proposed to be commissioned in late 2017;
- the proposed 450 MW capacity Karpower ship to be located in Tema Harbour and understood to be commissioned in late 2017; and,
- the completed Sunon Asogli plant expansion which may now also fire LCO.

The Trojan Tema III plant and VRA Station 3 expansion are of less concern given their small capacities and capacity to fire on gas when available.

Surrounding large industrial facilities including steel and aluminium production/processing installations are understood as currently having a reduced operating schedule due to, amongst other things, lack of sufficient electrical power. It is acknowledged that there is a risk that these facilities could potentially receive additional power from the Ghana Bridge Project following commissioning and that these facilities could therefore increase emissions to the local air-shed. However, decision making in this regard is at the GoG / EPA policy level and as such beyond the scope of any EPL agreement with GoG / ECG and therefore beyond the scope of this study.

EPL will continue to consult with the EPA and other stakeholders regarding status of new generation during the development phase of the Ghana Bridge Project. EPL has confirmed with the EPA and other generators during consultation that it is committed to working collaboratively with other emitters regarding long term ambient air quality within the air shed.

1.8 ESIA Updates

The original revision (1) of this document was submitted to the Ghanaian EPA in December 2015 in support of an application for an environmental permit, which was subsequently issued in January 2016.

The ESIA was then revised again in 2016 (Revision 1) and Following submission of Revision 1, EPL advised of some improvements to the project design, improving energy efficiency but requiring an additional development plot. An updated assessment (ESIA Revision 2) evaluated these changes and was submitted the EPA in June 2016. Further amendments to the project design and location since then have warranted a further iteration of the ESIA. This revision (Revision 2) incorporates the changes, and provides an updated assessment based on these changes. A summary of changes at Revision 1 and Revision 2 is provided below:

Revision 1

- Incorporation of heat recovery on the TM plants with conversion from open cycle to combined cycle in Phase 2, thus increasing the power generation capacity. As this requires additional space, the power facilities are now split between two sites (PPS1 which will be occupied by the TM plants and PPS2 which will be occupied by the LM plants);
- The use of the latest GE plant designs (TM 250 Gen 8) means that only five TM units are required, instead of six units in the original plan;
- Additional diesel lines are required from the Quantum petroleum to both power sites to provide back-up fuel supply;
- The route of the water supply pipeline now follows the RoW for the LPG pipeline; and
- Additional diesel and water lines are required from VRA station 3 to PPS1.

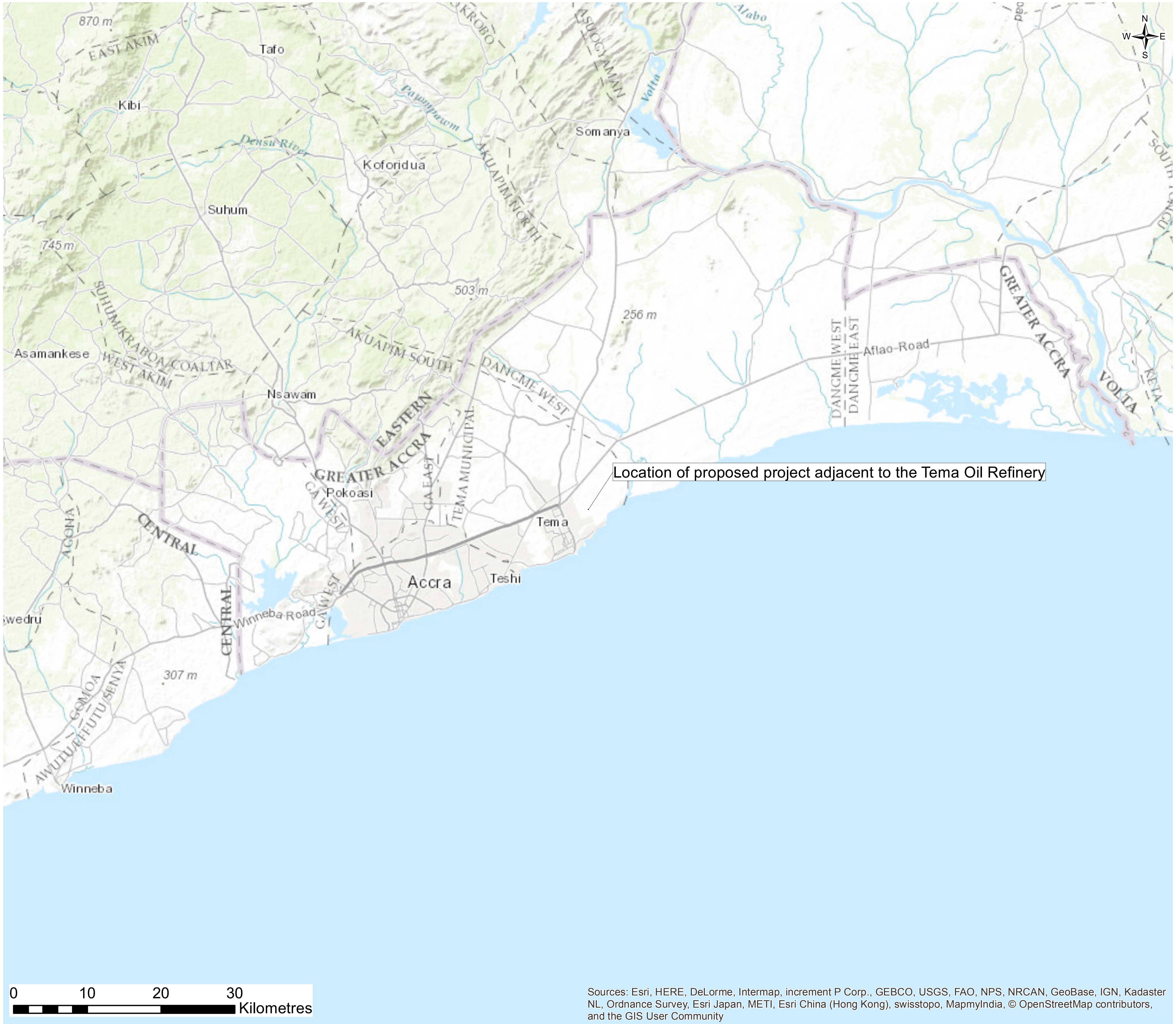
Revision 2

- Revision of previous 'Phases' to Stage 1a and Stage 1b (located on PPS1) and Stage 2 (located on PPS2);
- Location, capacity and unit composition of the two power plant sites. The former PPS1 is no longer to be used; the former PPS2 will now form PPS1 and an additional plot will be used as PPS2;
- Change to the routing of the LPG fuel delivery pipeline and transport access;
- Inclusion of potential for worst-case extended operation using diesel fuel oil DFO in the event of a significant disruption in supply of LPG outside of the project's control;
- Revised information regarding stack heights;
- Amendments to capacities of tank farm infrastructure;
- Update of water consumption rates; and
- Project schedule.

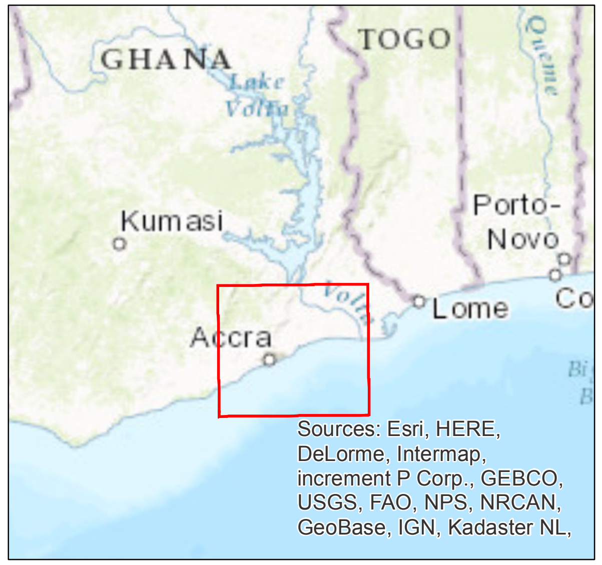
The ESMP which forms Volume III of this submission summarises the key environmental and social actions that are required by the project prior to construction. Table 1 of the ESMP summarises the actions required prior to construction. Table 2 of the ESMP summarises remaining construction and operational phase commitments for EPL and its contractors.

Table 1 of the ESMP can be used to form the basis of an environmental and social action plan for the international financial institutions financing the project. This will ensure the ongoing project commitment to addressing, managing and mitigating all identified environmental and social impacts.

FIGURE 1-1



Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community



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0	15/06/2016	Initial Issue	EW	RS	LR	JPW

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Project

Ghana Bridge Power Project ESIA

Drawing Title

Regional Project Location

Drawing Status

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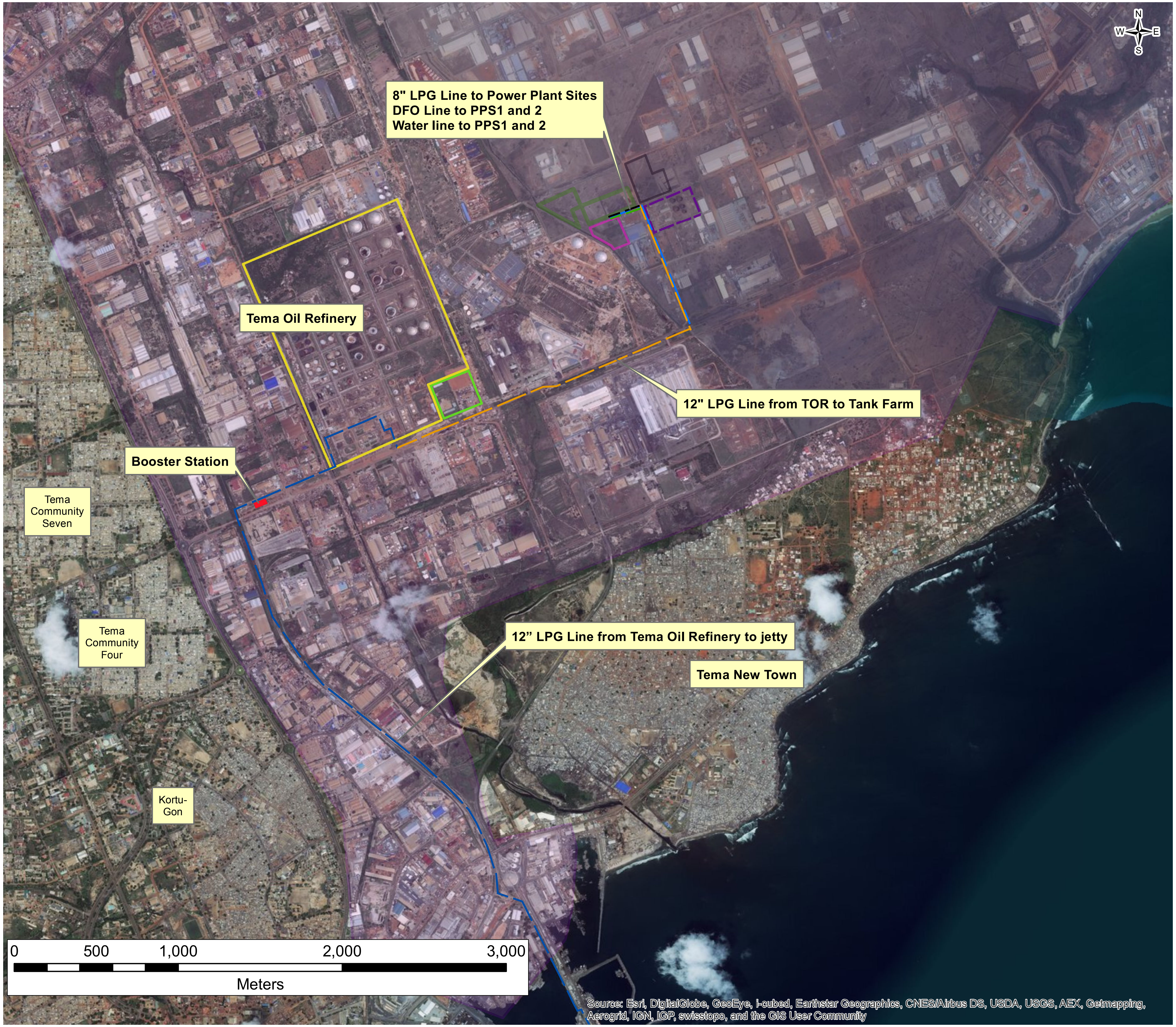
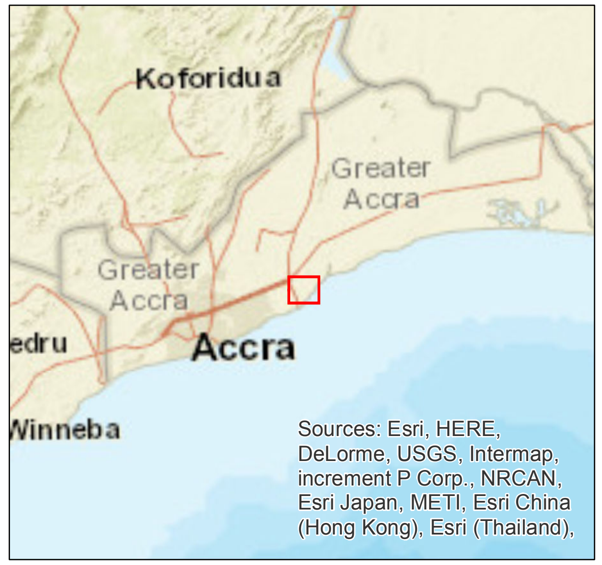
Client No.		
Drawing No.	60K36301/LVA/1_1	

FIGURE 1.2



Legend

- 12 " LPG Pipeline (Overground)
- 12 " LPG Pipeline (Underground)
- 8 " LPG Pipeline to Site (Underground)
- Diesel Pipeline
- Water Pipeline (Underground)
- Tema Oil Refinery
- Ghana Bridge Power Plant Site 1
- Ghana Bridge Power Plant Site 2
- Quantum Terminals Limited Tank Farm
- LPG Tank Farm
- Tema Heavy Industrial Area (THIA)
- Ghana Oil Company (GOIL)



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Drawing Title

Development Site Locations and Pipeline Routes

Drawing Status

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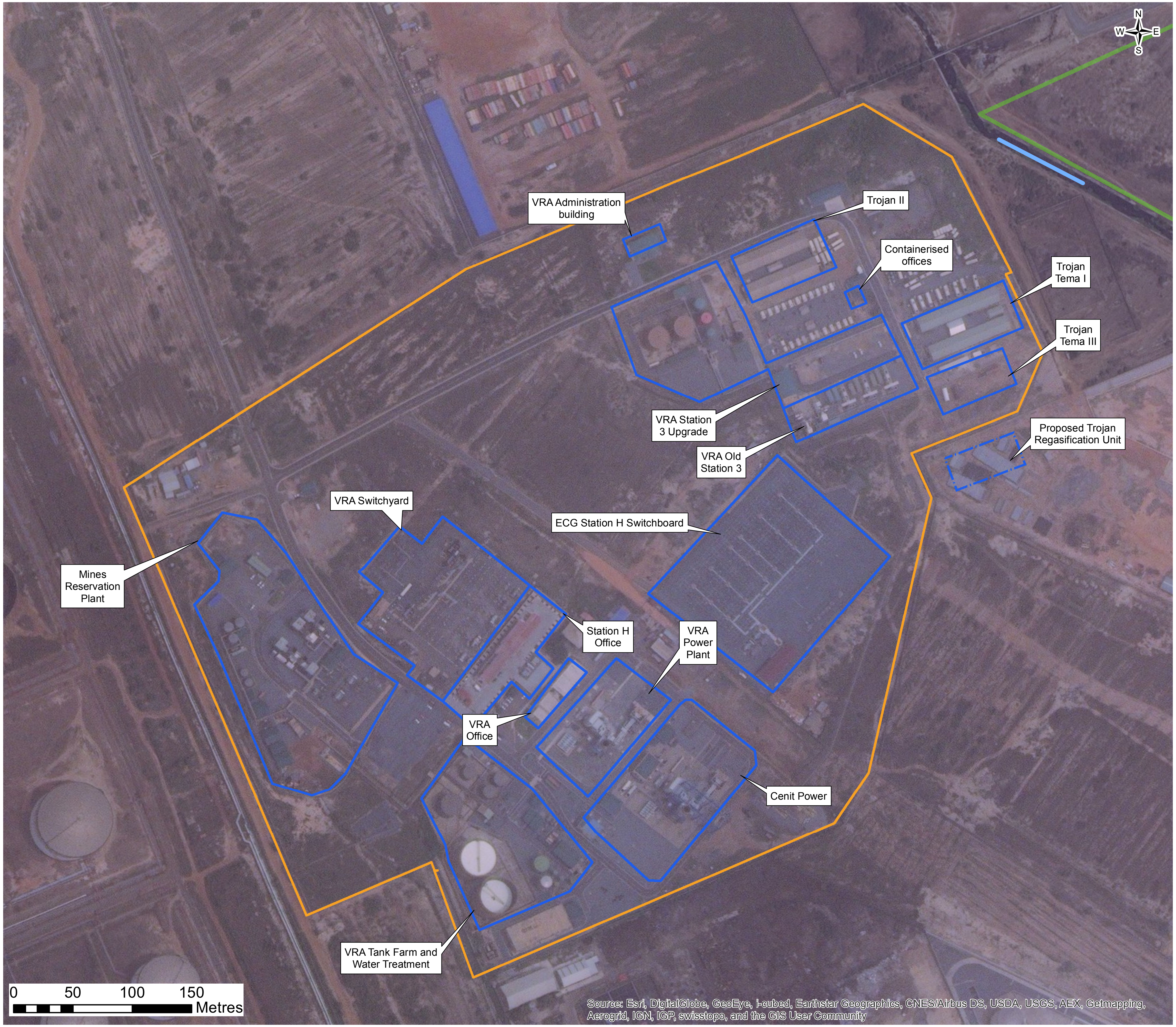
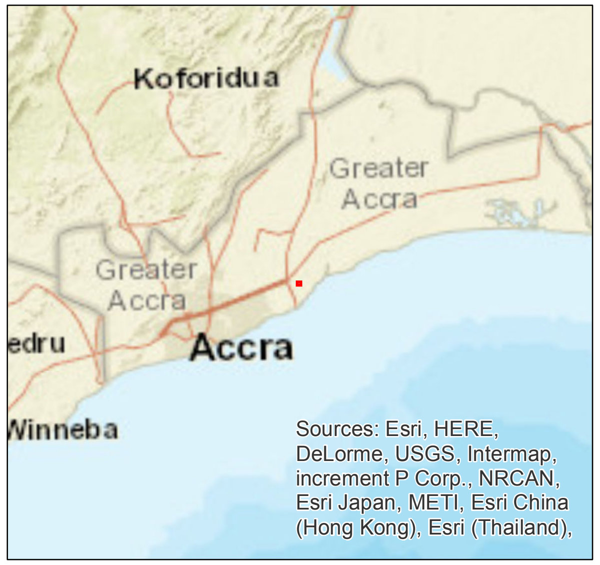
FIGURE 1-3a



Legend

- Storm Drain
- Tema Thermal Power Complex
- Industrial developments within the Tema Thermal Power Complex (TTPC)
- Industrial developments outside the Tema Thermal Power Complex (TTPC)
- Ghana Bridge Power Plant Site 2



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Project

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Drawing Title

Industrial Installations within the Tema Thermal Power Complex

Drawing Status

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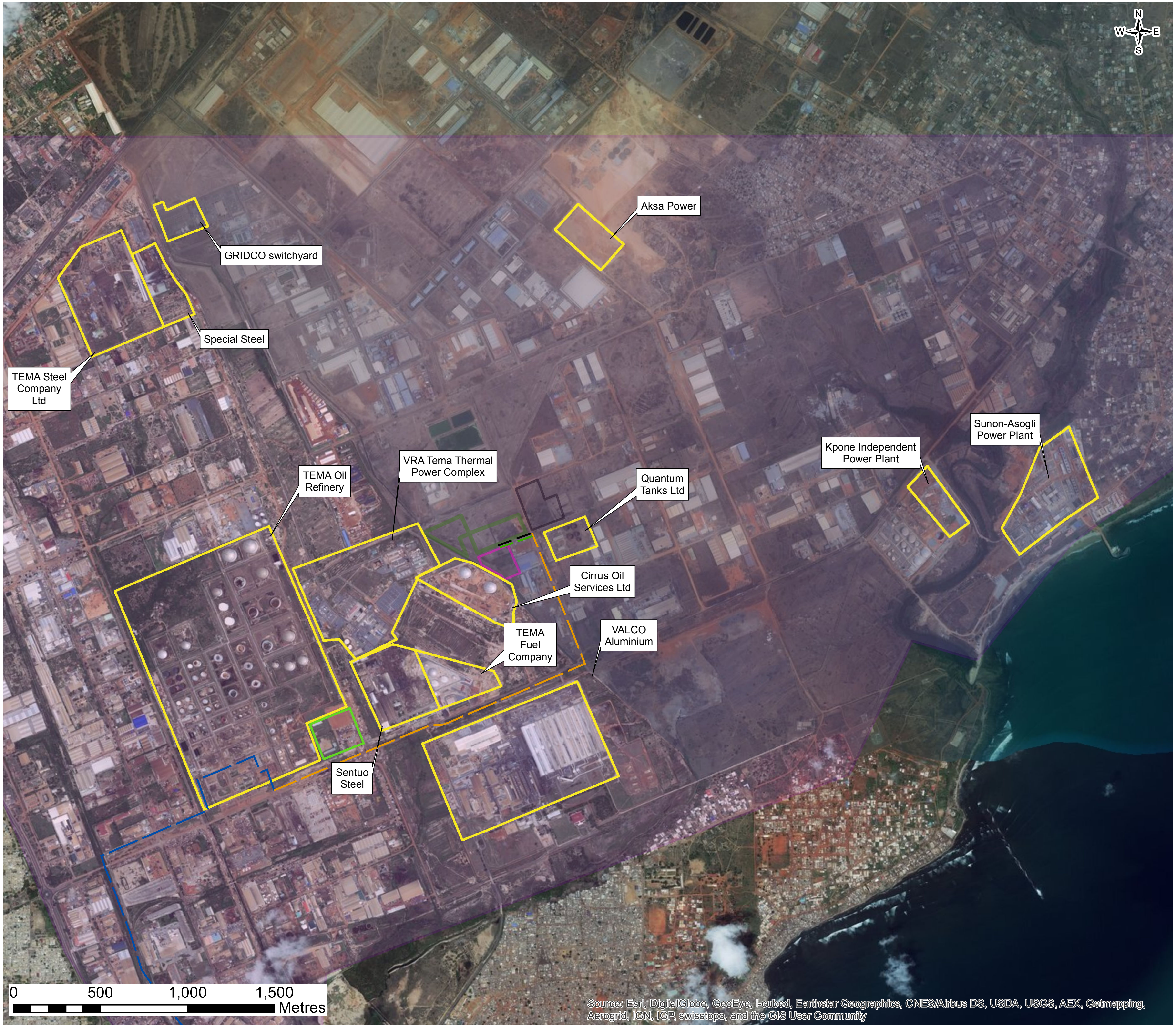
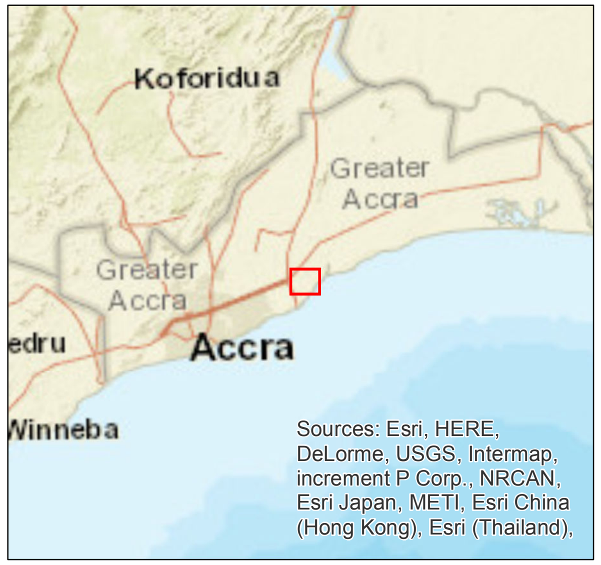


FIGURE 1-3b

Legend

- 12 " LPG Pipeline (Overground)
- 12 " LPG Pipeline (Underground)
- 8 " LPG Pipeline to Site (Underground)
- Diesel Pipeline
- Ghana Bridge Power Plant Site 1
- Ghana Bridge Power Plant Site 2
- LPG Tank Farm
- Tema Heavy Industrial Area (THIA)
- Surrounding Industrial Developments
- Ghana Oil Company (GOIL)



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Drawing Title

Major industrial installations in the Surrounding Area

Drawing Status

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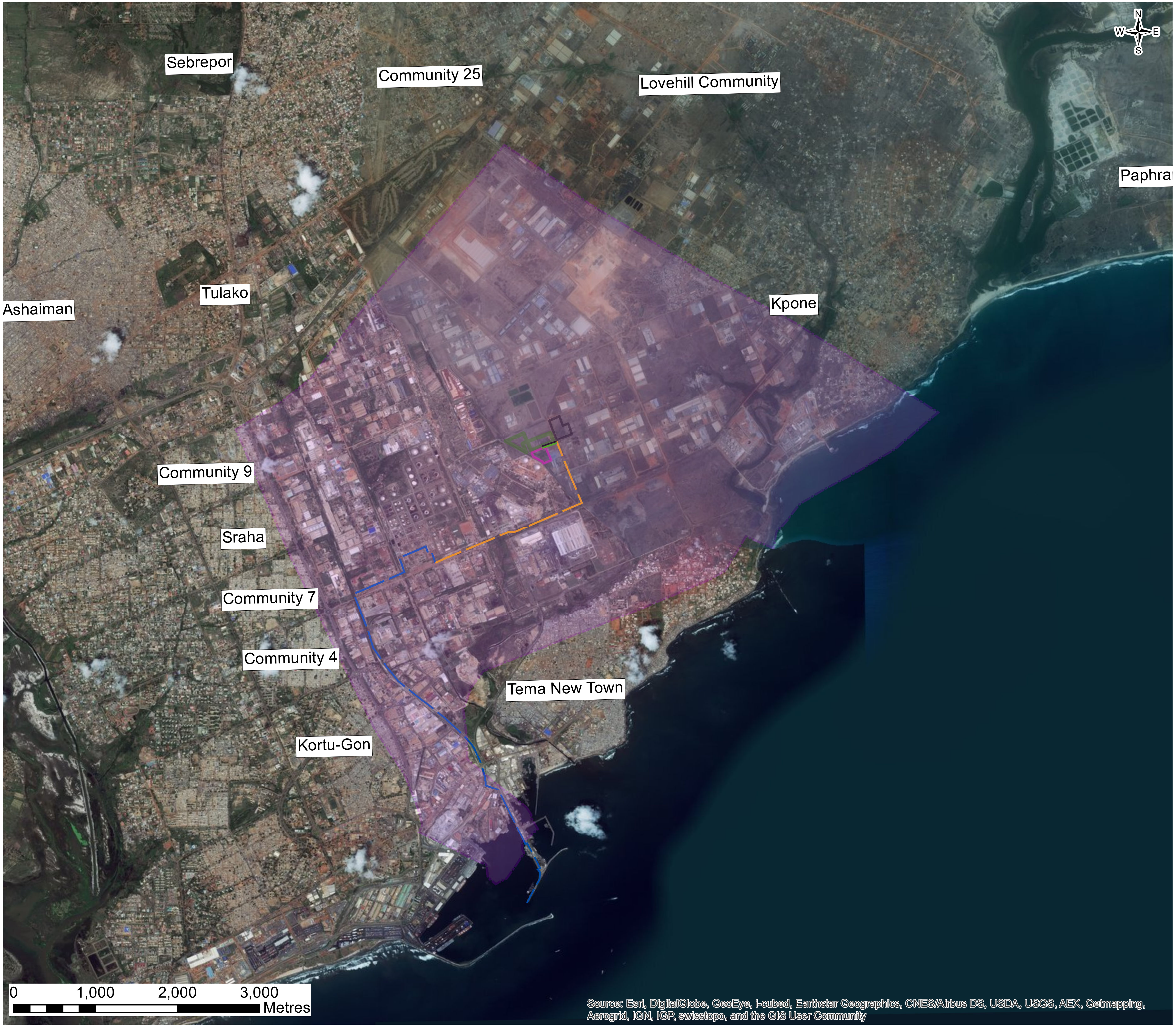
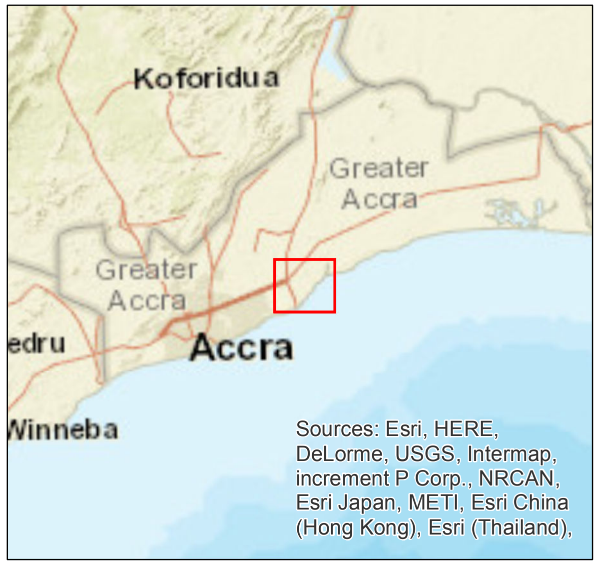
FIGURE 1-4a



Legend

- 12 " LPG Pipeline (Overground)
- 12 " LPG Pipeline (Underground)
- 8 " LPG Pipeline to Site (Underground)
- Diesel Pipeline
- Ghana Bridge Power Plant Site 1
- Ghana Bridge Power Plant Site 2
- LPG Tank Farm
- Tema Heavy Industrial Area (THIA)



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Project

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Drawing Title

Location of residential areas

Drawing Status

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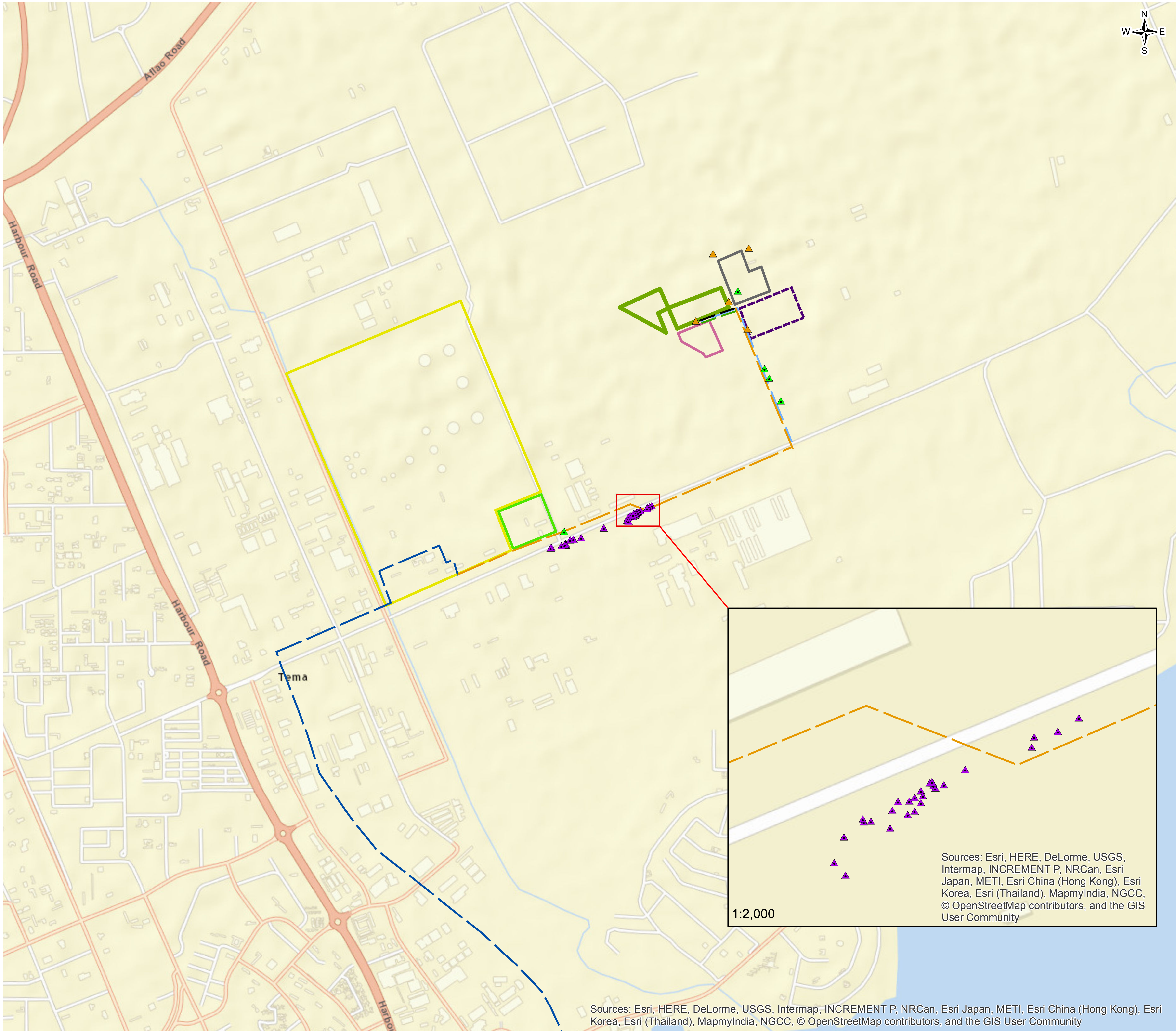
Client No.	N/A	

Drawing No.

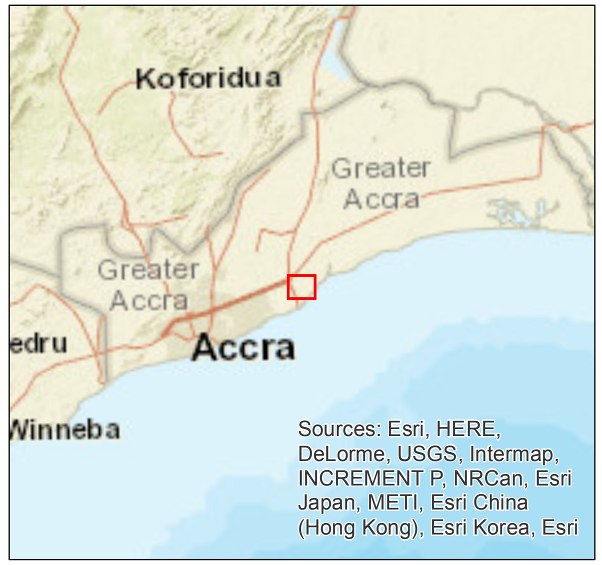
60K36301/LVA/1_4a

FIGURE 1-4b



Legend

- Stage 1 ARAP Kiosks
- Valco Road Kiosks
- New Kiosks 2017
- 12 " LPG Pipeline (Overground)
- 12 " LPG Pipeline (Underground)
- 8 " LPG Pipeline to Site (Underground)
- Diesel Pipeline
- Water Pipeline
- Ghana Bridge Power Plant Site 1
- Ghana Bridge Power Plant Site 2
- LPG Tank Farm
- Ghana Oil Company
- Quantum Terminals Limited Tank Farm



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Project

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Drawing Title

Location of Kiosks/Small business

Drawing Status

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Jacobs No.	60K36301	
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Drawing No.

60K36301/LVA/1_4b

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- Performance Standard 2: Labour and Working Conditions (PS2);
- Performance Standard 3: Resource Efficiency and Pollution Prevention (PS3);
- Performance Standard 4: Community Health, Safety, and Security (PS4); and,
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JACOBS Consultancy

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Section 2 – Project Description

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration		Rev No
Sep 2015	First issue		0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency		1
June 2016	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating details of the improved project designs, including where relevant:		2
	Section No.	***Change***	
	Wherever relevant	Reference to “power plant site” changed to reflect revised plan involving two power plant sites (PPS1 and PPS2).	
	Wherever relevant	Corrections to spelling, grammar and other changes for consistency. Abbreviated terms provided in full at first usage.	
	Section 2.5.5	Removed incorrect reference to seawater, as only mains water supplied by the Ghana Water Company will be used.	
August 2017	ESIA amendment issued to Ghana Environment Protection Agency, incorporating details of further project design changes, including:		3
	Section No.	***Change***	
	Wherever relevant	Location, phasing, capacity and unit composition of the two power plant sites (PPS1 and PPS2).	
	Wherever relevant	Change to the routing of the LPG fuel delivery pipeline.	
	Wherever relevant	Inclusion of text and/or data regarding potential for extended operation using diesel fuel oil DFO in the event of disruption in supply of LPG.	
	Section 2.2.3	Project schedule.	
	Section 2.2.7	Additional information regarding stack heights, temporary stacks and exit temperatures.	
	Section 2.3	Amendments to capacities of tank farm infrastructure.	
	Section 2.5.2	Update of water consumption	
	Section 2.13	Update of land ownership agreements, in light of ongoing transactions.	

Contents

Figures and Tables

2 Project Description

2.1 Overview of Project Components

This section provides an overview of the main project components. Detailed technical discussion of the individual components follows in subsequent sections.

The project includes the development of power plant facilities to provide commercially available power in a series of stages (Stage 1a, Stage 1b, Stage 2), on two sites. Net generation capacities will be 145MW (Stage 1a), 57MW (Stage 1b)[1], and 222MW for Stage 2, providing a total of 424MW.

Throughout the development, liquefied petroleum gas (LPG) will be used as the primary fuel, though the design allows for operation on diesel fuel oil (DFO) for start-up and for worst-case scenario operation during a significant disruption to the supply of LPG.

It is envisaged that within five years from the start of Stage 2 operation, the plant will switch to operation using natural gas (NG) should this be made available by the Government of Ghana (GoG).

The main project components are shown on Figure 1-2 and include:

- **Power Plants:**
    - **Power Plant Site 1 (PPS1)** – The layout of PPS1 is shown on Figure 2-1a. PPS1 will be developed in two stages with the operation of five GE TM2500 ('TM units') in open cycle gas turbine (OCGT) mode (Stage 1a) and combined cycle gas turbine (CCGT) generating mode (Stage 1b). A spare TM unit will be stored on site to be used as a maintenance replacement.
    - **Power Plant Site 2 (PPS2)** – PPS2 is located immediately north of PPS1, and west of the tank farm site. The design includes for 4 LM6000 PC Sprint variant units ('LM units') operating in CCGT mode. It is not expected that Stage 2 would operate in open cycle mode; however, the design includes bypass stacks to allow open cycle operation if required. The layout of PPS2 is shown on Figure 2-1b.

      Further details of the power plant facilities and development phasing are provided in Section 2.2.
- **LPG Pipeline** – A pipeline will transport LPG from the existing Tema Oil Refinery (TOR) jetty to the TOR plant site, through to the new project tank farm and then to the PPS1 and PPS2. The pipeline route is described in Section 2.4 and shown on Figure 1-2 and Figure 2-2a.
- **Tank Farm –** A new tank farm for storage of LPG prior to use by PPS1 and PPS2. The tank farm layout is shown on Figure 2-1c and detailed discussion is provided in Section 2.3.

[1] Guarantee provided by Phase 1 Engineering, Procurement and Construction (EPC) contractor

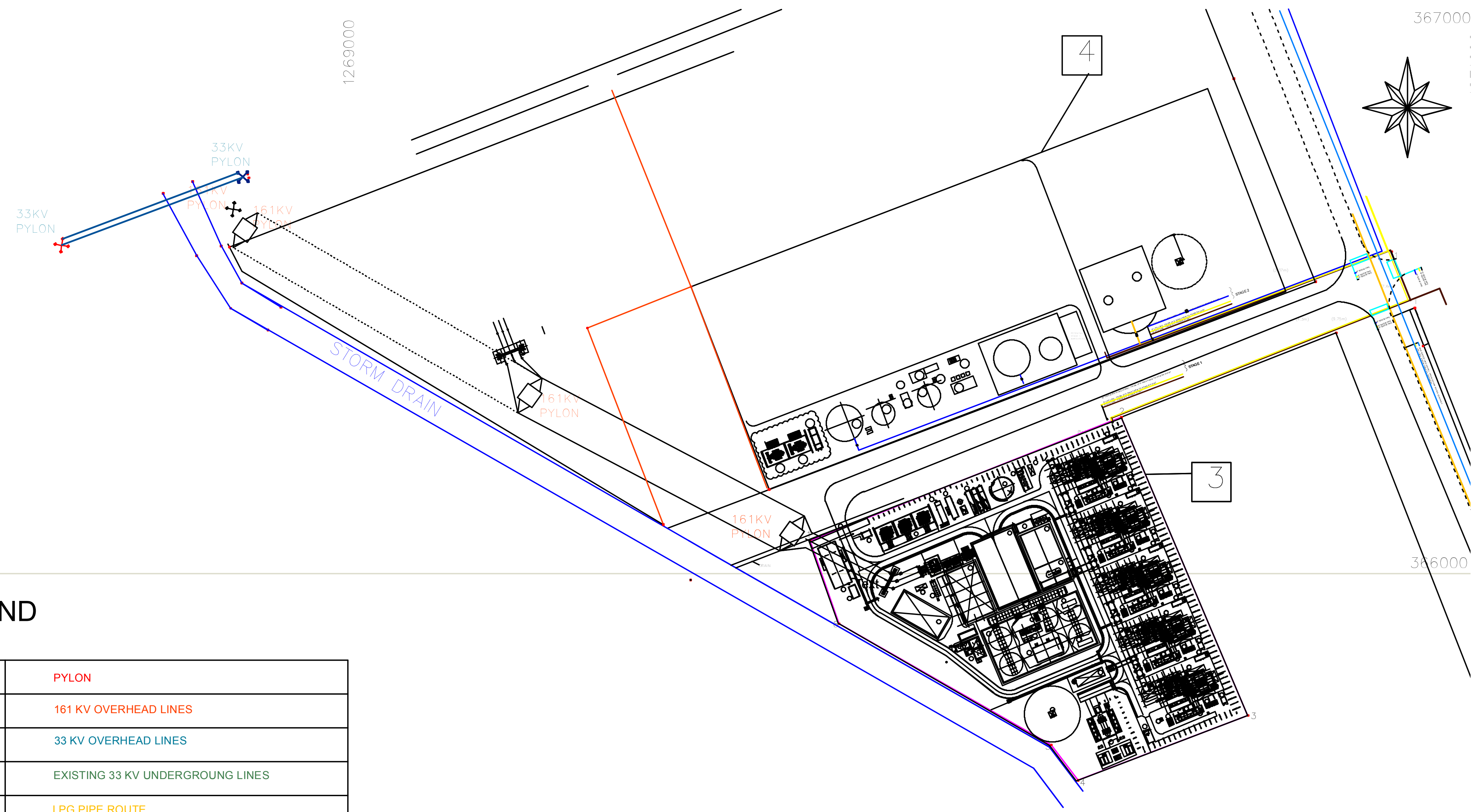
- **DFO Pipelines** – pipelines are required to transport DFO stored at the Quantum petroleum site to PPS1 and PPS2. The pipelines will follow a new Right of Way (RoW) along with the LPG routes between the tank farm and power sites.

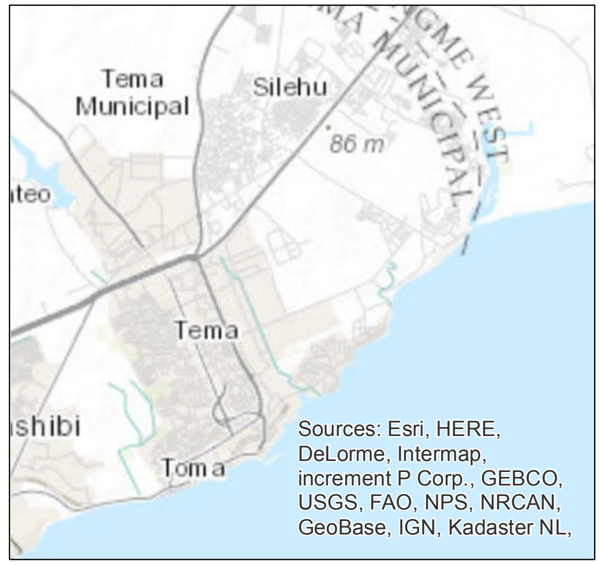
  The DFO pipelines are described in Section 2.4 and shown on Figure 2-2b.

- **Power evacuation** - Evacuation of the power for Stage 1a will be via underground connection to the existing Electricity Company of Ghana (ECG) Station H substation, adjacent to the Volta River Authority (VRA) Tema Thermal Power Complex (TTPC) at 33kV. Stage 1b evacuation will initially be via a new 161kV spur into a new double circuit 161kV overhead line to be constructed by GRIDCO by early 2018, which will run adjacent to the existing overhead lines that run east-west along the northern boundary of the Stage 2 site (PPS2). Stage 2 evacuation will be via a new substation into the new GRIDCO 161kV power lines. The Stage 1b evacuation spur will be transferred to the Stage 2 substation as that switch yard is completed. Details of the proposed power evacuation are provided in Section 2.2.2.

- **Water Pipelines** – A new pipeline will run from a Ghana Water Company (GWC) municipal supply network connection, approximately 900m south of the LPG tank farm. This pipeline will connect the municipal supply network to water storage facilities to be constructed within the LPG tank farm for fire protection purposes. Water pipeline spurs from the pipeline connecting to the municipal supply will supply water storage facilities located within the Stage 2 site to serve the water needs of both the Stage 1 and Stage 2 power facilities.

FIGURE 2-1a





LEGEND

	PYLON
	161 KV OVERHEAD LINES
	33 KV OVERHEAD LINES
	EXISTING 33 KV UNDERGROUNG LINES
	LPG PIPE ROUTE
	PROPOSED 33 KV RIGHT OF WAY CENTER LINE
	PROPOSED DFO ROUTE
	METER
	ANALYZER
	E.P.L. STAGE 1 POWER PLANT
	E.P.L. STAGE 2 POWER PLANT
	E.P.L. BOOSTER STATION

BOUNDARY DATA FOR STAGE1 POWER PLANT		
POINT	NORTHINGS	EASTINGS
1	366058.108	1269792.414
2	366276.625	1276344.091
3	365747.863	1270568.64
4	365633.122	1270267.687
5	365695.857	1270220.014
6	365910.83	1269843.707

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
1	22/07/2017	Revised generator operation	PW	GW	GW	MM

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Project

Ghana Bridge Power Project ESIA

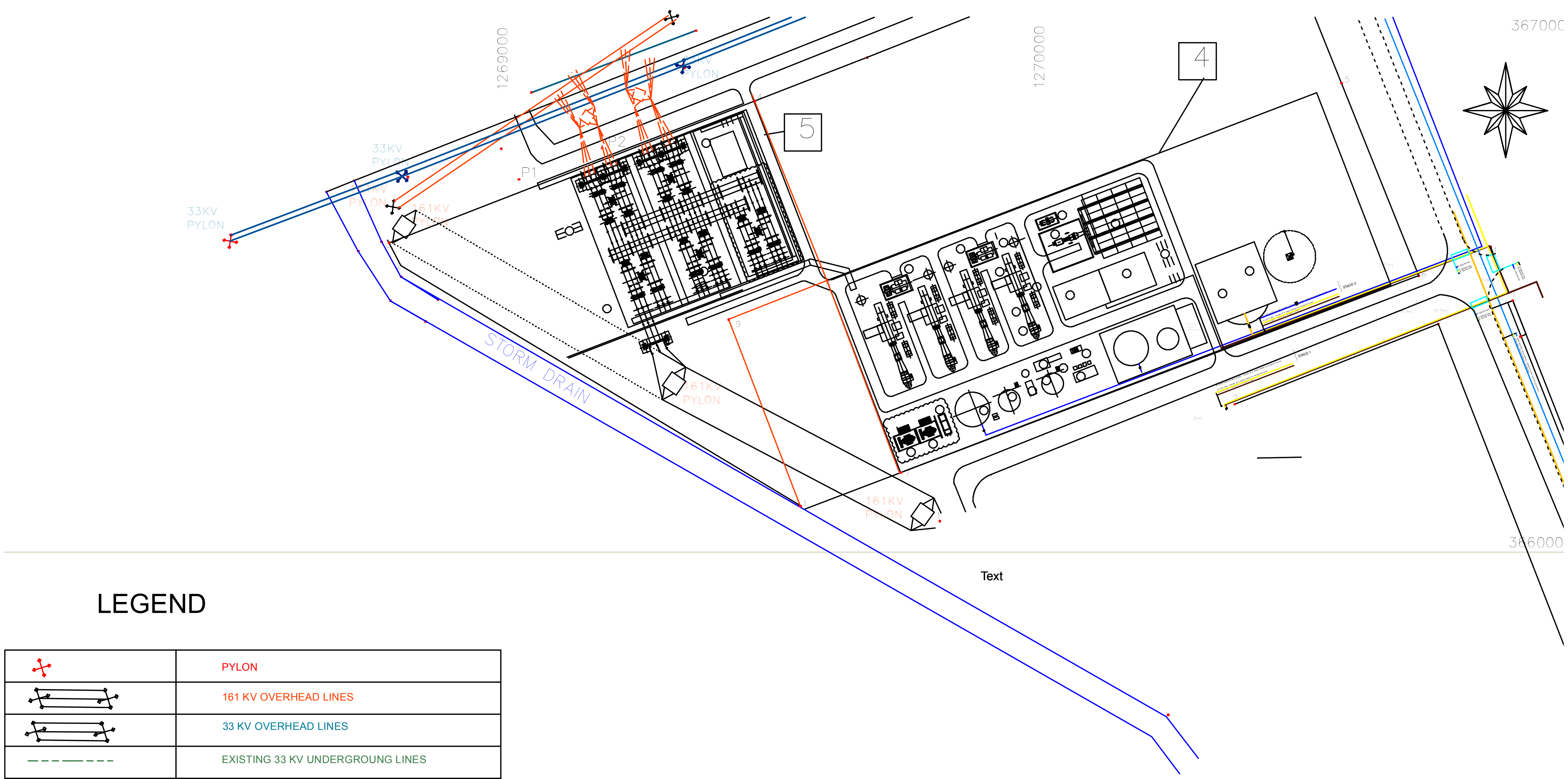
Drawing Title

Layout of Power Plant Facilities for PPS1

Drawing Status

Scale @ A3	1:9,200	DO NOT SCALE
Jacobs No.	60K36301	
Client No.		
Drawing No.	60K36301/287277C-L-001	

FIGURE 2-1b

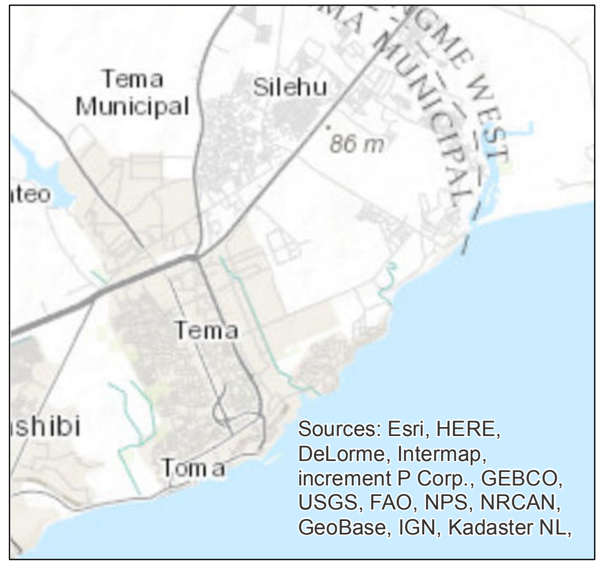


LEGEND

	PYLON
	161 KV OVERHEAD LINES
	33 KV OVERHEAD LINES
	EXISTING 33 KV UNDERGROUNG LINES
	LPG PIPE ROUTE
	PROPOSED 33 KV RIGHT OF WAY CENTER LINE
	PROPOSED DFO ROUTE
	METER
	ANALYZER
4	E.P.L. STAGE 2 POWER PLANT
	E.P.L. BOOSTER STATION

BOUNDARY DATA FOR STAGE2 POWER PLANT		
POINT	NORTHINGS	EASTINGS
1	366086.333	1269532.033
2	366535.797	1268784.706
3	366578.537	1268762.415
4	366843.227	1269446.357
5	366877.225	1270543.728
6	366517.18	1270688.48
7	366148.863	1269719.617
8	366508.291	1269581.24
9	366435.164	1269397.46

1269000 1270000 365000



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
1	22/07/2017	Revised generator operation	PW	GW	GW	MM

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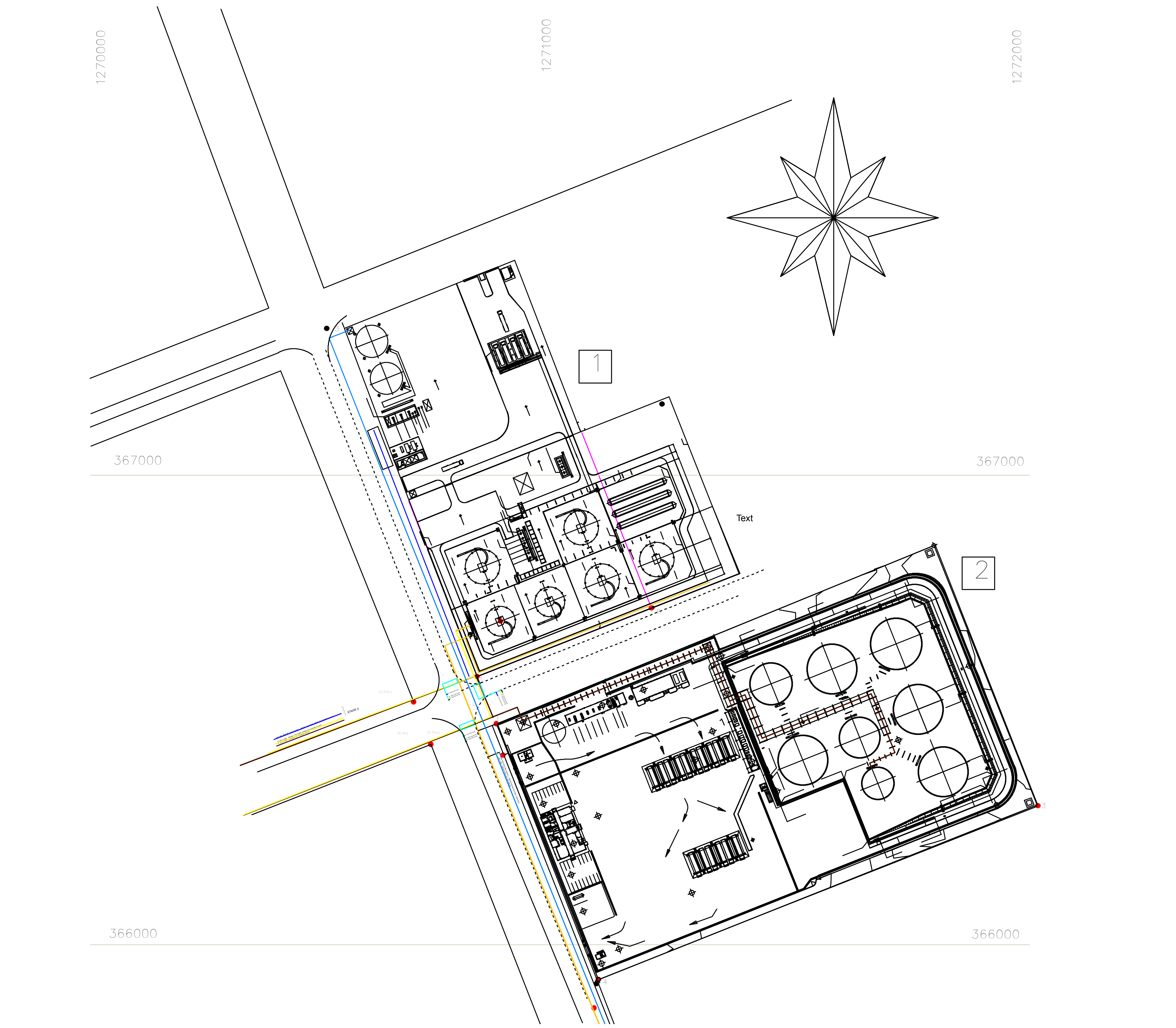
Drawing Title
Layout of Power Plant Facilities for PPS2

Drawing Status

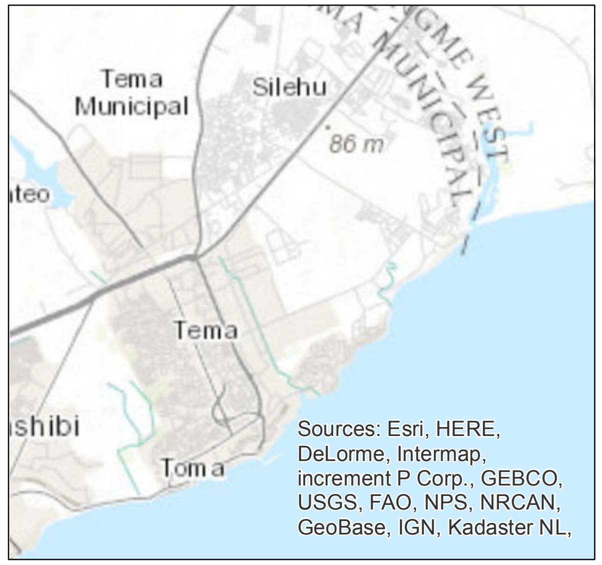
Scale @ A3	1:9,200	DO NOT SCALE
Jacobs No.	60K36301	
Client No.		
Drawing No.	60K36301/287277C-L-002	

FIGURE 2-1c



LEGEND

1	E.P.L. LPG STORAGE FACILITY
2	Q.T.L. DIESEL STORAGE FACILITY
	EXISTING 33 KV UNDERGROUNG LINES
	LPG PIPE ROUTE
	PROPOSED 33 KV RIGHT OF WAY CENTER LINE
	PROPOSED DFO ROUTE
	METER
	ANALYZER



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
1	22/07/2017	Revised generator operation	PW	GW	GW	MM

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Project

Ghana Bridge Power Project ESIA

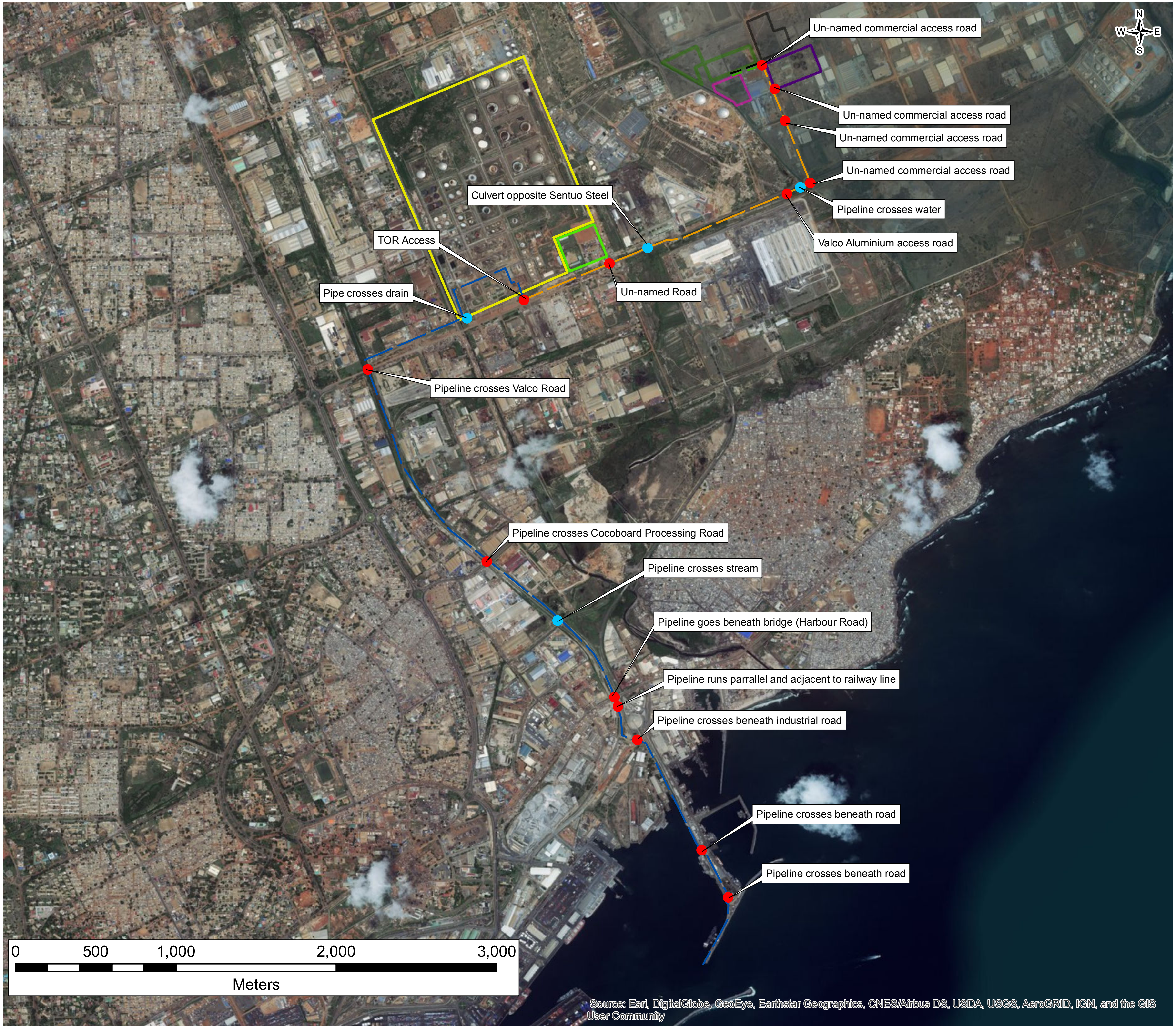
Drawing Title

Layout of LPG & DFO Tank Farms

Drawing Status

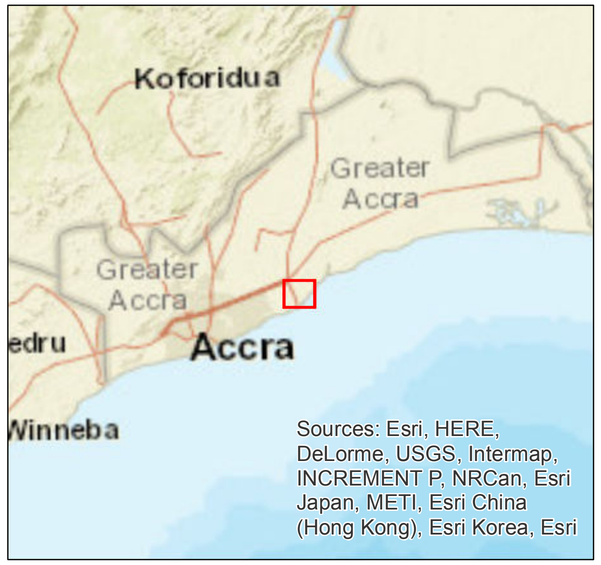
Scale @ A3	1:7,844	DO NOT SCALE
Jacobs No.	60K36301	
Client No.		
Drawing No.	60K36301/287277C-L-003	

FIGURE 2.2a



Legend

- Pipeline road crossing
- Pipeline water crossing
- 12 " LPG Pipeline (Overground)
- 12 " LPG Pipeline (Underground)
- 8 " LPG Pipeline to Site (Underground)
- Diesel Pipeline
- Water Pipeline (Underground)
- Tema Oil Refinary
- Ghana Bridge Power Plant Site 1
- Ghana Bridge Power Plant Site 2
- Diesel Tank Farm
- LPG Tank Farm
- Ghana Oil Company



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	06/07/17	Initial Issue	PW	DB	DB	DB

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Ghana Bridge Power Project ESIA

Drawing Title

LPG Pipeline Route and Road and Water Crossings

Drawing Status

Scale @ A3	1:23,000	DO NOT SCALE
Jacobs No.	60K28902	
Client No.	N/A	
Drawing No.	60K36301/LVA/2_2a	

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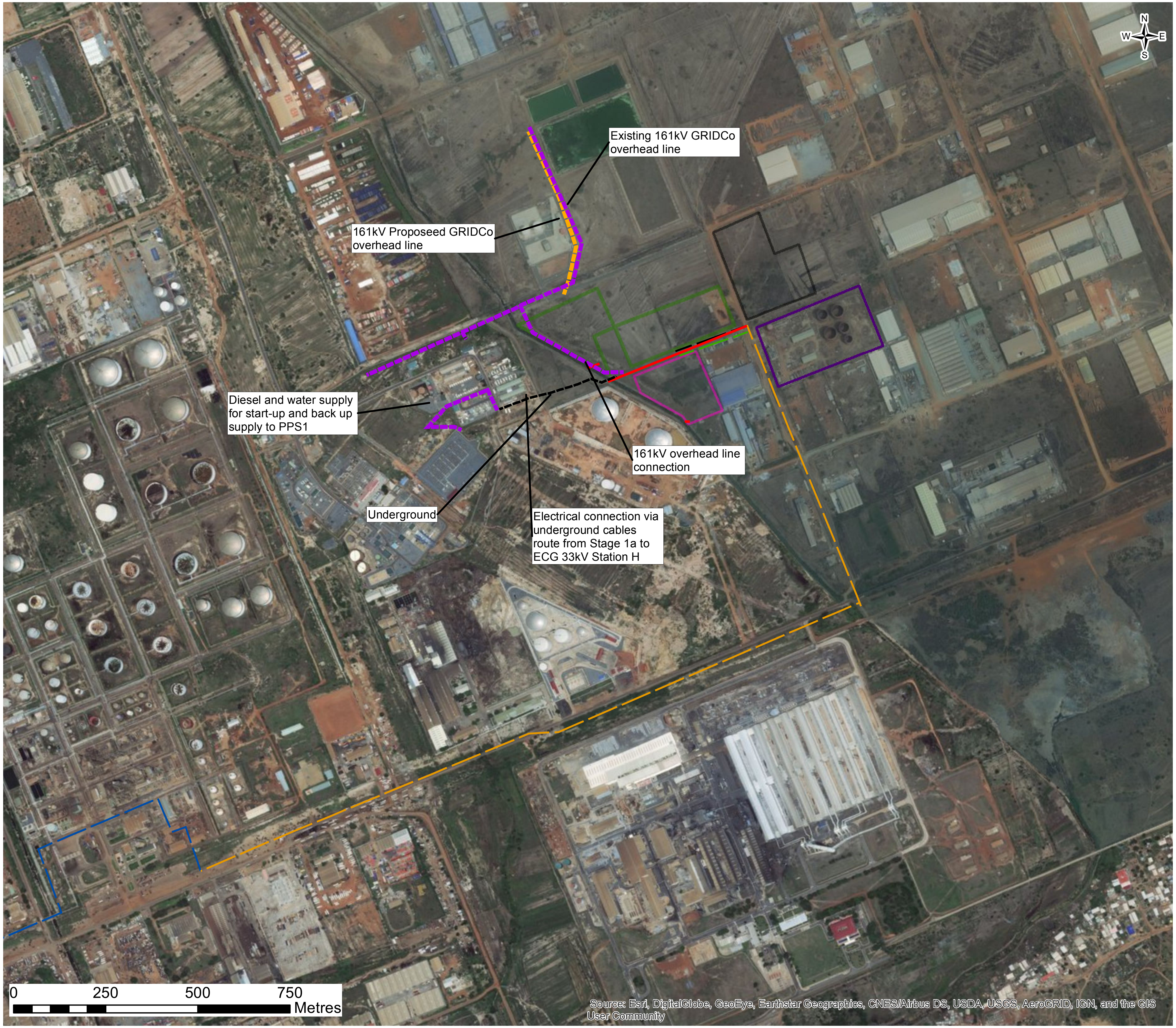
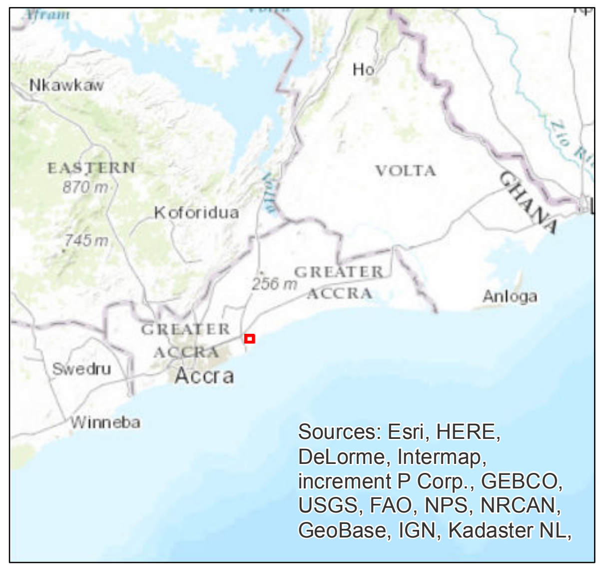
FIGURE 2-2b



Legend

- Underground_Line
- Proposed_Overhead_Line
- Electrical_Connection_Route
- Indicative Clean Waste Water Route to Tema Storm Drain
- 12 " LPG Pipeline (Overground)
- 12 " LPG Pipeline (Underground)
- 8 " LPG Pipeline to Site (Underground)
- Diesel Pipeline
- Ghana Bridge Power Plant Site 1
- Ghana Bridge Power Plant Site 2
- Diesel Tank Farm
- LPG Tank Farm



0	13/07/2017	Initial Issue	EW	RS	LR	JPW
Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd

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Project

Ghana Bridge Power Project ESIA

Drawing Title

Pipeline routes between development sites and lines for evacuation of power

Drawing Status

Scale @ A3	1:10,000	DO NOT SCALE
Jacobs No.	60K36301	
Client No.		
Drawing No.	60K36301/LVA/2_2b	

2.2 The Power Plants

2.2.1 Plant Layouts and Key features

The proposed layouts of the power plant facilities are shown on Figures 2-1a and b. The layouts detail the power block for each stage including additional ancillary plant and buildings (e.g. control buildings, workshop, water treatment plant, fuel treatment buildings, water storage tanks) and transmission infrastructure.

The plant at PPS1 will comprise 5 no. mobile GE TM2500 units ('TM units'), initially constructed as open cycle, and later converted into CCGT generating mode. At PPS2, Stage 2 will involve 4 no. LM6000 PC Sprint units ('LM units') which will operate in CCGT mode from the outset. The final net electrical capacity of 424 MW will be achieved through a staged development, as discussed in Section 2.2.4.

The gas turbines will be fired on LPG (or DFO in the event of interruption to LPG supply) whilst the steam for Stage 1b and Stage 2 will be provided respectively by a once through steam generator (OTSG) and a heat recovery steam generator (HRSG).

The TM units (in open cycle) will be cooled by integral closed loop system with radiators. Cooling for the OTSG/HRSG for Stage 1 and Stage 2 plants in CCGT mode will be by air-cooled condensers (ACC).

The project will require demineralised water for make-up to the steam / water cycle and for control of the emission of oxides of nitrogen (NO_x) in the flue gases from each gas turbine.

Associated project components will include:

- Safety LPG flaring system;
- Water supply pipeline;
- Raw water storage tanks, supplied by new pipeline to GWC;
- Individual 50m^3 capacity DFO tank for each TM machine;
- Individual 100m^3 capacity DFO tank for each LM machine;
- Water treatment (demineralisation) plants; and,
- Demineralised water storage tanks.

Diesel for black start and emergency operation (in the event of disruption to LPG supply) will be supplied via a pipeline connection to the Quantum tank farm located adjacent to the southern boundary of the project LPG Tank Farm.

Waste water (e.g. from boiler blowdown or the water treatment plant effluent) will be treated by dedicated waste water treatment units to control the composition and properties of the effluent to within limits as defined by the Ghana Environment Protection Agency (EPA).

The project will be designed for an operational life of at least 25 years. At the end of its life, depending on the requirements of the GoG at that time, the project may either continue to operate or be decommissioned. In the unlikely event that the project is decommissioned, the site would be reinstated as agreed with the relevant authorities including the EPA, and in line with the requirements indicated in this ESIA. Decommissioning will take account of the environmental legislation and the technology available at the time. Any necessary licences or permits will be acquired prior to commencement of decommissioning activities.

2.2.2 Power Evacuation

To export the generated power from Stage 1a, the five TMs with a generation voltage of 11kV will have three step-up transformers to step the power up to 33kV for direct connection via buried cables into Electricity Company of Ghana's existing Station H substation, adjacent to the VRA TTPC. For Stage 1b, the 11kV output from the steam generator will initially connect through a step-up transformer to a new 161kV overhead spur, adjacent to the storm drain and connecting to the exiting GRIDCo overhead 161kV line running east-west along the northern boundary of the PPS2 site.

For Stage 2, the four LM units and the single Heat Recovery Steam Generator (HRSG) within PPS2 will generate at 11kV and, via three step up transformers, connect to a new 161kV substation. The new substation will tie into a new GRIDCo double-circuit 161kV overhead line via a double-circuit line-in / line-out configuration. Stage 1b will also utilize this new substation for evacuation as the tie-line spur connection will be transferred to connect to the new substation.

GRIDCo, as part of its expansion plans in a separate construction project, will be carrying out construction of the new double-circuit overhead line to run from the nearby Aksa project to the Smelter 2 substation. This project is not being constructed by the EPL project and is not considered 'associated infrastructure' under the requirements of International Finance Corporation (IFC) Performance Standard 1 (PS1).

The power evacuation line routes are illustrated on Figure 2-2b.

2.2.3 Staged Development

The project will be constructed and operated in two main stages (1 and 2), but with Stage 1 split into sub-stages, as outlined in Section 2.2 and detailed below.

It is anticipated that the construction period will be a total of 34 months with the following schedule breakdown for each stage:

- **Stage 1a – 145MW net expected Commercial Operational Date (COD) May 2018**

  Located at PPS1, Stage 1 will involve five TM2500+ gas turbines at 50Hz in open cycle mode, operating on LPG, at maximum output. It is envisaged that operation will take place 9 months from full Notice to Proceed (NTP).

- **Stage 1b – 57MW net steam generation (202MW total CCGT) COD expected August 2019**

  Located at PPS1, includes the addition of five OTSG's and one steam turbine with associated balance of plant. It is expected that the Stage 1b CCGT commercial operation will commence 24 months from full NTP.

- **Stage 2 – 222MW net (424MW total for Stage 1 & 2) COD expected May 2020**

Located at PPS2, includes four GE LM 6000 PC Sprint gas tubines, four HRSG's and one steam turbine plus associated balance of plant. NTP for Stage 2 is expected to be in July 2018, with operation commencing 22 months from this point.

2.2.4 Fuel supply

2.2.4.1 Liquefied Petroleum Gas (LPG)

The project will use imported LPG as fuel. It is planned that the plant will convert from LPG to NG within five years of Stage 2 operation if NG is made available by GoG. The expected LPG consumption rate for base load operation at reference site condition for each phase is as follows:

- Stage 1a and 1b: 795 tonnes / day (TM units); and,
- Stage 2: 1,637 tonnes / day (TM and LM units).

The currently anticipated gas mix for LPG is approximately 90% propane with up to 10% butane.

The operating range for the pressure of the LPG at the gas turbine fuel intake will be specific to the gas turbine chosen for the project. The minimum pressure of the LPG will be designed to keep the LPG in liquid form until it requires a change of state to gas for use in the gas turbines.

The LPG will be delivered to the site from the TOR pier via construction of a new pipeline as described in Section 2.4.

2.2.4.2 Diesel Fuel Oil

It is anticipated that DFO will be used at project start up to a maximum anticipated period of two months and thereafter LPG will remain the primary fuel until NG is made fully available.

In the event of disruption to the LPG supply, it is likely that DFO will be used in the interim period until the LPG fuel supply is rectified. The air quality impact assessment (Section 11) includes consideration of 'worst-case scenarios' with the plant operating on DFO.

2.2.5 Equipment Description

2.2.5.1 Overview

The layout of power plant facilities is shown on Figures 2-1a, b and c. The power plant includes the following elements:

- OCGT operation:
    - Gas turbines;
    - Electrical generator(s) and transformer(s);
    - Flare (maintenance and emergency use only);
    - Raw / fire water storage tanks;
    - On-site switchgear;

  - Administration / workshop / warehouse and storage / etc. buildings;
  - Ancillary plant and equipment;
  - Water connection pipework;
  - Water treatment plant;
  - Demineralised water storage tank(s);
  - Main stacks;
  - LPG distribution pipes and pumps;
  - LPG vaporiser system; and,
  - LPG storage tanks;
- CCGT operation (in addition to the above):
  - Steam turbines;
  - OTSG and HRSG;
  - ACCs and auxiliary cooling; and,
  - Main stacks.

2.2.5.2 Gas Turbines

Each power block will comprise aeroderivative type gas turbines that will each include an inlet air filter, an air compressor, combustion chambers (including water injection for control of NO_x emissions), power turbine and exhaust silencer. Air will be compressed in the compressor of the gas turbine and gaseous fuel injected into the combustion chambers where the fuel will burn producing hot, high-pressure gases. These gases will expand across the rotor blades of the gas turbine, which will drive both the compressor and the electrical generator.

The GE TM unit installations generally comprise of TM2500+ gas turbine (Gen8) electrical generator rated at 29.6 MW gross on LPG (3 phase 50 Hz 11kV) at guaranteed by the EPC contractor..

The LM6000 PC Sprint variant turbine is rated at 44.4MW gross on LPG, as advised by GE. Associated equipment includes inlet plenum, exhaust stack, switchgear and auxiliary trailer with lube oil cooler, hydraulic starter, fuel and water pumps.

The main trailer generally includes:

- Inlet plenum;
- Exhaust stack;
- Switchgear; and,
- Trailer.

The auxiliary trailer generally includes:

- Lube oil cooler;
- Control room;
- Hydraulic starter;
- Fuel and water pumps; and,
- Trailer.

Technical data for the TMs on a net basis is summarised as follows for the gas turbine site condition rating on LPG: 29.1 MW, 10,766 kJ/kWh and 33.4% efficiency. Gas turbine site design conditions are:

- Temperature: 28 °C.
- Relative Humidity (RH): 85%.
- Pressure: 1.013 bar.
- Altitude: 5.0 m.

Approximate performance per machine is indicated as (new and clean with water injection):

- Gross Output: 29.6 MW on TM units and 44.4. MW on LM units.

2.2.5.3 Once Through and Heat Recovery Steam Generators

During CCGT operation, instead of letting the waste heat from exhaust gases go straight to atmosphere (as with open cycle operation), the exhaust gases will pass through an OTSG or HRSG where the waste heat is extracted and used to produce steam. That steam is then used to generate additional electricity which means that greater efficiency is achieved in the power generation process in closed cycle operation.

The OTSG and HRSGs include a series of tubes through which water is passed. The hot exhaust gases from the gas turbines flow across the tubes and heat the cold OTSG or HRSG inlet water to produce steam. The steam is then routed to the steam turbine which produces additional electricity. The OTSGs and HRSGs will not be supplementary fired. The OTSGs and HRSGs will be specifically designed to match the operating characteristics of the gas turbines and provide optimum performance for the project.

2.2.5.4 Steam Turbines

The steam from the OTSGs or HRSGs will be provided to the steam turbines at elevated pressure levels and will expand across the steam turbine blades. This expansion will, as within the gas turbines, rotate the turbine and drive the same or additional electrical generators to increase the electrical output of the project.

The residual heat within the spent steam will be rejected to atmosphere via the ACC systems and the resultant condensate will be returned to the OTSGs or HRSGs for re-use.

2.2.5.5 Cooling

Cooling of the TM units in open cycle mode will be through integral closed loop cooling circuits and radiators.

ACCs will be used to condense the steam exiting the steam turbines for re-use in the OTSGs or HRSGs during combined cycle mode. The ACCs will act in a similar manner to an automobile radiator. ACCs consist of an array of finned tubes (through which the spent steam will pass) and fans to provide sufficient air flow across the tubes to enable the air to act as the cooling medium thus removing the residual (non-useful) heat from the spent steam.

The use of air-cooling means that there is no need for cooling towers or a once-through cooling water system, thereby eliminating the environmental impacts associated with such systems, which include visible plumes from a cooling tower and abstraction from, or discharge to, a local water course with associated impacts to marine flora and fauna.

2.2.5.6 Vaporization Facilities

The vaporisation of LPG within the power plant areas will utilize a buffer tank feeding two heating systems. Each system will comprise a primary and a secondary pump system, which will feed an oil filled shell and tube heat exchanger, with the heat exchanger being fed from firing LPG.

2.2.5.7 Flare

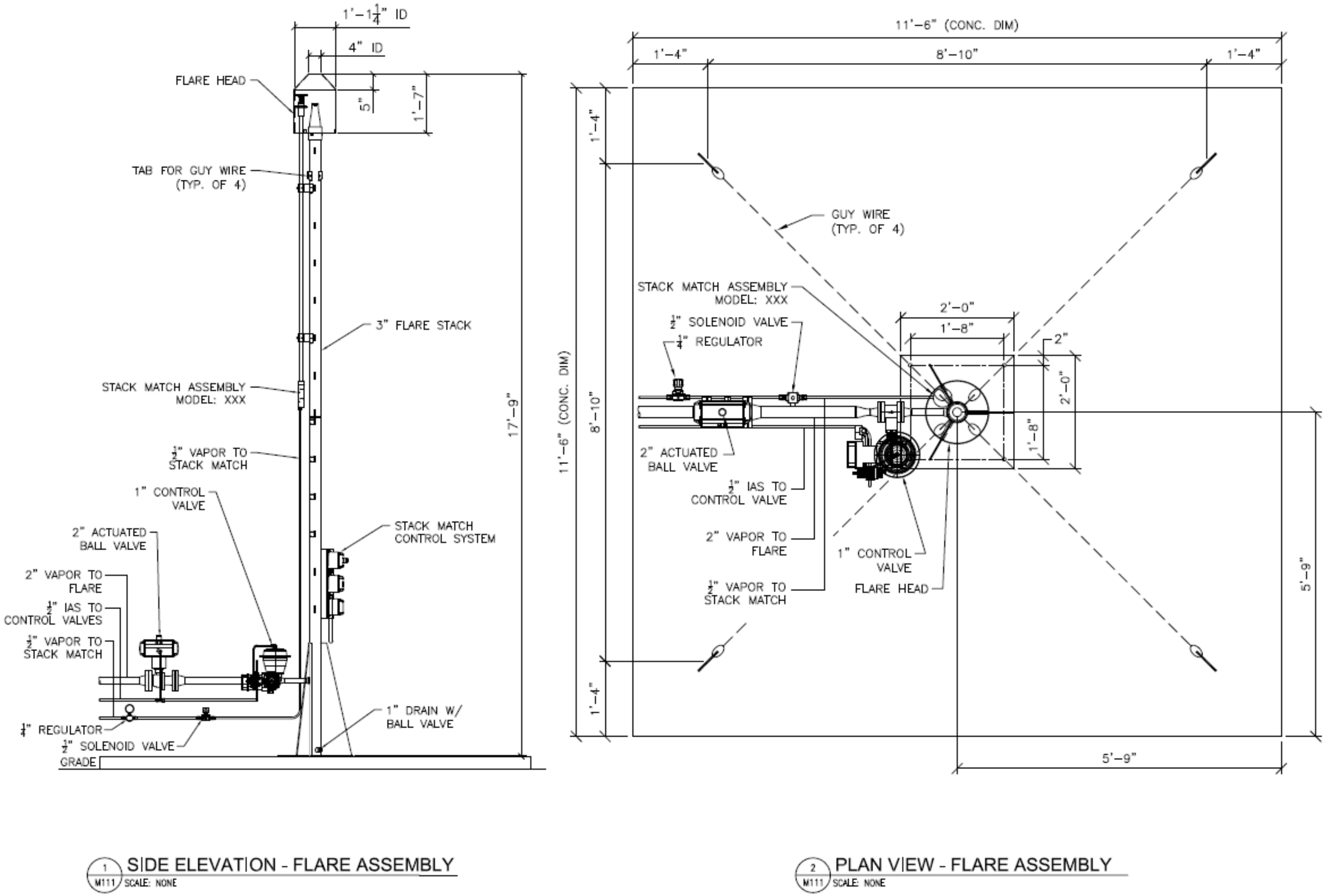
A flare facility will be utilised for the project to manage safe combustion of LPG and dispersal of emissions during commissioning, maintenance and emergency events.

The flare is envisaged to be in operation for around 3 hrs per annum and as such is considered as temporary operation. The flare design has considered relevant safety risks and as such the project design includes a confirmed exclusion zone of 15m radius around the flare, within the site boundary.

During periods of maintenance when the flare is in operation, some of the GTs will be offline for maintenance (this is the most frequent event, i.e. GT maintenance). Therefore, with the proposed flare design, the project designers consider that operation of the flare would likely result in no additional emissions being dispersed to atmosphere compared to the levels emitted under normal operating conditions.

The approximate dimensions of the flare are shown on Figure 2-4 below.

Figure 2-4: Flaring System Schematic Drawing (note units are Imperial)



2.2.5.8 Transformers

Transformers will be provided for plant electrical supplies. All transformers will not contain polychlorinated biphenyls (PCBs) and will be oil-filled. Each transformer will be provided with a containment bund that will retain all the transformer oil in the event of a spillage. Pumps will drain these sumps to an oil separator which in turn will discharge clean water to the site drainage system. The sumps will be installed with high level alarms to avoid overflow.

2.2.5.9 Switchgear

Sulphur hexafluoride (SF_6) will be used in the hybrid switchgear for the project.

One hybrid module will be located at PPS1, for the 161kV overhead line (OHL) 'T' connection for Stage 1b.

At PPS2 there will be 15 SF_6 hybrid modules, located in the new 161kV breaker and half substation to the north.

2.2.5.10 Control Systems

A compressed air system will be provided to compress and deliver air of a quantity and quality suitable for all general, instrument and control purposes at all appropriate points within the project.

Process parameters will be continuously recorded to ensure correct and efficient operation of the project. Any significant deviations will be alarmed and corrections carried out on occurrence. Records will be maintained of performance and deviation. Full facilities for interfacing information, control and alarm systems will be installed so that the plant can be operated from a central control room via the distributed control system (DCS). In the event of a fault in the turbines or other major plant items, the project will be designed to shut down automatically in a controlled manner.

2.2.6 Proposed Power Plant Technology

The project will be designed to provide a total generation net capacity of 424 MW. Under normal conditions both plants will operate in CCGT mode, apart from the short-term Stage 1a operation in OCGT mode. Figure 2-5 presents a schematic representation of the OCGT principle and Figure 2-6 presents a schematic representation of the CCGT principle.

Figure 2-5: Open (simple) cycle

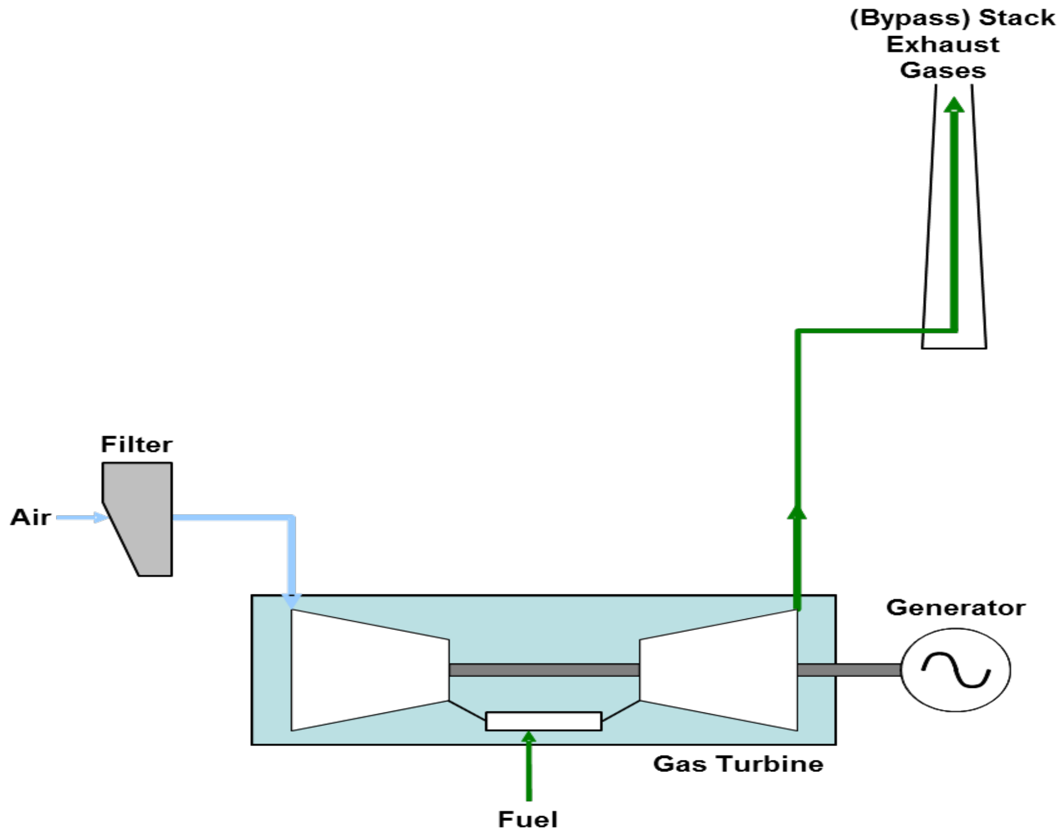
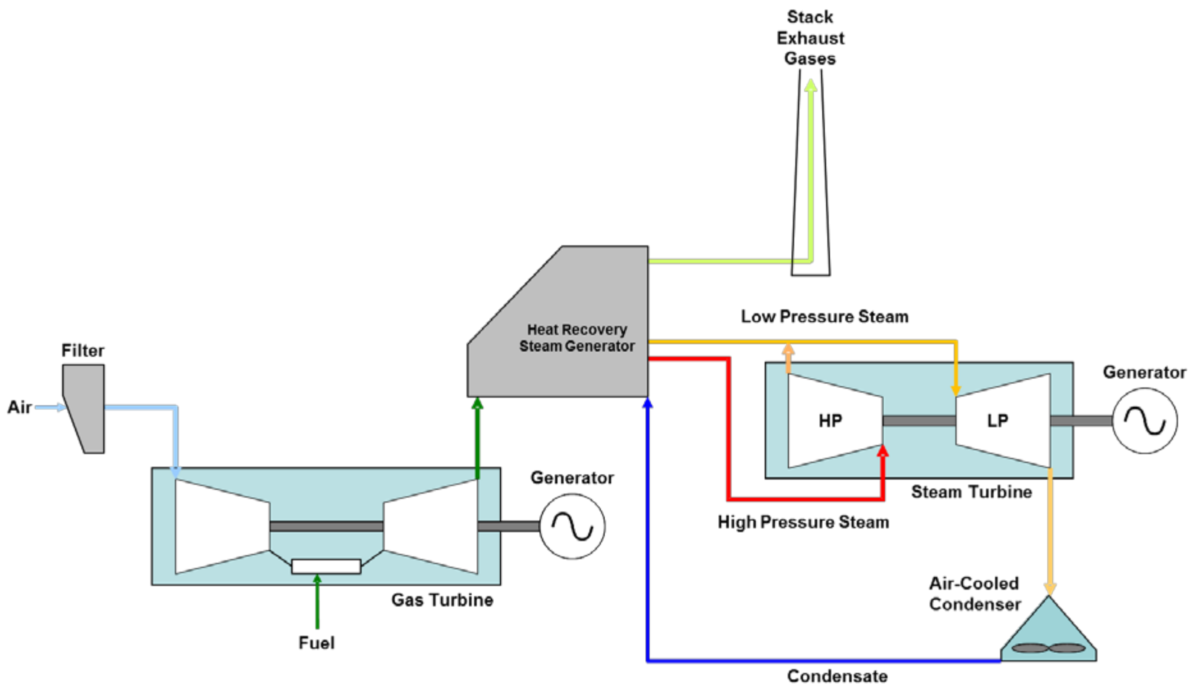


Figure 2-6: Combined Cycle



2.2.7 Stacks and Emissions

2.2.7.1 Overview

LPG is an inherently clean fuel, the combustion of which does not produce sulphur dioxide (SO_2) or particulate matter emissions associated with the combustion of coal or oil in a conventional power station.

The main pollutants associated with the combustion of LPG are oxides of nitrogen (NO_x), carbon monoxide (CO) and carbon dioxide (CO_2). Additional pollutants that will be produced during DFO firing include particulate matter (PM) and Sulphur Dioxide (SO_2). SF_6 has also been considered within the ESIA assessment due to its presence in hybrid switchgear. These pollutants are described below:

- Oxides of nitrogen – NO_x produced from gas turbines comprise nitric oxide (NO) and nitrogen dioxide (NO_2) – the proportion of NO and NO_2 within the exhaust gas varies but typically NO is the predominant species and comprises approximately 95% of the emitted NO_x at release. For LPG and NG combustion, the NO_x emissions are produced during combustion (i.e. the reaction of NG with air). NO is potentially less harmful than NO_2 and it is NO_2 that is associated with adverse effects upon human health. NO in the exhaust gas is oxidised in the atmosphere to form NO_2. However, the reverse process converting NO_2 to NO also takes place in the atmosphere.

- Carbon monoxide – CO emissions are a measure of combustion completion as higher values of CO indicate more incomplete combustion or less oxidation of CO to CO_2. CO can cause harmful health effects by reducing oxygen capacity of haemoglobin in blood and hence oxygen delivery to the body's organs and tissues.

- Carbon dioxide – CO_2 is one of the major greenhouse gases under the United Nations Framework Convention on Climate Change. The proposed project will primarily use LPG and then convert to NG, a less carbon intensive fossil fuel, to generate electricity thereby ensuring that the least amount of CO_2 is generated per unit of energy.

- Sulphur dioxide – SO_2 emissions are the result of combustion of fuel containing sulphur, such as DFO. The combustion of DFO during any temporary periods where LPG is not available will therefore result in emissions of SO2 (and particulate matter) in addition to those substances listed above. As such, the primary measure for the control of SO2 emissions is to utilise fuel (i.e. LCO) with the lowest sulphur content reasonably practicable. The IFC EHS Guidelines for Thermal Power Plants states that, for Projects of greater than 300MWth, liquid fuels containing <1 per cent sulphur should be used to limit the formation of SO_2 (reducing to <0.5 per cent, should the Project be located within an area classed as a degraded air shed).

- Particulate matter – PM emissions will be generated during any temporary DFO operation in the event that LPG is not available. PM emissions can be controlled by maximising the combustion efficiency within the gas turbine, which is generally an inherent part of the optimisation of during commissioning and testing.

- Sulphur hexafluoride – SF_6 would be emitted in much smaller quantities than CO_2, only as a result of fugitive emissions and leakage. However it has a higher global warming potential than CO_2. It is non-toxic, but can still be harmful to humans as it presents a risk of asphyxiation due to its density.

Further information on greenhouse gas emissions is provided in Section 18.

2.2.7.2 Bypass Stacks

The TM units when converted to CCGT mode will not require a bypass stack as they will be connected to an OTSG, which allows for a single exit stack.

For the LM units these exhaust gases will be discharged to atmosphere via dedicated stacks in Stage 2, from either the main HRSG stack under normal operation or bypass stacks if required.

For Stage 1, EPC contractor/manufacturer guarantees indicate exit temperatures of the exhaust gases from the TM gas turbines of 548°C during open cycle operation, and 140°C under combined cycle.

For Stage 2, the manufacturer guarantees exit temperatures from the LM units of 124°C during combined cycle operation. Stage 2 is not expected to operate in open cycle; however, the equivalent anticipated value is 466°C.

2.2.7.3 Main Stacks

During Stage 1a, temporary stacks will be added to extend the height of the short integral stacks on the TM units to a height of 30m above ground level to ensure adequate dispersal of emissions.

During CCGT operation in Stage 1b and Stage 2, after passing through the OTSG and HRSGs, the exhaust gases will be discharged into the atmosphere through the main stacks. Following the completion of a stack height assessment, a height of 40m was selected for the HRSG stacks for the LM units, while a height of 30m was selected for the TM units OTSG stacks. Typical temperatures of the flue gases from an OTSG/HRSG is around 95°C (given that the OTSG/HRSG removes the useful and recoverable heat energy) when operating on LPG. When operating on DFO, typical temperatures from the flue gas will be higher, at 140°C.

In total, the power plant will result in nine new emission points to air once the plant is fully operational. The new emission points to air will be phased in and have the potential to affect local air quality. A site layout drawing specifically highlighting the location of exhaust stacks for all phases are presented in Figure 11-1 of Air Quality Assessment in Section 11.

2.2.7.4 Emissions Control

It is anticipated that the gas turbines will utilise water injection for the control of NO_x from the gas turbines to levels at least in accordance with the IFC Environmental, Health and Safety Guidelines (EHS Guidelines) for Thermal Power Plants.

There are no guideline emission limit values for carbon monoxide within the IFC EHS Guidelines for Thermal Power Plants; however 100 mg/Nm^3 is considered to be readily achievable for gas turbine technology.

SO_2 is a combustion product of the sulphur content of relevant fuels including DFO. As such, the primary measure for the control of SO_2 emissions is to utilise fuel with as low sulphur content as is reasonably practicable. The WBG EHS Guidelines for Thermal Power Plants state that, for projects of greater than 300 MW, liquid fuel containing <1% sulphur should be used to limit the formation of SO_2 (reducing to <0.5% should the project be located within an area classed as a degraded air-shed).

PM emissions can be controlled by maximising the combustion efficiency within the gas turbine during commissioning/testing. DFO is the main project component with potential for production of PM; The IFC EHS Guidelines for Thermal Power Plants state that, for a non-degraded air-shed, the emissions of particulate matter (PM_{10}) should not exceed 50 mg/Nm^3 and 30 mg/Nm^3 in a degraded airshed.

2.2.8 Plant Commissioning

A Commissioning programme and procedure will be developed to comprise final erection checks, pre-commissioning and setting to work of individual plant component parts though to the overall testing to prove the technical acceptance of the plant. Tests on completion will demonstrate the fitness for purpose of the plant prior to commercial operation. Performance tests will demonstrate that the plant complies with the performance guarantees, including emission limits. Reliability will be demonstrated by operating the plant under commercial conditions for a period without major repair to any item of plant or equipment. The plant commissioning tests will be part of a wider commissioning programme that includes the tank farm, pipeline integrity checks and jetty connection commissioning.

2.2.9 Maintenance of the Power Plants

The design of buildings, enclosures and plant will minimise regular and long term maintenance. Sufficient spares will be held on-site to ensure reliable operation of the project. Materials and finishes will be selected to meet this objective and to ensure that the appearance does not deteriorate significantly over time.

Major plant maintenance shut downs will be planned on a long-term basis, with such outages likely to be infrequent (of the order of every four years) and of short duration only (up to six weeks). There may occasionally be forced outages which will be infrequent in nature and typically of very short duration.

2.3 Tank Farm

An indicative layout for the tank farm is shown on Figure 2-1c and includes the following:

- Stage 1: Three spherical tanks: two x 3800m^3 (2,071 tonnes) capacity and one x 6000m^3 (3,270 tonnes);
- Stage 2: Three spherical tanks: three x 6000m^3 (3,270 tonnes) capacity;
- Two fire water tanks of capacity 4080 m^3 each, sized to cover the largest fire on the tank farm; and,
- Ancillary equipment, including three propane pumps per Stage and four fire water main pumps.

The Stage 1 storage capacity is sufficient to allow unloading of a 9,000 tonne LPG shipment within an approximately four day delivery time at the jetty.

The total Stage 1 LPG storage on the EPL sites is equivalent to 9.3 days' storage for Stage 1 consumption with additional 3.8 days storage provided from TOR spheres and therefore a total of approximately 13 days' storage for Stage 1.

The total additional LPG storage on the EPL sites for Stage 2 is is equivalent to 11.7 days' storage for Stage 2 consumption.

DFO will be stored in $50m^3$ and $100m^3$ capacity day tanks on the power plant sites. For PPS1, one $50m^3$ capacity DFO tank will feed one TM. For PPS2, one $100m^3$ capacity DFO tank will feed on LM unit.

Bulk storage of DFO back-up fuel will be adjacent to the new LPG tank farm in Quantum Ltd's storage facility and a secondary pipeline will be installed in the same LPG pipeline trench to PPS1.

All fuel storage vessels will be designed in line with the more stringent of relevant Ghanaian standards, relevant WBG EHS Guidelines and/or other international standards, such as American Society of Mechanical Engineers (ASME).

Design of LPG vessels will consider elements such as pressure and temperature requirements, vacuum effects, materials of construction and vessel connections. Design and construction of foundations and supports for LPG storage vessels and pipelines will consider elements including materials selection, geotechnical information including potential for settlement of foundation, any piling requirements and vessel shell loads.

Siting of the tanks will consider elements such as risk to adjacent property presented by the storage facility and risk presented to the storage facility by a fire or explosion on adjacent property. It will consider access for emergency response and minimum distance between LPG tanks.

The drainage system will be designed to prevent liquid spilled from discharging from the site and from flowing under any other tank. It shall minimize the risk to piping and other infrastructure. Spill containment will be provided through bunding in line with good international industry practice, and the containment area shall not contain any other equipment, except as permitted by the design standards.

Fire protection provisions shall be based on a safety analysis of local conditions, exposure from or to other sites, availability of a water supply, and effectiveness of fire brigades and fire departments. The analysis will include possible but realistic accident scenarios that may occur, including scenarios of vapour release, ignition and fire.

2.4 Pipeline Routes and Associated Features

2.4.1 LPG Pipeline

The proposed LPG pipeline route is 9.2km long in total, comprising four main sections with various road/water crossings as shown on Figure 2-2a. The route is described below:

1. Jetty to the new Booster station: total length 5.2km, above-ground pipeline, diameter 12''.

   For this section the proposed pipeline will be tied into an existing pipe corridor. The pipe corridor travels northward from its origin at the TOR jetty at the Tema harbour, through industrial land east of Tema New Town to a new booster station, to the west of the TOR.

   The pipeline travels north from the loading arm bay, along the dry jetty dock, crossing beneath the jetty road at two locations. At the northern end of the jetty the pipeline travels underneath the east-west running industrial road which links the Tema shipyard to the west. The pipe corridor then runs along the western edge of the VALCO storage facility, parallel to the Accra-Tema railway. Beyond this point, the pipeline travels northward beneath a heavily accessed bridge on the fishing harbour road, and continues adjacent to the railway line, moving underneath Cocoa Processing Company Road and VALCO Road and links into a new booster station to be constructed as part of the project, located approximately 400m west of the TOR plant, adjacent to the existing TOR booster station. The new booster station is located within an easement owned by TDC and leased by the project, and will occupy an area of approximately 15m^2 currently comprising bare earth and scrub grass covering.

   The route is all within the THIA, running adjacent to industrial and commercial facilities with no residential areas in the vicinity. There are six road or access crossings including the TOR accesses and two water crossings. The vegetation in this section consists of grass and shrubs. There are some pylons a few metres from the pipeline in the section north of the jetty to VALCO road. This section of pipeline will follow the existing TOR RoW.

   Construction safety measures will be implemented as part of the detailed management plans for the short-term, temporary impacts associated with construction of the below ground sections of the pipeline. Whilst the project will transfer ownership of the pipeline to TOR at Stage 1a COD, the project has also proposed additional measures (including crash barriers on bridges) to increase the long-term operational safety of the TOR RoW.

2. From the new Booster Station to the project LPG tank farm, total length 4.0 km, pipe diameter 12''.

   The pipeline exits the new Booster Station and travels above ground, eastwards along the north side of Valco Road. It enters the TOR and travels approximately 850m within the TOR facility and exits adjacent to the east gate. Within the TOR facility, there will be a tie in to the existing TOR LPG system to allow connection to the two LPG storage tanks within TOR that will be utilised by the project.

   Upon exiting the TOR, the pipeline will travel underground to the tank farm. As discussed in Section 1.2.4, it is currently anticipated that the pipeline will travel along the north side of Valco road, beneath the Ghana Oil Limited (GOIL) driveway and cross to the south side of the road before the Sentuo Steel Limited driveway. It then runs along the south side of the road, in a utility easement until the storm drain. Here, the route turns north and runs along the eastern side of the local access road, to the tank farm site.

The first part of the route runs within the existing pipeline/road reserve in front of the large commercial/industrial installations noted above. The route section of the route along the south side of Valco Road to the storm drain passes through secondary vegetated area which has previously been disturbed during construction of another pipeline. This land consists of shrubs, grass and a few trees. The remainder of the route up to the tank farm and power plant sites is within grassed road reserve land.

The pipeline route will unfortunately displace some informal trader kiosks located within the ROW, who will require relocation as discussed in Section 20. However, as discussed in Section 1.2.4 and Section 20, the project has taken steps to change the pipeline route to avoid directly displacing a significant number of the kiosks located on the south side of Valco road (subject to the completion of further detailed pipeline route surveys).

There are at least ten road or access crossings including the various accesses to the commercial area close to the tank farm and at least two water crossings, including the storm drain. The two crossings beneath Valco Road will be undertaken using directional drilling.

Given the number of large industrial installations adjacent to the pipeline route, there is the potential for associated underground infrastructure which will need to be confirmed. Subsurface surveys using ground penetrating radar or other technology will be carried out as needed to confirm underground obstructions.

Generally, in the area, many of the road reserves are utilised for informal parking by tankers and other vehicles. Depending on the final design considerations, the use of land above the pipeline may need to be restricted for these vehicles and by informal kiosks or other business purposes. This will be determined following appropriate consultation with the relevant district authority.

3. LPG tank storage area to PPS1, total length approximately 170m, pipeline diameter 8''.

   The pipeline will continue underground for approximately 200m westwards, from the tank farm to the PPS1. The land use in this area is mainly of an industrial nature. The vegetative cover in is sparse and there were no water bodies identified in the area. This section of pipeline has a new RoW.

   This section of the LPG pipeline will also include a secondary DFO line routed from the Quantum Terminals Limited tank farm site, located adjacent to the southern boundary of the LPG tank farm site (see Section 2.4.2) and a water-supply line transporting water sourced from the main GWC line (see Section 2.4.3).

4 LPG tank storage area to PPS2, total length approximately 100m, pipeline diameter 8''.

The pipeline will be underground for approximately 100m westwards, from the tank farm to PPS2. Land use is predominantly industrial. The vegetative cover in this area is also sparse and no water bodies were identified along the route or in adjacent land. This section of pipeline will have a new RoW.

As with the LPG line to PPS1, this section of the LPG pipeline will also include a DFO line routed from the Quantum Terminals Limited tank farm site and a water line sourced from the main GWC line (see Section 2.4.3).

Note that whilst this document considers potential impacts associated with construction and operation of the LPG pipeline, permitting of the majority of the pipeline route (that within the TOR land and RoW) may ultimately be undertaken by TOR as a variation to their existing ESIA and EPA Environmental Permit.

A photomontage showing the land use along the pipeline route is provided in Figure 2-5.

Figure 2-7: Photographs of proposed LPG pipeline route and new tank farm

Figure 2-7a: Existing pipelines running from the TOR jetty

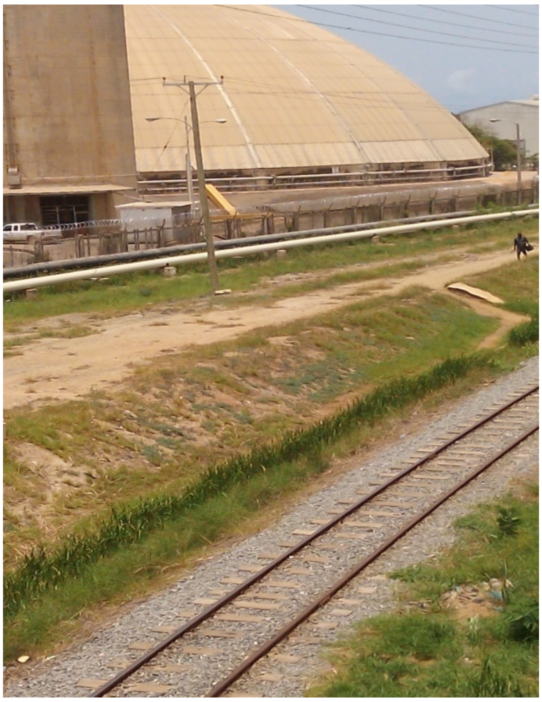


Figure 2-7b: Pipeline route parallel to the Accra- Tema Railway	Figure 2-7c: Pipeline route adjacent to VALCO storage facility on route to the TOR
	
Figure 2-7d: Existing pipeline adjacent to industrial facilities on route to the TOR	Figure 2-7e: Existing pipelines entering TOR

	
Figure 2-7f: Existing pipeline at TOR east gate	Figure 2-7g: GOIL depot driveway
	
Figure 2-7h: Informal businesses along Valco Road (south side)	Figure 2-7h: Undisturbed vegetated areas between the TOR and the Storm drain
	
Figure 2-7i: Tank Farm Site (under construction as of May 2017)	

Figure 2-7j: Pipeline route from tank farm to PPS1 and PPS2

2.4.2 DFO Pipeline(s)

The DFO pipelines are shown on Figure 2-2b.

New pipelines are required to transport DFO stored at the Quantum petroleum site to PPS1 and PPS2. The lines will follow the new RoW for the LPG routes between the tank farm and power sites, as described in Section 2.4.1.

2.4.3 Water Pipeline

The water pipelines are shown on Figure 2-2b.

Raw water for the project will be provided by the GWC municipal reticulation network via new pipeline facilities tied into the GWC municipal supply alongside Valco road. The new water pipeline will be installed alongside the LPG pipeline from Valco Road northwards in to the tank farm (approximately 900m in length) to supply storage tanks for fire protection. Two water supply pipelines will be teed westward from the new GWC pipeline (to the LPG tank farm) to supply the power sites. The waterlines to PPS1 and PPS2 each is approximately 200m in length.

2.5 Water, Wastewater and Drainage

2.5.1 Water Supply

As described in Section 2.4.3, the raw water for the project will be provided by the GWC municipal reticulation network via a new 225mm HDPE pipeline. GWC has indicated it can provide the full water requirements for the project. Water will be stored on site to ensure a three day storage capacity is maintained.

EPL is liaising with GWC to confirm that sufficient information is available to demonstrate that the water can be obtained without impacting other vulnerable water users including nearby communities and that future water supply projections by GWC include consideration of potential climate change-related impacts on rainfall in Ghana (as discussed in the Climate Change Assessment, Chapter 14 of this ESIA).

2.5.2 Plant Water Consumption

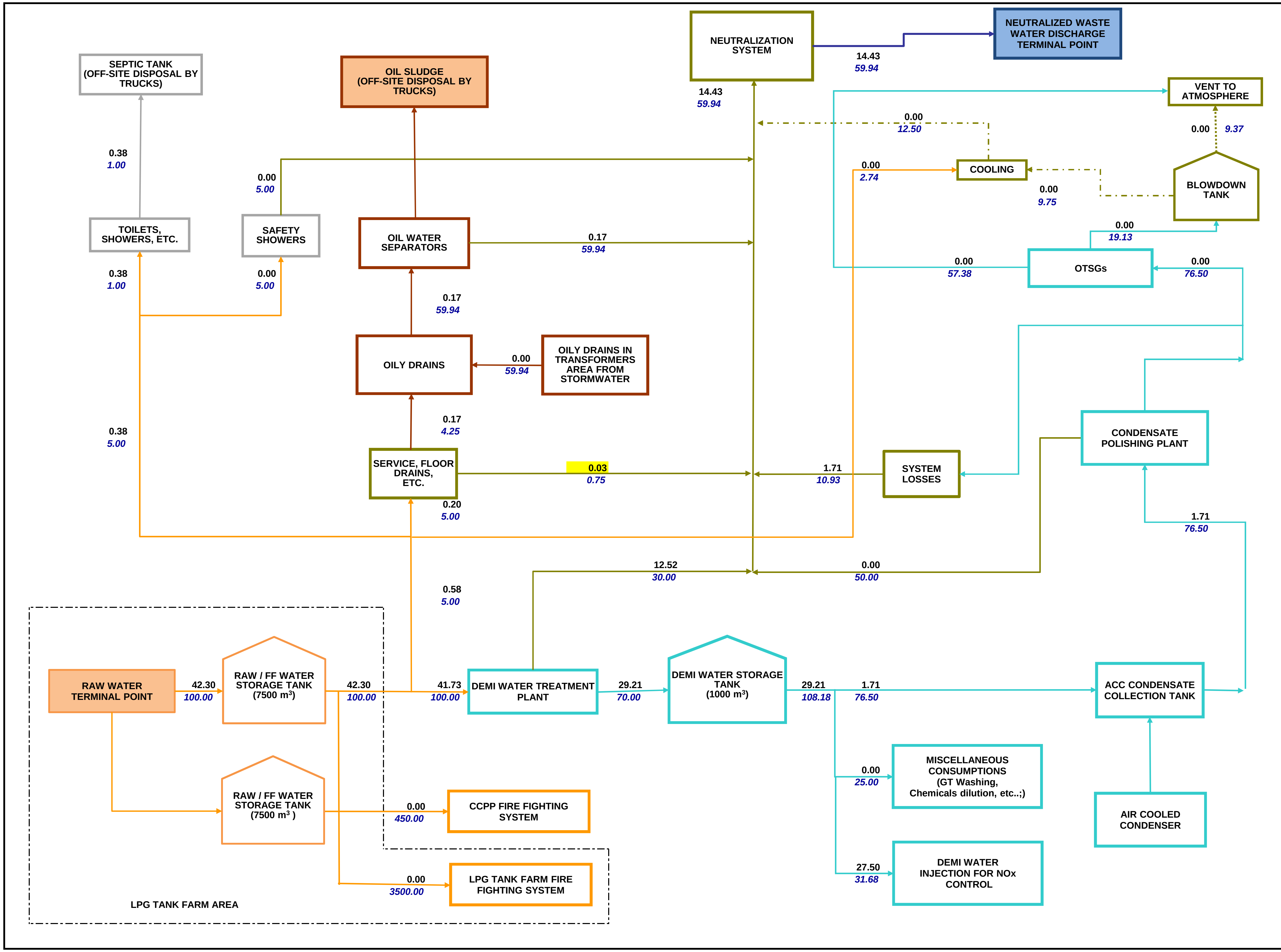
Table 2-1 provides a breakdown for expected water consumption during operation of the plant using LPG and DFO for Phase 1 and Phases 2, 3, 4 of the project respectively. These values are based on an assumed first stage reverse osmosis recovery rate of 50% and a second stage reverse osmosis recovery rate of 95%.

The total water consumption for the Stage 1 and Stage 2 when operating on LPG will be 166 m^3/hr (Stage 1: 42.3 m^3/hr, Stage 2: 112.7 m^3/hr). The water consumption for the plant is greater when operating on DFO than LPG.

Table 2-1: Water Consumption

Water Consumption (m^3/hr) per Fuel Type	Stage 1A	Stage 1B & Stage 2
DFO	49.9	127.1
LPG	42.3	112.7

The detailed water balance for Stage 1 of the project is presented in the following diagram. The detailed water balance for Stage 2 is not yet confirmed.



REFERENCE DOCUMENTS

1. POWER PROJECTS Proposal for BRIDGE POWER IPP.
2. Raw water analysis as per Inquiry documents - Appendix G.
3. Technical Clarifications.
4. Heat & Mass Balances T214, 1 GP002491-001 Rev 3.
5. Water demmand calculation, 161111-DA-FF-001 Rev A.

NOTES

1. GENERAL

1.1 All units in t/h.

1.2 Design Conditions: 28°C, 85% RH, LPG firing.

1.3 Normal flow consumptions are prorated to 24h if not continuous.

1.4 The balance is calculated for 5x5x1 configuration in CCPP mode.

1.5 **Black numbers** show normal flows and ***blue italic numbers*** show intermittent peak flows need to be considered for lines sizing only. All figures are preliminary

2. RAW / FIREFIGHTING WATER

2.1 Raw water is supplied from Terminal Point located at the LPG Tank Farm Site.

2.2 Raw water / Firefighting water tanks will be located at the LPG Tank Farm site.

2.3 Fire protection water is consumed in case of fire.

2.4 Firefighting water is supplied from TP located at the LPG Tank Farm.

2.5 Fire water tank capacity & Tank Farm water demand calc. are preliminary

3. CONDENSATE POLISHING

3.1 Condensate Polishing Plant will be equiped with a full flow bypass line

3.2 Condensate Polishing Plant featured as 2x100% trains of cartridge filters + cation bed ion exchangers + mixed bed ion exchangers.

4. DEMINERALIZED WATER

4.1 Demi Water Plant efficiency is considered equal to 70%.

4.2 Demi Water Treatment plant is featured as two (2x100%) trains with RO & EDI or Mixed Bed units with a nominal capacity of 35 m3/h

5. SANITARY / POTABLE / DOMESTIC WATER

5.1 Sanitary water consumption has been considered for 20 people with a normal allowance of 150l / person / day.

5.2 Potable water for human consumption will be supplied by bottles.

6. MISCELLANEOUS CONSUMPTIONS

6.1 Demineralised water consumption to GT washing, chemical dilution, ACC washing, Fin Fan Cooler washing. etc.

6.2 Allowance for system losses: 0,75% of condensate flow

6.3 Start up blowdowns are cooled to 85 C with quenching water

6.4 Simultaneous Start Up of the five (5) OTSGs is considered as worst case scenario

7. EFFLUENTS

7.1 It is assumed that 85% of service water goes to oily drain network.

7.2 Effluents shall be cooled down in the WWTP, if necessary, to adjust the maximum temperature permitted.

7.3 Effluents with high conductivity from WTP and CPS will be routed to the neutralization system and then removed by an authorised handler.

LEGEND

- RAW & FIRE FIGHTING WATER
- DEMI & CONDENSATE WATER
- INDUSTRIAL EFFLUENTS
- EFFLUENTS WITH OIL & SLUDGE
- SEWAGES
- NEUTRALIZED WASTE WATER

Project:	**BRIDGE POWER IPP**
Doc. Name:	**Water Balance Diagram**

Design Basis Conditions 5xTM2500 at 100% load firing LPG with Ambient Temperature of 28 C

BRIDGE POWER — METKA POWER PROJECTS

Document No:	Rev 00
	21 April 2017
KKS No.: 17011-10-YM-MDO-PPR-001	Sheet
	A1

2.5.3 Water Usage

Construction of the LPG pipeline will require minimal volumes of construction water which will be sourced from the TOR site.

The principal water uses for the project will be:

- Gas turbine water injection for control of NO_x emissions;
- HRSG blowdown (1% recirculation rate within the steam / water circuit);
- Other demineralised water consumption (dosing, sampling, laboratory: 2 m^3/hr for combined cycle, 1 m^3/hr for open cycle);
- Service water consumption (1 m^3/hr plant total); and,
- Potable water consumption (150 litres per person per day, 10 persons).

2.5.4 Fire Water

Fire water for the LPG tank farm will be stored on the LPG tank farm site and firewater requirements for the power facilities will be stored at PPS2. The combined fire water / raw water storage tanks (one each for PPS1 and PPS2 respectively) will be designed to comply with the relevant fire regulations (including National Fire Protection Association (NFPA) regulations) and will be installed together with fire pumps, hose reels, fire hydrants and portable extinguishers. The capacity of each storage tank (preliminarily sized with a working capacity of 7,500m^3) will be sized to store two hours' fire water reserve for the worst case fire risk event in a dedicated lower section and an additional 36 hours raw water consumption for each stage in the upper section (i.e. 72 hours total across both tanks).

2.5.5 Raw Water Treatment

The OTSG/HRSG will generate steam from high purity water which is used to protect against internal corrosion and reductions in operational efficiency as a result of fouling/scaling of equipment. Although of high purity, this water will contain some dissolved solids. The water quality within the water/steam circuit will be controlled by purging small quantities from the system (blowdown) to prevent the build-up of concentration of dissolved solids within the HRSGs. This water will be treated in waste water treatment plants and either re-used within the project or discharged via the site waste water discharge system.

Demineralised water will be required to replace the blowdown and will be supplied by on-site water treatment (demineralisation) plants (one on each power site). The water treatment plants are expected to treat the mains water supplied by the Ghana Water Company using reverse osmosis (RO). Demineralised water sufficient for up to one day of continuous operation (circa 1800 m^3) will be stored on each power site within dedicated storage tanks.

2.5.6 Waste Water

The main aqueous emissions from the plant will consist of the following:

- Boiler blowdown;
- RO brine and filter backwash;

- Water treatment (demineralisation) plant effluent;
- Oily water from fuel oil storage and main building drainage;
- Oily water from transformer compounds;
- Sanitary waste;
- Storm water via surface water drains;
- Gas turbine compressor wash effluent (intermittent); and,
- Miscellaneous minor process effluents.

Each power site will have a dedicated wastewater treatment plant to treat effluent from the respective RO plants to control the composition and properties of the effluent to within limits as defined by the EPA. The resulting effluent will then either be re-used within the project or discharged to the storm water outfalls.

At each power site, sanitary waste will be collected in a septic tank (sewage treatment) before being pumped out and disposed of offsite by licensed contractor.

The Ghana EPA and the IFC EHS guidelines for effluent discharge limits have been provided in Section 16.

2.5.7 Drainage

Both power plant sites and the tank farm site will be provided with appropriate storm water drainage system and contamination/leakage control systems in line with Ghana and World Bank/IFC standards.

Clean storm water within the power plant and tank farm sites will be collected via designated storm water drainage systems and discharged into the urban storm water drain which runs adjacent to the power plant sites (see Figure 2-2b). Connecting surface water drains will be built from the sites into the adjacent urban storm drain (Watercourse 2).

Existing storm drainage has been completed adjacent to the northwest corner of the tank farm site. However, no further work has been done by the authorities on the storm drainage since the inception of the project in 2015. EPL will work with KKDA and TDC to investigate potential for extending the storm drainage network up to the tank farm location.

All areas with the potential for contaminated runoff (e.g. hardstanding around the generators or hazardous materials storage) will be drained by a separate system which will be routed to an oil separator. Any oily wastes will be pumped out and reused/disposed of by licensed contractor. Water from the oil water separators will be routed to the storm drainage. The separator design will ensure minimal water oil content in compliance with Ghanaian and IFC EHS requirements.

2.6 Waste

2.6.1 Construction

A major component of construction wastes will be the generation of soil arisings from excavation and piling works. Other solid wastes generated in construction include:

- Building rubble;
- General construction waste, e.g. cement bags and waste concrete;
- Plastics;
- Electrical cabling;
- Empty oxy acetylene tanks;
- Scrap metals (mixed metals) including spent welding rods;
- Empty chemical containers;
- Packaging materials of cardboard and plastic;
- Fibreglass;
- Spilled oils and waste oils;
- Spilled oil clean-up materials;
- Paint;
- Waste wood.;
- Paper;
- Domestic waste;
- Sewage effluent; and,
- Grass/vegetation from stripping.

Expected quantities of specific waste streams are not yet defined; however, in relation to the size of the project, it is likely that only a moderate amount of waste will be generated during the site preparation and construction phase. Some of the waste produced is likely to be classified as hazardous, e.g. waste oil.

2.6.2 Operation

Once operational, there will be few significant sources of solid waste generated and the additional burden placed on the existing waste management infrastructure in the project area should be low.

The solid wastes could include:

- Domestic and commercial waste (cardboard, paper, pallets, packaging material from spares, waste printer cartridges, food wastes, dirty oil, etc.).

- Wastes produced during maintenance, including:
    - o Sludge removed from oil separators;
    - o Deposits removed from the HRSGs;
    - o Scrap metals from maintenance; and,
    - o Miscellaneous wastes (e.g. air filters).
- RO membranes from the demineralisation plant (typical lifespan of 5 to 10 years).
- Solid hazardous and other wastes from water treatment in the RO plant including process ferric and lime sludges.
- Paper and plastic packaging materials.

2.6.3 Decommissioning

When the Project is decommissioned, there will be potential for generation of significant quantities of hazardous and non-hazardous materials. It is likely that materials generated at decommissioning will include all of those mentioned above for the operation phase. There will also be arisings of building materials and components, equipment, fixtures/fittings, and other items that may be contaminated with hazardous residues and/or contain hazardous constituents. The decommissioning plan will aim to recover assets, recycle materials and minimise the need for solid waste disposal.

Additional waste may be generated from or include:

- Plant cleaning and decontamination activities;
- Miscellaneous demolition wastes;
- Residues or stabilised waste from on-site treatment activities such as chemical treatment, incineration, fixing in solids (cementitious backfills, refractory fixing, etc.); and,
- Arisings from land remediation where end of plant clean-up of soil and groundwater contamination is required to prevent future risk to people or the environment.

2.6.4 Hazardous Materials (all phases)

A hazardous waste disposal agreement will be signed with the Tema Metropolitan Assembly and all such disposals will be supervised by the Plant Environmental Officer.

The table below provides a list of the expected hazardous waste over the project life cycle.

Table 2-2: Hazardous Waste Streams

Hazardous Waste	Project Phase		
	Construction	Operation	Decommissioning
Excavated materials which may contain heavy metals, hydrocarbons / other contaminants	X		
Paint associated with construction and maintenance activities.	X	X	
Empty chemical containers	X	X	X
Spilled treated and untreated oil	X	X	X
Waste oil clean up materials	X	X	X
Chemicals and greases	X	X	X
Batteries	X	X	X
Medicinal wastes	X	X	X
Scrap metals	X		X
Waste fiberglass	X		X
Waste ion exchange resins		X	
Spent water treatment filters		X	
Boiler chemicals for boiler water treatment		X	
RO membranes		X	

Hazardous materials stored on the site include DFO. It is possible that accidental release of these and other materials (e.g. lubricating oils/grease/paint) could arise through construction and operational activities.

2.7 Chemicals / Storage

Chemical consumption requirements will be minimal. Currently it is anticipated that the only requirements will be for industrial detergents for gas turbine wash down. Chemicals added within the RO process will be sodium bisulphite (to remove excess chlorine from raw water), anti-scale additive, plus sodium hydroxide and sulphuric acid to adjust pH at different stages.

All chemicals will be stored in appropriately designed and protected areas with warning relevant signage in line with international standards.

2.8 LPG Delivery Components

2.8.1 LPG Unloading Facilities

LPG carriers will berth alongside the existing TOR jetty within Tema port and each carrier will be secured to the jetty using mooring lines. LPG transfer will take place according to an approved 'ship to shore' (STS) procedure.

The berthing area will be equipped with protective and emergency safety systems, including emergency release mechanisms in the LPG loading hoses, leak and fire detection and alarm systems, and personnel protection equipment.

A new 12" loading arm for transfer of LPG will be installed on the jetty to relevant international design standards. The new loading arm will replace the existing 6" loading arm. It is yet to be confirmed if the old loading will be scrapped or sold for reuse elsewhere. The LPG pipeline for the project will follow the existing TOR pipeline RoW along the jetty up to the connection point.

2.8.2 LPG Carriers

Operation of the project will require regular deliveries of LPG supplied from LPG carriers (LPGCs) loaded at various LPG facilities worldwide.

LPGCs will be of double-hulled design (that is, each carrier will have a double bottom and double sides along the full length of the cargo area). The double-hulled design greatly decreases the likelihood of LPG release in the event of grounding and collisions. The vessels will meet all local and international regulations for LPGCs.

The LPG containment system on LPGCs will consist principally of the cargo tank (sometimes called a primary barrier), the secondary barrier, and insulation. The containment system also will include monitoring and control and safety systems.

The LPGC proposed for use in the project will be required to comply with all relevant Ghanaian and international standards regarding LPG shipping. As such, carriers that transport LPG to the Project will be fitted with an array of cargo monitoring and control systems that will automatically monitor and control cargo pressure, temperature of the cargo tanks and surrounding ballast tanks, emergency shutdown of cargo pumps and closing of critical valves, the level of cargo in the tanks, and gas and fire detection. These systems are active while the carrier is at sea and during the remote-control phase of cargo operations at the jetty.

LPGCs will be fitted with many navigation and communication systems, such as the following:

- Two separate marine radar systems, including automatic radar plotting and radio direction finders;
- LORAN-C receiver;
- Echo depth finders; and,
- A satellite navigation system.

All LPGCs also will have redundant, independent steering control systems that are operable from the bridge or steering gear room to maintain rudder movement in case of a steering system failure.

2.8.3 Fire Protection

All LPGCs arriving at the jetty will be constructed according to structural fire protection standards contained in the “International Convention for the Safety of Life at Sea” (SOLAS). They also will be fitted with active fire protection systems that meet or exceed design parameters in Coast Guard regulations and international standards, such as the Gas Tanker Code and SOLAS, including:

- A water spray (deluge) system that covers the crew accommodation area and all main cargo control valves;
- A traditional firewater system that provides water to fire monitors on deck and to fire stations found throughout the carrier;
- A dry powder extinguishing system for LPG fires. The dry powder system will be used to extinguish LPG fires and prevent ignition of LPG leaks. Automatic dry powder extinguisher system will be integrated into the exposed deck of the cargo (LPG) area, loading arms and cargo tank domes, and in the LNG processing area; and,
- A CO_2 system for protecting the machinery, ballast pumps, emergency generators, and cargo compressors.

2.9 Construction Details

2.9.1 Construction of Components and Pipeline

Following award of the construction contract and the detailed design stage, it is anticipated that it will take from NTP around 9 months to construct Stage 1a, and a further 15 months to construct Stage 1b.

Stage 2 will take 24 months from NTP to COD. However this will be dependent on ground preparation works including any necessary remediation.

The development will proceed on a turnkey engineering, procurement and construction basis. A main contractor also known as an EPC contractor will be engaged to undertake the overall project work including civil, mechanical and electrical engineering works. The contractor will develop a detailed design, based on the outline specification, and manage the development of the design. An important feature of ‘turnkey’ contracts is to ensure that proper consideration is given to traffic movements and environmental constraints through implementation of the findings of the ESIA and the Environmental and Social Management Plant (ESMP), including detailed management plans such as a Traffic Management Plan (TMP) or equivalent document which shows how the potential impacts will be managed.

The main contractor will in turn appoint specialist subcontractors. The main contractor will be responsible for organising the site construction and installation works to the required safety standards and the project programme. The requirements of ESMP will be cascaded down to sub-contractors through the contracting process, but ultimately the responsibility for overall implementation of the ESMP remain with EPL and the main EPC contractor.

Early Power Ltd will employ a consultant, acting as Owner's Engineer, to monitor and report on the project construction and commissioning. Specialist environmental advisors will also be employed for the construction period, for assistance with environmental monitoring and the preparation of method statements.

An information board will be displayed in a publicly accessible location at all times, giving the name and telephone number of the developer's site representative. Warning signs will also be erected at appropriate locations.

Initial site works will comprise site clearance and remediation of any contamination present on the site should any such remediation be found to be present.

The main works would follow a straightforward sequence beginning with excavation for structural foundations and structural development. The final stages would be the installation of the CCGT equipment followed by commissioning activities, landscaping and the handover period.

The TMs are by nature portable units and require little foundation works; however, due to the installation of the OTSG units, as with the LM units, reinforced concrete raft foundations will be constructed. These will be designed subject to the results of the full site investigation. The final selection of the foundation types will be in accordance with the detailed design. Circular tanks will be supported on reinforced concrete ring beams. Pipe racks will also be supported on small reinforced concrete piles. Foundations for rotating or vibrating equipment will be designed in accordance with specified conditions to ensure that there will be no settlement of the units that could affect their operation, that vibration from the foundations will not adversely affect other nearby structures, and that there will be no resonance between the driving frequencies and the natural frequencies.

Temporary construction laydown and car parking areas will be required. The laydown areas will be for storage, fabrication, temporary site facilities including contractor's temporary site offices. These areas will be put into hardstanding and then reinstated. The location for the laydown area(s) will be posted on the message boards at each site. Appropriate construction design mitigation measures will be implemented for both areas.

All construction surplus and waste materials will be regularly removed from the site to an approved waste management site. All hazardous wastes and waste containers will be stored on the site in an appropriate manner before removal by a licensed contractor for disposal by an approved method. The disposal contractor and receiving location will be audited by the contractor to ensure that the facilities meet with appropriate Ghanaian and international standards.

In addition to the on-site construction works it will also be necessary to install LPG and water pipework. All pipelines will be designed and constructed according to international and local standards and with regard to mitigation measures identified in the ESIA. As Ghana Water Company will be constructing the water pipeline, EPL will monitor the construction activities and work with GWC to promote the application of good international industry practice with regard to safety and environmental/social management practices.

A peak construction work-force of up to 200 is expected; however, this is dependent on the turnkey contractor. Average numbers will be of the order of 100. The peak workforce would be onsite during the busiest construction period when multiple disciplines of contractors complete work simultaneously. Local contractors will be encouraged to tender for the civil and electrical works. Electricians, riggers, crane operators and heavy equipment operators will also be required.

2.9.2 Construction Materials

Limited construction materials will be required as the majority of the plant infrastructure will be prefabricated and transported to the site. The main requirements will be aggregate and concrete for civil engineering works (foundations, bunds, etc).

Similarly, much of the materials for the pipeline will be the pipes themselves. As much of the route will be over ground, there will be minimal civil works (and associated materials) for pipeline sleepers and fixings, and road/water crossing excavation or bridges.

2.9.3 Access to Power for Construction

During the plant construction phase, power facilities may be available from the existing commercial units in the area and from ECG's distribution network. Access arrangements will be agreed between the relevant EPC Contractors and ECG as required. Backup on site via generators will be required to ensure continuity of power supply. Power will typically be required at 400 V to provide construction power supply.

2.9.4 Construction Programme

Construction of the power facilities will be on a rolling programme. The construction activities on site will follow on from one month of design and manufacturing stages.

Any piling if required will only be undertaken during daylight hours, unless associated with an emergency.

2.9.5 Hydrostatic Testing

All pipelines will be hydrostatically tested (hydro test) upon completion of the sections constructed.

Detailed hydrostatic testing procedures will be developed during detailed pipeline design. Potable water will be used and the test water will not be treated when it is injected.

The pipeline will be dried upon completion of the hydrostatic test. Discharge will be into local storm drains. All international and local rules, regulations, and permits related to the pipeline design, engineering, construction, installation, and commissioning will be taken into consideration during the continued design development of the Project.

2.10 LPG Jetty Connection Commissioning

2.10.1 Overview

Following completion of construction, but prior to the start of standard operation, the new LPG connection must be commissioned. The commissioning process will focus on key activities pertinent to commissioning of an LPG terminal.

Equipment in the commissioning process will include:

- Jetty platform and associated equipment:
  - Marine loading arm; with quick release and emergency shutdown
  - Firefighting and gas detection equipment;
  - Gas meter(s); and,
  - Communications equipment.

2.10.2 Commissioning Activities

Commissioning will consist of the following activities:

- Functionality of the mechanics and automation control, including:
  - Loading arm;
  - Liquid transfer pipework;
  - Communications to storage facilities; and,
- Pipeline LPG from jetty through to site:
  - All emergency shutdown valves (ESDVs), shutdown valves (SDVs), SXNVs and FCVs shall have been opened prior; and,
  - The low pressure nitrogen in the pipeline shall be vented to atmosphere using the vent points at the plant end.

2.10.3 Environmental Compliance Inspection and Mitigation Monitoring

In preparing construction drawings and specifications for the project, the LPGC operator and EPC Contractor will incorporate all mitigation measures identified in the ESIA as well as requirements of international standards, conventions and requirements of the EPA. Contractors will be provided copies of applicable environmental permits and will be fully apprised of mitigation requirements and other applicable environmental commitments.

All construction personnel will be trained by the LPGC operator to ensure that they understand and are able to properly implement all mitigation measures. Such training will be conducted before commencement of construction and during construction, as needed.

In addition, local regulatory agency personnel will conduct inspections to monitor the project for compliance with the applicable environmental conditions.

2.11 Workforce Requirements

During the construction phase, there will be in the order of 100-200 staff for both construction of the plant and the pipelines, with employment opportunities for the local labour force.

No on site worker camps are currently planned for the project and workers are expected to be housed in local facilities such as hotels if they do not already reside in local communities.

As part of the temporary works, the EPC Contractor will provide portable office site accommodation for his own and sub-Contractors staff, site office accommodation for the Engineer / Owner's construction management personnel, toilet and kitchen facilities, graded parking areas and canteen facilities. All of these facilities will be located within the proposed site areas for PPS1 and PPS2. All office site accommodation will be required to conform with the IFC/European Bank for Reconstruction and Development (EBRD) Guidance Note on Workers Accommodation Processes and Standards (2009).

Estimated total staffing levels for the operational phase for the plant is estimated at 30-35 people generally working shiftwork.

2.12 Health and Safety Management Systems

Specific occupational health and safety issues associated with power projects include the potential for exposure to confined spaces, heat and air quality and noise impacts.

In addition to these occupational health concerns, there are also health and safety risks associated with construction, operation and decommissioning activities and emergency situations.

A health and safety system for construction and operational activities will be developed as a requirement of the ESMP for construction and operational phases. The operational system will be based on the requirements of ISO18001 for Occupational Safety and Health Management Systems.

A health and safety plan will be developed as a requirement of the ESMP that will include a process hazard analysis and a 'hazard and operability study' (HAZOP) which covers the full project infrastructure The information generated from the HAZOP will be used to prepare a pipeline failure safety plan.

The protection of personnel and equipment is of paramount importance. Fire safety and Emergency Response Plans will be developed and implemented as part of the ESMP. The designs for the plant will incorporate provisions for fire prevention (developed procedures), fire detection (sensors and alarms), and fire suppression (water and foam and portable extinguishers). The facility will have equipment installed including gas detection, heat sensors and manual pull stations in the event of a fire and an audible alarm system. Typically NFPA 850 recommendations will be implemented for insurance purposes. The Ghana National Fire Service will also carry out a site inspection and undertake a review of the proposed fire-fighting and other safety requirements prior to operation.

Additional safety measures will include:

- Worker PPE and associated health and safety training including procedures for emergency response;
- Worker first aid and safety training; and,
- Worker health monitoring to ensure proper management of occupational health and safety concerns as well as incidents.

2.13 Land Ownership

All aspects of the project infrastructure are located within the THIA, controlled and managed on behalf of the GoG by the Tema Development Corporation (TDC). The power plant and tank farm sites are the subject of long-term leases with TDC or sub-lease agreements with the existing leaseholders with TDC, on a willing transaction basis. Most agreements have been executed with a few close to finalization as of the time of compiling this report.

All pipeline RoWs are either already in place or agreed, subject to commencement of the project. As these agreements are commercially sensitive, further details can be provided by EPL on request, separately to this document.

2.14 Decommissioning

The design life of the major project equipment such as the turbines and HRSG to be used will be a nominal 25 years; however it is not uncommon for power plant such as the proposed development to operate for 40 years or more. The decision to decommission the power station will be depend on its economic viability with regards to fuel costs, plant life and environmental requirements.

The costs of decommissioning will be borne by the operator and are usually covered by the recycling value of certain items of plant.

Decommissioning will take account of the environmental legislation and the technology available at the time. Notice will be given to the EPA through a Decommissioning Plan in advance of the commencement of the decommissioning work. Any necessary licences or permits would be acquired.

The operator would develop a decommissioning plan and the works would be undertaken in accordance with an ESMP, which would cover safety and environmental issues and would be agreed with the relevant authorities not less than 12 months prior to commencement of decommissioning.

The first step of decommissioning will be to make the plant safe for work in accordance with relevant safety procedures. The power station would be de-energised. Stored materials would be sold where possible or disposed of off-site by a licensed contractor. Storage tanks and pipes would be emptied and cleaned. Closed vessels, pipes and other areas which could have hazardous gases present would be vented in accordance with normal operating procedures. These would then be tested to ensure that they are safe for removal or entry.

Once the plant is completely disconnected, and all hazardous materials removed, it will be handed over to a competent contractor (or contractors) to complete the dismantling and demolition work.

It is probable that most of the plant and equipment will be at the end of its useful operating life and will be obsolescent or obsolete and unsuitable for further use. It will therefore need to be dismantled for recycling, where it is economic to do so. Unsalvageable material will be disposed of at a licensed landfill. Any remaining aqueous effluents would be disposed of in accordance with the normal operating licence or as agreed with the regulatory authorities.

Site buildings and structures would be removed to permit the future use of the site. Soils would be remediated to the agreement of the EPA.

Further decommissioning actions and information is contained within the ESMP presented as Volume III of this ESIA package. Decommissioning is also discussed in each of the separate impact assessment sections.

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Section 3 – Project Justification

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration	Rev No
Sep 2015	First issue	0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency	1
June 2016	ESIA Amendment issued to Ghana Environment Protection Agency - no changes to this Section.	2
August 2017	ESIA amendment issued to Ghana Environment Protection Agency, incorporating details of further project design changes.	3

Contents

3 Project Justification: The Need for the Development

3.1 Overview

Inadequate electricity supply and transmission systems, coupled with an increasing demand for power as a result of an expanding population, leads to frequent power shortages in Ghana. As part of its short term strategy, the Government of Ghana (GoG) has requested the development of this emergency power solution. The objective is to deploy electrical energy as quickly as possible to support the immediate demand for reliable power in the area.

3.2 Demand for Power Generation

Ghana's electricity supply is both inadequate and unreliable. The current baseline production sources only generate electricity supply for 74% of the population (and only 60% in rural areas), and continued population growth is increasing the demand for electricity. Ghana's National Energy Policy (2010) included a goal to achieve universal access to electricity by 2020.

Electricity demand in Ghana is mainly domestic, accounting for 50% of demand, whilst commercial and industrial consumption stand at 12.5% and 37.5%, respectively. The annual growth rate for electricity demand in the country has typically been 10-15% in recent years. Peak power demand increased from 1,943 MW to 2,061 MW between 2013 and 2014. It grew further to 2,118 MW in 2015. Supply capacity has not kept pace with this growth in demand thereby putting the power system under great stress.

Various studies have established a strong relationship between real GDP growth rate and electricity consumption. Ghana had estimated population growth of 2.3% per annum to 2015, and GDP growth at 3.9 % per annum to 2015, such that electricity demand was projected to continue to grow by more than 6% per annum over 10 years. Increased energy supply and expanded energy infrastructure are needed to satisfy the increasing electricity demand. Based on Volta River Authority's (VRA's) capacity demand and supply balance (2013-2025), and in line with Ghana's power sector reform and major policy objectives, it is estimated that the country's current total installed generating capacity requires to be increased to 5,175 MW by 2023 in order to address the current power shortages, ensure an adequate supply of electricity, meet the country's forecast growth in demand requirements, and improve the quality of service and reliability of the power system. The Energy Commission, Ghana reported in the '*2016 Energy (Supply and Demand) Outlook for Ghana'* that the likely shortfall in capacity over 2016 would be 820MW. It is, therefore, imperative that rapid development of power plants and energy infrastructure take place if these energy shortfalls are to be met.

3.3 Sources of Power

The bulk of the power supply in Ghana, comprising about 50% of the power generation capacity, comes from hydro-based sources. These hydroelectric plants convert water trapped in a dam into electrical energy by using the gravitational force of flowing water to turn a turbine coupled to a generator. Installed hydro plants include the Akosombo Hydro station, Kpong Hydro Station and the Bui Hydro Dam. Together these plants have an estimated effective capacity of over 1250 MW.

The remaining 50% of Ghana's energy supply comes from thermal based plants which function by converting energy stored in fossil fuels such as oil and natural gas into electrical energy. The existing VRA Takoradi Power Plants currently generate a combined effective capacity of 682 MW, which is approximately 55% of power from thermal plants in Ghana. These plants operate using light crude oil (LCO) or gas.

3.4 Reliability of Supply

Ghana's reliance on few primary sources of power generation makes it vulnerable to power shortages. Hydroelectric power is dependent on availability of water and the thermal power plants are reliant on a sustained source of fossil fuel supply. Any disruption to the availability of these feedstocks leads to a shortfall in supply which cannot be met.

Hydroelectricity

In 2007 the electricity output in Ghana fell by 15%, primarily due to falling water levels in Lake Volta, which provides the source of electrical energy created by the Akosombo hydroelectricity plant. The crisis prompted investment into other forms of electrical supply including additional hydroelectricity source (the Bui Damn Project) and additional thermal power plants. Continuous investment is required to remove the risk due to uncontrollable weather and hydrological conditions.

Thermal Power Plants

Ghana's thermal power plants are reliant on supplies of natural gas although all but one can also operate using LCO. LCO is expensive and less environmentally friendly so operation with gas is preferred. The gas supply is sourced from Nigeria through the 678km West Africa Gas Pipeline (WAGP) which began supplying gas to Ghana in 2009. However, the available gas volume of 120 million standard cubic feet per day (mmcf/d) from Nigeria via the WAGP, a supply which equates to approximately half of Ghana's gas requirements, has been persistently unreliable. Contracted volumes have decreased year on year as of 2011. WAGP shipped an average of 65 mmcf/d of natural gas in 2012 (until August when the pipeline was shut down after becoming inundated with seawater) and about 40-50 mmcf/d in 2013. The unreliability of supply has been primarily due to technical and infrastructure problems, with vandalism of the pipeline in October 2012 also contributing to disruption. Nigeria's domestic gas needs have also impacted the volume of gas supplied via the pipeline with Nigerian gas producers choosing to supply industrial customers in that market over exports through the pipeline.

The risk of dependence on few power sources is highlighted when hydroelectric and power plant supplies are disrupted simultaneously. In September 2014, labour unrest in Nigeria disrupted supplies and denied Ghana 180 MW from the solely gas-fired Asogli thermal power plant. This disruption in gas supply coincided with reduced hydroelectricity supply due to low water inflows at the Bui and Akosombo Dams and a retrofit Project at Kpong hydroelectrical plant. This exasperated the energy shortage and highlights the vulnerability of Ghana's energy supply sources to disruption and the need for continued investment into power projects.

Demand at peak times

Even when power generation systems are working normally and there is technically sufficient capacity to meet the country's loads, there can be shortfalls in supply at peak usage time (6pm to 10pm). This is because the reserve available in the event of any contingency has become very low. Under normal operation there is a reserve margin of 20%, however this is regularly depleted and there have been instances where there was no reserve margin during peak periods. Given the current operating margins, any slight drop in the available supply or increase in the forecast demand results in frequency decay, which can lead to a total system shutdown. Thus, the high demand and vulnerability of power generation to disruptions results in frequent and often unannounced power shortages in Ghana.

External sources of power

Ghana's power supply can also be vulnerable to disruptions in power generation in the Ivory Coast which has been a major supplier of electricity to Ghana in the past and continues to deliver power to Ghana whenever the need arises. For example, in March 2012 an unexpected loss of 72 MW of electricity following equipment failure from the Ivory Coast supply caused a power outage in Ghana. Ghana needs to invest in power generation Projects, such as that proposed by Early Power Limited (EPL), to become self-sufficient. Increased power generation is required to maintain an adequate reserves margin.

3.5 Needs Case Summary

Investment in power generation facilities is required to both meet the immediate power shortfalls due to unreliable power generation and to meet the increasing demand for electricity, thereby ensuring continued long-term economic growth. The EPL development is one of many power plants required to meet the current energy shortfall and to help Ghana meet its development goal agenda. The meeting of increasing energy demands, both locally and within Ghana as a whole, is required to support continued growth, associated employment opportunities, social improvement and necessary infrastructure developments.

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Section 4 – Analysis of Alternatives and Site Selection

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration		Rev No
Sep 2015	First issue		0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency		1
June 2016	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating the following changes:		2
	Section No.	***Change***	
	Wherever relevant	Reference to “power plant site” changed to reflect revised plan involving two power plant sites (PPS1 and PPS2).	
	Wherever relevant	Corrections to spelling, grammar and other changes for consistency. Abbreviated terms provided in full at first usage.	
	4.3	Details of PPS2 added to introduction and “Tema” sub-section.	
	Figure 4-3	Updated to show PPS2 (“Bridge 3 site”) and updated supply pipeline arrangements	
	4.7	Details of on how electrical power is to be exported during phases 1 and 2.	
	4.8	Additional details on the routing of pipelines.	
August 2017	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating details of the revised project designs, including where relevant:		3
	Section No.	***Change***	
	1	Details of revised project timescale and reason for issue of Revision 3 of the ESIA.	
	1.1	Updated with new project information including phasing, capacity and unit composition of the two power plant sites.	
	1.2	Details of revised plot locations and surroundings. Updates to developments in the vicinity. Change to the routing of the LPG fuel delivery pipeline and revision of site access route(s).	
	1.5	Update to project development stages and schedule	
	1.7	Update to cumulative impact comments based on additional information about other plants in the area.	
	4.4	Updated to include use of DFO as back up fuel.	

Contents

Figures and Tables

4 Analysis of Alternatives and Site Selection

4.1 Overview

Throughout the course of the project development, many decisions have been made concerning, for example, the type of technologies, the location and the processes involved in the proposed development. Many of the identified potential alternatives were unable to be considered for reasons of technical, regulatory or economic grounds.

This section summarises the key elements of the alternatives that have been considered to date. No satisfactory project alternative has been identified.

4.2 'Do Nothing' Scenario

As outlined in Section 3 of this ESIA, there is a significant capacity deficit with regards power supply in Ghana. Investment in power generation facilities is required to both meet the immediate power shortfalls due to unreliable power generation and to meet the increasing demand for electricity, thereby ensuring continued long-term economic growth. The "do-nothing" scenario would not alleviate the current situation of limited, unreliable and poorly diversified power generating capacity.

The limitations to power supply development could adversely affect the economic development of Ghana. The opportunity to develop future generations of solutions that enhance efficiency and profitability, contribute to economic diversification, accelerate human development would be lost. Other growth drivers such as international competitiveness, labour and employment, governance and public sector reform would also be adversely affected. Therefore the "do-nothing" scenario is not a viable option.

4.3 Alternative Sites

The locations of project components are shown on Figure 4-1 and are described in detail in Section 1.2. The project is located within industrial and brownfield land within the Tema Heavy Industrial Area (THIA).

As described in Section 2, the power facilities will be spread across two sites: Power Plant Site 1 (PPS1) and Power Plant Site 2 (PPS2). PPS1 lies within brownfield land approximately 225m east of the TTPC. PPS2 is located immediately north of PPS1, separated by a strip of land c.25m wide.

The tank farm site lies in brownfield land approximately 30m east of PPS2 and 150m north-east of PPS1. The liquefied petroleum gas (LPG) pipeline from Tema Harbour to the industrial area to the north follows an existing pipe corridor for the first part of its route, to a new booster station to be constructed near to the existing TOR booster station. Upon exiting TOR, it follows a new right of way along Valco Road, passing from the north to the south side of the road at a point opposite Sentuo Steel. The route turns north at the storm drain to connect to the power plant and tank farm sites.

The nearest residential receptors are approximately 2km from the power site. The benefits of locating the power plants at the chosen locations is the proximity of existing industrial and power facilities, which have resulted in the industrialisation of the area, existing infrastructure and a well-developed road network.

During the feasibility studies for this project, an alternative location was considered at Aboadze, in a coastal area approximately 200km to the west of Tema. A site at Sanzule was also considered. Figure 4-1 shows the locations of Aboadze and Sanzule in relation to Tema. In addition, two alternative sites within the TTPC at Tema, was considered. More detailed plans showing the alternative sites at Aboadze and Tema are shown on Figure 4-2 and Figure 4-3. The sites and rationale for choosing the proposed sites are described below.

Aboadze

Aboadze lies approximately 200km west of Tema. The alternative site is within a developing industrial area and was considered viable due to the potential availability of gas supply from the West African Gas Pipeline (WAGP) and the proximity to the coast should any imported fuel be required. The site has been withdrawn due to the expanding requirements of many of the existing projects in the area and is no longer available for development.

Sanzule

A proposed site at Sanzule, in southwest Ghana was also considered due to the proximity to the gas tie in from the offshore gas fields. The location of the site is shown below. The potential site forms part of a large area of approximately 800 acres, located approximately 2km east of the town of Sanzule (8km northwest from Essiama), adjacent to the Gulf of Guinea, and approximately 100m inland from the sea. The area was indicated to be owned by families from a local community, located approximately 2km to the east of Sanzule, down a thin (approximately 100m wide) coastal bar strip which borders the 800 acres.

A site walkover identified that from an environmental and social perspective this site would have highly sensitive developmental issues. It was a completely greenfield site with potential resettlement and indigenous peoples issues. The site is also located at sea level just back from the coast on the coast and the lack of transmission and fuel supply infrastructure and good quality road network in the area which would be needed to support the development and enable efficient construction.

Tema

Two alternative sites for development of power facilities at Tema were considered. The site was known as the ‘Bridge 1 Site’ lies within the Mines Reserve Plant (MRP) within the Tema Thermal Power Complex (TTPC), as shown on Figure 4-3. The site was withdrawn following concerns raised by the Volta River Authority (VRA) on potential underground ducts. The VRA also wished to keep the area free for use as a warehouse or workshop area.

A second alternative, known as the ‘Bridge 2 site’ on Figure 4-3 was considered as there are no underground services in the area to interfere with developments. They were also considered more practicable due proximity to the proposed tank farm and the availability of existing RoW for the required gas and water pipelines. However, no agreement with VRA could be reached and as such the site was not ultimately not available for development.

Figure 4-1: Potential Site Locations: Aboadze, Sanzule and Tema

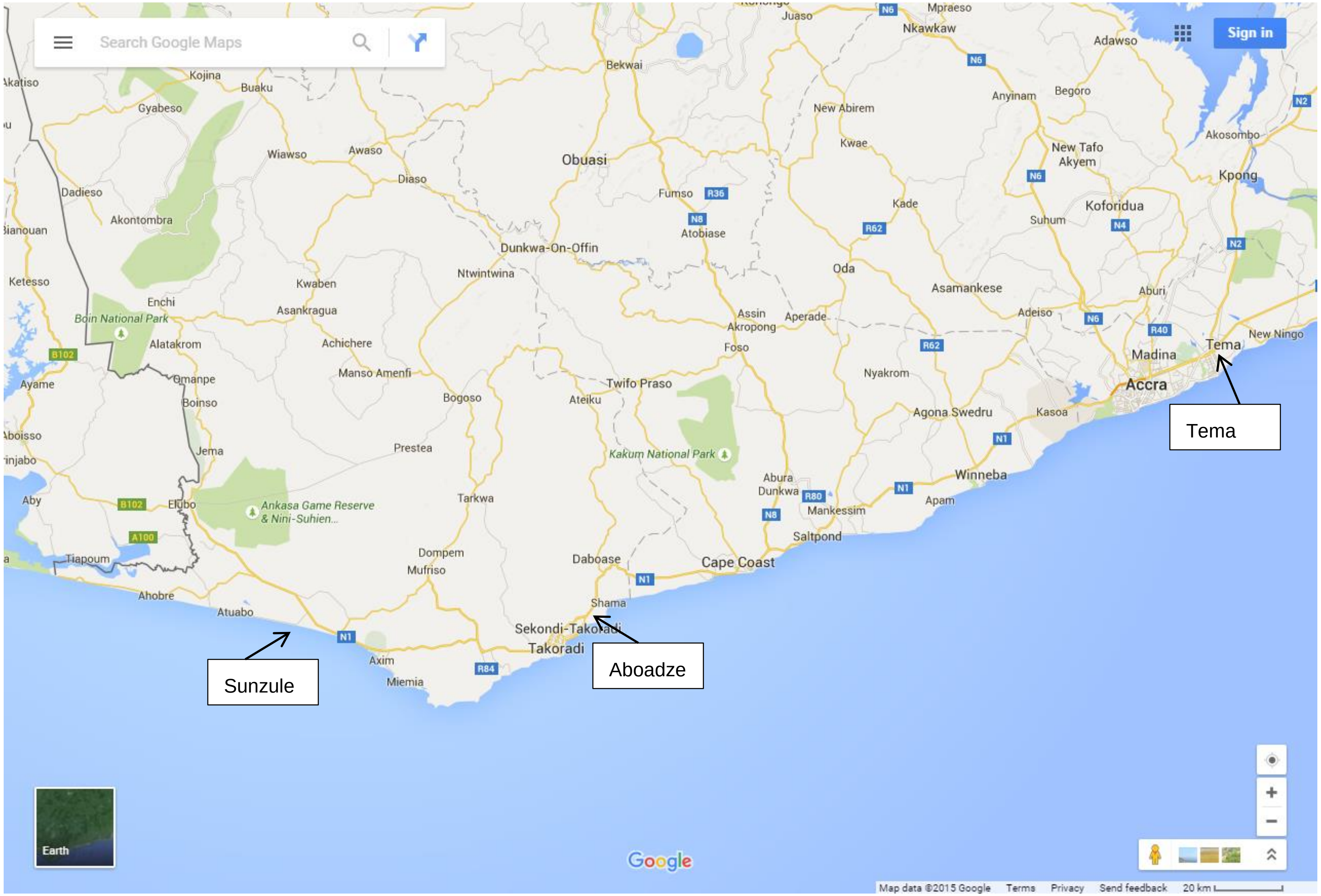
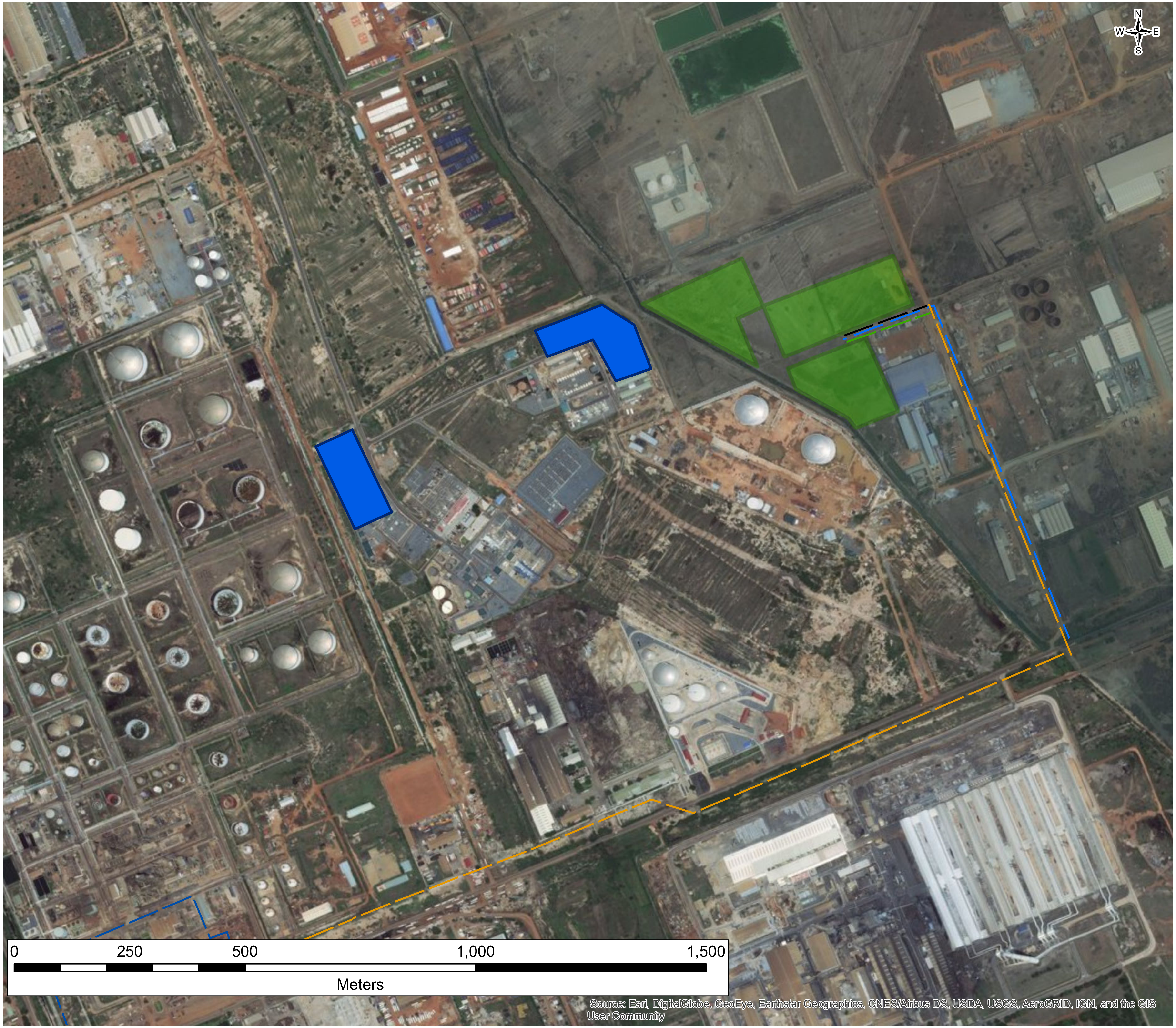


Figure 4-2: Alternative Site Location, Aboadze (now developed as the 'Emeri' Plant)

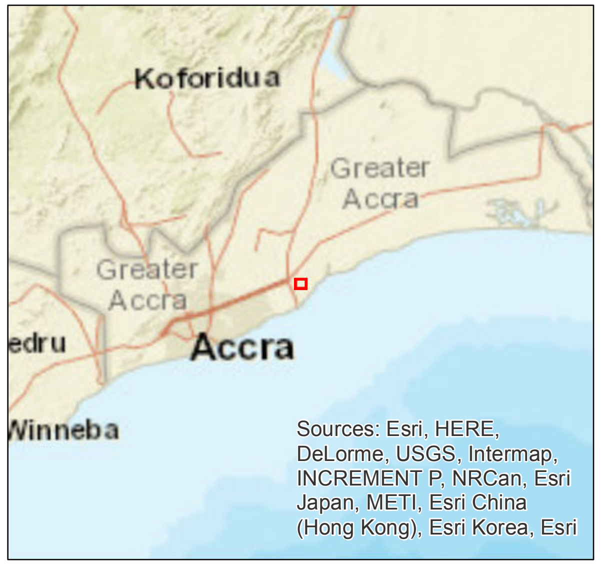
FIGURE 4.3



Legend

- 12 " LPG Pipeline (Overground)
- 12 " LPG Pipeline (Underground)
- 8 " LPG Pipeline to Site (Underground)
- Diesel Pipeline
- Water Pipeline (Underground)

- Alternative Sites
- Proposed Site Locations



0	05/07/17	Initial Issue	PW	DB	DB	DB
Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd

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Client

Early Power Ltd

Project

Ghana Bridge Power Project ESIA

Drawing Title

Alternative Site Location Tema

Drawing Status

Scale @ A3	1:8,000	DO NOT SCALE
Jacobs No.	60K28902	
Client No.	N/A	
Drawing No.	60K28902/LVA/4_3	

4.4 Fuel

The combustion of fossil fuels (coal, oil, natural gas) results in the creation of gaseous emissions such as oxides of nitrogen (NO_x), sulphur dioxide (SO_2), particulate matter, carbon monoxide (CO) and carbon dioxide (CO_2). The use of LPG however results in lower emissions of NO_x, CO and CO_2 and negligible emissions of particulate matter, volatile organic compounds (VOCs) and SO_2 when compared with other hydrocarbon fuels such as diesel fuel oil (DFO) or light crude oil (LCO) which are utilized in other nearby existing and proposed plants.

As such it is the preferred fuel for the power plant in the absence of a readily available supply of natural gas, although DFO will be used as a backup fuel in the event of significant interruption in the supply of LPG.

Imported LPG is proposed whilst extraction activities in Ghana's gas fields continue to develop. It is envisaged that within five years from the start of Stage 2 operation, the plant will switch to operation using natural gas, should this be made available by the Government of Ghana.

4.5 Alternative Generating Technologies

The main thermal generating configurations applicable to this project are conventional gas-fired boilers, Combined Cycle Gas Turbines (CCGT) and Open Cycle Gas Turbines (OCGT). CCGT is currently considered the best available technique (BAT) and is the most efficient and environmental friendly technology available for the combustion of LPG and natural gas.

4.6 Water Source

Options considered for water supply to the plant include the provision of water from the VRA, from the Ghana Water Company (GWC), seawater and groundwater abstraction. Groundwater abstraction has been discounted due to the lack of suitable aquifers in the region.

Seawater abstraction has been discounted due to the additional infrastructure (seawater take and pipeline) required to abstract and transport the water and for purification before it can be used, and the associated additional capital costs.

GWC advised that they can supply the power facilities with the water required for day to day operations. They do not envisage any shortage in supplies and have assured that supplies will not be diverted from elsewhere in order to ensure the operation of the plant. They have advised that some back-up water storage is included for any maintenance operations required which may reduce the availability of water. EPL is engaging with GWC and Government of Ghana in contract negotiations and is seeking proof that GWC can provide the necessary water requirements for the project without adversely impacting vulnerable water users.

VRA have a water supply close to the sites, supplied by GWC. The potential to use this supply was reviewed with VRA and GWC but was deemed to be restrictive for VRA as they would not be able to expand other sites if the Ghana Bridge Project was to connect. GWC offered the alternative to connect to a spur located approximately 1km south of the proposed plants, adjacent to Valco Road, via a RoW following the GRIDCo transmission into the VRA TTPC. The proposed connection to the municipal water supply provided by GWC was considered the most practicable and cost-effective option. The water pipeline route is shown on Figure 1-2.

4.7 Plant Layout and Export of Power

The layout of the plant has been adapted so that existing transmission systems are used where possible.

Evacuation of the power for Stage 1a will be via underground connection to the existing Electricity Company of Ghana (ECG) Station H substation, adjacent to TTPC at 33kV. Stage 1b evacuation will initially be via a new 161kV spur into a new double circuit 161kV overhead line to be constructed by GRIDCO by early 2018, which will run adjacent to the existing overhead lines that run east-west along the northern boundary of the Stage 2 site (PPS2). Stage 2 evacuation will be via a new substation into the new GRIDCO 161kV power lines. The Stage 1b evacuation spur will be transferred to the Stage 2 substation as that switch yard is completed.

4.8 Pipelines

The LPG supply pipeline route has been developed to minimise the disturbance of undeveloped land, the requirement for a new RoW and the need to relocate people, by following existing RoW corridors where possible. The existing TOR pipeline RoW will be used from the jetty to the TOR site. The following section of the pipeline from the TOR to the Quantum LPG tank farm will be buried, within a new RoW. It passes from the north side of Valco Road to the south side at a location opposite Sentuo Steel. The majority of this section of the route is through undisturbed secondary vegetated area consisting of shrubs, grass and a few trees.

A previous iteration of the route along Valco road passed along the north side of the road from the exit point of TOR. This route was then revised to the south side of the Valco road In order to minimise impacts on the commercial/industrial operators along the north side of the road. However, the revised route was identified to affect a number of a number of informal kiosk businesses located along the south side of Valco Road, and at the time of writing, a compromise route along this section is proposed. The crossing point currently selected minimises the number of displaced kiosks, whilst also minimising the number of driveway and access crossings required, thereby minimising potential disruption during construction for those facilities. Alternative premises and relocation of the affected traders is detailed in Section 20.

Further, to minimise disturbance, the water pipeline from the tie-in to the GWC supply at Valco Road to the tank farm will be (if acceptable to GWC) within the same RoW as the LPG pipeline along the same section. Water pipeline spurs from the pipeline connecting to the municipal supply will supply water storage facilities located within the Stage 2 site to serve the water needs of both the Stage 1 and Stage 2 power facilities.

The design of the plant allows for operation on diesel fuel oil (DFO) and for worst-case scenario operation during a significant disruption to the supply of LPG. Should it be required, DFO would be supplied to the power sites from the Quantum tank farm. To minimise disturbance, the diesel supply pipelines will be routed alongside the LPG and water pipelines between the tank farm and power plant sites.

4.9 Conclusion

Alternatives were considered in regards to the plant location, fuel types, pipeline routes and water sources, providing confidence in the final decision as to the best options for the new plant. The technology to be utilised is considered BAT with regard to resource and energy efficiency, as well as protection of the environment. The plant layout, connections for export of electricity and siting of new pipelines has been designed to enable the use of existing infrastructure and facilities where possible, thus minimising disturbance to people and the environment.

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Environmental and Social Impact Assessment

Section 5 – Policy, Legal and Administrative Framework

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration	Rev No
Sep 2015	First issue	0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency	1
June 2016	ESIA Amendment issued to Ghana Environment Protection Agency - no changes to this Section.	2
August 2017	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating updates in legislation and guidance since Revision 1.	3

Contents

Figures and Tables

5 Policy, Legal and Administrative Framework

5.1 Introduction

The project is required to comply with the relevant Ghanaian law, regulations and other national legislation and policy relevant to project activities. The project must also comply with international conventions to which Ghana is a signatory and with the relevant international standards, including financial institution environmental and social performance standards. These include International Finance Corporation (IFC) Performance Standards for Environmental and Social Sustainability and the IFC Environmental, Health and Safety (EHS) Guidelines. Each set of requirements is discussed in this section.

5.2 National Legislation and Guidelines

The Constitution of Ghana (1992) states that '*the State shall take appropriate measures needed to protect and safeguard the national environment for posterity; and shall seek cooperation with other states and bodies for purposes of protecting the wider international environment for mankind*' (Section 6 (41) (9)).

Environmental regulation within Ghana falls under the requirements of the Environmental Protection Agency Act 1994 (Act 490) and the Environmental Assessment Regulations 1999 (LI1 652). The function of these and other relevant national legislation tools relevant to the project are outlined in this section.

5.2.1 National Acts and Regulations applicable to the Project

The Environmental Protection Act, Act 490 (1994)

The Environmental Protection Act 1994 (Act 490) established the Environmental Protection Agency (EPA) of Ghana. The Act sets out the authority, functions, responsibilities, structure and funding of the EPA. Part I of the Act sets out the functions of the EPA which include the formulation of environmental policy, the issuing of environmental permits and pollution abatement notices and the prescription of standards and guidelines. Part II of the Act sets out provisions for enforcement and control. The EPA is mandated with responsibility for environmental compliance in both the planning and execution of development projects and compliance of existing projects. The Act empowers the EPA to appoint ''Environmental Protection Inspectors'' and any other employees necessary to provide the functions of the Act.

Environmental Assessment Regulations LI 1652 (1999)

The Environmental Assessment Regulations (1999) LI1 652 (as amended 2002) is the principle enactment to the provisions of Act 490. The Regulations mandate the EPA to ensure that both new and existing developments don't affect the environment negatively. Part I of the Regulations set out the requirements for Environmental Permitting and Part II of the Regulations sets out the requirements of ESIAs.

The Regulations set out the requirements for the following:

- Environmental Permitting;

- Preliminary Environmental Assessments (PEAs);
- Scoping;
- Environmental Impact Statement (EIS) (also termed the ESIA Report);
- Public Consultation;
- Environmental Certificates; and
- Environmental Management Plans (EMPs).

An Environmental Permit is required for the proposed development under Schedule 1, Regulation 1, section 23 (construction) and an EIA is mandatory under Schedule 2, Regulation 3, sections 12 (Petroleum pipeline- onshore and offshore) and 13 (Power Generation and Transmission). In addition, these regulations stipulate that, within 24 months of the commencement of operations, an Environmental Certificate will need to be obtained from the Agency following the provision of details of compliance with mitigation measures laid out in the ESIA. An Environmental Report is required to be submitted to The Agency annually and an Environmental Management Plan is required to be submitted within 18 months of commencement of operations, to be reviewed every 3 years.

Environmental Protection Agency Fees and Charges (Amendment) Instrument LI 2206 (2013), subsequently superseded by Environmental Protection Agency Fees and Charges (Amendment) Instrument LI 2216 (2014)

In exercise of the powers conferred on the Minister responsible for the Environment, under section 28 of the Environmental Protection Agency Act, 1994 (Act 490) and on the advice of the EPA Board, Legislative Instrument 2206 was promulgated to serve as legal backing to the Environmental Processing and Permit fees charged under the principal act. The LI 2206, 2013 stipulates the *"fees and charges for environmental permits and certificates*"; its Schedules were subsequently superseded by LI 2216 in 2014.

LI 2216 invokes a new Schedule and revokes the former. It indicates the respective fees for processing, permit and environmental certificates for different categories of undertakings (large scale and others). The fees are graded according to the scale of impact entailed by the project activities, and in the case of Hotels, the occupancy or number of rooms. Some of the industrial groups covered under the LI 2216 of 2014 include the Mining, Energy, Manufacturing, Agricultural, Tourism, and General Construction Sectors among others.

Energy Commission Act, Act 541 (1997)

The Energy Commission is the government agency mandated to regulate, manage, develop and utilise energy resources in Ghana. In its stated capacity, it provides licences for all companies that transmit, wholesale supply, distribute and sell electricity and other sources of energy. The Act provides for the functions of the Commission in regulating, management, development and utilization of energy resources in Ghana; and to promulgate rules, standards and procedures; and grant licenses for the transmission, wholesale supply, distribution and sale of electricity, and natural gas refining, storage, bulk distribution marketing and sale of petroleum and also to provide for related matters.

The provisions of the Energy Commission's 'PUBLIC NOTICE – EC N. 003' require the Early Power consortium to register the proposed project with the Commission and to obtain a permit prior to the commencement of construction of the proposed project. This permit is subject to the granting of an Environmental Permit by the EPA. A "*Licensing Manual for Service Providers in the Electricity Supply Industry*" was developed and issued by the Energy Commission of Ghana in 1996 to formally establish the framework for licensing electricity production, supply, and distribution and sale services in the power sector of Ghana as stipulated by the Energy Commission Act (Act 541), 1997.

As a New Entrant the following will be required to accompany the Early Power consortium application:

- A detailed business plan;
- Requirements pertaining to the Energy Commission Public Notice EC.N. 001;
- Feasibility reports on new facilities or installations;
- Environmental Impact Assessment (ESIA) Report certified by Environmental Protection Agency (EPA) on new facilities or installations to be used by the service provider;
- Evidence of Energy Commission's authorization permit to construct new facilities;
- Implementation agreement;
- Power purchase agreement;
- Land conveyance agreement;
- Ownership structure and agreement;
- Fuel Supply Agreement;
- Construction Contract; and
- Operation and maintenance agreement.

Ghana Investment Code, PNDCL 116, (1985)

The 1985 Investment Code, PNDCL 116, requires that the Ghana Investment Promotion Centre, which is the government agency for the promotion and coordination of private investment in the Ghanaian economy must in its appraisal of enterprise, have regards to any effect the enterprise is likely to have on the environment and the measures proposed for the prevention and control of any harmful events to the environment before giving approval for its establishment.

Factories, Offices and Shops Act, Act 328 (1970)

Act 328 promotes and ensures the health, welfare and safety of persons employed in the country as well as the responsibilities of the employer. Under the Act, employers are required to ensure that a safe and healthy workplace is provided for the safety, health and welfare of all employees.

Public Utilities Regulatory Commission (PURC) Act 538 (1997)

The Public Utilities Regulatory Commission (PURC) 1997, Act 538 requires the PURC to set up guidelines for pricing of power generated by utility companies taking into consideration assurance of financial viability of power produced, investor interests and best use of natural resources. PURC is also responsible for the determination of actual tariffs for both production and service providing utilities including electricity hence will be responsible for pricing of the electric power to be generated from the plant.

Pesticides Control and Management (regulated under Part II of the EPA Act 490 (1994))

The Act enables the control, management and regulation of chemicals and pesticides in Ghana. It provides the EPA the powers to register and classify chemicals, to determine Restricted and suspended chemicals, to license and approve dealers, and to ensure enforcement and penalties. The Act states that no person shall import, export, manufacture, distribute, advertise, sell or use any chemical in Ghana unless the chemical has been registered by the Environmental Protection Agency in accordance with this Act.

National Museums Decree, NLCD 387 (1969)

NLCD 387 provides for the care of any archaeological finds. This is the law governing the activities and operations of the National Museums and Monuments Board. Procedures to be followed on the discovery of any such artefacts are outlined in NLCD 387.

Ghana National Fire Service Act, Act 537 (1997)

The Ghana National Fire Service Act of 1997 (Act 537) states that a Fire Certificate shall be required for premises used as a public place or place of work. The owner or occupier of the premises shall apply to the Chief Fire Officer for a Fire Certificate, which will be valid for 12 months from the date of issue and subject to renewal. Hospitality facilities require a fire certificate.

Fire Precaution (Premises) Regulations, LI 1724 (2003)

LI 1724 among other requirements requires that adequate measures are taken to eradicate potential sources of fire outbreaks and that a fire certificate be acquired for any project or facility.

Electricity Company of Ghana (ECG) Act, Act 461 of (1997)

The Electricity Corporation of Ghana (ECG) was established by a decree (NLC Decree No.125) in 1967 and replaced the Electricity Department of the Ministry of Works and Housing. However, under the provisions of the Statutory Corporations (Conversions to Company) Act, 1993 (Act 461), ECG has since 1997 been converted into a limited liability company called Electricity Company of Ghana. Prior to 1987, ECG was responsible for distributing electricity throughout Ghana when it receives bulk supply from the VRA. The ECG's responsibility for distribution is now limited to the Ashanti, Western, Central, Eastern, Greater Accra and Volta Regions.

Electricity Transmission (Technical, Operational And Standards Of Performance) Rules, LI 1934 (2008)

LI 1934 provide rules and define the national interconnected transmission system; and establish the requirements, procedures, practices and standards that govern the development, operation, maintenance and use of the high voltage national interconnected transmission system. The rules are to ensure that the transmission system provides a fair, transparent, non-discriminatory, open access, safe, reliable, secure and cost efficient transmission and delivery of electricity.

Electricity Regulations, LI 1937: (2008)

The purpose of these Regulations is to provide for (a) the planning, expansion, safety criteria, reliability and cost effectiveness of the national interconnected transmission system; (b) the regulation of a wholesale electricity market; (c) the market operations of the electricity transmission utility; (d) the technical operations of the electricity transmission utility; (e) minimum standards and procedures for the construction and maintenance of facilities and installations; (f) the protection of the mains and electrical installations and services; (g) the protection of life and property and the general safety of the public in respect of electricity services; (h) minimum reserve margins to satisfy demand; and (i) the development and implementation of programmes for the conservation of electricity.

Town and Country Planning Ordinance (cap. 84) No.13 of 1945

The Act provides for the orderly and progressive development of land, towns and other areas, to preserve and improve their amenities and for related matters.

Lands Commission Act, Act 483 (1994)

Act 483 provides for the management of public and vested lands and the certification of stool lands transactions. Indeed, the 1992 Constitution requires that there shall be no disposition or development of any stool land unless the Lands Commission of the region in which the land is situated has certified that the disposition or development is consistent with the development plan drawn up or approved by the planning authority for the area concerned.

Lands Statutory Way leaves Act, Act 186 (1963)

Act 186 provides for entry on any land for the purpose of the construction, installation and maintenance of works of public utility, and for the creation of rights of way for such works. The owner/occupier of the land must be formally notified at least a week in advance of the intent to enter, and be given at least 24 hours‘ notice before actual entry. (An authorized person may enter at any time for the purpose of inspecting, maintaining, replacing or removing any specified works (Section 5). Any damage due to entry must be compensated in accordance with the established procedure, unless the land is restored or replaced. (In the case of roads, not more than one-fifth of a plot may be taken and the remainder must be viable, or the entire plot must be taken; Section 6-3(b).

The Lands (Statutory Way leaves) Regulations, LI334 (1964)

LI 1334 law restates the principles of the Lands (Statutory Way leaves) Act of 1963, and establishes provisions for Way leave Selection Committees to determine the optimal routing and to ensure that the selected way leaves are consistent with town and country planning.

Farm Lands (Protection) Act 107 (1962)

The Farm Lands Act upholds the principles that where a person, in this Act referred to as a farmer, acquires land after the commencement of this Act for the purposes of farming and does not farm a part or the whole of that land for a period of eight years from the date of the acquisition, his title to the whole of the land or that portion that has not been farmed shall be deemed for all purposes to have been extinguished.

Where a farmer has, in good faith, at any time after the thirty-first day of December, 1940, and before the commencement of this Act, acquired any land by customary law or otherwise in a prescribed area for purposes of farming and has begun farming on that land within eight years from the date of such acquisition, this section shall, notwithstanding any defect in the title to the contrary, operate to confer valid title on such farmer provided that the land in question had not been farmed by any other person for a period of eight years previous to the acquisition by the farmer.

Any person who procures or attempts to procure any other person to give up possession of land by any means other than by due process of a Court of competent jurisdiction shall be guilty of a misdemeanour.

State Lands Act, Act 125 (1962)

Act 125 vests in the President the authority to acquire land for the public good. The President “may, by Executive Instrument, declare any land specified in the instrument to be land required in the public interest” (Sect. 1-1). On the publication of an Instrument, the land shall, without any further assurance than this subsection, vest in the President on behalf of the Republic, free from any encumbrance whatsoever” (Sect. 1-3). The State Lands Act 1962 places responsibility for registering a claim on the party affected, for it recognises that it is only the affected person who can best establish the nature of his or her interest among others.

The State Lands Act, 1962 defines the terms “cost of disturbance”, “market value”, “and replacement value” and other damage (Sect. 7). “‘Cost of disturbance’ means the reasonable expenses incidental to any necessary change of residence or place of business by any person having a right or interest in the land.” “‘Market value’ means the sum of money which the land might have been expected to realize if sold in the open market by a willing seller at the time of the declaration made under Section 1 of this Act.” “’Replacement value’ means the value of the land where there is no demand or market for the land by reason of the situation or of the purpose for which the land was devoted at the time of the declaration made under Section 1 of this Act, and shall be the amount required for reasonable re-instatement equivalent to the condition of the land at the date of the said declaration.” Finally, “’other damage’ means damage sustained by any person having a right or interest in the land or in adjoining land at the date of the declaration made under Section 1 of this Act, by reason of severance from or injurious affection to any adjoining land.”

State Lands (Amendment) Act, Act 586 (2005)

The Act makes provision for the resettlement of affected parties taking into consideration their economic, social and cultural backgrounds.

The act states that a lump sum compensation is payable to claimants and provides that in the determination of compensation the Lands Commission shall take into consideration the market value or the replacement cost of the land, the cost of disturbance, the extent to which the land has been affected and also the increase in value to neighbour properties.

Administration of Lands Act, Act 123 (1962)

Act 123 of 1962 was enacted to facilitate the management and administration of Stool lands (and other lands). The Act empowers the Minister responsible for the lands to manage Stool lands in accordance with the provision of the law. The entitlements are however to be assessed by giving due consideration to the values of the land (and other losses suffered) and the benefits to be derived by the people in the area (by way of the use to which the state is going to put the land).

Labour Act No Act 651 (2003)

Part XV, Section 118 (1) and (2a-h) of the Act enjoins employers to ensure that every worker employed by him or her works under satisfactory, safe and healthy conditions, and is further obliged to provide necessary information, instructions, training and supervision to ensure the health and safety at work of those other workers engaged in a particular work.

Workmen Compensation Act (1987)

This Act outlines the circumstances in which an employer is liable to pay compensation, methods of computing earnings and remuneration, requirements for application for compensation, medical requirements and treatments, requirements for determination of claims and the jurisdiction of the court.

Boiler and Pressure Vessel Safety Regulations, LI 663 (1970)

In Ghana manufacturers, operators and importers of boilers and pressure vessels must conform to LI 663. In Ghana manufacturers, operators and importers of boilers and pressure vessels must conform to LI 663.

Water Resources Commission Act, Act 52 (1996)

Act 1996 established a Water Resources Commission, with mandate for the regulation and management of water resources in Ghana as well as the co-ordination of any policy in relation to these functions. The Commission is also mandated to propose comprehensive plans for the utilization, conservation, development and improvement of water resources; initiate, control and co-ordinate activities connected with the development and utilization of water resources; grant water rights; collect, collate, store and disseminate data or information on water resources; require water user agencies to undertake scientific investigations, experiments or research into water resources in addition to monitoring and evaluating programmes for the use and management of water resources.

Water and Sewerage Corporation Act, Act 310 (1965)

The Act establishes a body mandated with:

(*a) the provision, distribution and conservation of the supply of water in Ghana for public, domestic and industrial purposes; and*

(b) the establishment, operation and control of the sewerage systems for such purposes.'

In addition, the Water and Sewerage Corporation is authorised to formulate regulations regarding the prevention of water pollution.

Wild Animals Preservation Act, Act 235 (1964)

The Act provides for various matters relating to the protection of wildlife in Ghana including the appointment of game officers, collection of specimens for scientific purposes and hunting and the identification of wholly or partially protected faunal species.

Wildlife Conservation Regulations LI685 (1971) (as amended)

The Regulations provide further regulations for hunting, commercialisation of animals and various other provisions for the conservation and protection of faunal species in Ghana.

The Wild Reserves Regulations LI 740 (1971)

The Regulations allow for the designation and proclamation of protected areas, in various categories. The regulations prohibit certain activities (eg hunting, removal of faunal or floral species) allowed within the various reserves without a permit. The regulations forbid the pollution of water resources and littering within a protected area.

The Wild Animals Preservation Act 235 (1964) enforced by the Wetland Management (Ramsar sites) Regulation, (1999)

The Act establishes wetlands as 'Ramsar sites' as per the Convention of Wetlands of International importance and prohibits certain activities (and during certain seasons) within the designated Ramsar site.

Forestry Commission Act, 571 (1999)

This Act re-established the Forestry Commission in order to bring under the Commission the main public bodies and agencies implementing the functions of protection, development, management and regulation of forests and wildlife resources and to provide for related matters.

Fisheries Commission Act, 457 (1993)

The Act established a Fisheries Commission and provides for its composition and functions relating to the regulation and management of the utilisation of fishery resources of Ghana and for connected purposes.

Fisheries Act, 625 (2002)

The Act provides for the regulation, management and development of fisheries and promotes the sustainable exploitation of fishery resources. Section 93 of the Fisheries Act stipulates that if a proponent plans to undertake an activity which is likely to have a substantial impact on the fisheries resources, the Fisheries Commission should be informed of such an activity prior to commencement. The Commission may require information from the proponent on the likely impact of the activity on the fishery resources and possible means of preventing or minimising adverse impacts. The project will need to ensure that it meets the requirements of this Act with regard to any impacts on fishing.

5.2.2 National Policy Documents

National Environmental Policy

Ghana's National Environmental Policy outlines the environmental baseline of Ghana, including current management activities and identifies the challenges and emerging issues facing the country. It presents a vision for the future and identifies a number of goals and objectives. It outlines the environmental policies of individual sectors and presents an overview of policy implementation mechanisms including legislation, published action plans, financing and environmental monitoring.

Sustainable development and enhancement of natural and human resources are part of the Government's policy on environment which is outlined in the Ghana National Environmental Action Plan (NEAP).

The Environmental Policy aims to ensure that a preventive approach is adopted in the pursuit of sound environmental management. The main preventive tool envisaged in the policy is the environmental impact assessment (EIA).

National Energy Policy

The National Energy Policy outlines the Government of Ghana's policy direction regarding the current challenges facing the energy sector. The document provides a concise outline of the Government's policy direction in order to contribute to a better understanding of Ghana's Energy Policy framework. It is hoped that the document will facilitate the effective management and development of the energy sector as well as provide the public with information about the Government's policy goals. At the time of its publication in 2010, the energy sector vision was to develop an Energy Economy to secure a reliable supply of high quality energy services for all sectors of the Ghanaian economy, and also to become a major exporter of oil and power by 2012 and 2015 respectively.

National HIV/AIDS STI Policy (2004, updated 2013)

The National HIV/AIDS STI Policy was developed to address the very serious health and developmental challenges posed by HIV/AIDS. The policy provides the framework for Ghana's strategy to reduce the spread of HIV infection. It provides the necessary statement of commitment around which a legislative framework is being built for an Expanded Multi-Sectoral response to reduce further spread of the epidemic, and for the protection and support of people infected with HIV/AIDS in Ghana. Subsequently, a National HIV/AIDS Strategic Framework for Ghana was formulated in recognition of the developmental relevance of the disease. Ghana, by this document joined the global community in a united effort to combat the epidemic. The Strategic Framework document is updated periodically and it provides for a "Workplace HIV Policy". Ghana has an updated National HIV/AIDS Strategic Plan 2016-2020, published in July 2016.

The Ghana Land Policy 1999

The Government of Ghana in 1999 put together the Land Policy to serve as a broad framework and policy guidelines aimed at enhancing land management systems, land use, conservation of land resource and enhancing environmental quality. All these are intended to ensure coordinated and orderly use of land, a vital resource, by present and future generations. Ultimately the policy seeks to give protection to proprietary rights and promote the concept of prompt payment of adequate and fair compensation for compulsorily acquired lands and also create the enabling environment for community participation in sustained land management.

5.2.3 Governance Structure of Ghana

In Ghana there are two parallel government systems operating at the local level, the district assembly administrative structure and the traditional administrative system. The district administration consists of elected representatives and central government appointed personnel, whereas the traditional administration is derived from the chieftaincy institutions. At the community level, an elected assembly person serves as the main link between the district assembly and the community.

Chiefs and elders comprise the traditional administrative institution and they have both judicial and executive functions within the communities.

In the Tema area the land is termed “Stool Lands” and comes under the control of the Paramount Chief but the right of use lies with the families who are direct beneficiaries of any returns from the land. The Stool is the custodian of the land and as such can release land for projects of community or national interest. They can also reassign land, for example making land available to compensate displaced farmers.

5.2.4 Tema Municipal Administration

The Tema Metropolis (and therefore the Tema Metropolitan Assembly - TMA) was created from the Tema Municipality in 2007 with the promulgation of Legislative Instrument (LI) 1929.

The Tema Metropolis has three Sub-Metropolitan Councils namely; Tema West, Tema East and Tema Central.In 2012, the Kpone-Katamanso Sub-Metropolitan Council was carved out of the Tema Metropolis to establish the Kpone-Katamanso District Assembly (KKDA).

In accordance with the Local Government Act, 1993 (Act 462), the assemblies exercise deliberative, legislative and executive functions, including approval of development plans and enforcement of by-laws. As such, EPL will require approval by both bodies, in addition to agreements with Tema Development Corporation (TDC).

The TDC is a public entity set up by GoG in 1952 and tasked with the planning and development of the Tema city area. Whilst it is not a municipal government as such, it retains a strong planning and development role and is the primary land owner within the THIA.

5.2.5 National Environmental Guidelines and Quality Standards

The EPA has issued formal guidance on regulatory requirements and the ESIA process. The following documents are relevant to the ESIA process and this project:

- The Environmental Assessment Guidelines for the Energy Sector, Volume 1 and 2, September 2011;
- Environmental Assessment in Ghana, a Guide to Environmental Impact Assessment Procedures (EPA, 1996);
- National Environmental Quality Guidelines which include:
  - Environmental Quality Guidelines for Ambient Air (Ghana EPA);
  - Environmental Quality Guidelines for Ambient Noise (Ghana EPA);
  - General Environmental Quality Standards for Industrial or Facility Effluents, Air Quality and Noise Levels (EPA); and
  - Sector Specific Effluent Quality Guidelines for Discharges into Natural Water Bodies (EPA).

5.2.6 Land Rights in Ghana

Laws on Compulsory Acquisition

In Ghana, lands are acquired by either private treaty or compulsorily via the enabling legislation described below. Ghanaian Law provides that involuntary acquisition of private property must be done in accordance with laid down statutory procedures.

The Constitution of the Republic of Ghana (1992) upholds the principle of private ownership of lands. Adequate safeguards from deprivation of private property rights have been provided for, in the 1992 Constitution. Even the state's inherent powers to compulsorily take possession of, or acquire private property rights have been considered and somewhat controlled.

Article 20 of the constitution prescribes that under no circumstance should private properties be compulsorily taken unless there are weighty and justifiable grounds for such acquisition, which invariably must be in the public interest. It is expressly provided in Article 20 (Section 1(a) and Section1 (b)) that "No property of any description or interest or right over any property shall be compulsorily taken possession of or acquired by the state unless:

(i) The taking of possession or acquisition is necessary in the interest of defence, public safety, public morality, public health, town and country planning or development or utilization of property in such a manner as to promote public benefit; and

(ii) The necessity for the acquisition is clearly stated and is such as to provide reasonable justification for causing any hardship that may result to any person who has an interest in or right over the property."

Section 2 (a) notes that sufficient provision must be made for the prompt payment of fair and adequate compensation and Section 2 (b) indicates that aggrieved persons must have right of access to the High Court for redress. Article 20 (2) expressly stipulates that where the compulsory acquisition involves the displacement of any inhabitants the state shall resettle them on suitable alternative site having regard to their socio-cultural values and economic wellbeing.

Various landholding interests and/or rights exist in Ghana. Five main interests categorisation in land are discussed below.

Allodial Title

In the Ghanaian context, this is the highest interest capable of being held in land. The Allodial title is customarily communally owned and is generally held or vested in stools or skins. In some traditional areas, it is held by clans, families or individuals. Being generally in the form of communal interest in land it accrues to the entire community and is administered by the recognized traditional authority. The owner of the allodial title has complete and absolute freedom to use and dispose of the land only subject to the restrictions, or limitations or obligations as may be imposed by the general laws of the country. The mode of acquisition of the allodial title is by: discovery by hunters or pioneers of the stool of unoccupied land and subsequent settlement thereof and use by the subject; conquest, purchase or gift.

Customary Freehold

The customary freehold is an interest or title which a member of the larger community which holds the allodial title acquires in the communal land. It is an interest which is held as of right by virtue of being a member of the community. It is of indefinite duration and thus potentially subsists forever. The member who holds such interest has the right of beneficial occupation; unfettered use (also subject to the laws of the country). Upon death, the interest devolves on his/her successors in title and infinitum. This interest prevails against the whole world including the allodial title from which it was derived. The customary freehold may however be terminated by the occurrence of any of these occasions; failure of successors, compulsory acquisition by the state; sale or gift by owner, abandonment or forfeiture in rare circumstances where for example the holders denies the absolute title of the allodial owner.

Customary Tenancies

These are lesser interests in land and are created by the holder of the allodial title or customary freehold (or common law freehold). These types of tenancies are in nature share cropping arrangements. They are quite common in Ghana and occur when a tenant-farmer gives a specified portion of the farm produce to the land owner at each harvest time in consideration for use of the land.

The Common Law Freehold

This is an interest held for an indefinite period. It is derived from the rules of common law. The holder of this interest has the right of beneficial occupation and may subject to the laws of the land use in any manner. This type of freehold is created only by express grant. The grantor may thus impose terms on the grantee provided such terms are reasonable and not contrary to public policy or unconscionable. Currently, the laws of the land forbid non-Ghanaians from acquiring freehold in lands in Ghana.

The Leasehold

This type of interest is also a creation of the common law and not Ghanaian customary law. It is an interest in land for a specified period. The leasehold may be granted by the allodial holder in respect of lands in which no conflicting interest exists; or by a customary freeholder; or common law freeholder. In Ghana, leasehold may be for a maximum duration of 99 years (again non-Ghanaians can only acquire leases up to 50 years). Various terms and conditions may be imposed by the grantor including the payment of rent as consideration for the grant.

5.3 International Legislation and Guidelines

Ghana is signatory to a number of international conventions and development work is subject to conformance with IFC Performance Standards. These are detailed in this section.

5.3.1 International Conventions

Ghana has ratified or acceded to a large number of environmental and social international treaties and conventions. Those which may be relevant to the project are listed in Table 5-1.

Table 5-1: Treaties and Conventions Applicable to all Aspects of the Project

Treaties and Conventions	Year Ratified
Conventions regarding ecology and biodiversity	
International Convention for the Conservation of Atlantic Tunas	1966
African Convention on the Conservation of Nature and Natural Resources	1968
The Convention on Wetlands of International Importance Especially Waterfowl Habitat (Ramsar Convention)	1971
The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Washington	1973
Convention on the Conservation of Migratory Species of Wild Animals (CMS)	1979
International Convention for the Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region-the Abidjan Convention	1981
Convention on Biological Diversity	1992
Agenda 21 of the United Nations Conference on Environment and Development (the Rio Declaration)	1992
United Nations Convention on Biological Diversity	1996
United Nations Convention to Combat Desertification	1997
CMS Memorandum of Understanding Concerning Conservation Measures for Marine Turtles off the Atlantic Coast of Africa	1999
Conventions regarding climate change	
The Vienna Convention on the Protection of Ozone Layer	1993
Montreal Protocol on Substances that Deplete the Ozone Layer	1993
United Nations Framework Convention on Climate Change	1996
Kyoto Protocol to the FCCC	1997

Treaties and Conventions	Year Ratified
UNFCCC Paris Agreement	2016
Conventions regarding pollution	
International Convention on Civil Liability for Oil Pollution Damage	1969
International Convention on the Establishment of an International Fund for Compensation of Oil Pollution Damage	1971
International Convention of Oil Preparedness, Response and Co-operation (ORPC)	1990
Stockholm Convention	2001
Conventions regarding social and cultural aspects	
Convention 29 on Forced Labour Convention	1930
International Labour Organization (ILO) Convention 87 on Freedom of Association and Protection of the Right to Organize Convention	1948
ILO Convention 98 on the Right to Organize Collective Bargaining	1949
Convention 100 on Equal Remuneration	1951
Supplementary Convention on the Abolition of Slavery, the Slave Trade, and Institutions and Practices similar to Slavery	1956
Convention 105 Concerning the Abolition of Forced Labour	1957
Convention 111 on Discrimination	1958
International Convention on the Elimination of All Forms of Racial Discrimination	1969
The Convention Concerning the Protection of World Cultural and Natural Heritage	1972
International Covenant on Civil and Political Rights	1976
Convention concerning the protection of workers against occupational hazards in the work environment due to air pollution, noise and vibration (ILO No.148)	1987
African Charter on Human and Peoples' Rights	1989
International Covenant on Economic, Social and Cultural Rights	2000
Conventions regarding pollution, chemicals and wastes	
Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movements of Hazardous Wastes within Africa	1990
Rotterdam Convention of Prior Informed Consent Chemicals	1998
The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	2003

In addition to the environmental conventions, Ghana is a signatory to 51 of the International Labour Organisations Conventions. The full list is presented in Table 5-2 at the end of this chapter.

5.3.2 International Standards

To secure international finance the project will also need to meet international standards as required by international financing institutions (IFI). These generally require compliance with the requirements of the Equator Principles and IFC PSs and EHS Guidelines which are internationally authoritative. Some IFI have their own standards or guidance and there can be minor variations in requirements or procedures of different IFI; however, the approach to ESIA technical assessment in itself (to meet good international industry practice – GIIP – as defined in the IFC PS) will meet the expectations of the IFI. The application of the Equator Principles and IFC performance standards to the project is outlined below.

5.3.2.1 The Equator Principles III

The Equator Principles are a voluntary set of standards intended to ensure that projects financed by Equator Principle Finance Institutions (EPFIs) are developed in a manner which environmentally and socially responsible.

The Equator Principles are in their third iteration (EPIII) and apply to all new project financings with a total project capital cost in excess of US$ 10 million or more. There are ten principles:

- Principle 1: Review and Categorisation;
- Principle 2: Environmental and Social Assessment;
- Principle 3: Applicable Environmental and Social Standards;
- Principle 4: Environmental and Social Management System and Equator Principles Action Plan;
- Principle 5: Stakeholder Engagement;
- Principle 6: Grievance Mechanism;
- Principle 7: Independent Review;
- Principle 8: Covenants;
- Principle 9: Independent Monitoring and Reporting; and
- Principle 10: Reporting and Transparency.

The Early Power project has undertaken this ESIA under the requirements of Principle 2 and the ESIA approach is in line with other relevant Principles.

5.3.2.2 International Finance Corporation (IFC)

For projects located in non-designated[1] countries such as Ghana, Equator Principle 3 requires the project to be compliant with the IFC PS and the general and applicable sector-specific World Bank Group / IFC Environmental, Health and Safety (EHS) Guidelines.

The applicable IFC PS are as follows:

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[1] Designated Countries are those countries deemed to have robust environmental and social governance, legislation systems and institutional capacity designed to protect their people and the natural environment.

http://www.equator-principles.com/index.php/ep3/designated-countries

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts (PS1);
- Performance Standard 2: Labour and Working Conditions (PS2);
- Performance Standard 3: Resource Efficiency and Pollution Prevention (PS3);
- Performance Standard 4: Community Health, Safety, and Security (PS4); and,
- Performance Standard 5: Land Acquisition and Involuntary Resettlement (PS5).

The applicable EHS Guidelines including:

- General EHS Guidelines (2007);
- EHS Guidelines for Thermal Power Plants (2008);
- EHS Guidelines for Onshore Oil and Gas Facilities (2007); and,
- EHS Guideline for Electric Power Transmission & Distribution (2007).

5.3.2.3 IFC Performance Standards and their relevance to the development

The objectives of each Performance Standard (PS) and the obligations of EPL under each PS relevant to the project are outlined below.

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

PS1 requires the management of environmental and social performance throughout the life of a project through an effective Environmental and Social Management System (ESMS). The objectives are to:

- Identify and evaluate environmental and social risks and impacts of the project.
- Adopt a mitigation hierarchy to anticipate and avoid, or where avoidance is not possible, minimize, and, where residual impacts remain, compensate/offset for risks and impacts to workers, Affected Communities, and the environment.
- Promote improved environmental and social performance of clients through the effective use of management systems.
- Ensure that grievances from Affected Communities and external communications from other stakeholders are responded to and managed appropriately.
- Promote and provide means for adequate engagement with Affected Communities throughout the project cycle on issues that could potentially affect them and to ensure that relevant environmental and social information is disclosed and disseminated.

To meet the objectives of PS1, the Early Power project will:

- Establish an ESMS to include: (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 (vii) monitoring and review. The ESIA addresses these issues from the outset of the project.

- Establish an overarching policy defining the environmental and social objectives and principles. The project objectives are outlined in Section 1.3. Environment and social objectives and principles are outlined throughout the ESIA.
- Establish and maintain a process for identifying the environmental and social risks and impacts of the project such that:
  - the impacts of physical elements are assessed in context of the project's area of influence;
  - impacts from unplanned events and facilities which will not have existed without the project are included; and,
  - cumulative impacts from other developments are included.

The above objectives have been met by the project via this ESIA. The ESMP and ongoing commitment by the project to manage risks in compliance with national and international standards will be met, by the project's continued compliance with their permit and loan agreement terms from the international financial institutions invested in the project.

- Take into account the findings and conclusions of related and applicable plans, studies, or assessments prepared by relevant government authorities or other parties that are directly related to the project and its area of influence when identifying risks and impacts. The project is developed in consideration with Ghana's national policy, needs and development goals and in consideration of other developments.
- Identify individuals and groups that may be directly and differentially or disproportionately affected by the project because of their disadvantaged or vulnerable status. This has been included in ESIA. See Section 20.
- Establish management programs that describe mitigation and performance improvement measures and develop environmental and social action plans which define desired outcomes. Programs may consist of some documented combination of operational procedures, practices, plans, and related supporting documents. This has been included within the scope of the ESIA, and ESMP has been developed and these documents will be active and updated through each phase of the project.
- Identify mitigation and performance measures and establish corresponding actions to ensure the project will operate in compliance with applicable laws and regulations and requirements of PS 1 to 8. This has been identified through each of the individual assessments undertaken as part of the ESIA.
- Establish, maintain, and strengthen as necessary an organizational structure that defines roles, responsibilities, and authority to implement the ESMS. To be developed as the project progresses.
- Ensure project personnel have the knowledge, skills, and experience necessary to perform their work and to ensure that the process of identification of risks and impacts will consist of an adequate, accurate, and objective evaluation and presentation, prepared by competent professionals. The ESIA and project developments have and will

be undertaken by fully trained professionals. All work undertaken for the ESIA includes detailed peer review, consultation with relevant stakeholders and is subject to regulatory approval.

- Establish and maintain an emergency preparedness and response system. To be developed over the course of the project.
- Collaborate with the potentially Affected Communities. A rigorous consultation process involving all Affected Communities has been undertaken and will continue throughout the project life cycle. See Section 21.
- Establish procedures to monitor and measure the effectiveness of the management program, as well as compliance with any related legal and/or contractual obligations and regulatory requirements. To be developed over the course of the project and as part of the permitting process.
- Undertake internal inspections and audits, where relevant, to verify compliance. To be developed over the course of the project.
- Review the performance of senior management. To be undertaken over the life of the project.
- Ensure appropriate stakeholder engagement, ongoing throughout the life of the project. This includes the development of a Stakeholder Engagement Plan and disclosure of all relevant information. Affected Communities to have opportunity to express their views on project risks. A Stakeholder Engagement Plan for the project has been developed and Stakeholder engagement has been undertaken as part of the ESIA (Section 21) and will be continued throughout the project life cycle.
- Implement and maintain a procedure for external communications. This has been developed through the consultation process and identified within the Stakeholder Engagement Plan.
- Establish a grievance mechanism to receive and facilitate resolution of Affected Communities and provide periodic reports to the Affected Communities that describe progress with implementation of the project. This has been developed through the consultation process and identified within the Stakeholder Engagement Plan.

Performance Standard 2: Labour and Working Conditions

PS2 aims to protect the fundamental rights of workers.

The objectives of PS2 are to:

- Promote the fair treatment, non-discrimination, and equal opportunity of workers.
- Establish, maintain, and improve the worker-management relationship.
- Promote compliance with national employment and labour laws.

- 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.
- Promote safe and healthy working conditions, and the health of workers.
- Avoid the use of forced labour.

To meet the objectives of PS2, the Early Power project will:

- Adopt and implement human resources policies and procedures appropriate to its size and workforce that set out its approach to managing workers consistent with the requirements of this Performance Standard and national law.
- Provide workers with documented information that is clear and understandable, regarding their rights under national labour and employment law.
- Identify migrant workers and ensure that they are engaged on substantially equivalent terms and conditions to non-migrant workers.
- Implement the IFC / European Bank for Reconstruction and Development (EBRD) temporary workers policies on the quality and management of the accommodation offered to workers.
- Comply with national law regarding workers' rights to join organisations for workers of their choosing and to allow workers to elect representatives.
- Make employment decisions related to inherent job characteristics and not on the basis of personal characteristics.
- Comply with national law on non-discrimination and employ requirements of PS2 without contravening national law.
- Ensure that all workers receive notice of dismissal and timely severance payments mandated by law and any outstanding back pay and social security benefits and pension contributions.
- Carry out an alternative to retrenchment prior to implementing any dismissals.
- Provide a grievance mechanism for workers to raise workplace concerns.
- Not employ children in any manner that is economically exploitative, or is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development. Identify the presence of all persons under the age of 18. Follow the applicable national laws in child labour. Ensure children under the age of 18 are not employed in hazardous work. Undertake appropriate risk assessment and regular monitoring of health, working conditions, and hours of work for all children under the age of 18.
- Ensure there is no forced labour, this includes withholding the passports / identification cards of migrant workers for the term of their contract.

- Provide a safe and healthy working environment taking into account inherent risks. This includes the identification of potential hazards and provision of preventative and protective measures and appropriate training for employees.
- Ensure contractors are legitimate enterprises with appropriate ESMS.
- Establish procedures for managing and monitoring the performance of such third party employers.
- Ensure contractors have access to a grievance mechanism.

All of the above will be adopted throughout the life of the project.

Performance Standard 3: Resource Efficiency and Pollution Prevention

PS3 aims to ensure that the generation of increased levels of pollution and use of resources are managed effectively to ensure minimal impacts and resource efficiency throughout the life of the project. The objectives are to:

- Avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities.
- Promote more sustainable use of resources, including energy and water.
- Reduce project-related greenhouse gas (GHG) emissions.

To meet the objectives of PS3, the Early Power project will:

- Consider ambient conditions and apply technically and financially feasible resource efficiency and pollution prevention principles and techniques that are best suited to avoid, or where avoidance is not possible, minimize adverse impacts on human health and the environment. Use of principles and techniques in accordance with good industry practice including the EHS Guidelines. Refer to guidelines as appropriate.
- Implement technically and financially feasible and cost effective measures for improving efficiency in consumption of energy, water, as well as other resources and material inputs.
- Consider alternatives and implement technically and financially feasible and cost-effective options to reduce project-related GHG emissions during the design and operation of the project.
- Undertake operational reviews of GHG emissions for projects over 100,000 tCO_{2e}/yr (applicable to this project - see project GHG assessment in Section 18).
- Monitor and quantify throughout operation direct emissions from the facilities owned or controlled within the physical project boundary.
- Adopt measures that avoid or reduce water usage so that the project's water consumption does not have significant adverse impacts on others.

- Avoid the release of pollutants or, when avoidance is not feasible, minimize and/or control the intensity and mass flow of their release.
- Address potential adverse project impacts on existing ambient conditions. Undertaken as part of the ESIA.
- Avoid the generation of hazardous and non-hazardous waste materials, reduce generation of waste and recover and reuse waste in a manner safe for human health and the environment. Dispose of any waste that cannot be reused or recycled in an environmentally sound way, including control of emissions and residues generated in disposal.
- Adopt GIIP alternatives for disposal of hazardous wastes and ensure contractors are reputable and follow good practice including use of Chain Of Custody documentation of wastes.
- Ascertain whether licensed disposal sites are being operated to acceptable standards and reduce wastes sent to sites where standards are not complied with and consider alternative disposal options to these sites.
- Assess the production, transportation, handling, storage, and use of hazardous material and consider use of less hazardous substitutes.
- Avoid the manufacture, trade, and use of chemicals and hazardous materials subject to international bans or high levels of toxicity to living organisms.

All of the above will be adopted throughout the life of the project. Monitoring of emissions will be undertaken as part of the environmental permitting process. A waste management plan will be developed and implemented.

Performance Standard 4: Community Health, Safety, and Security

PS4 aims to avoid or minimize the risks and impacts to community health, safety, and security that may arise from project related-activities, with particular attention to vulnerable groups.

The objectives of PS4 are to:

- Anticipate and avoid adverse impacts on the health and safety of 'Affected Communities' during the project life from both routine and non-routine circumstances.
- Ensure that the safeguarding of personnel and property is carried out in accordance with relevant human rights principles and in a manner that avoids or minimizes risks to the Affected Communities.

To meet the objectives of PS4, the Early Power project will:

- Evaluate the risks and impacts to the health and safety of the nearest communities during the project lifecycle and will establish preventive and control measures consistent the IFC requirements. Assessed within ESIA, see Section 20.

- Design, construct, operate, and decommission the structural elements, associated infrastructure and other components of the project in accordance with good industry practice, taking into consideration safety risks to third parties including community health and safety. Included within the scope of the ESIA – see individual assessments for discussion, but particularly the socio-economic assessment (Section 20) with regards to safety implications of the above ground section of the LPG pipeline.
- Use of competent and certified professionals to design and construct structural elements.
- Avoid the occurrence of incidents and injuries to members of the public associated with the operation of equipment. Safety aspects will be addressed throughout the project through engineering design to best practice.
- Avoid or minimize the potential for community exposure to hazardous materials throughout the project including during decommissioning.
- Identify potential impacts to ecosystem services which may result in adverse health and safety risks and impacts to Affected Communities to avoid these impacts where possible. Where impacts are unavoidable mitigation measures will be implemented. Assessed within the ESIA, see Sections 15 and 20.
- Assist and collaborate with the Affected Communities, local government agencies, and other relevant parties, in their preparations to respond effectively to emergency situations. Emergency response plans and management procedures will be developed and implemented by the project.
- Assess the risk posed by its security arrangements to those within and outside the project site, where contractors are used, ensuring that those providing security are fully trained and competent and have not been implicated in past abuses. Policies and procedures will be in place to ensure site security and due diligence of security staff will be required.
- Consider and, where appropriate, investigate all allegations of unlawful or abusive acts of security personnel and report unlawful abusive acts to public authorities.

The health and safety of workers and members of the public will be assessed and reviewed throughout the project design and reviewed during construction and operational phases. A decommissioning plan will include health and safety assessment and mitigation measures / good practice to ensure the health and safety of workers and members of the public during decommissioning activities.

Performance Standard 5: Land Acquisition and Involuntary Resettlement

PS5 aims to effectively manage project-related physical or financial displacement associated with land acquisition and/or restriction on land use which may have adverse impacts on communities and persons using the land.

The objectives of PS5 are to:

- Avoid, and when avoidance is not possible, minimize displacement by exploring alternative project designs.

- Avoid forced eviction.
- Anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land acquisition or restrictions on land use by (i) providing compensation for loss of assets at replacement cost and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected.
- Improve, or restore, the livelihoods and standards of living of displaced persons.
- Improve living conditions among physically displaced persons through the provision of adequate housing with security of tenure at resettlement sites.

To meet the objectives of PS5, the Early Power project will:

- Consider feasible alternative project designs to avoid or minimize physical and/or economic displacement, while balancing environmental, social, and financial costs and benefits, paying particular attention to impacts on the poor and vulnerable. Alternative options for site selection have been considered within the scope of the ESIA (see Section 4).
- Apply consistent and transparent compensation standards to communities or persons affected by the displacement.
- Engage with local communities in an appropriate manner that is commensurate to the project impacts and area of influence (part of the ESIA consultation process, outlined in Section 21) and implement grievance mechanisms.
- Collect socio-economic baseline data to identify displaced personnel and determine compensation requirements. Undertaken as part of the ESIA (see Section 8).
- Undertake resettlement and/or livelihood restoration planning in line with the criteria of this performance standard (see Section 20).

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

PS6 aims to minimise the direct and indirect impacts on biodiversity and ecosystem services. Ecosystem services are the benefits that people, including businesses, derive from ecosystems. As no significant impacts to biodiversity or ecosystem services have been identified during the ESIA process, this PS is therefore not relevant to the project.

Performance Standard 7: Indigenous Peoples

This performance standard aims to protect the rights of indigenous people. No indigenous communities will be impacted by the development and PS 7 is not relevant to the project.

Performance Standard 8: Cultural Heritage

PS8 aims to ensure cultural heritage is protected during the course of project activities. As no significant impacts to cultural heritage have been identified during the ESIA process, PS8 is therefore not relevant to the project.

5.4 Environmental Quality Standards

National and international standards and guideline values for air and water quality and noise emissions provide a benchmark for the assessment of environmental impacts.

The following standards appropriate to the assessment have been considered:

- National Environmental Quality Guidelines which include:
    - Environmental Quality Guidelines for Ambient Air (Ghana EPA).
    - Environmental Quality Guidelines for Ambient Noise (Ghana EPA).
    - General Environmental Quality Standards for Industrial or Facility Effluents, Air Quality and Noise Levels (Ghana EPA).
    - Sector Specific Effluent Quality Guidelines for Discharges into Natural Water Bodies (Ghana EPA). (Discharge Limits for Thermal Power Plants).
    - Guidelines for Emissions from Sources (Ghana EPA).
- Environmental Protection Agency (EPA), The Environmental Impact Assessment Guidelines for the Energy Sector Volumes I and II, September 2011 (Volume II Section 7, Recommended limits for stationary plants- Air Quality).
- World Health Organisation (WHO) (2005) Ambient Air Quality Standards.
- WHO Guidelines for sleep disturbance.
- Relevant IFC EHS Guidelines (see Section 5.3)

The benchmark values provided in these documents have been for screening of environmental impacts. The relevant benchmark values are provided within the impact assessments for each environmental aspect within this report.

5.5 List of ILO Conventions

Table 5-2: ILO Conventions

Convention	Date	Status
C001 - Hours of Work (Industry) Convention, 1919 (No. 1)	19 Jun 1973	In Force
C008 - Unemployment Indemnity (Shipwreck) Convention, 1920 (No. 8)	18 Mar 1965	In Force
C011 - Right of Association (Agriculture) Convention, 1921 (No. 11)	14 Mar 1968	In Force
C014 - Weekly Rest (Industry) Convention, 1921 (No. 14)	19 Jun 1973	In Force
C015 - Minimum Age (Trimmers and Stokers) Convention, 1921 (No. 15)	20 May 1957	Not in force
C016 - Medical Examination of Young Persons (Sea) Convention, 1921 (No. 16)	20 May 1957	In Force

Convention	Date	Status
C019 - Equality of Treatment (Accident Compensation) Convention, 1925 (No. 19)	20 May 1957	In Force
C022 - Seamen's Articles of Agreement Convention, 1926 (No. 22)	18 Mar 1965	In Force
C023 - Repatriation of Seamen Convention, 1926 (No. 23)	18 Mar 1965	In Force
C026 - Minimum Wage-Fixing Machinery Convention, 1928 (No. 26)	02 Jul 1959	In Force
C029 - Forced Labour Convention, 1930 (No. 29)	20 May 1957	In Force
C030 - Hours of Work (Commerce and Offices) Convention, 1930 (No. 30)	19 Jun 1973	In Force
C045 - Underground Work (Women) Convention, 1935 (No. 45)	20 May 1957	In Force
C050 - Recruiting of Indigenous Workers Convention, 1936 (No. 50)	20 May 1957	In Force
C058 - Minimum Age (Sea) Convention (Revised), 1936 (No. 58)	20 May 1957	In Force
C059 - Minimum Age (Industry) Convention (Revised), 1937 (No. 59)	20 May 1957	Not in force
C064 - Contracts of Employment (Indigenous Workers) Convention, 1939 (No. 64)	20 May 1957	In Force
C065 - Penal Sanctions (Indigenous Workers) Convention, 1939 (No. 65)	20 May 1957	In Force
C069 - Certification of Ships' Cooks Convention, 1946 (No. 69)	18 Mar 1965	In Force
C074 - Certification of Able Seamen Convention, 1946 (No. 74)	18 Mar 1965	In Force
C081 - Labour Inspection Convention, 1947 (No. 81)	02 Jul 1959	In Force
C087 - Freedom of Association and Protection of the Right to Organise Convention, 1948 (No. 87)	02 Jun 1965	In Force
C088 - Employment Service Convention, 1948 (No. 88)	04 Apr 1961	In Force
C089 - Night Work (Women) Convention (Revised), 1948 (No. 89)	02 Jul 1959	In Force
C090 - Night Work of Young Persons (Industry) Convention (Revised), 1948 (No. 90)	04 Apr 1961	In Force

Convention	Date	Status
C092 - Accommodation of Crews Convention (Revised), 1949 (No. 92)	18 Mar 1965	In Force
C094 - Labour Clauses (Public Contracts) Convention, 1949 (No. 94)	04 Apr 1961	In Force
C096 - Fee-Charging Employment Agencies Convention (Revised), 1949 (No. 96). *Has accepted the provisions of Part II*	21 Aug 1973	In Force
C098 - Right to Organise and Collective Bargaining Convention, 1949 (No. 98)	02 Jul 1959	In Force
C100 - Equal Remuneration Convention, 1951 (No. 100)	14 Mar 1968	In Force
C103 - Maternity Protection Convention (Revised), 1952 (No. 103)	27 May 1986	In Force
C105 - Abolition of Forced Labour Convention, 1957 (No. 105)	15 Dec 1958	In Force
C106 - Weekly Rest (Commerce and Offices) Convention, 1957 (No. 106)	15 Dec 1958	In Force
C107 - Indigenous and Tribal Populations Convention, 1957 (No. 107)	15 Dec 1958	In Force
C108 - Seafarers' Identity Documents Convention, 1958 (No. 108)	19 Feb 1960	In Force
C111 - Discrimination (Employment and Occupation) Convention, 1958 (No. 111)	04 Apr 1961	In Force
C115 - Radiation Protection Convention, 1960 (No. 115)	07 Nov 1961	In Force
C116 - Final Articles Revision Convention, 1961 (No. 116)	27 Aug 1963	In Force
C117 - Social Policy (Basic Aims and Standards) Convention, 1962 (No. 117)	18 Jun 1964	In Force
C119 - Guarding of Machinery Convention, 1963 (No. 119)	18 Mar 1965	In Force
C120 - Hygiene (Commerce and Offices) Convention, 1964 (No. 120)	21 Nov 1966	In Force
C138 - Minimum Age Convention, 1973 (No. 138) *Minimum age specified: 15 years*	06 Jun 2011	In Force
C144 - Tripartite Consultation (International Labour Standards) Convention, 1976 (No. 144)	06 Jun 2011	In Force
C147 - Merchant Shipping (Minimum Standards) Convention, 1976 (No. 147)	10 May 2005	In Force

Convention	Date	Status
C148 - Working Environment (Air Pollution, Noise and Vibration) Convention, 1977 (No. 148)	27 May 1986	In Force
C149 - Nursing Personnel Convention, 1977 (No. 149)	27 May 1986	In Force
C150 - Labour Administration Convention, 1978 (No. 150)	27 May 1986	In Force
C151 - Labour Relations (Public Service) Convention, 1978 (No. 151)	27 May 1986	In Force
C182 - Worst Forms of Child Labour Convention, 1999 (No. 182)	13 Jun 2000	In Force
C184 - Safety and Health in Agriculture Convention, 2001 (No. 184)	06 Jun 2011	In Force
MLC - Maritime Labour Convention, 2006 (MLC, 2006) *In accordance with Standard A4.5 (2) and (10), the Government has specified the following branches of social security: medical care; sickness benefit; old-age benefit; employment injury benefit; maternity benefit; invalidity benefit and survivors' benefit.*	16 Aug 2013	In Force

5.6 Legislation pertaining to Greenhouse Gases

There are a number of legislative drivers for undertaking a carbon balance on the proposed project.

5.6.1 International Agreements

The United Nationals Framework Convention on Climate Change (also known as the Kyoto Protocol) was first adopted for use on the 11th December 1997. The Framework was set up to tackle global warming by introducing targets for countries to reduce emissions of greenhouse gases to a stable or lower level. The key aim of the Kyoto Protocol was to ensure a collective reduction in emissions by 5.2% compared to 1990 levels for all industrialised countries.

The Kyoto Protocol has largely been superseded by the Paris Agreement, which sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C above pre-industrial levels and to pursue efforts to limit it to 1.5°C. The Agreement requires all Parties to put forward nationally determined contributions (NDCs), and to review and strengthen these efforts in the years ahead. The Paris Agreement came into force in Ghana in November 2016.

Ghana Second National Communication to the UNFCCC

Ghana made an initial submission in 2001 and submitted the Second National Communication to the UNFCCC in October 2011. This document reported that, in 2000, the total direct greenhouse gas emission (including land use change and forestry emissions) in

Ghana was estimated at 12.2 million tons of carbon dioxide equivalent ($MtCO_2e$[2]). This represented a 173% increase over 1990 levels of -16.8 $MtCO_{2e}$ (minus as Ghana was a net carbon sink on account of its forestry) and by 2006 emissions had increased by 242.3%. It identified the energy sector as the largest contributor to total national emissions, accounting for 38% of total emissions in 2000 and 40% in 2006.

5.6.2 National Legislation and Policy

Ghana National Climate Change Adaptation Strategy

The Strategy aims to integrate climate change and disaster into national development. It recognises that historical data show a progressive decrease in mean annual rainfall in all the six agro-ecological zones and rise in temperature from 1961 to 2000; the average annual temperature has increased 1°C in the last 30 years. The impacts of climate change in Ghana will be seen in rising temperatures, declining rainfall totals with increased variability, rising sea levels and high incidence of weather extremes and disasters. Such changes leave the hydroelectric sector vulnerable as demonstrated by comparison of output of 3,885 gigawatt-hours (GWh) in 2003 (a particularly dry year) with 6,610 GWh in 2000 (a relatively wet year). This roughly 60% drop required emergency supply of thermally generated electricity to be brought on line to partially compensate.

'Ghana Goes for Green Growth' National engagement on climate change

This discussion document was produced by the Government of Ghana in November 2010 and recognised Ghana as *"an African country that is high growth and energy-hungry and, at the same time, vulnerable to climate change and its variability[3]"*. One quarter of Ghana's population lives less than 30 metres above sea level, meaning a projected global sea level rise of 1 metre by 2100 could affect 1,120 square kilometres of land putting hundreds of thousands of people at risk.

Whilst back in the mid-1990s Ghana's forests made the country a carbon sink, a growing population and economy mean emissions are increasing. In 2006, Ghana's emissions amounted to 24 $mtCO_2e$, with emissions from the energy sector representing the fastest growing source of greenhouse gas emissions. Ghana aims to derive 10% of its energy from renewable resources other than large-scale hydropower by 2020 and is developing a proposal to establish its own Renewable Energy Fund under the Renewable Energy Law.

It notes the areas of greatest concern in relation to the potential impacts of climate change include: increased pressure on water, reducing the potential for hydropower; reduced agricultural outputs; increased migration; deteriorating health; severe impacts on land use, biodiversity, soil fertility, land degradation and increased deforestation; the impact on women, who are particularly vulnerable.

[2] Included carbon dioxide, methane, nitrous oxide and perfluorocarbons
[3] In 2007, for example, 112 mm of rain fell in 24 hours in one town in northern Ghana – 20% of the annual average in one day.

Low carbon growth is listed as one of the three objectives[4] of the National Climate Change Policy Framework (NCCPF). Even low carbon growth will result in increased emissions, but impacts will be less than those of a 'business as usual', high carbon pathway.

Policy Brief — Low Carbon Growth for Ghana (part of the Technical Assistance to the Ghanaian NCCPF December 2010)

This document identifies involvement of the private sector in options that have direct positive economic and development benefits; government provides the right regulatory framework and fiscal environment and the private sector investment. This collaborative approach will assist in identifying barriers to low carbon growth, whilst continued accretion of an evidence base will help in the development and dissemination of successful low carbon projects

It again recognises the energy sector as one of the most important sources for GHG emissions with growth outstripping that of other key emissions sectors such as agriculture and land use change.

UNEP Emission Reductions Profile Ghana

This 2013 report reiterated the key role the energy sector has in the overall emissions profile of Ghana. It reports that electricity demand is increasing by an estimated 10% each year, with government estimates indicating an additional 200 MW capacity would need to be installed annually to meet this growing demand.

[4] The other two are; i) Effective adaptation to climate change and ii) Social development

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Environmental and Social Impact Assessment

Section 6 – Impact Assessment Methodology

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration	Rev No
Sep 2015	First issue	0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency	1
June 2016	ESIA Amendment issued to Ghana Environment Protection Agency - no changes to this Section.	2
August 2017	ESIA amendment issued to Ghana Environment Protection Agency, incorporating details of further project design changes.	3

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Figures and Tables

6 Environmental and Social Impact Assessment Methodology

6.1 Overview of the formal ESIA process and the requirements of this ESIA

An Environmental and Social Impact Assessment (ESIA) is a systematic, scientific and participatory process to assess potential environmental and social impacts of a development, including consideration of project alternatives, cumulative impacts with other planned developments, the use of natural resources and potential implications of climate change. The ESIA process ensures that new developments, and extensions to existing developments, are located and designed in such a way as to minimise environmental and social impacts.

The objectives of an ESIA are:

- Identify environmental constraints and opportunities within the study area, taking account of the characteristics of the development and the local environment;
- Identify potential impacts and interpret the nature of these impacts;
- Describe the mitigation measures required to prevent, reduce and where possible offset any significant adverse effects on the environment and people, including appropriate avoidance and prevention measures; and,
- Determine the significance of any residual environmental and social effects following mitigation measures.

The ESIA process involves a number of key phases. Table 6-1 below summarises the key ESIA phases and documentation required for National Permitting and International Standards. The process involves public consultation and disclosure of findings at every phase.

Table 6-1: Summary of Key ESIA Documentation required for National Permitting in Ghana and International Standards

Stage (Required for National / International / Both)	Documentation Required	Approximate National Approval Timescale[1]	Phase / project Status
Screening (Both)	A proponent has to submit a registration form or environmental screening form to the Environmental Protection Agency (EPA) for all activities listed in Schedule I and II of the Environmental Assessment Regulation 1999, LI1652. The screening documentation submitted by the proponent should contain information on: • Details on the proposed activity (including	A maximum of 25 days.	EPL submitted a detailed Screening Report and received approval for their screening application on the 23 February 2015. Approval for a revised detailed Screening Report was given on April 16 2015. Relevant EPA letters are

[1] Timescales are provided within publically available information from the Ghana EPA. Timescales are likely to vary in practice.

Stage (Required for National / International / Both)	Documentation Required	Approximate National Approval Timescale[1]	Phase / project Status
	a description of waste generation); • The proposed location (location, zoning, site description, land cover and topography); • Infrastructure and utilities; • Environmental impacts (air quality, biological resources, cultural resources, water quality and hydrology, noise, other impacts); • Health and safety impacts; • Management of impacts (air quality, biological resources, cultural resources, water quality and hydrology, noise others); • Alternatives to the establishment of the activity; and • List of stakeholders consulted (including evidence). Lenders have their own internal risk screening process for categorization including Lenders that are signatories to the Equator Principles.		provided in Appendix F of this ESIA.
Scoping (dependent on EPA requirement)	The Scoping process generally identifies potential impacts in a scoping report, resulting in an approved Terms of Reference (ToR) for the ESIA. During scoping, the proponent should consult with affected parties (see Section 21 for details of consultation activities undertaken to date and proposed). The scoping report is made available for the general public. The EPA reviews the Scoping report with the help of a cross-sectoral technical committee and has to approve the report and the ToR before the full ESIA can be completed.	A maximum of 25 days.	Due to the project location, limited potential for community impacts and time constraints due to the rapid need for emergency power generation, a scoping report was not requested by the EPA. The EPA requested the compilation of Preliminary Environmental Report to fulfil the Ghanaian permitting requirements. However, due to the need to also meet international standards, this 'full' ESIA has been produced as agreed with the EPA.
ESIA[2] Report (both)	The ESIA study report has to contain information on direct and indirect impacts of the project on the environment at the pre-	The draft ESIA report is reviewed	ESIA assessment and reporting (this document)

[2] Note that national legislation only refers to EIA although there is an expectation that social issues will also be addressed. Lenders use the term ESIA and the two should be considered to be interchangeable in the context of this project.

Stage (Required for National / International / Both)	Documentation Required	Approximate National Approval Timescale[1]	Phase / project Status
	construction, construction, operation, decommissioning and post-decommissioning phases. In this instance the ESIA will fulfill the requirements of the Environmental Impact Statement (EIS). The draft ESIA report is reviewed by the EPA, assisted by a cross-sectoral technical committee at the regional and national levels. EPA uses an 'instructions for reviewing ESIA reports' document. The review should result in a summary of strengths and weaknesses of the report, needs for further study (if any), any impact monitoring required and any terms and conditions that should apply if approval is granted. The EPA and Committee make the decision whether a revision of the ESIA report is required or whether approval can be issued by the EPA. Then the ESIA report may be finalized A final version of this ESIA will be completed following EPA, lender and stakeholder review.	in a maximum of 50 days.	
Environmental Permit (National)	After finalization of the ESIA report the Environmental Permit should be issued within a maximum of 15 days. The EPA is bound by legislation to complete all its reviews/responses (e.g. for screening, scoping and draft ESIA/permit award) in not more than 90 days – though this does not include time for any public hearings if these are required.	Environmental permit should be issued with 15 days on finalization of the ESIA.	Environmental Permit was issued for the project as per ESIA Revision 1 in January 2016. The EPA has confirmed that the permit will only require minor modification as a result of the latest design change and ESIA amendment.
Consultation and disclosure Both (at all stages)	Public concerns are key criteria for the screening decision. For a full ESIA, the affected and interested parties should be consulted at every stage of the ESIA process (see Section 21 for details of consultation activities undertaken to date and proposed for this project). The public may make comments on the draft ESIA report and, if a public hearing is deemed necessary, be	A minimum 21 day period for public disclosure is required. In case a public hearing is	Stakeholder Consultation / Public Participation and disclosure See Section 21 for details of consultation events undertaken for the project. Due to the limited extent of project impacts, and

Stage (Required for National / International / Both)	Documentation Required	Approximate National Approval Timescale[1]	Phase / project Status
	involved in the public hearing. The draft ESIA has to be published for 21 days so that the public can express their concerns. During the review process, EPA can decide to hold a public hearing in the following cases: • The expected environmental impacts are considered extensive and far reaching; • There is great adverse public reaction to a proposal; and/or • There will be relocation or dislocation of communities. The EPA will then appoint a panel of three to five persons to gather information on the public concerns and how these could be addressed. At least one-third of the panel members must be residents of the geographic area where the activity will be undertaken. The stakeholders to be involved are: the general public, relevant public agencies, organizations, NGOs, Metropolitan, Municipal and District Assemblies and local communities. See Section 21 for a full list of the stakeholders identified for this project. When a draft EIS has been prepared, the proponent publishes a notice for at least 21 days in at least a national and a local newspaper. No specific language requirements are made in the regulations for reporting. The EPA decision on the environmental permit is published in the Gazette and through mass media.	held, the panel shall make recommendations in writing to the EPA within a period of not less than 15 days from the date it starts hearing representations. Draft ESIA need to be publically disclosed for 21 days.	particularly the lack of direct impacts to any communities, a very focused approach to community consultation was taken to avoid raising undue expectations amongst the nearest local communities. This was agreed with the EPA and discussed informally with an Environmental and Social Advisor at a leading IFI.
Monitoring Both	Monitoring is required. The EPA has established Field Offices and head office	Provisional EMP – 18	Monitoring / compliance as detailed within the

Stage (Required for National / International / Both)	Documentation Required	Approximate National Approval Timescale[1]	Phase / project Status
(construction, operation and decommissioning)	departments that undertake compliance monitoring, evaluation and enforcement of conditions. The monitoring regimes and parameters are defined in permitting schedules on a case by case basis. Firstly self-compliance is expected from the proponent. In general, the proponent is required to submit a (provisional) Environmental Management Plan (EMP) to the EPA within 18 months of the commencement of the activities and thereafter every three years. The EMP shall set out steps that are intended to manage any significant impacts that may result from the operation of the undertaking. Moreover, an Annual Environmental Report should be submitted to the EPA after 12 months and every 12 months thereafter. These deliverables have to be approved by the EPA. Within 24 months after commencing the activity, the proponent should send evidence to the EPA that the activity is in line with the conditions written in the ESIA. The proponent then obtains an Environmental Certificate, if the first Annual Environmental Report has been submitted. For international finance, lenders will expect to see EMPs produced as part of the ESIA and the EMP will underpin the lenders internal Environmental & Social Action Plan (ESAP) that will be used to monitor compliance with lenders requirements throughout the life of the project. Lenders construction monitoring will take place every 4-6 months, following commencement of the project and there will be periodic monitoring (generally annually) during the operational phase.	months of commencement of activities and every 3 years subsequent. Within 24 months of commencement report documenting alignment with EPA conditions.	Environmental and Social Management Plan (ESMP) which comprises Volume III of this submission.

6.2 The ESIA

This document is the ESIA. Whilst a PER was originally requested by the EPA, it was agreed with the EPA that in order to adhere to international standards to satisfy the requirements of the project lenders, a 'full' ESIA study would be undertaken, as presented in this ESIA. It records the results and conclusions of the ESIA process carried out to determine the potential impacts (both adverse and beneficial) of the proposed Ghana Bridge project. It also seeks to identify potential measures to avoid, reduce or remedy any adverse effects. This ESIA is supplemented by the ESMP which is provided as Volume III of this ESIA. The ESMP summarises the mitigation action plan and shows how these will be implemented, managed, monitored and reported.

This ESIA has been written to enable the EPA, local communities and other key stakeholders to determine whether or not the proposals (including recommended mitigation) are acceptable. This report also informs the permitting process as the recommended mitigation measures and other actions included in the ESMP form conditions of the EIA Permit issued by the EPA.

The following sections present the key findings of potential environmental and social effects identified for the proposed project.

The environmental and social aspects requiring detailed assessment were identified during the screening phase of the ESIA which was undertaken between January and March 2015. The identified aspects were the subject of detailed investigation and supplemented by survey / modelling work (where appropriate).

The aspects which have been investigated in detail and included within the scope of this ESIA are:

- Air quality effects from stack emissions;
- Ecological impacts at the site and along the pipeline route;
- Noise impacts;
- Land quality impacts;
- Traffic impacts;
- Impacts associated with water discharge;
- Impacts associated with solid wastes;
- Flood risk and impacts;
- Climate change impacts; and
- Socio-economic impacts.

Each of the assessments above considers cumulative impacts where appropriate.

During the detailed screening phase it was agreed that no significant impacts were associated with the following:

- Trans-boundary issues;
- Cultural heritage; and
- Indigenous people.

These aspects have not been assessed and are not included within the ESIA.

Prior to assessment of project impacts, it is necessary to gain an understanding of the current baseline conditions in the surrounding area which may be affected by project activities. Section 7 of this document provides the environmental baseline and Section 8 provides the socio-economic baseline. The subsequent specialist assessments make use of the baseline data in evaluating the significance of potential impacts from the project.

In order to evaluate environmental impacts and determine their effects and significance, it is important that assessment criteria are identified. In some instances environmental standards and guidelines are available which provide significance thresholds (e.g. General Environmental Quality Standards (Ghana) Regulations 20[3] or the IFC EHS Guidelines). The various methodologies that have been used within each specialist area or discipline are made clear within the appropriate sections of this ESIA.

Each specialist impact assessment section includes the following information:

- **Thresholds used to determine significance of impacts:** the amount or type of impact, which constitutes a substantial or potentially substantial change in the environment. Some thresholds are quantitative (e.g. noise), while others are qualitative (e.g. cultural heritage effects). Thresholds are used to help the reader understand the basis for the conclusions reached regarding whether a particular impact should be considered by the decision making authority as significant or not significant. Published thresholds are not available for certain aspects of the environment;
- **Predicted effects:** an evaluation of the proposed project's impacts in quantitative and qualitative terms. In general, the effect of an impact is assessed by a combination of sensitivity of the environment and the degree of alteration from the baseline state (both positive and negative) which can be predicted. Environmental sensitivity may be categorised by a multitude of factors such as the threat to a rare or endangered species, transformation of landscapes or changes to soil quality or land use. Impacts can have both direct and indirect effects, be cumulative, short term, medium term or long term, permanent or temporary and have positive or negative effects. Impacts can be analysed in terms of the source of pollution and the pathways by which they travel to arrive at a receptor;
- **Significance of effects:** project impacts are determined to be 'significant' or 'not significant'. Significance is a combination of magnitude and sensitivity to change and is evaluated in terms of the geographic effect, duration and frequency, irreversibility, and any regulatory standards which may apply. For effects where an assessment of

[3] Environmental Protection Agency (2009). Standards for industrial/facility discharges into Water Bodies and Water courses, standards for air quality and standards for noise Regulations.

significance cannot be determined (e.g. for reasons of uncertainty), this issue will be highlighted and an explanation given as to why significance could not be determined.

- **Mitigation measures:** a description of the measures proposed to minimise potential significant adverse effects; and
- **Residual impacts:** determination of the project's remaining level of effect after all the required and recommended mitigation measures are implemented.

6.3 Procedure for Assessment of Environmental Impacts and their significance

The methodology developed and adopted for the impact assessments provides a tool for assessing and evaluating the significance of effects and is based on the following criteria:

- The type of effect (i.e. whether it is positive/acceptable, negative/unacceptable, neutral or uncertain);
- Duration and/or frequency of occurrence (short term/frequent, long term/long return period, intermittent);
- The policy importance or sensitivity of the resource under consideration in a geographical context (whether it is international, national, regional or local, as defined in Table 6-2); and
- The magnitude of the effect in relation to the resource that has been evaluated, quantified if possible, or rated qualitatively as high, medium or low, as defined in Table 6-3.

Both professional judgement and the results of modelling analysis are used to assess the findings in relation to each of these criteria to give an assessment of significance for each effect. Effects are considered to be major, minor or negligible and can be negative or positive. Where positive impacts are identified mitigation is not required.

Table 6-2: Geographical Context and Policy Importance

Geographical Context	Topic Definition
International	Important at global, African or trans-boundary levels
National	Important in the context of Ghana
Regional	Important in the context of Greater Accra
District	Important in the context of the Tema District
Local	Important within the site and up to 1 km from the site

Table 6-3: Magnitude Criteria

Magnitude of effect	Negative effects	Positive effects
High	• Widespread community concern. • Failure to meet legal compliance requirements. • Fatality or serious health disability. • Severe or possibly irreversible damage to an important ecosystem or resource.	• Widespread community benefit. • High contribution to safety or prevention of fatalities. • High level of technology transfer. • Prevents serious damage to an important ecosystem or resource.
Medium	• Local community opposition and levels of complaint. • Regulatory concerns. • Lost time injury or short term health effects. • Medium term damage to an ecosystem or resource.	• Contributes to local development and economy. • Provides confidence to regulators. • Prevents medium term damage to an ecosystem or resource.
Low	• Economic benefits not distributed locally. • Local/minor health effects requiring short-term treatment. • Short-term, minor damage to an ecosystem or resource. • Minor community opposition or complaints.	• Able to comply with legal requirements. • Low level of community support.

As a guide Table 6-4 presents a significance evaluation tool which calculates the significance of the effect by a combination of importance/ sensitivity and magnitude.

Table 6-4: Evaluation of Significance of Effect

Sensitivity of Impact	Magnitude of Impact		
	Low	Medium	High
International	Minor / Major	Major	Major
National	Minor / Major	Major	Major
Regional	Minor / Major	Minor / Major	Major
District	Negligible / Minor	Minor / Major	Minor / Major
Local	Negligible	Minor	Minor / Major

6.4 Approach to Mitigation

Mitigation measures are proposed through the consideration of alternatives, physical design, project management or operation to avoid, reduce or remedy any significant adverse effects on people and the environment resulting from the proposed development.

The mitigation strategy employed is a hierarchical one which aims to primarily avoid potential impacts, reduce those that remain, and lastly, where no other measures are possible, put forward compensatory measures. This approach is outlined as follows:

- Minimisation of environmental effects through avoidance and therefore minimising the number of reduction and remediation measures required to be 'built-in' to the project design;
- Minimisation of any remaining potential effects (e.g. by the use of appropriate construction methods or timing); and
- Thirdly, where avoidance or reduction are not feasible, measures to remedy any remaining effects predominantly during the construction phase of the project have been promoted (e.g. habitat management and landscaping proposals).

6.5 Other Developments and Cumulative Effect Assessment

It is a key part of any ESIA process that the additional or cumulative impacts associated with nearby existing or proposed developments be considered and the results reported. This cumulative effect assessment is concerned with identifying situations where a number of effects from separate projects combine to cause a significant effect on a particular resource.

projects being developed by others can be considered if operational, under construction, holding planning permission or in the planning process. The proposed location of the project lies within an area reserved for industrial development and a number of proposed new power projects are currently progressing through the planning process. The main project sites (PPS1, PPS2 and tank farm) are located to the east and adjacent to an existing power enclave consisting of a number of operating power plants. The details of the identified existing and proposed surrounding power developments are provided in Section 1.2.8.

The cumulative impacts, taking into consideration existing and appropriate developments under construction or proposed, have been assessed for relevant environmental aspects and findings are included in the detailed assessments (Sections 9 to 20).

6.6 Sources of Information and Data Collection

As described in Table 6-1, this report presents the findings following multiple phases of study work in the area in which the development will take place (the "area of influence").

6.6.1 Baseline Information

Information on the environmental and social context (the baseline) was obtained from a combination of the following:

- Desk reviews of identified publically available information.;
- Site walkovers; and
- Feedback during consultation events.

6.6.2 Detailed Assessment

The detailed assessment process has included both additional desk study and data review combined with independent field surveys and computer modelling where appropriate. The detailed assessment has included:

- Survey of terrestrial ecology at the power plant sites, tank farm site and along the pipeline route – for various project design iterationa, during April 2015, May 2016 and May 2017;
- Socio-economic baseline survey and stakeholder / community consultation – February 2015, August 2015, May-December 2016, January 2017 and May-June 2017;
- Ambient noise monitoring programme – 21st and 22nd April 2015 and additional monitoring at adjacent industrial facility in May 2017;
- Ambient air quality monitoring programme – April-September 2015 and May-October 2016.
- Transport baseline surveys in April and May 2015.

6.7 Preliminary Environmental and Social Management Plan

An ESMP has been produced as part of the ESIA. The ESMP is sufficiently robust to support International Lending requirements as stipulated in IFC Performance Standard 1 and meet the requirements of the EPA EIA requirements.

The ESMP ranks and prioritises recommended environmental and social actions, describing time period for implementation. In addition, the ESMP indicates the roles and responsibilities of project personnel and third parties such as local and regional administrations and sub-contractors.

The ESMP report follows the following format:

- project description;
- Applicable regulatory standards and guidelines;
- Environmental and social management plan – This section provides the environmental and social aspects and impacts along with the proposed outline mitigation measures for the construction and operational phases for key issues. This includes: summarising all anticipated significant adverse impacts, identification of measures to prevent, minimise, mitigate, compensate, offset and otherwise manage and control such impacts and identification of monitoring requirements to demonstrate compliance with applicable standards and guidelines and measure the effectiveness of impact mitigation measures. The environmental management plan provides technical details in respect of the mitigation measures to be implemented and define the responsibility for such measures;
- Environmental and social monitoring – Monitoring requirements are included within the ESMP. This includes physical and biological environmental monitoring and measurement for the construction and operational phase; and
- Reporting and review requirements.

The ESMP addresses the construction, operation and decommissioning phases of the project.

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Ghana Bridge Project

Environmental and Social Impact Assessment

Section 7 - Physical Environmental Baseline

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration		Rev No
Sep 2015	First issue		0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency		1
Jun 2016	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating the following changes:		2
	Section No.	***Change***	
	Wherever relevant	Reference to "power plant site" changed to reflect revised plan involving two power plant sites (PPS1 and PPS2)	
	7.17	Additional comments pertaining to watercourses in relation to PPS2	
	7.6.2	Updates to table 7-2 Industrial facilities within proximity of the Ghana Bridge site	
	7.6.4	Details of project specific monitoring programme added	
	7.8.3	Updates to field ecology report summary including field survey of PPS2]	
August 2017	ESIA amendment issued to Ghana Environment Protection Agency, incorporating details of further project design changes, including:		3
	Section No.	***Change***	
	Wherever relevant	Updated references to power plant site (PPS) in line with revised configuration, including new PPS2 site and change of former PPS2 site to become PPS1	
	7.17	Additional comments pertaining to overland flow direction within sub-catchment 2b	
	7.1.10	Updated geology, hydrogeology section with site investigation results	
	7.3	Updated comments regarding information on historical flooding	
	7.5	Addition of noise monitoring data from adjacent factory worker accommodation	
	7.6	Addition of new power plant facilities in the area and fuel types for existing plants	
	7.8	Update to ecology baseline with survey of new PPS2 site and potential alternative pipeline route	

Contents

Figures and Tables

7 Physical Environmental Baseline

7.1 Land Use, Geology, Hydrogeology and Hydrology

7.1.1 Sources of Information

The baseline information has been collated by undertaking a desk-based review of identified publically available information, site walkovers of the project area, information from the ground investigation reports for each site and feedback during consultation events. The following is a list of the key sources of information used to inform the baseline assessment:

- Environmental Impact Assessment of the Kpone Thermal Power Project (KTPP). Final Report, Volta River Authority, August 2012 (VRA 2012).
- Kpone Independent Power Plant (KIPP), Volume 1, Environmental and Social Impact Assessment (ESIA), SKM, February 2013 (SKM 2013).
- Environmental Impact Assessment, West African Gas Pipeline (WAGP). Prepared for West African Pipeline Company, June 2004.

The above documents are referred to within the text. Other sources of information are included within footnotes to this section.

7.1.2 Surrounding Land Use

Current land use at the proposed power plant and tank farm sites, along the pipeline routes and in the surrounding areas is described in detail in Section 1.2. Details on the surrounding community areas and socio-economic baseline are provided in Section 8.

7.1.3 Historical Land Use

The modern town of Tema was commissioned by Ghana's first president, Kwame Nkrumah and developed on the site of an old fishing village. The town and surrounding industry grew rapidly following the development of Tema Port in 1961.

The land surrounding the power plant sites has been used for industrial purposes since the 1960s, when both the Tema Oil Refinery (TOR) and VALCO sites commenced operations. The TOR (formerly the Ghana Italian Petroleum Company became a private limited company in 1960. Aluminium production at the VALCO site commenced in 1967.

The above ground section of the liquefied petroleum gas (LPG) pipeline in the existing TOR Right of Way (RoW) runs adjacent to the operational Tema–Accra Railway which has been established since 1954. The TOR pipelines are likely to have been in operation since the commissioning of TOR. No information has been identified regarding historical spills or incidents with the TOR pipelines, but the potential remains for contamination associated with the railway use and TOR pipelines.

Other developments include Tema Steel Company, Tema Special Steel, Tema Thermal Power Complex (TTPC), various tank farms (including the SAGE petroleum tank farm established in 2009) and the Sentuo Steel reprocessing facility (established in 2011). A second phase of development works at Sentuo Steel is expected in the near future.

Quantum Petroleum Ltd. is currently developing a tank farm to the east of Power Plant Site 2 (PPS2). Many of the surrounding industrial facilities, particularly the TOR and other tank farm facilities, have the potential to be a source of historical contamination in terms of potential for spillages of hazardous materials, air and water emissions, and in terms of materials used in construction (e.g. asbestos).

The power plant and tank farm sites do not appear to have been subject to any significant historical development and no information has been identified to indicate otherwise. The potential for contamination of soils and groundwater beneath the plant and tank farm sites will be confirmed through an intrusive site investigation, as discussed in land quality assessment (Section 9).

7.1.4 Hydrology and Surface Water

7.1.4.1 Geographic Context

The hydrological context of the area and regional catchments are illustrated on Figure 7-1. The watercourse alignments around the proposed development site are shown on Figure 7-2 and Figure 7-3.

Tema is located on a relatively flat area of land at the southern end of the broad ridge which separates the catchments of the Dzorwulu and Dechidaw Rivers. The area lies to the south of the Akuapim Mountains which run southwest to northeast from the Densu Delta to Lake Volta.

The Dzorwulu River runs south east from its source in the Akuapim mountains before entering the Sakumo Lagoon west of Tema, approximately 8km south-west of the power plant site. The Dechidaw River drains the area to the north and east of Tema and discharges to the sea via the Gao Lagoon, located 5km north-east of the power plant site. Both of these rivers are reported to be ephemeral (Ministry of Food and Agriculture 2015) and have been dammed at Ashaiman and Dawhenya respectively to provide a constant water supply. The Gao Lagoon has cultural significance and provides an important fishing resource for the local communities. The assessment undertaken prior to construction of the WAGP pipeline reported generally good water quality, with nutrient levels consistent with marine waters. Some localised contamination of the lagoon was noted, included oil/ grease residues and elevated levels of coliform and faecal bacteria. There have been reports of pollution of the lagoon with sewage due to problems with sewage infrastructure. Given the distance to these rivers and associated lagoons, they are not considered as potential receptors to the project.

The rivers and their catchments are described in Sections 7.15 and 7.16.

In addition to the major catchments, there are a number of minor watercourses within the vicinity of the power plant sites. Three watercourses, un-named on the available mapping, have been identified running through the Industrial area of Tema. They have been termed watercourses 1, 2 and 3 for the purpose of this assessment and are described in detail in Section 7.17 and shown on Figure 7-2 and Figure 7-3. Watercourse 1 flows straight from northwest to southwest along the western side of the Tema Refinery whilst Watercourse 2 initially flows from the northwest to the southeast before flowing eastwards just north of Tema New Town and converging with watercourse 1.

The alignments shown on Figure 7-2 have been digitised based on open streetmap mapping, aerial photography and the modelled flow paths based on the Shuttle Radar Topography Mission (SRTM) digital terrain data. It should be noted that these catchments are estimates discussed for indicative purposes, and that particularly for smaller catchments the actual drainage are likely to differ due to the coarse nature of the terrain data and the potential for artificial drainage to divert water between natural catchments.

7.1.5 Dzorwulu River

As illustrated on Figure 7-1, the Dzorwulu River flows around 6km to the west of the power plant sites and discharges to the sea around 8 km to the southwest via the Sakumono Lagoon. The lower reaches of the main channel and a number of its tributaries flow through the outskirts of Tema where its channel has been culverted beneath roads and also more generally modified as development has encroached onto its floodplain.

In total, it is estimated that the river drains a catchment of around 280km^2 which extends to a maximum elevation of around 500m above sea level. A review of satellite imagery indicates that this catchment is predominantly rural although a number of significantly sized settlements are present in the lower part of the catchment including Ashaiman and Tema.

Approximately one quarter of the total catchment area drains to the Ashaiman reservoir. At this point, river flows are controlled by a dam constructed for water supply. Water is only discharged from the reservoir when it is full which typically occurs during the wet season. When the reservoir is not spilling, there will typically still be a significant flow in the main river as approximately three quarters of the catchment does not discharge through the reservoir.

Levels between the lower reaches of the river and the site rise to more than 30m above datum. Therefore, it is considered highly unlikely that flows from this watercourse would impact on the site directly.

7.1.6 Dechidaw River

Land to the north and east of Tema is drained by the Dechidaw River which discharges to the sea around 5km to the northeast of the power plant sites via the Gao Lagoon adjacent to the Kpone district.

In total, it is estimated that the river drains a catchment of around 715km^2 which extends to a maximum elevation of around 500m above sea level. Land use is similar to the Dzorwulu catchment with agriculture predominating although a number of larger settlements such as Dawhenya are present in the lower reaches.

Approximately two thirds of the Dechidaw catchment drains to the Dawhenya reservoir. This reservoir, completed in 1978, has a capacity of 5.8 million m^3 and is used mainly to irrigate over 200ha of agricultural land during the dry season. As a result of the dam, flows are likely to be significantly reduced compared to what would be expected in an unmodified catchment. However, as a significant proportion of the total catchment does not flow into the reservoir, there is still potential for large flows in the lower reaches of the river close to the site.

Levels between the lower reaches of the river and the site rise to more than 20m above datum. Therefore, it is considered highly unlikely that flows from this watercourse would impact on the site directly.

7.1.7 Minor Catchments

As illustrated on Figure 7-2, three small catchments flow into the sea between the major river systems detailed above. These are not named on the available mapping and so have been assigned numbers. These are detailed below:

Watercourse 1

Base mapping and the inferred flow paths from the SRTM data indicates that the area east of the site, including the majority of the TOR, is within the catchment of an open drain that runs along the eastern side of the refinery, approximately 1.3km from the TTPC site before discharging to the sea just west of the port.

The catchment area is 12.4km^2 from its confluence with Watercourse 2 and the highest elevation within the catchment is approximately 60m above datum. The catchment is almost entirely urban in nature. Whilst no detailed information about the channel is available, it is crossed by several roads and is likely to be culverted beneath these. The proposed pipeline will cross this watercourse at Valco Road.

Watercourse 2

The EPL power plant sites are located in a small catchment with an area of approximately 14.8km^2. Of the total catchment, approximately 5.6km^2 is upstream of the power plant sites (sub-catchment 2a) and almost all of it is urban in nature. A second urban sub-catchment of approximately 2km^2 encompasses the tank farm site (sub-catchment 2b).

Watercourse 2 runs effectively forms the western boundary to both PPS1 and PPS2. A site walkover indicates that the channel is a concrete lined and trapezoidal in cross section with a bank to bank width of approximately 10m and a depth of approximately 2.5m. Immediately upstream of PPS2, a wall has been constructed over the channel (Photo 7-1 below) creating an aperture that has the potential to become blocked.

Approximately 1km downstream, the channel was observed to be in a poorer state of repair with vegetation growth within the channel in the vicinity of the Valco Road crossing (see Photo 7-2 below). However, it is noted that on a subsequent visit this vegetation had been cleared (see Photo 7-3). In addition during the 2017 survey of the Watercourse 2 channel, it was confirmed that the capacity of the channel reduces significantly just south of Valco Road, adjacent to the Valco Aluminium facility. These factors indicate that the area may be at risk of flooding under an extreme rainfall event. Associated potential risks are discussed in Section 13 (Flood Risk Assessment) and the associated technical appendix, presented in Appendix C.

No watercourse was observed on mapping or during the site walkover within sub-catchment 2b. However, the surface topography suggests that the historical surface water flow path would have passed through the tank farm site and to the south of PPS2. It was observed during the site visits that some formal drainage infrastructure is constructed in the local area, but no further work has been done by the local authorities since the inception of the EPL project in 2015.

It was also observed during the June 2017 site visit that surface water run off during the rainy season was primarily constrained by access roads and land parcel walled boundaries, with accumulations and drainage along the local access roads.

Watercourse 3

Another minor watercourse flows from north to south approximately 3km east of the proposed tanks farm. This has an urban catchment area of 35.8km^2 and a high point of approximately 60m. Levels between the lower reaches of the river and the site rise to more than 20m above datum. Therefore, it is considered highly unlikely that flows from this watercourse would impact on the site directly.

Photo 7-1 – looking Upstream along Watercourse 2 adjacent to the TTPC

Photo 7-2 – looking Upstream along Watercourse 2 from Valco Road in February 2015

Photo 7-3 – The same location in August 2015 following clearance

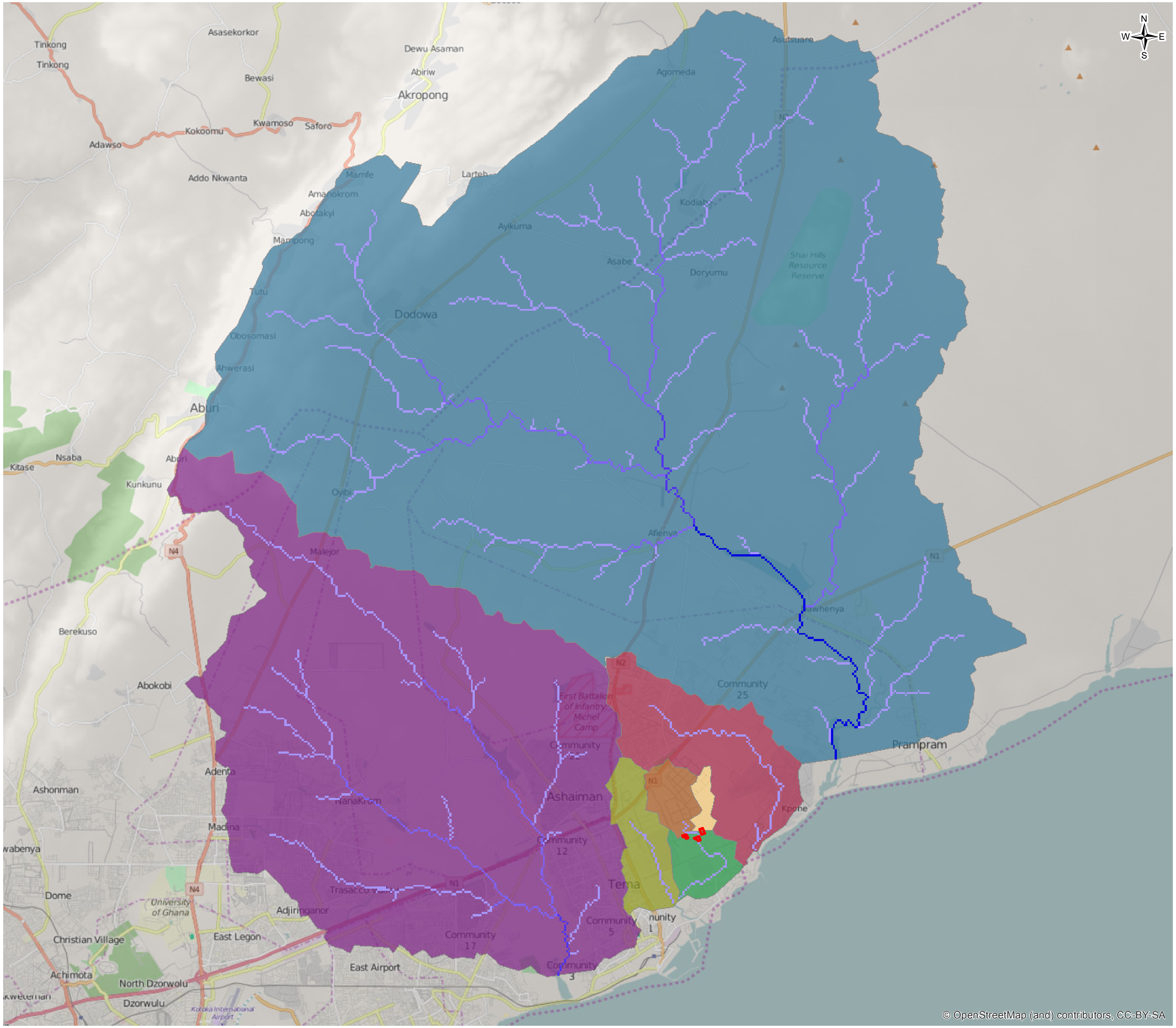


FIGURE 7-1

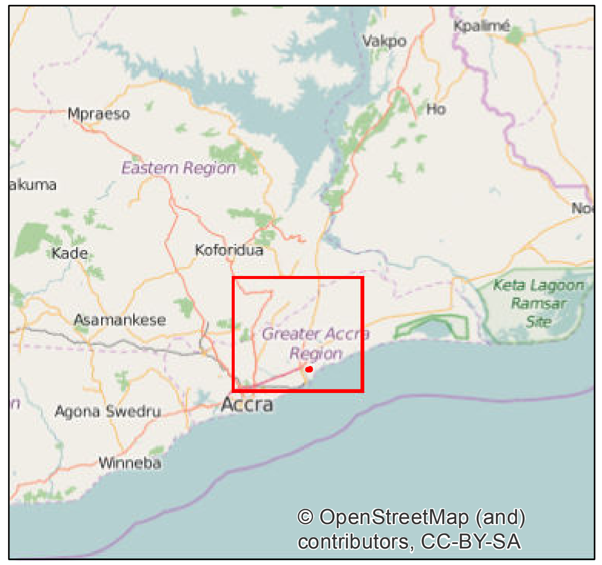
Legend

Indicative site location

Catchments

- Dechidaw River
- Dzorwulu River
- W1
- W2 Downstream of site
- W2b
- W2a
- W3

0 2,000 4,000 6,000 Metres



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
3	23/06/2016	Initial Issue	CD	DW	JPW	RS

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Project

Ghana Bridge Power Project ESIA

Drawing Title

Regional Hydrological Context

Drawing Status

Scale @ A3	1:161,508	DO NOT SCALE
Jacobs No.	60K36301	
Client No.		
Drawing No.	G002_Hydrological_context_Rev3	

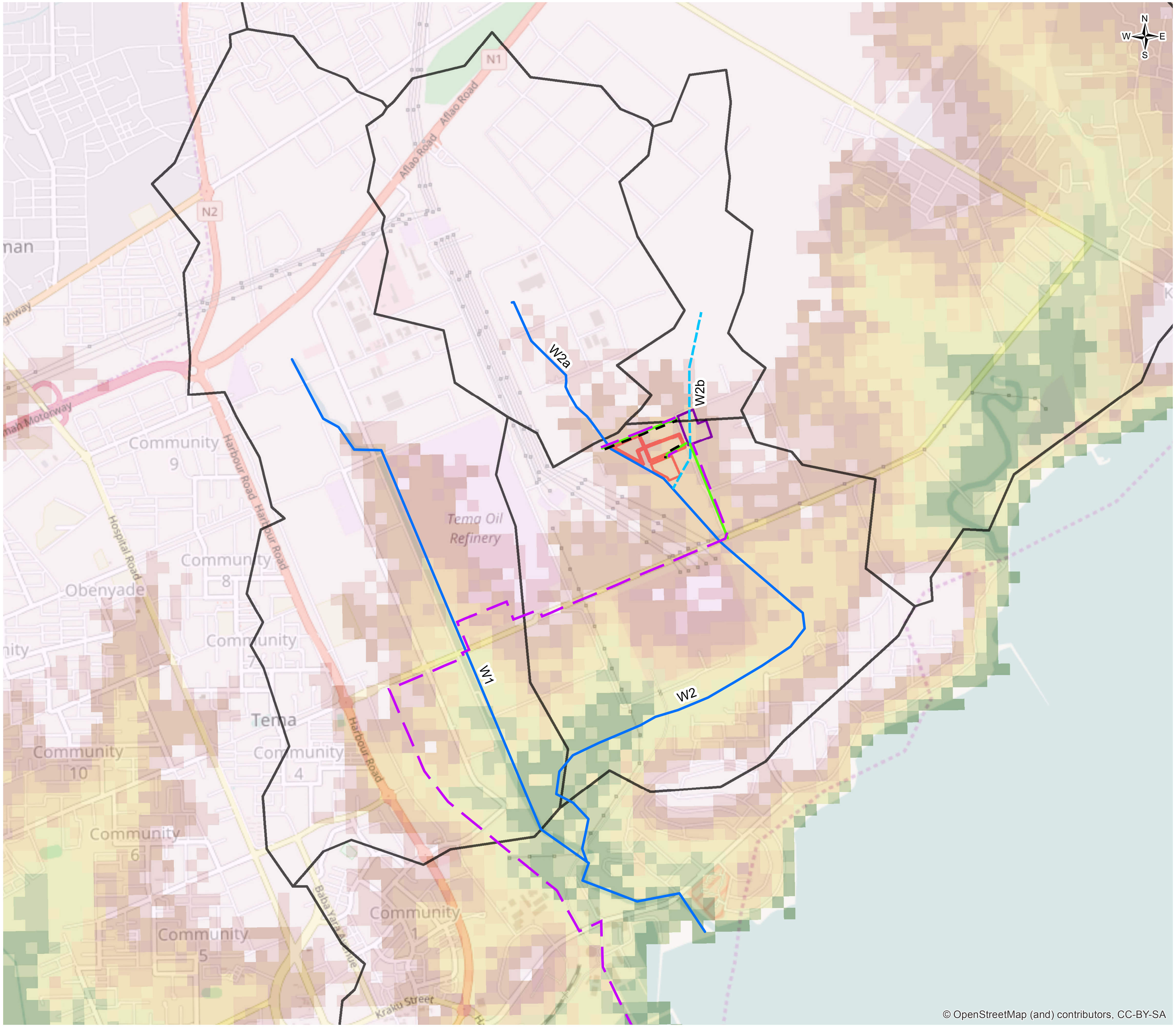


FIGURE 7-2

Legend

Catchment boundaries

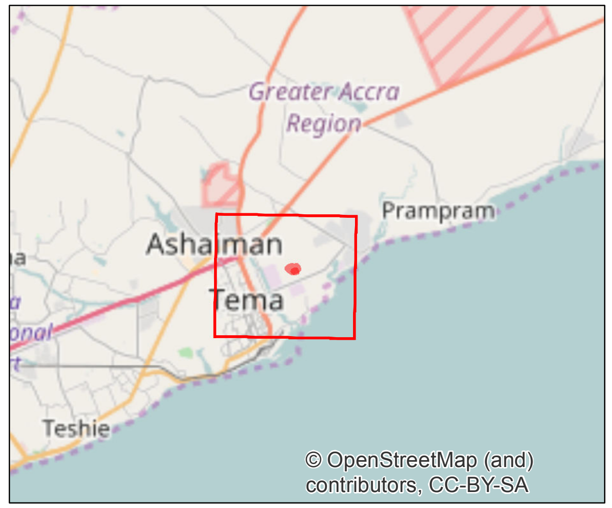
Elevation (m)

- 1 - 5
- 5.1 - 7.5
- 7.6 - 10
- 10.1 - 12.5
- 12.6 - 15
- 15.1 - 17.5
- 17.6 - 20
- 20.1 - 22.5
- 22.6 - 25
- >25.1

- Inferred flow route
- Watercourse
- Indicative Site Locations
- LPG Tank Farm
- LPG Pipeline
- Diesel Pipeline
- Water Pipeline

Elevation based on NASA data collected as part of its Shuttle Radar Topography Mission (SRTM)

0 500 1,000 1,500 Metres



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Drawing Title
Site Elevation and Minor Catchments

Drawing Status

Scale @ A3	1:30,000	DO NOT SCALE
Jacobs No.	60K36301	
Client No.		
Drawing No.	G004_Topography_Rev7	

FIGURE 7-3

Legend

- Indicative site locations
- 10 m contour
- LPG Tank Farm
- Inferred surface water flow path
- Watercourse

Aerial photography captured in December 2008 by DigitalGlobe

0 200 400 600 Metres

3	13/07/2017	Initial Issue	CD	DW	JPW	RS
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Drawing Title

Site Hydrological Context

Drawing Status

Scale @ A3	1:10,000	DO NOT SCALE
Jacobs No.	60K36301	
Client No.		
Drawing No.	G005_Site_context_Rev3	

7.1.8 Topography

Data from the SRTM[1] has been sourced for the site and its surrounding areas. While the resolution and vertical accuracy are not sufficient for detailed assessment they are sufficient to provide a high level review across the local area.

A plot of the topographic data is presented in Figure 7-2. The refinery site is at between 25m and 35m above datum with levels then falling to around 20m in the vicinity of the TTPC site and the tank farm. Watercourses in the vicinity of the power plant sites are shown in Figure 7-1 and Figure 7-2. The data indicates that levels fall down to around 17m in the vicinity of Watercourse 2 immediately adjacent to the power plant sites.

7.1.9 Geology and Soils

7.1.9.1 Soils

The soils in the Tema region are calcimorphic vertisols (tropical black earth soils). The investigation work undertaken prior to construction of the WAGP reported that the soils were acidic at the coast (pH values between 4.7-5.19), becoming less acidic further in land (pH 5.7 to 6.9 recorded 700m inland from high-tide). The Total Organic Carbon (TOC) content was reported as being very low (0.2 to 1.9 %).

7.1.10 Geology Overview

The regional geological formations of the Ghana coastal areas are heavily influenced by the processes of continental drift during the Cretaceous period (about 135 million years ago), when Africa broke away from South America.

Tema is underlain by rocks of Dahomeyan series (Late Pre-Cambrian), consisting principally of Gneisses and Schists, which are in turn intruded in the places by rocks of the Togo Series (Early Pre-Cambrian) made up of quartzites, schists and phyllites.

The rocks of the Dahomeyan series generally occur in alternating acidic and basic layers, comprising muscovite-biotite gneiss, quartz-feldspar gneiss, eugenic gneiss and minor amphibolites. These formations are weathered or decomposed at the surface with a thickness of the weathered component not generally exceeding 12m[2]. The decomposed portion is slightly permeable calcareous clay and sandy gravels.

The area is known to exhibit little or no structural instability in its geology, the presence of faults and lineaments are not likely.

7.1.10.1 Site Geology

[1] Upstream catchments have been derived from this data to inform the flood risk assessment (see Section 13). The SRTM data product has a spatial resolution of 30m, a mean vertical error of 0.2 m and a 95 % confidence limit plus or minus 8m around the stated elevation. The datum for this dataset is the World Geodetic System (WGS) 1984 datum.

[2] K. B. Dickson and G. Benneh, A New Geography of Ghana, Longman Group UK Limited, Longman House, Burnt Mill, Harlow, Essex, England, 1988.

The information provided here is as identified by the 2016 ground investigation undertaken by RIMOG Ltd between 26 October 2016th and 13th November 2016. The geology encountered during the ground investigation is summarised below. The borehole log for BH01 is summarised in Table 6-1.

Topsoil

The topsoil at the site is between 0.2 – 0.5m thick and consists of clayey, silty fine sand and clay with roots. In the western area of the site (BH08), topsoil was not encountered, with made ground described as 'fill' present.

Superficial Deposits

The topsoil is underlain by gravelly clay layers of approximately 2.5 – 3m thick. The gravel within these layers consists of crystalline quartz schist. A sand layer approximately 3.5m thick underlies the clay, consisting of quartz schist gravel.

Bedrock

The sand is underlain by highly weathered schist. The schist is described as foliated biotite-chlorite schist. The top of the schist was encountered between 2.9 – 7mbgl across the site. The bottom of the schist was not encountered during the site investigation.

Table 7-1: Summary of a borehole log (BH01) from the 2016 ground investigation

Depth (mbgl)	Lithology	Description
0 – 0.5	Topsoil	Very loose brown and dark grey very silty fine sand with grass roots
0.5 - 2	Clay	Dark grey and grey brown sandy, silty clay
2 – 3.1	Clay	Greyish brown and light yellowish grey gravelly, sandy, silty clay. Gravel is crystalline Quartz Schist.
3.1 – 6.7	Sand	Light yellow brown and greenish grey gravelly, slightly silty and clayey, thinly laminated sand. Gravel is quartz schist.
6.7 – 7.7	Schist	Yellowish brown and greenish grey, highly weathered foliated schist

7.1.11 Hydrogeology

There is the potential for two groundwater bodies, a perched groundwater body within the surficial weathered material and deeper groundwater contained within bedrock. Surficial groundwater has been encountered between 4 and 6m below ground level in the area.

The British Geological Survey (BGS) has classified the geology of the area as being a low productivity aquifer capable of abstractions of between 0.1 and 0.5 l/s. The low productivity is due to the impermeable nature of the bedrock gneiss deposits such that the potential to store groundwater is low and mainly restricted to fractures. The fractures are not well developed and the degree of interconnection is low and therefore these groundwater bodies can often be isolated. Bedrock aquifers have been encountered between 14-19m below ground level in the area, and the groundwater in the area is saline in nature.

A hydrogeological map of the region was prepared by the Geological Survey Department of Accra in conjunction with the Federal Institute for Geosciences and Natural Resources of Hanover, Germany. The map classifies groundwater in the Dahomeyan formation to be of *low* vulnerability and indicates that groundwater can be encountered <5m below ground level.

Groundwater at the site location was encountered during the 2016 ground investigation at levels of approximately 5 – 6mbgl, however groundwater levels were not recorded in all boreholes.

Table 7-2: Summary of groundwater levels recorded during the 2016 ground investigation

BH ID	mbgl	Groundwater Elevation
BH03	6	10.792
BH05	5.2	12.025
BH06	5.9	10.761

Given the industrial nature of the land surrounding the project it is considered that there is the potential for contamination of groundwater sources. However, given the expected limited extent and low vulnerability of groundwater, the risks to people and the environment from groundwater pollution are not thought to be significant. Detailed information on the soil and groundwater conditions (including sampling for contamination) was collected as part of the 2016 ground investigation and is presented in in Section 9 – Land Quality.

7.1.12 Water Resource

Ghana has significant water resources including its many dams and reservoirs. However, whilst rich in water availability, Ghana still faces significant water supply challenges, including intermittent supply, high water losses and low water pressure. The water sector has been under reform for over 20 years, including privatisation, decentralisation of rural supply and increased community participation in the management of rural water systems.

The lack of large regionally expansive aquifers capable of sustaining industrial scale abstractions means that water supply for Tema’s industries (and for the project) comes from surface water abstractions, urban reticulation networks (operated by the Ghana Water Company, GWC, since 2000) from surface water reservoirs or from project specific sea water desalination.

GWC supplies water to the TTPC and other industrial users in the Tema Heavy Industrial Area (THIA). GWC has indicated that it can supply all the water needs of the project via a new pipeline from its local reticulation system to the power facilities. EPL is engaging with GWC to confirm that this supply can be provided without affect supplies to other water users, including vulnerable communities.

7.1.13 Seismicity

Seismic studies have indicated that Ghana's seismicity is associated with active faulting, particularly near the intersection of the east-west trending Coastal Boundary Fault and the northeast trending Akwapim Fault Zone.

Southern Ghana is not a highly active seismic area; however, it is a region capable of producing significant earthquakes and previous studies have identified an earthquake risk due to a periodically active seismic area approximately 100-200km east-southeast of the Tema area. Risk of earthquakes and associated tsunami (in respect of the jetty and pipeline facilities) will need to be considered in the detailed design.

7.2 Oceanography

The oceanography of the West African region is influenced by the meteorological and oceanographic processes of the South and North Atlantic Oceans. The coastline in the region of Tema, consists primarily of sandy beaches with rocky outcrops.

The tide on Ghana's coast is regular and semi-diurnal. The tidal wave has virtually the same phase across the coast of the country. The average range of Neap and Spring tides increases from west to east. Tidal currents are low and have an insignificant influence on coastal processes except within tidal inlets.

Long term records of tide levels have not been identified for Tema. Therefore, data from Takoradi in the west of Ghana have been analysed[3]. These records suggest a mean sea level of 0.9m above chart datum and a maximum spring tide elevation regionally of 1.8m above chart datum (the lowest astronomical tide).

No conversion factors have been identified to convert chart datum into the World Geodetic System (WGS) 1984 datum that the STRM topography data is based on. However, as the WGS1984 datum is based on average sea level, it is assumed that subtracting 0.9m from water levels quoted in reference to chart datum will give a reasonable approximation of the levels in respect to the WGS 1984 datum. This would mean that astronomical forcing, in isolation, could result in sea levels of around 0.9m above mean sea level.

Modelling across the Gulf of Guinea undertaken by the Nigerian Institute for Oceanography and Marine Research[4] suggests that storm surges associated with low pressure systems have historically elevated sea level by as much as 2m above the astronomical tidal elevation giving an indicative peak 'still' water level of 3.8m above chart datum. Wave action will also occur on top of this and the same study indicates that further along the coast, within the Gulf of Guinea under storm surge condition wave heights can reach as high as 4m. As wave heights are measured from crest to peak this means that wave action could realistically be expected to add a further 2m on top of maximum 'still' sea levels. Therefore, the peak tidal level expected in Tema would be approximately 5.8m above chart datum or 4.9m above mean sea level.

3 Mobile Geographics website, http://tides.mobilegeographics.com/calendar/year/6334.html, accessed 15/01/2015
4 Meteorological induced storm surge in the Gulf of Guinea: Consequences on coastal resources and infrastructure, PMB 12729, Nigerian Institute for Oceanography and Marine Research, 2008

7.3 Records of Historic Flooding

An internet search identified several reports of floods that occurred in June 2015[5] and 2010[6] which resulted in the displacement of large numbers of people mainly from communities adjacent to the Dzorlulu River in addition to a number of deaths. It was also reported that the 2010 floods also caused the shutdown of the TOR[7]. Whilst no detailed analysis of the cause of the flooding could be located, the reports generally refer to flash flooding and blockages or other deficiencies in the drainage infrastructure are commonly blamed which indicates that pluvial flood mechanisms are likely to be important.

Another record of flooding is detailed in a PhD thesis[8] which details floods in Tema resulting in damage to property in 2007, 2002, 1995, and 1988. However, the location of these floods relative to the site is not known, nor is the mechanism by which these floods occurred and no anecdotal information has been recovered from workers at the TTPC which indicates that that site has been subject to flooding.

During the various stakeholder consultation activities from the outset of the ESIA process, up until the May and June 2017 site visits, discussions were held with all relevant local authorities and multiple local stakeholders. No information was identified to indicate that the Watercourse 2 catchment has experienced any significant flooding historically.

7.4 Baseline Climate Profile

Developing a climate profile helps to identify the climate risks to which the project may be exposed and to assess sensitivity of the project to these factors. The profile is developed from meteorological and other records of previous climate events or climate hazards and projections of climate change. Its composition reflects the existing and projected climate risks which are posed within the project area. This profile includes a characterisation of the typical climate of the project area so that the site and operational sensitivity to exposure to climate events and hazards can be assessed.

7.4.1 Ghana's Regional Climate

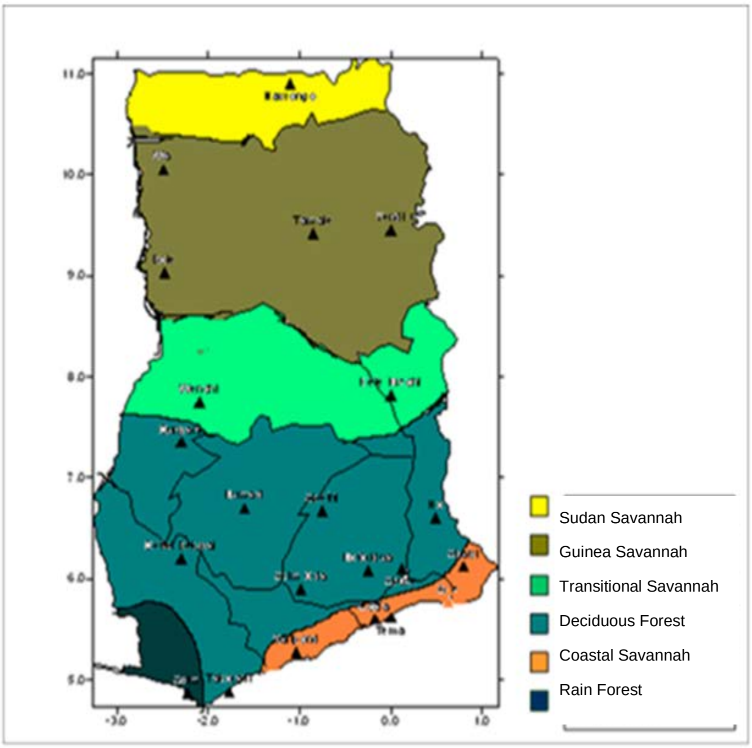
Ghana has a tropical climate characterised by prevailing high temperatures and variation in the amount, duration and seasonal distribution of rainfall. There are two main seasons; the wet and dry seasons. The occurrence of these seasons corresponds with the migration of the Inter-Tropical Convergence Zone (ITCZ) which is the location at which tropical continental and maritime air masses meet. The area of Ghana where the project is located has two periods of peak rainfall (April to June and September / October). Annual rainfall ranges from about 1,100mm (about 43in) in the north of the country to about 2,100mm (about 83in) in the southeast.

Ghana's Second Communication to the United Nations Framework Convention on Climate Change (UNFCCC 2011) split the country into six regional eco-climatic zones with varying

[5] http://citifmonline.com/2015/06/05/accra-floods-over-5000-tema-residents-displaced/ accessed August 2015
[6] https://www.modernghana.com/news/622671/1/tema-residents-mourn-victims-of-circle-fire-and-fl.html accessed August 2015
[7] http://www.modernghana.com/news/281377/1/tor-pleads-calm-as-floods-force-plants-shutdown.html accessed August 2015
[8] V. Ametefe (2009) Using reservoir Storage effects for urban flood management: Case Study of the Mamahuna Basin of Tema Phd Thesis College of Civil and Geomatic Engineering

conditions across the country. These range from Sudan Savannah region in the North to Rainforest in the South West. The Project is located in an area that is termed Coastal Savannah on the South East Coast.

Figure 7-4: Ghana's Eco-Climatic Zones



Variations in temperature both annually and daily are quite small. Throughout the year, maximum temperatures are around 30°C, dropping three or four degrees during the brief respite between rainy seasons with minimum temperatures of around 23°C. The coolest time of year is between June and September when the main rainfall occurs. The humidity is constantly high, at about 80%.

During the dry season, Ghana is influenced by the northeast trade wind system. A dry desert wind, known as the "Harmattan'', blows from the northeast. The wind is relatively free of clouds and rain, and is cool, dry, but dust-laden. During the wet season, the south east trade winds bring increased cloud and precipitation.

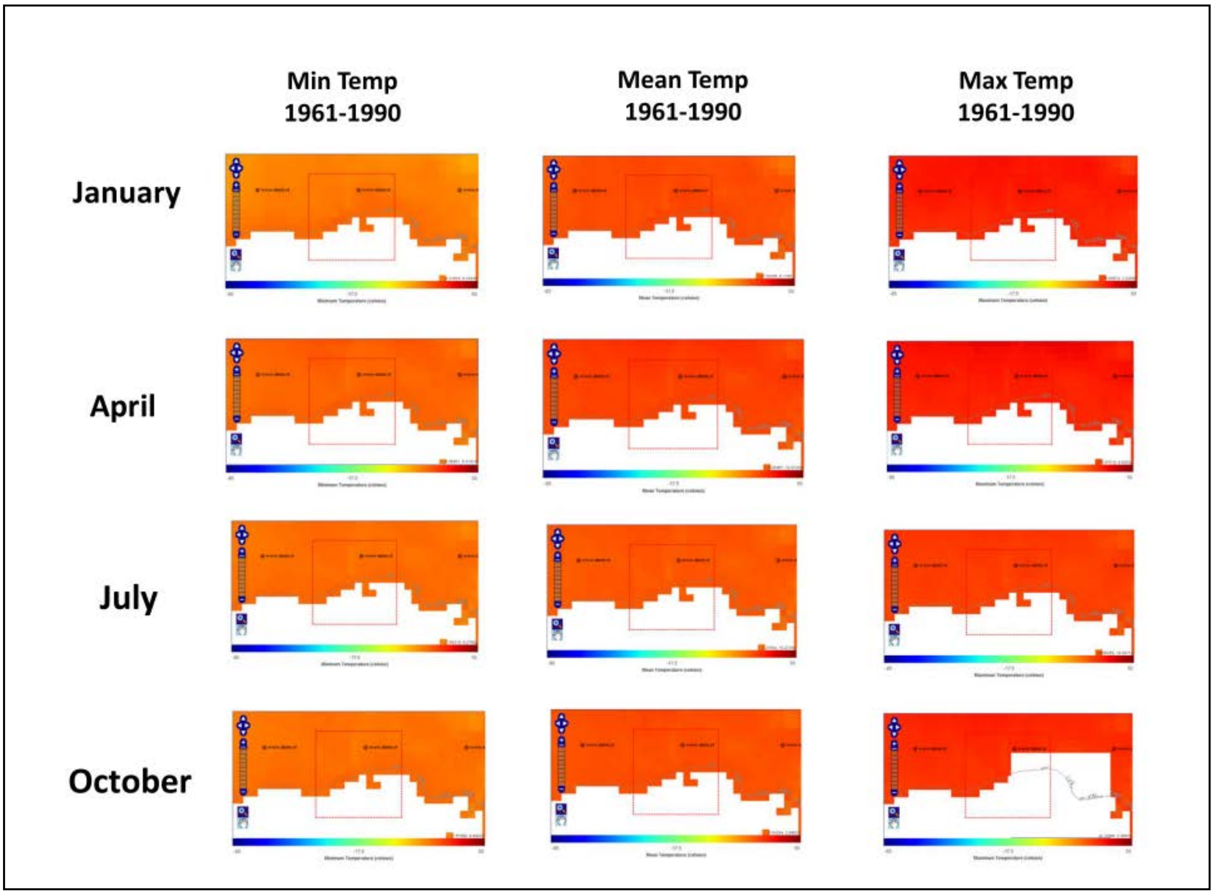
Overall, the climatic conditions across Ghana are characterised as warm and comparatively dry along the southeast coast, where this Project is located; hot and humid in the southwest and hot and dry in the north.

7.4.2 Local Climate

Temperature

Provided in Figure 7-5 are screen shots of temperatures at the project location taken from Observed climate conditions: 30 year averages from the Climatic Research Unit (CRU) dataset (http://www.ipcc-data.org/maps/). The data in this figure are consistent with the relatively stable temperatures, as outlined in the previous section.

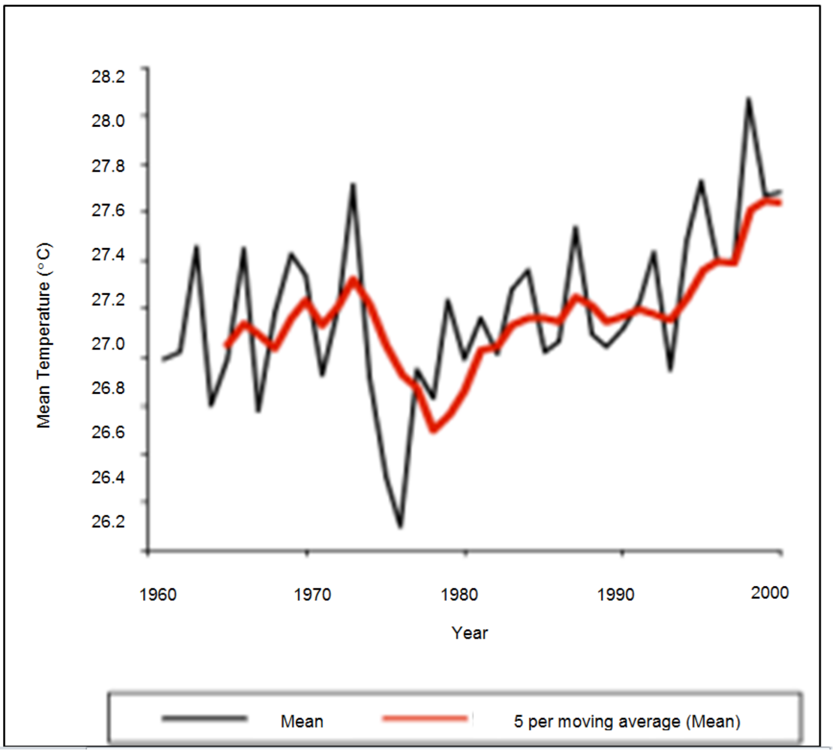
Figure 7-5: Minimum, Mean and Maximum Temperature at the Location Site from 1961-1990



The scale is measured in degrees Celsius, with the left hand blue end being -85°C and the right end being 50°C and the middle point being -7.5°C.

Figure 7-6 below, taken from Ghana's Second National Communication to the UNFCCC 2011), shows mean annual daily temperature in the Coastal Savannah Zone (1961-2000) where the Project is located. This shows an increasing mean temperature over the last 40 years.

Figure 7-6: Mean Annual Daily Temperature in Ghana



Available temperature data indicates a warming climate in Ghana with the drier northern area warming more rapidly than southern Ghana. Since 1960 for Ghana as a whole, mean annual temperature rose by 1.0°C. (United Nations Development Programme (UNDP) 2010).

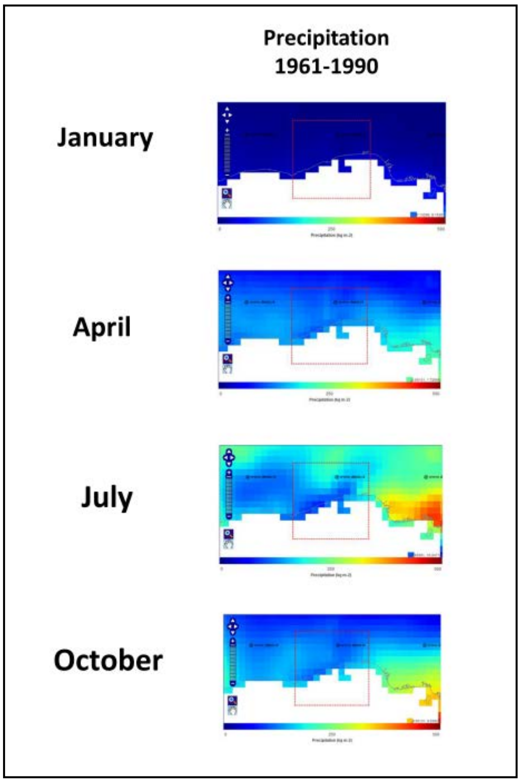
According to the UNFCCC (2011) the Coastal Savannah region where the Project is located in Ghana increased from 27.0°C in 1960 to 27.7°C. This report notes that small changes of only 0.1°C can have significant impacts on the ecology of the area.

A "hot" day is defined by the temperature that is exceeded on 10% of days in the current climate in the region and season. Similarly, "cold" days are defined by the temperature below which 10% of the coldest days or nights are recorded in the current region and season. The frequency of "hot" days and nights in Ghana increased from 1961 to 2003, whilst the number of cold days decreased over the same period.

Precipitation

Figure 7-7 shows screen shots of precipitation at the Project location taken from 30 year averages based on observed climate conditions from the Climatic Research Unit (CRU) dataset (http://www.ipcc-data.org/maps/). The Project location is shown by a red box on the screen shots. The screen shots show that rainfall is seasonal with the lowest rainfall occurring in January and highest rainfall in July.

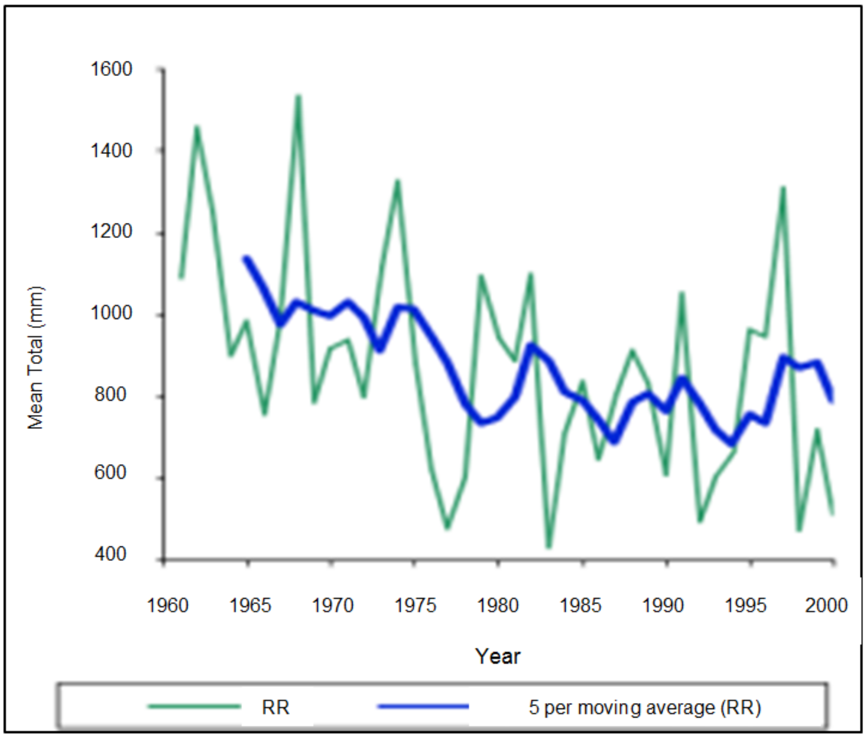
Figure 7-7: Precipitation at the Project location from 1961-1990



The measurement scale from left to right:
with dark blue being 0 kg/m^2 of rainfall and to red being 500 kg/m^2.

Annual rainfall in Ghana is highly variable making identification of long-term trends difficult. In the 1960s, rainfall in Ghana was particularly high and decreased to lower levels in the late 1970s and early 1980s. This leads to an overall trend of decreasing rainfall in the period 1960 to 2006, of an average 2.3mm per month (2.4%) per decade. A fall in annual rainfall over the last 40 years is supported by the Ghana's Communication to the UNFCCC outlined in Figure 7-8, below.

Figure 7-8: Mean Total Annual Rainfall in the Coastal Savannah Eco-Climatic Zone from 1961-2000



There was no evidence that extreme rain events have either increased or decreased since 1960 (United States Agency for International Development (USAID) 2011).

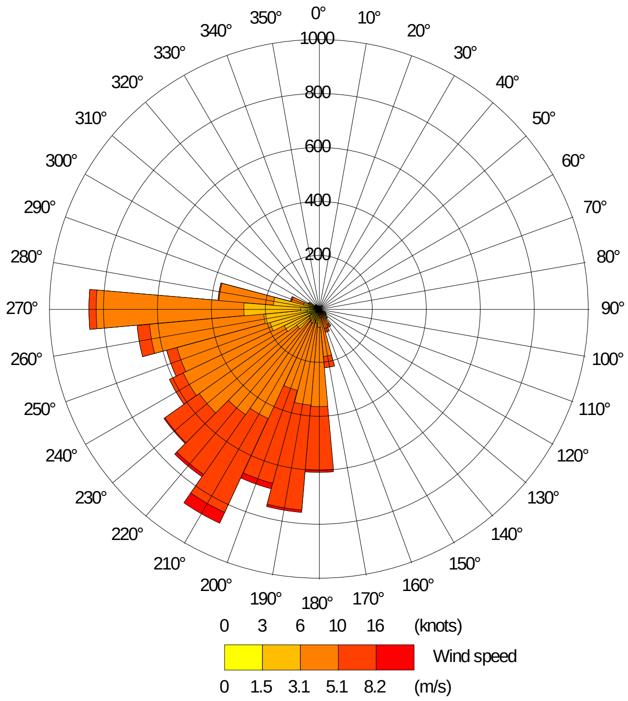
Rainfall intensities recorded in the Greater Accra area of Ghana can be high. Rainfall intensity duration frequency (IDF) curves developed for Tema, indicate that rainfall intensities in excess of 100mm/hr can be expected during short duration storms with an annual exceedance probability of 10% or less (Logah, et al 2013).

Wind speed and Direction

Wind data were obtained for Accra airport, which is located approximately 22km west south-west from the proposed site, between 2009 and 2014. These indicate a prevailing south-westerly wind with relatively constant wind speeds, predominantly ranging between 3m/s and 5m/s, but occasionally dropping to 0m/s or rising to over 8m/s. Research and current available data indicate that there is no recorded occurrence of cyclones.

The wind rose for the region (Accra airport 2014) is shown in Figure 7-9.

Figure 7-9: Wind Rose for Accra (2014)



7.5 Noise

The new development is situated in an industrial area, with nearest residential receptors located approximately 2.1km south of PPS1.

Associated Consultants has undertaken baseline noise measurements at three off-site locations which are shown in Figure 10-1 of Section 10. Measurements at Sraha are considered to be representative of the noise environment at residential areas to the west and north. Measurements at Newtown are considered to be representative of the residential areas to the south of the site and the VRA Station is considered to represent the industrial area surrounding the site.

In addition, Jacobs undertook noise monitoring adjacent to the JQ workers Accommodation Buildings in May 2017.

The measured noise levels are set out in Appendix A to this ESIA, the Noise Technical Appendix, and are summarised in Table 7-3 below.

Table 7-3: Measured Baseline Noise Levels, dB

Location	Period	L_{Aeq}, dB			L_{A90}, dB		
		Min	Max	Average	Min	Max	Average
VRA Station 1	Day	58	67	60	51	59	56
VRA Station 1	Evening	59	66	61	52	59	56
VRA Station 1	Night	49	62	57	43	60	52
Sraha	Day	55	68	62	47	57	53
Sraha	Evening	60	67	62	51	56	54
Sraha	Night	26	60	35	26	41	29
Newtown	Day	46	62	53	42	51	46
Newtown	Evening	50	60	54	44	51	47
Newtown	Night	26	58	34	26	53	30
JQ Workers Accommodation	Day	44	62	51	40	53	43
JQ Workers Accommodation	Evening	48	52	49	45	50	47
JQ Workers Accommodation	Night	44	52	48	41	51	45

As the existing night-time noise levels are currently below the International Finance Corporation (IFC) absolute guideline levels, the assessment criterion will relate to the lowest of the fixed EPA limits or IFC guideline levels.

The ground level in and around the site is assumed to be generally flat and therefore there are not expected to be any topographic screening effects for noise generated by the development The intervening ground between the Project and the closest dwellings is generally natural scrub land, and therefore is considered to be acoustically porous.

7.6 Air Quality

7.6.1 Introduction

Data on the existing air quality baseline was drawn from publically available information supplemented by new monitoring undertaken at 6 locations surrounding the new plants.

7.6.2 Sources of Air Pollution in the Study Area

The main sources of air pollution in the vicinity of the proposed project site are emissions from industrial facilities within the Tema Industrial Area. Table 7-42 presents the known facilities currently operating which are likely to contribute to ambient concentrations within the industrial area and surrounding residential areas.

Table 7-42: Industrial facilities within proximity of the Ghana Bridge Site

Facility Type	Capacity	Fuel Type	In Operation (start date)	Approximate Distance from PPS1	Direction (from PPS1 / PPS2)
Mines Reserve Plant (MRP)	80 MW	Gas	Yes (unknown)	0.7km	WSW (PPS2)
CENIT Thermal Power Plant	220 MW	LCO/ Gas	Yes (2012)	0.6km	SW (PPS2)

Facility Type	Capacity	Fuel Type	In Operation (start date)	Approximate Distance from PPS1	Direction (from PPS1 / PPS2)
VRA Thermal 1 Power Plant (TT1PP)	220 MW	LCO/ Gas	Yes (2009)	0.6km	SW (PPS2)
Trojan Power Ltd – Tema I	26 MW	Gas / Diesel	Yes (2010)	110m	SW (PPS2)
Trojan Power – Tema II	21 MW	DFO	Yes (unknown)	115m	WSW (PPS2)
Trojan Power Ltd – Tema III	56 MW	Gas	When gas available (2016)	115m	WSW (PPS2)
VRA station 3	32 MW	Gas / Diesel	Yes (unknown)	0.03	SW
VRA Station 3 upgrade	42 MW	Gas / Diesel	14 MW commissioned, others built	0.005	SW
Cenpower Kpone Independent Power Plant	350 MW	LCO / Diesel / Natural Gas	No (2016)	2.5	E
Sunon-Asogli Power Plant Phase 1	200 MW	Natural Gas	Yes (Unknown)	3.4	E
Sunon-Asogli Power Plant Phase 2	360 MW	Natural Gas / LCO	Yes (Unknown)	3.4	E
Tema Oil Refinery	-	Crude Oil	Yes (unknown) Stopped during 2015	1.0	W
AKSA Heavy Fuel Oil (HFO) Power Plant	200 MW	HFO	Yes (2017)	~0.8km	NNW
Karpower Ship	225 - 450 MW	HFO	225MW operating 2016 (new 450MW ship late 2017)	~5 km	SW (PPS1)
Tema Steel	-	-	Yes (unknown)	2.2	NNW
Sentuo Steel	-	-	Yes (unknown)	0.8	S
Valco Aluminium Smelting (VALCO)	-	-	Yes (2011 at 20%) Stopped 2007-2011	1.4	S

Note: The operation of gas-fired plants is intermittent as limited by availability of gas.

The wider environ, beyond approximately 2km around the power plant sites, is predominantly residential / commercial in character. As a result of unreliable power supply in the area, the use of diesel run domestic/ commercial-scale power generators is one of the primary emission sources within neighbouring townships. Other sources include the burning of household / commercial wastes, residential wood and charcoal ovens, road traffic emissions and re-suspended dust / particulate matter from poorly surfaced or unsurfaced roads. These sources collectively contribute to increased emissions of substances associated with combustion in addition to those emitted by road traffic, for example, nitrogen dioxide, sulphur dioxide, particulates and carbon monoxide.

The presence of poorly surfaced roads is also likely to lead to high levels of dust generation during the dry season. During the rainy season the potential for dust generation is lower. Emissions of particulate matter (PM) or sulphur dioxide (SO_2) are not considered in this assessment as LPG will not give rise to significant amounts of particulates.

7.6.3 Published Air Quality Data Relevant to the Project

A desktop review of publically available ambient air quality information was undertaken and it appears that existing robust data (of the key pollutants in this assessment) is either not available from the EPA or not made public by the individual plants operating in the area.

The most relevant publically available data was from the Kpone IPP ESIA, 2013. This comprised monitoring for seven months in 2004 between April and November for the pollutants SO_2 and CO, with additional monitoring in 2008 for the pollutant NO_2. This involved a six week survey between August and October which measured average NO_2 levels between 11 µg/m^3 and 14 µg/m^3. The higher NO_2 concentration was adopted in the Kpone ESIA, along with the monthly mean SO_2.

Table 7-5: Assumed Ambient Annual Average data for Kpone Power Plant Site, 2013

Measurement	Pollutant Concentration, µg/m^3 (EPA AAQG)		
	NO_2 (40)	SO_2 (50)	CO
Period Average	14.0	21.0	<DL

<DL = below detectable limits

As shown, the measured CO concentrations were below detectable limits for the duration of the monitoring period, and are considered to be trace/ negligible.

7.6.4 Project Specific Monitoring

Due to the lack of current data and the fact that the published data from the proposed Kpone plant is 2.5km to the east, the project commissioned six months of monitoring at a number of locations around the project site in 2015 for nitrogen dioxide (NO_2) and sulphur dioxide (SO_2).

An additional six-month monitoring programme commenced in April 2016 for the pollutants NO_2 and ozone, the latter being added to enable the derivation of a site specific conversion factor for the oxides of nitrogen emitted from the plant, mainly in the form of nitric oxide (NO) to NO_2, which is harmful to human health. As SO_2 is not a significant pollutant from LPG and back up operation on DFO was not considered at that time, no additional background SO_2data was collected in 2016.

The 2016 monitoring included two additional locations within the residential area of Tema New Town, downwind of the project site and in a residential area where cumulative impacts may be significant.

These monitoring locations are shown on Figure 11-2 in Section 11 and described in Table 7-6 below..

Table 7-6: Monitoring Locations around Development Site

Sample Location	Distance from PPS1 to Monitor	Direction from PPS1	Relevant to Residential Exposures	Comments
1	0.7	ENE	N	Adjacent to a minor road servicing the industrial estate
2	2.9	NE	Y	20m from the roadside. Relevant exposure distance to dwellings opposite
3	1.7	ESE	N	Influenced by traffic, set back from busy Valco Rd ~50m
4	2.5	SE	Y	10m from a minor industrial estate road. Concentrations likely to be lower at relevant residential locations, given these are set back further from the road ~30m
5	1.9	WSW	N	30m from Sanyo Rd, within the Industrial Estate. Nearest dwellings ~80m W of monitoring site.
6	0.8	NE	N	Adjacent to a minor road servicing the industrial estate
7	4.0	E	Y	2016 monitoring only: within the residential area of Kpone, downwind of project site
8	4.1	E	Y	2016 monitoring only: within the residential area of Kpone, downwind of project site

The measured pollutant concentrations provide background measurements for the area and are used to ascertain whether the proposed site is within a degraded or non-degraded air-shed. 'Background' is the average concentration of pollutants present in ambient air and is used to enable assessment of the impacts of particular emission sources to air without the need for all sources in the area to be considered explicitly.

The air quality monitoring was managed by Associated Consultants, which has experience of air quality monitoring in Ghana, and was undertaken using passive diffusion tubes. The tubes were supplied and analysed by Gradko International Limited (Gradko) based in the UK. Gradko is a reputable supplier and analyst, and is accredited to undertake the analysis in line with the requirements in the UK, providing services to many local authorities as part of the national reporting requirements.

Triplicate sets of passive diffusion tubes were deployed at each monitoring location and the results averaged to provide a reading for each monitoring period.

The average concentrations are shown by location in Table 7-7, as well as the overall mean results from the work.

Table 7-7: Summary Results for NO_2 and SO_2 Monitoring

Sample Location	Concentration, µg/m^3 (EPA AAQG)			Distance from site to Monitor (km)	Direction from site
	NO_2 2015 * (40)	NO_2 2016 (40)	SO_2 * (50)		
1	22.0	20.8	5.20	0.7	ENE
2	19.2	15.8	6.77	2.9	NE
3	28.5	25.0	7.94	1.7	ESE
4	19.7	29.0	5.85	2.5	SE
5	20.8	25.6	4.47	1.9	WSW
6	25.6	26.2	9.87	0.8	NE
7	-	24.4	-	4.0	E
8	-	31.7	-	4.1	E
Mean	**22.6**	**24.8**	**6.7**		

* Mean of six rounds of one month duration
** Result of one round of two weeks' duration

Concentrations of both NO_2 and SO_2 were below the Ghana EPA Annual Air Quality Guideline concentrations at all locations and over all of the monitoring rounds. The results indicate that the area is not within a degraded air-shed for NO_2.

The averaged concentration of available data (of the monitoring locations) is considered to be representative of areas where the closest sensitive receptor locations have been identified and is an appropriate value to use. The mean NO_2 concentration of 24.8 µg/m^3 from the most recent monitoring was therefore utilised as the baseline concentration for the assessment work reported in Section 11, to represent a conservative approach.

The short term NO_2 background concentration is assumed to be the annual mean background concentrations multiplied by two. This is also well below the EPA/WHO guideline of 200 µg/m^3.

In the absence of specific monitored background CO concentrations, the concentration of 140 µg/m^3 was adopted as the baseline ambient air concentration based on information within the WHO Air Quality Guidelines report (2000)[9].

7.7 Landscape and Visual

7.7.1 Overview

This baseline assessment process comprises desk study and analysis. As part of the desk study, the baseline landscape and visual resource was defined within a 5km radius study area and the main users of the area, key viewpoints and key features were identified. Existing map and written data on the application site and its surroundings within the study area were reviewed, including:

[9] WHO Air Quality Guidelines for Europe – second Edition, Chapter 5.5 Carbon monoxide, 2000

- Survey data (mapping and aerial photography) for the application site; and,
- Plans/elevations of the proposed development.

The potential extent of visibility of the proposed development was identified by reference to map data. The desk survey also identified potential visual receptors likely to be sensitive to and affected by the proposed development. From these sensitive receptors a representative range of viewpoints was selected according to the following criteria:

- Type of receptor – residential, recreational, footpath, road etc. including different landscape character types as appropriate;
- Distance of receptor from proposed development; and,
- Direction of the receptor from the proposed development, with the aim of achieving a distribution from different compass points around the application site.

A detailed description of the project including the power plants and tank farm sites and pipeline infrastructure is provided in Section 2. The location of the development site to the Project and the extents of the study area are indicated in Figure 12-1, Section 12.

7.7.2 Landscape Character

The landscape character to the development site can be broadly characterised as one of two types, these being:

- 'Industrial Land' Landscape Character Type (LCT). Characterised by the presence of an extensive areas of industrial units, lay down areas, Valco aluminium works, the TOR and tank farms. This LCT, for the purposes of this assessment is considered to be of low sensitivity to change and be of low value, reflecting its brownfield status and surrounding industrial usage, clearly defined industrial qualities, and that the Project is in itself of an industrial nature; and
- 'Residential' LCT. The Residential LCT is characterised by housing, typically low rise, interspersed by small scale residential, commercial and public buildings. These areas are located over 2km from the plant and tank farm sites. This LCT for the purposes of this assessment is considered to be of medium sensitivity to change associated with the Project owing to the prevalence of low rising housing and amenity value of some areas.

The extents of these character types are illustrated on Figure 12-1, Section 12. The project is identified as falling within the Industrial Land LCT.

7.7.3 Landscape Designations

No designated sites of landscape value were identified in the vicinity of the study area.

7.8 Ecology

7.8.1 Introduction

This section provides an overview of Ghana's biodiversity and ecological importance, international context with respect to conservation, and a summary of the on-site ecology.

7.8.2 Global Context

Biodiversity richness

Ghana consists of richly biodiverse habitats which include forests and savannah. The eight types of forest (including mangrove) are mainly located in the southern-western regions. The remaining land is typically either a transition forest or savannah. The 1992 Convention of Biological Diversity (CBD) estimated that Ghana supports 3,600 species of flora, 221 species of reptiles and amphibians, 728 species of birds and 225 mammalian species. Out of these 1,174 animal species, eight are thought to be endemic to Ghana (Ministry of Environment and Science, 2002). The high forest regions account for an estimated 83% of the species presence. Ghana has the greatest number of butterfly species in Western Africa, with over 85% of western African species being found there, more species than Europe and North America combined. It also has a high degree of butterfly endemism, with 23 species being classified as endemic or near endemic (Larsen, 1994). It is thought that another 5% of butterfly species are yet to be found. This demonstrates Ghana's important role in the world's biodiversity.

In the shallow waters of the Ghanaian coast, many of the soft bottom benthic macro-fauna are thought to be new and previously unrecorded. The coastline is lined with lagoons, several river estuaries and rocky shores. Within the adjacent marine environment, up to four threatened species of turtles are present of which one is now thought to be locally extinct (Ministry of Environment and Science, 2002).

Status and trends of biodiversity, main pressures and drivers of biodiversity changes

Threats to the biodiversity of Ghana are typically anthropogenic. They can be classified into eight categories: land use conversion, habitat degradation, over exploitation, invasive alien species, climate change, predation, wild fires and poaching (CBD). From these categories, the International Union for Conservation of Nature (IUCN) has written that the main threats to Ghana's biodiversity are poaching, bush fires and land conversion for grazing and farming (Ministry of Environment and Science, 2002).

In 1992, deforestation was estimated at 1.3% per annum (CBD). Logging of the forest causes simplification of the ecosystem which in turn increases pressure on species. Deforestation can often lead to desertification which can in turn result in increased flooding and reduced farming productivity. Another cause of deforestation is mining. Ghana has long standing gold, diamond, bauxite and iron ore mines. In particular, the chemicals used during gold mining causes serious threats the biological rich forests (Ministry of Environment and Science, 2002).

7.8.3 Site Context

The project location and surrounding areas are described in Section 1 (overview) and Section 2 (detail). The project sites are situated within the middle of a heavily industrialised area characterised by tank farms, oil refinery infrastructure, aluminium works, in addition to industrial sheds and lay down areas. Beyond the industrial area the land use is given over to extensive areas of residential development.

Current habitats are typical of a brownfield site and include bare ground, rough grassland and secondary habitats such as patches of shrub or bush-like vegetation.

The field ecology reports (Appendices D1, D2 and D3) describe the results from desk-based research and field surveys of the tank farm site (2015), PPS1 (2016), and PPS2 and the pipeline route (2017). The survey results report mainly grassland vegetation (dominant species is *Sporobohis pyramidalis*) with low biodiversity. Over all the areas surveyed, 59 unique species of flora were identified, as well as one reptile, twelve birds, one mammal and three insect species. Of the bird species observed, Cattle egret (*Bubulcus ibis)* is completely protected under the Ghanaian Wildlife Conservation Regulation and is of national importance. No nests were identified, and as a migrant species it may only be a visitor to the site rather than an inhabitant. Fruiting trees such as mangos and avocado were recorded on site, along with the invasive Neem tree (*Azadirachta indica)*. The chaff flower (*Achyranthes sp.)* is a member of a group of species of which some are of conservation importance. It was encountered rarely, being present only in a single stand.

A desk study identified 87 wildlife species within the locality of Greater Accra. Of those, two are noted to be of conservation importance, Hooded vulture (*Necrosyrtes monachus)*, and straw-coloured fruit bat, (*Eidolon helyum)*. IUCN lists these species as Endangered and Vulnerable respectively; however, these were not viewed during the field survey. Even though the development sites are thought to be of little ecological importance, Ghana is a very biologically rich country.

7.8.4 Nationally/Internationally Recognized Legally Protected Areas (IUCN Protected Area Management Categories)

While the development sites are not within a nationally or internationally recognized protected area, it is worth noting any such features nearby.

In 2011, International Union for Conservation of Nature (IUCN) stated there were 21 wildlife protected areas, of which seven are national parks, six are resources reserves, two are wildlife sanctuaries, one is a strict nature reserve and five are coastal wetlands, totalling 1,347,600ha of protected land (IUCN Parks and reserves of Ghana). However, the area and number of protected sites dramatically increases if national and local designations are also included.

Within 30km of the site, three nationally designated forest reserves are located:

- Dechidan Stream;
- Fiankonya Stream; and
- Chipa Tributaries.

Dechidan Stream is the closest of the three, approximately 13 km from the Project sites.

Ghana's environmental legislation has been poorly implemented resulting in areas outwith the reserves having little to no protection. As a result, the non-protected habitats have generally been lost, causing fragmentation of the remaining reserve areas. The management across the reserves are under resourced, poorly coordinated and therefore not consistent.

Ramsar sites

There are six Ramsar sites in Ghana, however only three Ramsar Coastal Wetland sites are located within 70 km of the power plant sites:

- Sakumo (6 km from sites);
- Songor Lagoons (30 km from sites); and,
- Anlo-Keta Lagoons (70 km from sites).

Sakumo Lagoon has a narrow connection to the sea. It is thought to support over 70 species of birds. The lagoon also supports fish species, notably 97% of the blackchin tilapia population. It is suffering from urbanisation and pollution (Ramsar, Sakumo Ramsar Site).

Songor Lagoon is associated, along with Anlo-Keta lagoons, with the Volta River; however, direct connection has now been blocked. Its only connection with the sea is via diffusion through the narrow sand dune separating the lagoon and the sea. The lagoon is 50cm deep at its deepest point. The invasive Neem tree is colonising the area. Three species of turtle nest along the beach and over 50,000 tern nests have been counted during September and October (Ramsar, Songor Ramsar Site).

Anlo-Keta Lagoon is fed by three rivers and is, for most of the year, closed off from the sea by a narrow ridge of land. It is thought that the construction of the Akosombo Dam, upstream on the Volta River has cause significant ecological changes to the lagoon. The lagoon has been recorded to be used by over 76 species of birds. Birdlife has identified the lagoon to be the fourth most important site in the Gulf of Guinea.

7.8.5 Relevant Internationally Recognized Areas of Conservation Importance

Key Biodiversity Areas (KBAs)

Key Biodiversity Areas (KBAs) are areas that fulfil globally standardised criteria however are nationally identified. Their purpose is to safeguard viable species populations for the benefit of global conservation. 44 KBA exist within Ghana. The Ramsar and IBA sites noted above are included within the KBAs of Ghana.

Endemic Bird Areas (EBAs)

2500 species of birds are thought to have a global range of less than 50,000 km^2 and will thus be described as endemic to that area. Where two or more of these ranges overlap, the area is classified as an Endemic Bird Area (EBA) by Birdlife International. EBAs are important for conservation and indirectly help protect flora and other fauna. 70% of EBAs overlap with areas known to be important for plant endemism. EBAs are typically found on islands or mountainous regions and are typically a forest habitat.

Birdlife International has identified the Upper Guinea Forest as an EBA. This EBA spans over 5 countries; Côte d'Ivoire, Ghana, Guinea, Liberia, Sierra Leone and consists of 57 Important Bird Areas (IBA). Of these 57 IBAs, 25 are situated in Ghana predominantly in the south west. 15 endemic species with a further two unidentified species are thought to inhabit the Upper Guinea Forest.

None of the identified EBA are within close proximity to the site.

Important Bird Areas (IBAs)

Birdlife International have identified areas that, if safeguarded, would ensure the continuation of viable populations for most global bird species, these areas are known as Important Bird Areas (IBAs). Currently, there are approximately 12,000 IBA in over 200 countries. Less than 40% of IBAs have any form of protection while a lot have protection in writing but not in practice.

Within these 12,000 IBAs, Birdlife have classified 358 as “IBA in Danger” this refers to the potential imminent loss of the areas if nothing is urgently done. Birds are thought to be biodiversity indicators thus IBA are often situated in areas important for other flora and fauna species. In Ghana there are currently 40 IBA none of which are identified as “IBA in danger” (Birdlife 3).

As well as being classified as Ramsar sites Anlo-Keta Lagoon, Songor Lagoon and Sakumo Lagoon, have been recognised as IBA and marine IBA. Additionally, Shair Hills Resource Reserve is named as an IBA.

WWF Ecoregions – Global 200 sites

The WWF has identified ecoregions of global important which cover various types such as forest and woodlands, grasslands, savannahs and shrub lands, deserts, freshwater and marine ecoregions.

WWF identifies the Eastern Guinean lowland forests that extend through Ivory Coast and the southwest of Ghana, extending to within approximately 20km of the Project sites.

The area has been identified as a Global 200 Ecoregion as it contains high species richness with local and regional endemism. However, considerable areas of forest have since been converted to farming areas incorporating ‘farmbush’ and urban population continues to increase in the nearby city of Accra, including the site location which is highly industrialised. Therefore, sensitive flora and fauna components are unlikely within the proposed project site and its surrounding area.

7.8.6 IUCN Red List Species (Threatened status) known to exist in the project area

Terrestrial

As detailed in the baseline ecology reports (Appendix D) there are three species which are listed as threatened (“Vulnerable” or above) on the IUCN Red List that may be present within the vicinity of the site: one bird species, hooded vulture, (*Necrosyrtes monachus*); one bat species. straw-coloured fruit bat (*Eidolon helvum*) and a plant, the chaff flower (*Achyranthes* sp.). It should be recognised that the IUCN \Red List notes species range by country and generally do not give further details of the locality within those countries.

Marine

11 dolphins, 7 whales and 4 turtle species are resident to Ghana’s marine coastal habitat. Furthermore, manatees have been reported in Ghana. Of the 18 cetaceans, four species of dolphins and five species of whales are listed as Data Deficient (DD) on the IUCN Red List.

This may indicate there has not been enough targeted research to get reliable numbers, or that the species' life history prevents it from being studied, or that the limited information is a result of dangerously low population numbers. As a result of the potentially low population numbers, care needs to be taken around the DD species. The sperm whale is the only species of whale present in Ghana's waters that are not listed as DD or "of Least Concern" by IUCN Red list, but it is listed as Vulnerable (VU).

There have been arguments that stated the oil exploitation of the coast of Ghana is the cause for the recent surge in whales being stranded and consequently dying (Hirsch, 2013). Dolphins are often caught in fishermen's nets as a by-catch; however, there is evidence that indicate dolphins are also targeted prey.

The CBD in 1992 reported Ghana to have four species of marine turtles. However, their fourth report on Ghana states the Hawksbill turtle is now locally extinct in Ghana. Other sources now quote the presence of only three turtle species nesting in Ghana (Adjei et al 2001). The Hawksbill turtle is classified by the IUCN Red List as Critically Endangered (CR) and the IUCN does not include Ghana in its habitat range.

The leatherback and olive ridley turtle species are listed as VU while the green turtle is listed as Endangered (EN) by the IUCN. The Ghana Wildlife Society wrote an article for the Marine Turtle newsletter stating a key area for turtle nesting is the 80km stretch of beach between Prampram and Ada (Adjei et al 2001). Prampram is approximately 5km from Tema where the project will be located.

It would not be unreasonable to think the turtles may also be present on the beach in Tema, directly south of the brownfield site; however, the stretch of beach is not extensive and the project has no planned infrastructure in the vicinity of the beach. The main threat to turtles in Ghana is the result of illegal hunting for turtle meat by locals (Adjei et al 2001). With increased construction in the locality of the beach and thus increased lighting in the area may encourage more humans to approach the beach and interfere with turtle nests.

The West African Manatee is a VU species according to the IUCN and its habitat ranges from Angola to Senegal and in land to Mali. The West African manatee is located in Ghana, in particular in the flooded area created by the Akosombo dam in the Volta River. The dam was built in 1964 trapping a large number of manatees upstream. The dam caused a large area to flood creating suitable habitat for the manatees. The Ghanaian manatees have also been recorded in Songor Lagoon, 30km to the east of the site. With the locality of the manatees they may even encroach closer to the site than 30km.

The "Endangered Creatures" website lists 19 endangered fish species within the Ghanaian waters, although notes that potentially not all the EN species are listed. It is therefore important to ensure the water surrounding the site does not get contaminated with pollutants, to minimise the project's impact on fish, manatees, dolphins, other marine species, and their habitats.

7.8.7 Invasive Species

The field ecology report (Appendix D) noted Neem trees within the tank farm site. The Neem tree, found in numerous countries, is considered an invasive species with its ability to spread quickly and out compete native species. Within the Shair Hill Resource Reserve and Songor Lagoons, Neem trees are present and Ghana has devised a control programme for the Shair Hill Resource Reserve even though it has been relatively ineffective (Dowsett-Lemaire et al 2013).

7.9 Transport

7.9.1 Introduction

Baseline information on transport comprises both road traffic and ship traffic into Tema Port.

The sections of the road network for which baseline information is presented have been selected on the basis of the potential effect of increased traffic associated with the construction and operational phase of the project.

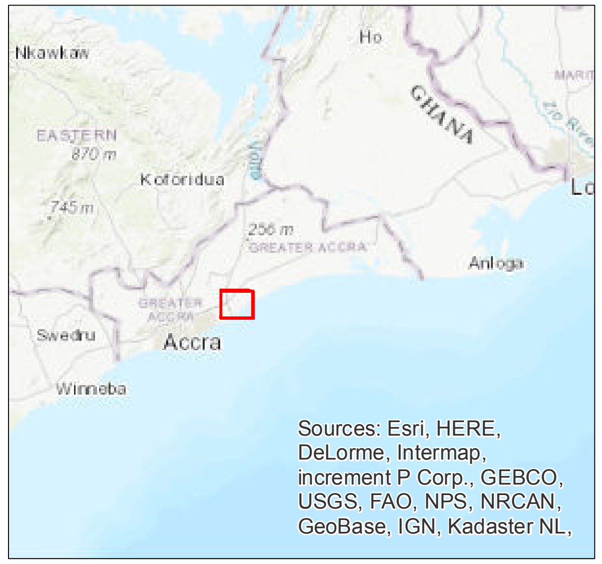
7.9.2 Highway Network

The key highway routes for the transportation of materials associated with the construction phase of the Project are shown in Figure 7-10, below.

Figure 7-10

Legend

- 12 " LPG Pipeline (Overground)
- 12 " LPG Pipeline (Underground)
- 8 " LPG Pipeline to Site (Underground)
- Diesel Pipeline
- Roads
- Ghana Bridge Power Plant Site 1
- Ghana Bridge Power Plant Site 2
- Diesel Tank Farm
- LPG Tank Farm
- Tema Oil Refinary



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1	17/07/2017	Initial Issue	PW	RS	LR	JPW

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Project

Ghana Bridge Power Project ESIA

Drawing Title

Local Road Network relevant to the Project

Drawing Status

Scale @ A3	1:40,000	DO NOT SCALE
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7.9.3 Baseline Traffic Data

In 2015, baseline traffic flow data was obtained from commissioned traffic surveys, between Monday 4th May and Saturday 9th May 2015. The baseline traffic flow data is reported in the Associated Consultants report 'Traffic Assessment for the Ghana Bridge Power Project, June 2015' provided in Appendix E1 to this document. The baseline traffic counts were undertaken on the following key roads which will accommodate construction traffic associated with the Project:

- Harbour Road between Tema Port and Harbour Roundabout;
- Harbour Road between Harbour Roundabout and Community Four Roundabout;
- Harbour Road between Community Four Roundabout and Tema Motorway Roundabout; and
- Aflao Road between Tema Motorway Roundabout and Thermal Village Junction.

In addition 24 hour traffic surveys were undertaken on Wednesday 19 August 2015 on the following roads:

- Valco Road;
- Access Road from Thermal Village Junction to Power Plant; and
- Access Road from Valco Road to the Tank Farm site.

For each traffic counter, the data has been processed to provide Average Daily Traffic (ADT) flows in each direction. The baseline daily traffic flows for each counter location are summarised in 8, below. The table also indicates the appropriate Urban All Purpose (UAP) road type as detailed in Table 7.9 and discussed in the Traffic and Transport Impacts Assessment, Section 19. Each UAP has an associated notional capacity derived from guidance within the Design Manual for Roads & Bridges (DMRB) Volume 5, Section 1, Part 3 TA 79/99 'Traffic Capacity of Urban Roads'.

Table 7-8: 2015 Baseline ADT Flows

No.	Route	Northbound Baseline ADT 2015 All Traffic (*Eastbound)	Southbound Baseline ADT 2015 All Traffic (*Westbound)	Combined Baseline ADT 2015 All Traffic	Combined Baseline ADT 2015 Heavy Goods Vehicles (HGVs)
UAP 1 - High standard single / dual carriageway road carrying predominantly through traffic with limited access. Speed Limit – 40 to 60mph for dual and generally 40mph for single carriageway					
1	Harbour Rd between Tema Port and Harbour Rbt (Dual C/Way)	12,320	12,890	25,211	3,392
2	Harbour Rd between Harbour Rbt and Community Four Rbt (Dual C/Way)	12,311	15,506	27,816	2,873

No.	Route	Northbound Baseline ADT 2015 All Traffic (*Eastbound)	Southbound Baseline ADT 2015 All Traffic (*Westbound)	Combined Baseline ADT 2015 All Traffic	Combined Baseline ADT 2015 Heavy Goods Vehicles (HGVs)
3	Harbour Rd between Community Four Rbt and Tema Motorway Rbt (Dual C/Way)	12,360	16,539	28,899	2,303
4	Aflao Rd between Tema Motorway Rbt and Thermal Village Junction (Dual C/Way)	15,423*	15,750*	31,173	2,135
UAP 2 - Good standard single/dual carriageway road with frontage access and > two side roads per km Speed Limit – Generally 40mph					
5	Valco Road (Single C/way)	4,536*	5,254*	9,790	1,743
UAP 3* - Variable standard road carrying mixed traffic with frontage access, side roads, bus stops and at-grade pedestrian crossings. Speed Limit – 30mph to 40mph					
6	Access Road to Power Plant (Single C/Way)	412	426	838	29
7	Access Road to Tank Farm (Single C/Way)	632	599	1,231	226
* - UAP 3 deemed to be most suitable category for the access roads					

Table 7-9: Road Type Capacities

Road Type*	Road Type Description	Two-way Daily Flow (vehs)
UAP 1	High standard single / dual carriageway road carrying predominantly through traffic with limited access.	48,960 / 172,800
UAP 2	Good standard single/dual carriageway road with frontage access and more than two side roads per km.	48,960 / 172,800
UAP 3	Variable standard road carrying mixed traffic with frontage access, side roads, bus stops and at-grade pedestrian crossings.	43,200
UAP 4	Busy high street carrying predominantly local traffic with frontage activity including loading and unloading.	36,000

A delivery route survey report of the key roads was undertaken on 16 May. The delivery route survey report provided by Associated Consultants is provided in Appendix E2 to this document.

7.9.4 Port Facilities and Shipping Traffic

Tema Port is the largest port in Ghana, occupying over 3.9 million m^2 of land area. The port receives an average of over 1650 vessel calls per year. These comprise container vessels, general cargo vessels, tankers, Ro-Ro and cruise vessels amongst many others.

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Section 8 – Socio-economic Baseline

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description gf Alteration		Rev No
Sep 2015	First issue		0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency		1
June 2016	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating the following changes:		2
	Section No.	***Change***	
	Wherever relevant	Reference to "power plant site" changed to reflect revised plan involving two power plant sites (PPS1 and PPS2).	
	Wherever relevant	Corrections to spelling, grammer and other changes for consistency. Abbreviated terms provided in full at first usage.	
	8.1	Refers to June 2016 update.	
	8.3	Description of PPS2 added.	
	8.6	Further details of PPS2 added, as well as updated information on the LPG and water pipelines.	
	8.13	Definition of "ecosystem services" added.	
August 2017	ESIA amendment issued to Ghana Environment Protection Agency, incorporating details of further project design changes, including:		3
	Section No.	***Change***	
	Wherever relevant	Details of revised power plant location changes.	
	Wherever relevant	Updated referencing to reflect supplementary baseline data collected.	
	8.3	Updated to reflect observations from 2017 site visits regarding new kiosks locations	
	8.16	Updates to site access roads to reflect new sites configuration.	
	8.5.4	Section removed due to relevance and repeat of information provided in earlier chapters.	

Contents

Figures and Tables

8 Socio-economic Assessment

8.1 Introduction

This section presents the socio-economic baseline of the area and established the existing characteristics of the surrounding communities. The information is based upon the Social Baseline Studies prepared by Associated Consultants Limited in September 2015 and updated in June 2016 along with supplementary data collected between October 2016 and July 2017. The information is used to inform the socio-economic impacts assessment which is provided in Section 20.

8.2 Sources of Data

In order to characterise the social setting of the project and those impacted by land acquisition and associated activities, a limited socio-economic survey, focus group discussions with key communities, and general consultation activities with adjacent businesses, local leaders, and institutions were conducted within the project Area of Influence shown in Figure 1-4a. A summary of key data sources is provided below.

Primary Data Collection

Key data sources included the following:

- IFC's Performance Standards on Environmental and Social Sustainability;
- District Profile for Kpone-Katamanso District;
- Social Baseline Studies for ESIA Ghana 1000 Gas to Power Project, One Energy, Ghana;
- Ghana Statistical Service (GSS), 2014. 2010 Population and Housing Census; District Analytical Report for the Tema Metropolitan Assembly;
- O P 4.01 Environmental Assessment;
- Ghana Health Service (GHS), 2012. 2010 GHS Facts and Figures; District Analytical Report for the Tema Metropolitan Assembly; and,
- www.ghanadistricts.com.

8.3 Study Area

A detailed description of the project location and surrounding land use context is provided in Section 1.2 and Section 2 and the locations shown on Figure 1-2.

The proposed project is located in Tema on the southeast coast in the Greater Accra region of Ghana. The project will consist of the construction of two power plants on two separate parcels, Power Plant Site 1 (PPS1) and Power Plant Site 2 (PPS2), along with a liquid petroleum gas (LPG) tank farm and associated fuel supply lines.

The project infrastructure is all located within the Tema Heavy Industrial Area (THIA), between Tema town and the district of Kpone, which has been zoned for industrial / commercial land use by the Tema Metropolitan Assembly (TMA) and Kpone Katamanso District Assembly (KKDA). PPS1, PPS2 and tank farm sites are located on brownfield land, approximately 4km north of Tema Harbour and a short distance to the east of the Volta River Authority (VRA) Tema Thermal Power Complex (TTPC).

The nearest formally established settlement to the power plant and tank farm sites is Tema New Town, which is located approximately 2km to the south. Kpone is located a similar distance to the east and several urban communities (Community Four, Community Seven, Community Eight) in the town of Tema are located a little over 2km to the west of the site.

In addition to the established communities in the area, there are also a number of informal commercial kiosks selling food and drinks and various other items in the industrial area. According to the TMA and KKDA, many of the businesses in the area are supposed to have canteens on the premises, but do not. Thus, many food and drink sellers have located in the vicinity as there are many workers to provide business.

During the 2017 site visits, it was noted that a number of new kiosks are present in the wider THIA, reflecting the continuing relatively rapid pace of development in the industrial area. This development is not within the control of the project and the majority of these kiosks will not be directly affected by the project. Management of this growth is the responsibility of the local planning authorities.

The 2017 site visits also identified a newly established residential dwelling approximately 200m east of the tank farm site. This dwelling has been established after the 2015 and 2016 baseline and supplementary studies for the original ESIA and ESIA amendment 1. Displacement impacts to this dwelling, will be considered as part of the Stage 2 resettlement planning process, as discussed in Section 20.

Data in this section is presented for the Tema Metropolitan Area, where the relevant project communities and project site are located and is supplemented by health statistics from the nearby Kpone-Katamanso District where specific community data for the Tema Metropolitan Area was not available.

8.4 Population Demographics

The total population of the Tema Metropolitan Area according to the 2010 Population and Housing Census (PHC) was estimated to be two hundred and ninety-two thousand, seven hundred and seventy-three (292,773) persons. In all, females were estimated to be more than their male counterparts representing 52.2% of the population, while males represented 47.8% respectively.

Table 8-1: Population Size of the Tema Metropolitan Area

Sex	Population Size	%age
Male	139,950	47.8
Female	152,823	52.2

Total	292,773	100

Source: Tema Metropolitan Analytical Report, (Ghana Statistical Service, 2014)

The average household size in the Tema Metropolitan Area is 4.1 persons per household with children constituting the largest proportion of the household at 34.1%. The Study Area has a migrant population of 166,506 (75.3%). In terms of nationality, 94.5% of the populations are Ghanaians by birth, 0.7% by naturalization, 2.4% dual nationality (Ghanaian and other) and the remaining 2.5% made up of foreigners. The highest proportion of the population is in the 25-29 year age group and the smallest being the oldest age group (95-99 years). The Tema Metropolitan area generally can be said to have a youthful population.

8.5 Project Area of Influence

Within the project area, three main communities were the focus of the baseline survey because they were in closest proximity to the proposed development and represented the main communities that employment would be likely to come from. These communities are identified as the primary area of influence for the social impact assessment. These include Tema New Town to the south, Kpone to the east, and Communities Four, Seven and Nine in Tema located to the west of the development (collectively referred to as Tema herein). Communities to the north of the project are located approximately 4.5km away and across a motorway and were, therefore, considered less likely to be within the project area of influence. Data on the population size for each of these communities is not available, therefore, information for the larger Tema Metropolitan Area is presented here.

8.5.1 Tema New Town

Tema New Town is the nearest settlement located approximately 2km to the south from the development sites and can generally be characterized as a mixture of mainly residential with light commercial and industrial properties. Tema Manhean is the native name of the Tema Newtown Community. According to the locals, the people of Tema migrated from Israel through to Ile-Ife in present day Nigeria. From Ile-Ife, the early settlers then migrated in batches to the current location of the Tema.

The late Dr. Kwame Nkrumah, the then President of Ghana, acquired the land of Tema for industrial development activities. The industrialization of the area created the need for the locals to resettle all over Tema especially around the harbour area. The main occupations at the time were fishing and farming. However, in later years, farming activities in the area have dwindled due to constant industrialization that has taken over the area. Although Tema Manhean is generally inhabited by the native Ga people, in recent times it has become a more integrated community, dominated by the Akans, Ewes and Ga-Adangbes. Due to the decline in economic activity in the area, poverty is becoming more prevalent. According to the Ghana Statics Services, about 80% of the inhabitants of Tema New Town live in poverty while the remaining 20% consist of an equal balance of average income and wealthy residents. Most residents in the area live in kiosks with no proper settlements.

8.5.2 Kpone

Kpone is located approximately 2-3km from the development sites to the east. Similarly to Tema New Town, according to the cultural history of local communities, the people of Kpone initially migrated from Israel through Ile-Ife to Ghana in the Eastern Region and eventually to Kpone driven by industry and political struggles. The town is divided into two major suburbs namely Jorshie and Alata. Prior to central governance in Ghana, the Kpone area was ruled and controlled by the traditional authority. Kpone is a largely residential area.

8.5.3 Tema

The nearest communities to the development sites (Communities Four, Seven and Nine) in Tema town are located a little more than 2km to the west. This area of Tema was initially built and developed by the Tema Development Corporation (TDC). TDC still owns much of the land in the area including the Tema Heavy Industrial Area (THIA). This area is considered largely cosmopolitan and would be characterised as a generally urban area with the typical market and services that generally accompany this. Many of the communities within Tema still utilize their traditional names.

8.6 Ethnicity and Religion

The traditional communities of Tema are predominantly of the Akan origination (mainly Fante). The ethnic groups in this area also include Ewe and Ga. Christianity is the predominant religion practiced in this part of Ghana. Traditional beliefs along with Muslims and atheists also have a presence in the community.

8.7 Indigenous People

According to the IFC PS 7, Indigenous Peoples are defined as social groups with identities that are distinct from mainstream groups. As such, they may be more vulnerable to the adverse impacts associated with project development and their needs must be carefully considered and protected accordingly. There are a wide variety of ethnicities in Ghana, however, based on the reconnaissance survey and other survey work completed for the project, no information has been identified which indicates that Indigenous Peoples are living within or directly adjacent to the project site. Therefore, issues associated with impacts to Indigenous Peoples from the project are not considered further in this assessment.

8.8 Economic Profile

The local economy can generally be divided into three primary sectors: agriculture (including fishing), industry and commerce/service. Industry would be the sector of highest activity in the metropolitan area due to the community's historic designation for industrial uses.

8.9 Agriculture

Although agriculture is recognized as the mainstay of the Ghanaian economy, agricultural activities are not very common in the Tema Metropolis due to its predominantly urban characteristics. Crop farming and livestock rearing are the main agricultural activities practiced here. The main livestock reared include chickens, which is the most dominant followed by goats and cattle. According to the 2010 PHC, about 3.6% of households are engaged in agricultural activities. Out of this, 74.7% engage in crop farming and / or engage in other activities: 27.3% rear livestock, 4.6% are in tree planting, and 1.0% are engaged in fish farming.

8.10 Industry

The Tema Harbour was officially opened in February 1962 and is the hallmark of economic activities in the Metropolitan Area. The Metropolitan Area serves as the industrial hub of Ghana with over 500 industries that produce chemicals, clothing, consumer electronics, electrical equipment, furniture, machinery, refined petroleum products, steel and tools. Tema houses the country's biggest port and harbour facilities.

Stone quarrying, sand mining and mineral deposits are the main industrial activities that are being carried out in the peripheral and remote areas of the District. The stone quarrying and sand mining operation is dominant as a result of the occurrence of granite in large quantities. The main areas of quarrying in the District are Ohiamadwen, Anto, Aboso, Kobina Andoh-krom, Apemenyim and Asemasa. Mining activities are usually practiced on a small scale and this is done close to rivers in the District with gold as the main product extracted by means of surface mining. The local government however hopes to partner with investors to extract these materials / minerals to the maximum benefit of the citizenry.

8.11 Commerce

There are over 20 financial institutions, such as, Ecobank, Zenith Bank, Ghana commercial Bank and Barclays Bank among others with branches spread throughout the Metropolitan Area. Almost all the major communities within the Tema Metropolis have market facilities, and this is due to the fact that the city was planned using the Neighbourhood Concept of Town Planning.

8.12 Ecosystem Services

The IFC PS6 guidance now recognises the importance of ecosystem services, whereby if a project is likely to adversely impact on ecosystem services, as determined by the impact assessment process, a systematic review to identify priority ecosystem services, and any impacts on Affected Communities must be avoided and impacts on the ecosystem services minimised. Ecosystem services are defined by the IFC (2012) as the benefits that people, including businesses, derive from ecosystems. They are organized into four types: (1) provisioning services (the products people obtain from ecosystems); (2) regulating services (the benefits people obtain from the regulation of ecosystem processes); (3) cultural services (the nonmaterial benefits people obtain from ecosystems); and (4) supporting services (the natural processes that maintain the other services). It was confirmed during the ecology baseline survey that ecosystem services are not impacted by the project as the area is largely industrial and this issue is not considered further in this assessment.

8.13 Quality of Life

The quality of life in the Tema Metropolitan Area is considered relatively high by the local community in comparison to neighbouring Accra. The focus groups for the project noted that the local communities in the Tema Metropolitan Area are relatively well planned in comparison to Accra because of the presence of a lot of industry. However, it was noted in that pollution is higher in the area due to the presence of substantial industry.

8.14 Water Supply

The availability of and accessibility to drinking water is considered to have an important influence on the health of household members. The main source of water supply in the Tema Metroplitan Area is from the Kpong water works. According to the GSS, approximately 49.4% of households use pipe-borne water inside dwelling units, followed by pipe-borne water outside dwelling units (25.4%), public tap/standpipe (16.0%), and sachet water (6.5%) as their sources of drinking water. Occasional breakdown of activities at the water works causes major water supply problems for people in Metropolitan Tema.

Water supply for the project is being provided by GWC. Discussions are ongoing between EPL and GWC in order to confirm that this water can be provided without risking the security of existing GWC supply to vulnerable users.

8.15 Solid Waste Disposal

Residents in the Area dispose of solid waste mostly by public dump via refuse containers. The 2010 Population Census indicates that 32% of households use the public dump (container) to dispose of waste, while 29.2% of households also use the trash collection method and 5.2% of households dispose their rubbish indiscriminately in the local District. The Tema Metropolis District contains a land fill site that is currently serving the District and other areas including the Accra Metropolis and Ashaiman Municipality. Odours and the visibility of the dump are becoming an issue of concern for the District.

8.16 Roads

The majority of the local road network in the Tema area was noted to be in good condition with sealed surfaces on main roads. The power plant and tank farm sites will be accessed by the main Harbour Road from Tema Port and via Valco Road. The distance from the port via this route is approximately 11km.

The majority of the road route to the site is suitable for heavy loads as required for delivery of the major equipment to the site (i.e. gas turbines, transformers etc.). Although the last section of the access road, from Valco road to the plant and tank farm sites, is a dirt/gravel road and will require some maintenance during the construction period. It is understood that there are existing municipal protocols in place for construction transport controls within the Tema Metropolitan area.

There are no significant roadway upgrades planned for the project given existing condition of the roads. However, some minor regrading of the access road from Valco road to the plant and tank farm sites may be required.

8.17 Cultural Profile

IFC PS 8 also recognizes the value of preserving community cultural heritage, which can include tangible resources of cultural value such as scared groves, sacred bodies of water or other natural resources and intangible forms of culture such as cultural knowledge, innovations and traditional lifestyles that could be impacted by a project.

There are already a number of industrial uses in the project area, so the influence of the proposed project on intangible aspects of culture is unlikely to be significant. In addition, no tangible resources of cultural value have been identified within the project site or its immediate vicinity. Therefore, issues associated with impacts to cultural resources from the project are not considered further in this assessment.

8.18 Educational Profile

The Ghana Education Service (GES) implements approved policies made by the Ministry of Education (MoE). In the Tema Metropolitan Area, educational concerns are addressed by the Metropolitan Education Directorate. The Area contains many public and private tertiary and pre-tertiary educational institutions.

Out of the 338 schools in the Metropolis, 185 are private and 153 are public schools. Also the area includes one fully fledged private university, the Datalink University, and satellite campuses for three other universities, namely, Presbyterian University, GIMPA and KNUST. In spite of the advancements of education in the Metropolis, the budget allocation for the education sector by the Metropolitan Assembly is consistently inadequate to meet local demand.

8.19 Health Profile

Tema contains both public and private health facilities that are spread across the entire Metropolitan Area and classified by type of facility, based on their functions and the range of services they provide. Some of the major health facilities include the Tema General Hospital, Nabita Hospital and the Port Clinic.

There are 46 health facilities in the public sector (54.2%), which is higher than the number of private health facilities (16 facilities accounting for 38.9%). This means that in terms of accessibility to health facilities in the Area, the public sector has a wider coverage in the provision of healthcare than most areas in Ghana. However, due to a rapid increase in the population of the Metropolis, expansion of health facilities both public and private has become necessary to meet the needs of the population.

The most common diseases in the Kpone-Katamanso District (which includes the project area) and their incidence rates are presented in Table 8-2 below.

Table 8-2: Common Diseases and their Incidence Rates in the Kpone-Katamanso District

Common Diseases	Number of Cases	Incidence Rates (%)
Malaria	14,400	37.4
ARTI (Anti-Retroviral Drug Regimen)	4,726	12.3
Skin disease and ulcers	1,961	5.1
Anaemia	1,839	4.8
Diarrhoea diseases	1,807	4.7
Acute urinary tract infection	1,693	4.4
Rheumatism	1,411	3.7
Total	**31,172**	**80.9**
All other	7,336	19.1
Grand Total	**38,508**	**100.0**

Source: Kpone-Katamanso District Health Office, 2014

8.20 HIV/AIDS

Data on HIV/AIDS in the District is not very comprehensive since the District is relatively new. A 2013 report by the Health Directorate indicated that 258 people were tested for HIV/AIDS, out of which 37 were positive: 28 males and 9 females. Although this represents a very limited data set, it shows that 14% of the population generally tested positive and that men represented a higher percentage of HIV positivity than women. This is consistent with the percentage of ARTI (anti-retroviral drugs) incidences cited above. Generally speaking, there is still a need to develop more education and sensitization programmes to promote HIV/AIDS awareness in the community.

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Section 9 – Land Quality

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description gf Alteration		Rev No
Sep 2015	First issue		0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency		1
June 2016	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating the following changes:		2
	Section No.	***Change***	
	Wherever relevant	Reference to “power plant site” changed to reflect revised plan involving two power plant sites (PPS) - PPS1 and PPS 2.	
	Wherever relevant	Corrections to spelling, grammar and other changes for consistency. Abbreviated terms provided in full at first usage.	
	9.3.3	Updates to the quantities and location of hazardous material storage.	
	9.4.1	Additional details on existing contamination on the two power plant sites (PPS 1 and PPS 2).	
August 2017	Subsequent ESIA amendment to reflect updated site configuration and the following changes:		3
	Wherever relevant	Updated to incorporate details of 2016 site investigation findings for what is now PPS1 (formerly PPS 2) and 2017 investigation of the new Stage 2 site and tank farm.	
	9.2	Addition of Ghanaian drinking water quality standards.	

Contents

9 Land Quality

9.1 Introduction

Land quality is a consideration in respect to potential risks arising from existing contamination at a development site, as well as the potential for additional impacts arising during construction, operation and decommissioning of the development. In this context, the term “land” comprises soil, sub-surface strata, groundwater and surface waters.

Contamination of land has the potential to harm people, buildings and building services, surface water and groundwater, and environmental receptors including land and aquatic-based flora, fauna and habitats. Contamination may exist in solid form, dissolved form, “free” (floating) form or as a gas. While sources are primarily introduced by human activities, natural sources may also contribute to local risks.

Baseline information on historic and surrounding land use, geology, hydrogeology and hydrology is provided in Section 7.1.

9.2 Assessment Standards

9.2.1 Soils and Sediments

No published Ghanaian national soil quality standards or guideline values have been identified. In the absence of national standards, the IFC EHS General Guidelines for Contaminated Land (2007) specify that other sources of risk-based standards or guidelines should be consulted to obtain comprehensive criteria for screening soil concentrations of pollutants. They specifically recommend the US EPA Region 3 (Mid-Atlantic region) Risk-Based Concentrations (RBCs), known as Generic Screening Levels (SLs).

The RBCs are chemical concentrations corresponding to fixed levels of risk to human health from exposure to contaminated soil. These are considered appropriate for assessing risks of potential exposure to contaminants. Reference Dose intakes (RfDs) and Cancer Slope Factors (CSFs) have been combined with “standard” exposure scenarios to calculate RBCs. The derived generic SLs correspond to either a 10^{-6} risk level for carcinogens or a Toxicity Hazard Quotient (THQ) of 0.1 for non-carcinogens. The generic SLs appropriate to this assessment are considered those for soils on sites with an industrial end use.

The above standards have been used to screen results from the environmental soil samples collected during the geotechnical investigation work in order to assess the risks to human health and the environment.

9.2.2 Groundwater and Surface Water

For water quality risk assessment, contaminant values within groundwater are compared against environmental quality standards for surface waters and drinking water. In the absence of Ghanaian standards for environmental water quality, guideline values from internationally accepted regulatory regimes have been adopted for use in addition to the Ghanaian Drinking Water Standards for the assessment of groundwater quality at the development sites.

The EC Directive 2008/105/EC on environmental quality standards in the field of water policy, sets out environmental quality standards concerning the presence in surface water of 33 pollutants and substances or groups of substances identified as priority on account of the substantial risk they pose to or via the aquatic environment. Additional “operational” environmental quality standards are provided for surface water risk assessment in the UK by the Environment Agency.

The World Health Organisation publishes guidelines for drinking water quality, which are considered to provide an authoritative basis for risk-based health protection.

Groundwater data collected from intrusive investigations of the development sites has been assessed by comparison with the EC Directive criteria and UK operational guidelines for freshwaters, as well as the World Health Organisation (WHO) and Ghanaian standards for drinking water.

9.2.3 Liquid Effluent

The Ghanaian EPA has formal discharge limits for liquid effluents from thermal plants. The IFC also maintains standards for effluent discharges. Details of these are provided in Section 16.

9.3 Potential Impacts to Land or Water Quality

9.3.1 Impacts from Existing Land Quality

Overview

Existing land contamination can pose risks to the construction or future use of the land. This could arise from the presence of harmful substances and pathways by which potential receptors could be harmed, e.g. petroleum products absorbed onto soil which workers may come into contact with, ingest or inhale during construction works. There is also the potential that existing contamination could be mobilised during construction works, e.g. contamination in near surface soils could be pushed down into bedrock groundwater during piling activities.

The surrounding land uses described in Section 7.1 include the oil refinery, petrochemical storage tanks, thermal power generation, transmission stations, steel works, industrial manufacturing, yards and offices. A storm drain is located adjacent to the western boundary of PPS 1 and PPS 2.

The majority of the development sites have no previous known industrial use, although some structures comprising masonry walls and a few abandoned buildings were noted on PPS 2 (west plot) at the time of intrusive site investigation. Similar structures were observed on the LPG Tank Farm during a site visit in October 2016. One building on PPS2 (east plot) was inhabited, though these people will be resettled as part of the land acquisition process (discussed further in the socio-economic assessment – Chapter 20).

A fuel oil storage area remains in place on the east portion of PPS 2 (east plot), where extensive surface staining from hydrocarbon spillage was evident. Additional trial pits were excavated to delineate the extent and depth of hydrocarbon contamination in this area. Reworked excavation spoil and mounds of tipped soil were also observed in the west of PPS

2 (west plot) during the investigation. PPS 1 and PPS 2 (west plot) have both had extensive use in recent years for subsistence farming.

Based on evidence from site observations as well as the surrounding land use history, contaminants of concern for the development areas include aliphatic and aromatic petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAH), which are found in diesel for example), heavy metals, asbestos, sulphur-compounds and fluorides. Organic chemicals, including petrochemicals and organic pesticides, as well as metals may be encountered along the pipeline route. Sewage contamination has been reported in nearby surface water courses, which may also be polluted by the substances mentioned above.

The potential presence of these contaminants was investigated during intrusive ground investigations in 2016 and 2017 undertaken by RIMOG Company under the direction of WSP. The investigation comprised:

- Cable percussion boreholes to weathered bedrock (nine boreholes in PPS 1 and five in PPS 2);
- Installation of piezometers in all boreholes to enable monitoring of groundwater levels and collection of groundwater samples;
- Trial pits excavated to a maximum depth of 4.5m (five trial pits in PPS 1; 24 trial pits in PPS 2; 11 trial pits in the LPG tank farm); and,
- Collection of soil and groundwater samples for chemical analysis, as well as two samples of ponded surface water in the fuel oil storage area in the east of PPS 2 (east plot).

The results of the chemical analysis have been compared with the assessment criteria for soil and water in Tables 9-1 and 9-2 below.

Soil quality

Table 9-1 summarises the data collected on soil quality. The concentrations of contaminants determined from the soil samples collected are well below the RBCs, with the exception of a few results for arsenic on all development plots and one result for hexavalent chromium on PPS 1. The arsenic exceedances are only slightly in excess of the RBC (3 mg/kg) and the averages across each plot (1.07 mg/kg on PPS 1, 1.49 mg/kg on PPS 2 and 2.36 mg/kg on the LPG tank farm) are below. These results are not considered to indicate the presence of any significant risk.

On PPS 1, the mean hexavalent chromium (2.95 mg/kg) was less than half of the RBC (6.3 mg/kg). Although the source of the hexavalent chromium is uncertain, the result at BH08 is evidently localised and is not considered likely to result in significant risk to site workers.

On PPS 2, Total Petroleum Hydrocarbons (TPHs) were found in concentrations of up to 336 mg/kg in the vicinity of the existing fuel storage tanks. As no speciation was undertaken, the fractions present were not identified. However, as the contamination was highest in the near surface soil, it is likely to consist of heavier, low boiling point species which are unlikely to pose a significant risk to workers during construction due to their low volatility and the limited area affected. Samples collected at depths below 0.5 m had concentrations of less than 100 mg/kg.

The overall results indicate that soil quality of the development plots is generally good. The area affected by the hydrocarbon contamination in PPS2 is limited in extent and not considered to pose a significant pollution risk to human health or the environment.

Groundwater quality

Table 9-2 summarises the data collected on groundwater quality, along with two samples of ponded surface water collected near the fuel storage tanks in the east of PPS2 (east plot).

The only widespread contaminants identified was zinc, which was present in concentrations across the development site monitoring wells and exceeded the freshwater guideline concentration by substantial amounts. Due to the extent of elevated results across the plots and the predominantly undisturbed nature of the sub-soils observed during the ground investigation, it is considered possible that the elevated concentrations result from natural sources of zinc in the bedrock aquifer rather than a specific contamination source. The zinc does not pose a risk to people but has the potential to affect freshwater aquatic ecology. However, it is considered unlikely that the groundwater would feed any surface water courses in the vicinity. There is a surface water drain on the western boundary of the development plots but it is concrete lined and sits above the groundwater level. It is most likely that groundwater flow is towards the sea a few kilometres from the site, where it would be subject to substantial dilution on release to surface water. On this basis, the risk to freshwater ecology is considered to be negligible.

The investigation also found one location in the middle of the western PPS2 plot where sulphate was elevated, 560 mg/l SO_4 compared with a freshwater guideline of 400 mg/l, and Ghanaian drinking water standard of 250mg/l. Arsenic, at 0.75 mg/l, was also substantially higher than the drinking water guideline of 0.01 mg/l as well as the freshwater environmental quality standard of 0.05 mg/l. There is no drinking water abstraction locally, however, and as discussed above in relation to the zinc concentrations, there is no risk to freshwater ecology as the groundwater is unlikely to enter a river.

All other results from groundwater samples were well below the Ghanaian and WHO drinking water guidelines and EC / UK freshwater standards. On this basis, the existing groundwater quality in the development areas is considered to be good.

Results from ponded surface water samples

The ponded surface water was collected in the vicinity of the fuel storage tanks as it was observed to be contaminated with hydrocarbons. This was confirmed by the chemical analysis which reported a maximum concentration of 208 mg/l of TPHs although no PAHs were detectable.

The surface water was also contaminated with elevated concentrations of heavy metals (arsenic, cadmium, chromium, iron, lead, nickel and zinc) which might be considered to pose a risk to people or to freshwater ecology. The latter risk can be largely discounted. Although the contaminated water might enter the surface water drain from over ground flow under heavy rain conditions, the drain discharges to sea and it is unlikely that significant freshwater ecology would be affected.

Risks to people from the contaminated water lying on the ground surface could arise from work undertaken in the area before or during construction as a consequence of dermal contact and ingestion. However, as the area affected is relatively small, presence of contamination is obvious and the duration of work in the area will be limited, it is unlikely that significant health effects would result from any contact. Once the site is developed, the contaminated material would be removed or covered over, thus eliminating this source of risk to operational workers.

Table 9-1: Measured Soil Quality and US EPA Risk Based Guideline Values

		PPS 1	PPS 2	LPG Tank Farm
	Sample depths	0.2 - 0.35 m	0.1 – 2.0 m	0.1 – 2.0 m
Analyte	**US EPA RBC**			
General Parameters				
pH	N/A	6.2 - 8.4	6.6 - 9.3	7.3 - 9.1
Organic Matter, %	N/A	0.9 - 6.6	0.05 - 17.4	0.04 - 4.2
Sulphate (water-soluble), mg/kg	N/A	13.4 - 208	19.3 – 189	17 - 178
Asbestos. mg/kg	N/A	< 0.01	< 0.01	< 0.01
Total Cyanide, mg/kg	15 (CN^-)	< 0.01 - 0.84	0.064 - 1.0	0.051 - 0.93
Metals/metalloids				
Arsenic, mg/kg	3.0	0.22 - 3.12 (mean = 1.07)	0.146 - 3.26 (mean = 1.49)	0.934 - 4.72 (mean = 2.36)
Cadmium, mg/kg	98	0.23 - 3.16	0.061 - 21.5	0.31 - 1.23
Total chromium, mg/kg	N/A	12.8 - 200.0	2.37 - 42.6	11.84 - 82.5
Hexavalent chromium (Cr VI), mg/kg	6.3	0.18 - 36.8 (mean = 2.95)	0.033 - 2.16	0.094 - 1.42
Copper, mg/kg	4,700	3.5 - 63.9	11.3 – 133	11.8 - 136
Lead, mg/kg	800	1.37 - 12.3	3.04 - 43.8	1.18 - 13.6
Mercury (mg/kg)	4.6	0.02 - 1.09	0.054 - 1.59	0.11 - 0.91
Nickel, mg/kg	1,200	1.73 - 19.6	5.63 - 65.4	9.7 - 81.5
Zinc, mg/kg	35,000	59.1 - 164	19.4 – 359	33.8 - 308
Organics				
Phenol, mg/kg	25,000	0.19 - 6.9	0.044 - 2.4	0.031 - 2.8
Total Petroleum Hydrocarbons, mg/kg	42 - 350,000 *	< 0.001	< 0.001 (BH & TP101 - 121) 36 - 336 (TP122 - 124) #	< 0.001
Polyaromatic Hydrocarbons:				
• Naphthalene, mg/kg	17	< 0.000001	< 0.000001	< 0.000001
• Phenanthrene, mg/kg	N/A	< 0.000001	< 0.000001	< 0.000001
• Anthracene, mg/kg	23,000	< 0.000001	< 0.000001	< 0.000001
• Fluoranthene, mg/kg	3,000	< 0.000001	< 0.000001	< 0.000001
• Benz(a)anthracene, mg/kg	2.9	< 0.000001	< 0.000001	< 0.000001
• Chrysene, mg/kg	290	< 0.000001	< 0.000001	< 0.000001

* 42 mg/kg for low boiling range aromatics up to 350,000 mg/kg for high boiling range aliphatics

The three trial pits (TP122, 123 and 124) were excavated in the east side of the east plot where surface spillage of hydrocarbons was evident in the vicinity of fuel storage tanks.

Table 9-2: Measured Water Quality compared to Guideline Values

Parameter	Units	Ghanaian Drinking Water Standards	WHO Drinking Water Guidelines	EC / UK Fresh water Standards, Annual Averages	PPS 1 – Groundwater	PPS 2 – Groundwater	PPS 2 – Ponded surface water
General Parameters							
pH	pH Unit	6.5-8.5	NA	6 - 9	7.0 - 7.5	7.4 - 7.6	6.8, 7.0
Sulphate (SO_4)	mg/l	250	NA	400	238 - 560	89.7 – 237	12.4, 18.7
Sulphide	mg/l	0.05	NA	NA	< 0.005	< 0.005	< 0.005
Total Cyanide	mg/l	NA	NA	0.001	< 0.001	< 0.001	< 0.001
Metals and Semi-Metals							
Arsenic	mg/l	0.01	0.01	0.05	< 0.001	< 0.001- 0.75	0.60, 0.74
Cadmium	mg/l	0.003	0.003	0.08 - 0.25 (hardness dependent)	< 0.002	< 0.002 - 0.003	0.18 - 0.33
Chromium (total)	mg/l	NA	0.05	0.0047	< 0.010 - 0.078	< 0.001	0.14, 0.24
Chromium hexavalent(Cr IV)	mg/l	0.05	NA	0.0034	< 0.010	< 0.010	< 0.010
Copper	mg/l	2	NA	0.001	< 0.010 - 0.036	< 0.001 - 0.036	0.038, 0.084
Iron	mg/l	0.3	NA	1	0.033 - 0.139	0.069 - 0.204	1.38, 4.82
Lead	mg/l	0.01	0.01	0.0012	< 0.005	< 0.005	0.058, 0.091
Mercury	mg/l	0.001	0.006	0.00007 (maximum)	< 0.001	< 0.001	< 0.001
Nickel	mg/l	0.02	0.07	0.004	< 0.010	< 0.010	0.54, 0.85
Zinc	mg/l	NA	NA	0.0109	0.030 - 0.081	0.084 - 0.26	0.16, 0.21
Organics							
Phenols (Total)	mg/l	NA	NA	0.0077	0.019 - 0.083	1.89 - 4.74	1.89 - 4.74
Total Petroleum Hydrocarbons	mg/l	NA	NA	NA	< 0.001	< 0.001	102, 208
Poly-Chloro-Byphenols	µg/l	NA	NA	NA	< 0.001	< 0.001	< 0.001
	Polyaromatic Hydrocarbons (Speciated)						
Naphthalene	µg/l	NA	NA	2	< 0.001	< 0.001	< 0.001
Phenanthrene	µg/l	NA	NA	NA	< 0.001	< 0.001	< 0.001
Anthracene	µg/l	NA	NA	0.1	< 0.001	< 0.001	< 0.001
Fluoranthene	µg/l	NA	NA	0.0063	< 0.001	< 0.001	< 0.001

Parameter	Units	Ghanaian Drinking Water Standards	WHO Drinking Water Guidelines	EC / UK Fresh water Standards, Annual Averages	PPS 1 – Groundwater	PPS 2 – Groundwater	PPS 2 – Ponded surface water
Benz(a)anthracene	µg/l	NA	NA	NA	< 0.001	< 0.001	< 0.001
Chrysene	µg/l	NA	NA	NA	< 0.001	< 0.001	< 0.001
	Organo-Chlorine Pesticides						
4,4'- DDD	µg/l	NA	NA	NA	< 0.001	< 0.001	< 0.001
4,4' –DDE	µg/l	NA	NA	NA	< 0.001	< 0.001	< 0.001
4,4'- DDT	µg/l	NA	1	0.01	< 0.001	< 0.001	< 0.001
Aldrin	µg/l	0.03	NA	NA	< 0.001	< 0.001	0.009, 0.018
Aldrin + dieldrin	µg/l	0.03	0.03	NA	< 0.001	< 0.001	0.009, 0.018
Alpha BHC	µg/l	NA	NA	NA	< 0.001	< 0.001	0.018, 0.026
Alpha-Endosulfan	µg/l	NA	NA	0.005	< 0.001	< 0.001	< 0.001
Beta BHC	µg/l	NA	NA	NA	< 0.001	< 0.001	0.003, 0.01
Beta-Endosulfan	µg/l	NA	0.005	0.005	< 0.001	< 0.001	< 0.001
Delta BHC	µg/l	NA	NA	NA	< 0.001	< 0.001	0.006, 0.011
Dieldrin	µg/l	NA	NA	NA	< 0.001	< 0.001	< 0.001
Endosulfan Sulfate	µg/l	NA	NA	0.005	< 0.001	< 0.001	< 0.001
Endrin	µg/l	NA	0.6	NA	< 0.001	< 0.001	< 0.001
Endrin Aldehyde	µg/l	NA	NA	NA	< 0.001	< 0.001	0.004, 0.01
Endrin Ketone	µg/l	NA	NA	NA	< 0.001	< 0.001	< 0.001
Gamma BHC	µg/l	NA	NA	NA	< 0.001	< 0.001	0.012, 0.019
Heptachlor	µg/l	0.03	NA	NA	< 0.001	< 0.001	< 0.001
Heptachlor Epoxide	µg/l	0.03	NA	NA	< 0.001	< 0.001	0.005, 0.009
Methoxychlor	µg/l	20	20	NA	< 0.001	< 0.001	< 0.001

NA = Not applicable

9.3.2 Impacts from Construction

If not properly managed and contained, some materials encountered or used during the construction phase have the potential to impact land quality. Identified materials and potential contamination pathways are outlined below:

- Soil arisings — it is possible that contaminated arisings could be brought to the surface. Any run-off generated from stockpiles or water released during dewatering of materials could infiltrate into groundwater or enter surfaces waters.
- Spilled oils and waste oils — if able to infiltrate to ground, these could contaminate soils and groundwater.
- Concrete — on-site concrete mixing and washing down of mixing areas during construction results in contaminated wastewater that could contaminate soils, groundwater or surface waters through run off from the mixing areas.
- Paints — if able to infiltrate the ground these could contaminate soils and groundwater.
- Fuel for vehicles — if spilled during fuelling, this could infiltrate soil or groundwater or run off into surface waters.
- Solvents, degreasers and other cleaning products — spills or leaks could impact soil, groundwater or surface water.
- Waste products such as sewage, general construction materials and packaging waste — these could be released accidently or deliberately.
- Fill material brought to site or excavated from elsewhere on site if it is contaminated — this could lead to leaching of contaminants to ground or surface waters or contamination of surrounding soils.

9.3.3 Impacts during Operation

During the operational phase of the project, release of hazardous materials from storage areas and during delivery / unloading operations could occur.

The LPG fuel will be stored in the new tank farm. The anticipated storage for each stage will be:

- Stage 1: Three spherical tanks: two x 3800m^3 (2,071 tonnes) capacity and one x 6000m^3 (3,270 tonnes); and
- Stage 2: Three spherical tanks: three x 6000m^3 (3,270 tonnes) capacity.

All tanks will be fully bunded to contain any releases.

There is very little requirement for the storage of fuels and other hazardous materials on the power plant sites. Diesel Fuel Oil (DFO) is to be used as a back-up fuel should there be a shortage of LPG. DFO will be stored in 50m^3 and 100m^3 capacity day tanks on the power plant sites. For PPS1, there will be one 50m^3 capacity DFO tank and for PPS2, one 100m^3 capacity DFO tank.

Underground electricity cables are often oil filled and if they leak can cause contamination. Evacuation of the power for Stage 1a will be via underground connection to the existing Electricity Company of Ghana (ECG) Station H substation, adjacent to the Volta River Authority (VRA) Tema Thermal Power Complex (TTPC) at 33kV. However, EPL has confirmed that all cables used for the project will be solid insulation.

A treated fuel skid will also be available for storage of treated fuel oils. All storage areas will be bunded to contain any releases. Full details of mitigation measures are described in Section 9.5.

There will also be chemicals used for purification of water in reverse osmosis plants on both power plant sites and treatment of wastewater, including sodium bisulphite, antiscalant additive, sodium hydroxide and sulphuric acid. The water purification chemicals will be stored in containerised units that come as part of the treatment plants. The LPG pipeline will be designed to international standards to prevent releases.

9.4 Impacts Assessment

The methodology adopted for assessing the significance of effects is presented in Section 6 Environmental and Social Impact Assessment Methodology.

Based on the baseline information reviewed and presented above, the sensitivity of the sites and surrounding areas with respect to land and water quality is considered to be of “local” geographical context (see Section 6.3 for geographical context definitions).

9.4.1 Existing Contamination

Power Plant and Tank Farm Plots

Based on the intrusive investigations undertaken, existing contamination of ground and groundwater at the development sites is limited and not considered to pose a risk to the operational workforce or the environment. There are a few areas of localised contamination around an existing fuel oil storage area at the east end of PPS 2 where contamination by hydrocarbons and heavy metals may pose a risk to people during the construction phase without appropriate mitigation.

Pipelines

Contamination of ground and groundwater along the pipeline route may be present as a consequence of past releases from neighbouring power plants and industrial facilities, which are present along the entire pipeline route. Shallow excavations will be required where the pipeline is to be buried. Excavations may also be required should any new or replacement foundations be required for the above ground portion of the LPG route or to allow direction drilling if this is utilised (e.g. to drill beneath water courses). It is considered impractical to undertake a meaningful sampling exercise along the pipeline route to assess existing contamination issues.

For the purposes of managing potential contamination issues during the pipeline construction, the following assumptions should be made when considering excavation and pipeline line design and construction practices:

- Contamination is likely to be present that may include petrochemicals, chemicals and asbestos in soil at the surface or sub-surface. This may pose a potential risk to human health via inhalation, ingestion or dermal contact;
- Sulphate compounds and petroleum hydrocarbons, confirmed or likely to be present in the made ground, are aggressive to concrete;
- Where shallow excavations are required, these are unlikely to exacerbate existing groundwater or surface water impacts at any location; and,
- Shallow groundwater is unlikely to be encountered.

Summary of Impacts

The magnitude that any effect from existing land contamination may have on human health or the environment is assessed as medium given the industrial nature of the land and the potential for further unidentified ground contamination. As the effects are only likely to affect the local area, the significance is assessed as minor without mitigation.

9.4.2 Construction

The following potential land quality impacts associated with construction processes have been identified:

- Spills, leaks, failure of tanks or pipelines or deliberate discharges of hazardous materials could occur during construction. Substances may include raw materials, fluids, intermediate products, wastes and effluents.
- Application of water in construction (e.g. for dust suppression), rainfall/storm water infiltration or de-watering activities could cause mobilisation of any contaminants present into soils and groundwater.
- Suspended sediments from excavations, exposed ground or stockpiles, plant and wheel washing, dust and mud on site access roads or de-watering could reach surrounding soils or surface waters through rainfall runoff and when construction areas are washed down. The site drainage could discharge water off-site onto adjacent land or water courses if mitigation measures are not implemented.
- On-site concrete mixing and washing down of mixing areas during construction will result in contaminated wastewater which could enter ground or surface waters. Concrete and cement products are highly alkaline and their release into the environment could have adverse effects on flora and fauna and on general water quality.
- The potential exists for introduction of contamination to the sites from imported soils or other construction materials.

The magnitude of any effect that construction of the development may have on land or water quality or the effect that existing land or water quality may have on human health or the environment is assessed as medium. As the effects are only likely to affect the local area, the significance is assessed as minor without mitigation.

9.4.3 Operation

Potential impacts to land and water quality during the operational phase of the project are associated with spills or releases of materials used and stored on the sites whether during routine operations or following an accident. Details of materials which will be stored and used on site are provided in Section 9.3.3.

The magnitude of any effect that the operation of the development may have on land or water quality or the effect that existing land or water quality may have on human health or the environment is assessed as low based on the new build design and compliance with Ghanaian requirements and applicable international guidance and standards. The significance of the effect of the operation of the plant is therefore assessed as low without mitigation.

9.4.4 Cumulative Impacts Assessment

The operation of the new power stations in an area where existing power stations operate and where others are scheduled to come on line in the future will add to the loading on district surface water drainage and sewage network (in the event they are connected). Therefore the risk that surface drains could become contaminated with run-off will increase without appropriate mitigation controls.

There will also be a potential increase in risk from releases of hazardous materials into the ground and groundwater in an area where older, oil-fired power stations and other industrial facilities already pose a risk to local land and water quality.

The magnitude of any cumulative effects that the construction and operation of the development may have on land or water quality is assessed as medium. The cumulative significance of effect of the development is therefore assessed as minor/major without mitigation.

9.4.5 Decommissioning

When the power plant is eventually decommissioned, there will be potential impacts to land and water quality which will require mitigation.

There will be hazardous materials stored on the sites and residual materials within equipment which could leak or spill into the surrounding environment. These materials could impact land or water quality unless mitigation measures are implemented. Hazardous materials within storage tanks, plant and equipment will need to be identified and removed prior to demolition.

It is possible that some localised undetected soil or groundwater contamination may occur during the operation of the power station. This could be disturbed during decommissioning and lead to more widespread contamination. Site investigations will be needed prior to or during decommissioning and demolition to identify as far as possible any areas of soil or groundwater contamination such that they can be remediated safely.

The magnitude of any effect that the decommissioning of the development may have on land or water quality is assessed as low. The significance of effect of the decommissioning of the plant is therefore assessed as negligible without mitigation.

9.5 Management and Mitigation Measures

9.5.1 Existing Contamination

A limited extent of existing contamination has been identified on the development plots in the vicinity of old fuel tanks in the east of PPS2. The area has been vertically and laterally delineated and is approximately 40m by 80m in extent, with the hydrocarbon contamination mainly concentrated in near surface soils.

While the risks to worker health are considered low, an appropriate management strategy should be implemented by the EPC contractor. Although no sampling for contamination is currently planned along the pipeline route, there could be benefits in investigation of the physical ground conditions in advance of installation of the buried pipeline sections. If such work is undertaken, then samples should be collected and analysed for contaminants.

The following actions should be adopted to manage general risks associated with contamination:

- Available investigation information should be submitted to the appointed Contractor (or to Contractors during tendering), to develop safe systems of work;
- Workers should be briefed on visual indicators of contamination (e.g. signs of oil, chunks of fibrous material) and procedures established for reporting and management to maintain safe working conditions;
- On a precautionary basis, good practices should be implemented to minimise exposure to vapours, soil and liquid arising during construction work, including minimisation of fugitive dust emissions and appropriate hygiene measures; and,
- The presence of unknown areas of contamination or below ground obstructions should be anticipated and appropriate contingency allowed for assessment and remediation should any such areas of contamination be identified during construction.

9.5.2 Construction

The following management and mitigation measures will be employed to minimise the likelihood and severity of potential impacts during construction:

- Training of workers in the handling, storing and disposal of hazardous materials;
- In the event of an accidental release of hazardous materials, emergency procedures and management plans will be in place so that any spills or leaks can be contained immediately;
- Storage of potentially hazardous construction materials will take place on hard surfacing and within appropriate containers. Where necessary, these would be covered and incorporate spill or leak containment measures;
- Chemicals that would react together if brought into contact will be located in segregated storage areas;

- Emergency spill containment material and clean up equipment will be readily available; and,
- Drainage design and management will ensure that potentially contaminated surface run-off does not flow directly into watercourses without treatment. This should include any areas where cement or wet concrete is processed or stored.

9.5.3 Operation

The design and operation of the Project components to good internationally recognised standards will aim to prevent any accidental hazardous material releases and minimise the potential consequences such that any potential effects should be minimised.

The following mitigation and management measure will be implemented to minimise potential impacts to land quality during operation:

- Workers will be trained in the handling, storing, and disposal of hazardous materials. In the event of an accidental release, emergency procedures and management plans will be in place so that the spill can be contained immediately, cleaned and disposed appropriately;
- Chemicals will be stored in designated bunded areas with bunds having the capacity to contain at least 110% of the volume of chemicals stored;
- Wherever possible, there will be no bund wall penetration and all pipework will be routed over the bund wall;
- Operational storage tanks will be designed and constructed in accordance with internationally recognised standards (such as BS EN 14015 or API 650) ensuring they are robust and fit for purpose;
- Chemicals that will react together if brought into contact will be located in segregated storage and bunded areas;
- Operational areas and roads where spills or leaks of hazardous materials could occur will be constructed in low permeability hardstanding to minimise potential for infiltration of contaminants to ground;
- Emergency spill response procedures will be in place, and containment materials and clean up equipment will be readily available;
- Drainage design and management will ensure that potentially contaminated surface run-off does not flow directly into watercourses. Stormwater / surface water run-off will be channelled to oil separators / interceptors and silt traps prior to disposal to outfalls; and,
- The pipeline design in the buried sections should consider the potential use of the overlying ground following completion of construction, particularly in those areas currently used as temporary parking for tankers and other vehicles.

9.5.4 Assessment of Impacts Following Mitigation

Following implementation of the mitigation measures identified above, the magnitude of any effect that the construction and operation of the development may have on land or water quality is assessed as low. The significance of effect is therefore assessed as negligible with the implementation of appropriate mitigation measures.

9.6 Conclusions and Recommendations

The presence and significance of existing contamination has been assessed through an intrusive investigation of the development plots. Only limited contamination was identified on the Stage 2 / PPS 2 (eastern portion) and this is considered to pose a low risk to workers during construction. Appropriate management arrangements to address the localised contamination will be devised and implemented by EPC contractor, as part of site preparation works.

Potential impacts relating to land and water quality during construction and operation of the development have been identified. These will require mitigation to reduce the potential significance of effect.

The construction environmental management plan will set out the mitigation measures required during construction including spill response procedures. Emergency response plans should be included to identify how any accidental discovery or release of contaminants should be dealt with. Contact details of persons responsible for key aspects of the plan should be included together with emergency contact information.

An operations environmental management plan should also be developed to capture and monitor the mitigation measures required during the project’s operation. As a minimum, the environmental management plan should include identification of the mitigation measures in place, identification of key roles and responsibilities, maintenance requirements, monitoring and reporting requirements, accident and environmental incident management plans, environmental training requirements and procedures for auditing and performance review.

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Environmental and Social Impact Assessment

Section 10 – Noise Assessment

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description gf Alteration		Rev No
Sep 2015	First issue		0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency		1
June 2016	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating the following changes:		2
	Section No.	***Change***	
	Wherever relevant	Reference to “power plant site” changed to reflect revised plan involving two power plant sites (PPS1 and PPS2).	
	10.3.2	Updated information on the phases and operational dates for the development	
	10.4.2 – Input data – Site layouts	Updated information on PPS1 and new information on PPS2	
	Table 10-5	Updated information on equipment sound power levels	
	10.5.2	Updated assessment of noise impacts associated with the operational phase.	
	10.6	Updated mitigation information	
	10.7	Updated summary	
	Figures	Updated with new modelling results	
August 2017	ESIA updated based on revised power plant locations and layouts, and consideration of additional identified receptors		3
	Wherever relevant	Reference to “power plant site” changed to reflect revised plan involving two power plant sites (PPS1 and PPS2).	
	10.2.4	Addition of discussion on WHO indoor noise criteria	
	10.3.2	Updated information on the phases and operational dates for the development	
	10.3.4	Addition of new receptors (factory worker accommodation)	
	10.4.2 – Input data – Site layouts	Updated information on PPS1 and new information on PPS2	
	10.5.2	Updated assessment of noise impacts associated with the operational phase.	
	10.6	Updated mitigation information	
	10.7	Updated summary	
	Figures	Updated with new modelling results and additional figures provided to support discussion of impacts and mitigation for worker accommodation receptors.	

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10 Noise

10.1 Introduction

This Section assesses the likely significant operational impacts of the Project with respect to noise.

Noise disturbance is frequently raised as a significant issue by local communities concerned about development, and is often the focus of complaints relating to operations. In some situations, it can lead to adverse health impacts. It is therefore appropriate to consider, and if necessary mitigate, the potential noise impacts that the project may have.

An overview of noise and potential noise effects from the project are provided in Appendix A of this ESIA, the Noise Technical Appendix. The baseline noise levels in the development area are outlined in Section 7.5.

10.2 Noise Level Guidelines

10.2.1 Overview

International guidelines for ambient noise levels are set out by the WBG/IFC in their general and sector-specific EHS Guidelines. In addition, Ghana EPA provides national guidance on maximum permissible noise levels for prescribed areas. Furthermore, the WHO has set out international guidelines for internal noise levels to avoid sleep disturbance. Each of these guidelines is described in more detail below.

10.2.2 WBG/IFC EHS Guidelines

The EHS Guidelines for Thermal Power Plants set out industry-specific examples of good international industry practice. In respect of noise, these guidelines note that amongst the principal sources of noise in thermal power plants are turbine generators and auxiliaries, boilers and auxiliaries, fans and ductwork, pumps, compressors, piping, valves and cooling towers.

Noise impacts, control measures and recommended ambient noise levels for industrial facilities including thermal power plants are presented in the General EHS Guidelines. These Noise Level Guidelines are presented in Table 10-1 below. It is required that noise abatement measures should achieve either the levels in Table 10-1 or a maximum increase in background levels of 3 dB(A) at the nearest receptor location.

All of the guidelines are in terms of A-weighted equivalent continuous noise levels (L_{eq}) expressed in decibels. There are two commonly used notations for this: e.g. 55 dB(A) L_{eq} or 55 dB L_{Aeq}, but they both mean the same thing. A full definition of all technical terms is provided in Appendix A.

Table 10-1: Noise Level Guidelines (dB) from the WBG/IFC General EHS Guidelines

Receptor	Daytime 07:00-22:00 hrs ($L_{Aeq\ 1hr}$)	Night-time 22:00-07:00 hrs ($L_{Aeq\ 1hr}$)
Residential; institutional; educational	55	45
Industrial; commercial	70	70

The guidelines are typically interpreted as being relevant to the long-term operational noise emissions from the project, rather than the short-term construction noise levels.

The EHS guidelines also present examples of noise reduction options that should be considered where noise levels exceed these guideline values, along with recommendations for noise monitoring to be carried out either to establish existing ambient noise levels or to verify operational noise levels.

The General EHS guidelines do not stipulate any environmental vibration criteria.

10.2.3 Ghanaian EPA Guidelines

The Ghanaian EPA provides guidance on maximum permissible noise levels for prescribed areas, presented in Table 10-2 and Table 10-3 below.

Table 10-2: GEPA Prescribed Areas

Zone	Description
A	Residential, domestic or private recreational areas.
B	Residential, educational (schools) and health (hospital, clinics) facilities.
C	Commercial areas, entertainment spots, points of public assembly and places of worship (churches & mosques)
D	Light industrial areas.
E	Heavy industrial areas.

Table 10-3: GEPA Guideline Noise Levels

Zone	Description of Area of Noise Reception	Permissible Noise Level dB(A)	
		Day (06:00 – 22:00)	Night (22:00 - 06:00)
A	Residential areas with negligible or infrequent transportation	55	48
B1	Educational (School) and health (Hospital, clinic) facilities.	55	50
B2	Areas with some commercial or light industry.	60	55
C1	Areas with some light industry, places of entertainment or public assembly, and places of worship such as churches and mosques.	65	60
C2	Predominantly commercial areas.	75	65
D	Light industrial areas.	70	60
E	Predominantly heavy industrial areas.	70	70

It is assumed that the noise levels above are in terms of L_{Aeq}, although this is not explicitly stated in the guidelines. L_{Aeq} is a statistical noise index which is commonly used to describe sound levels that vary over time, resulting in a single decibel value which takes into account the total sound energy over the period of time of interest, using the A-weighting setting built into all sound level meters.

Ambient noise levels are normally expressed in terms of L_{Aeq} and it would be virtually impossible, and unreasonable for a power plant, for the guidelines to be interpreted as a maximum instantaneous noise level.

Comparing the EHS guidance and EPA noise limit, it is observed that for residential, educational and institutional (e.g. hospitals) premises, the day-time noise limit is similar. However, the key criteria for noise assessment are the night-time limits and the EHS Guidelines value is 3 dB(A) lower for residential and 5 dB(A) lower for educational and institutional. In line with the requirements IFC PS1, this assessment has adopted the EHS Guideline value, as the most stringent.

10.2.4 WHO Guidelines for Indoor Noise Levels

The World Health Organisation (WHO) 'Guidelines for Community Noise' (1999) provides guidance on acceptable internal and external noise levels in buildings and outdoor living areas. Within the document it is recommended that in order to preserve 'good' conditions for sleeping, the sound level within bedrooms should not exceed 30 dB(A) for continuous background noise.

The WHO standards are considered to represent a high level of protection. Relevant guidance is also provided by BS8233:2014, which states that the internal target levels recommended by the WHO may be relaxed by up to 5 dB and 'reasonable' internal conditions still achieved.

Therefore, in relation to sleeping conditions, an internal level of 30 dB(A) is considered to represent a 'good' standard, and an internal level of 35 dB(A) is considered to represent a 'reasonable' standard.

10.3 Potential Sources of Noise Impact

10.3.1 Construction Noise

Potential construction noise impacts to humans include sleep disturbance, an increased incidence of social and behavioural problems (including annoyance and increased aggressive behaviour) and in extreme cases, hearing impairment of construction workers not wearing hearing protection or taking other preventative measures.

Construction noise levels will vary depending on the activity being undertaken, the construction plant being used and the distance from receptors. Major phases of construction are likely to be:

- Earthworks and Site Preparation;
- Piling;
- Creation of Hard Standings;

- Construction of Foundations;
- Building Erection;
- Creation of Roads; and,
- Creation of the pipeline.

Construction traffic on the roads approaching the site can also generate impacts to nearby receptors.

Neither the EHS Guidelines or the Ghanaian EPA criteria set limits for temporary noise from construction.

10.3.2 Operational Noise

This assessment considers noise emissions arising from the operation of the following power generation plant associated with the three operational stages of the Project:

Table 10-4: Summary of Power Generation Equipment during each Operational Stage

Stage	Power plant site 1 (PPS1)	Power plant site 2 (PPS2)
1a	5 x TM2500 in open cycle mode	-
1b	5 x TM2500 in combined cycle mode	-
2	5 x TM2500 in combined cycle mode	4 x LM6000PC Sprint in combined cycle mode

The assessment does not consider noise effects associated with operation of the tank farm or the pipeline as there is minimal noise produced during operation of these components.

All of the scenarios consider operation under steady-state conditions, rather than during start-up, maintenance or emergency conditions.

The key noise sources associated with the three development Stages of the project are:

- **Gas Turbines:** The gas turbines generate noise as a result of the flow of air and combustion gas. Noise is emitted from the gas turbine casings, and from the associated air intakes and exhausts. In combined cycle mode, a significant proportion of the exhaust gas is directed through HRSG and then exits through 60m tall vertical flues. The HRSGs generate steam to feed the steam turbines. The exhaust gas which does not enter the HRSGs is vented through a 30m tall bypass stack.
- **Air Inlet Filters:** Air to the gas turbines is filtered before entering the inlet plenum to minimise the potential for pollen, dust and sand to cause damage. The filters collect particulates in the air, and must be cleaned periodically by high-pressure air pulses, which blow the particles off the filter surface.
- **Electrical Transformers:** Noise from electrical transformers is caused by magnetostriction (where the metal sheets forming the core extend and contract in response to the alternating magnetic field), and from the cooling system.
- **Air Cooled Condensers (ACC):** ACCs are heat exchangers that use the ambient air to cool and condense steam which has been through the steam turbine, in order for it to be recirculated to the waste heat boilers. Each ACC comprises an array of large fans, which

blow cool air over finned tubes containing the steam. Each fan and its associated finned tubes is referred to as a cell. Noise is generated by the fan gearbox, fan blades and the movement of air across the heat exchange surface.

- **Steam Turbines:** Steam turbines convert thermal energy in the form of pressurised steam to mechanical work and ultimately, electrical power through a generator. Noise is generated in the turbine by rotating parts and pressure changes in the steam.

The air inlet filters will be fitted with a pulse cleaning system that will operate intermittently to clear debris from the air intake. Although these systems will be occasionally audible in the vicinity of the air intake filters they will not normally operate, and will not make a significant contribution to the long term LAeq in the surrounding area due to the intermittent and impulsive nature of the noise.

Due to the distance between the air intake filters and the nearest residential receptors, they will be inaudible at all residential receptors; although they will be audible at commercial/industrial receptors closer to the site

Noise from pulse cleaning systems has therefore not been included in the noise modelling exercise described below.

10.4 Assessment Methodology

10.4.1 Assessment of Construction Noise

Estimation of off-site noise levels associated with construction work was based on a simple calculation of noise level reduction with distance.

10.4.2 Assessment of Operational Noise

Noise Modelling

Noise modelling software provides a way of constructing a three-dimensional computer model of terrain, ground characteristics and noise sources which enables the prediction of noise at any point within the modelled area.

In order to compute the environmental noise emission level from plant items and operations at the representative noise sensitive receptors, noise emission modelling was undertaken using the Cadna/A noise prediction software. The software was configured to use the noise prediction methodology set out in ISO9613[1], which is suitable for the prediction of noise levels in surrounding areas from sources of known sound emission.

The noise prediction method described in part 2 of ISO9613 is general, and is suitable for a wide range of engineering applications where the noise level outdoors is of interest. The noise source(s) may be moving or stationary and the method considers the following major mechanisms of noise attenuation:

- Geometrical divergence (also known as distance loss or geometric damping);

[1] International Standard: ISO 9613-2: 1996(E): Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation.

- Atmospheric absorption;
- Ground effect;
- Reflection from surfaces; and,
- Screening by obstacles.

The method predicts noise levels under metrological conditions favourable to noise propagation from the sound source to the receiver, such as downwind propagation, or equivalently, propagation under a moderate ground based temperature inversion as commonly occurs at night. These conditions allow the model to predict the noise levels under 'worst-case' conditions.

Input Data

Site Layouts

The site layouts, position and the height of buildings / plant in the noise model are derived from Parsons Brinkerhoff drawing 62104520-PB-L-005-Rev 3 - Phase 1 and 2 (dated 10/05/2017).

The ground level in and around the sites is assumed to be generally flat (further details on topography are presented in Section 7.1.9, and therefore no topographic screening effects have been considered in the noise model. The intervening ground between the Project and the closest dwellings is a combination of brownfield scrub land, which is considered to be acoustically porous, and industrial/commercial installations. A ground absorption coefficient for 'mixed ground' (i.e. G=0.5) has been used in the calculations.

Sound Power Levels

Noise emission data for the proposed equipment selections has been provided by GE. Therefore, the following A-weighted sound power levels have been used in the noise predictions, which are based upon empirical formulae in technical literature, noise measurements of similar equipment or other manufacturer's data for similar equipment. The detailed 1/1 octave band data which comprises each broadband value is provided in Appendix A of this ESIA, the Noise Technical Appendix.

Table 10-5: A-weighted Sound Power Levels for Equipment

Equipment	Representation in Model	Sound Power Level, dB(A)	Source of Noise Data
LM6000 Combustion Air Inlet Filters & Shell	Omnidirectional Point Source at 7m a.g.l.	106	Equipment supplier
LM6000 Turbine Enclosure	Omnidirectional Point Source at 6m a.g.l.	99	Equipment supplier
LM6000 Generator	Omnidirectional Point Source at 6m a.g.l.	107	Equipment supplier

Equipment	Representation in Model	Sound Power Level, dB(A)	Source of Noise Data
LM6000 Combustion Exhaust Stack (Open Cycle)	Omnidirectional Point Source at 11.6m a.g.l.	109	Equipment supplier
LM6000 Exhaust via HRSG (Combined Cycle)	Omnidirectional Point Source at 23.2m a.g.l.	102	Based on experience and data from previous projects
Auxiliary and BOP Equipment (per LM6000 unit)	Omnidirectional Point Source at 2m a.g.l.	103	Equipment supplier
TM2500 Gas Turbine Generator	Omnidirectional Point Source at 4m a.g.l.	103	Equipment supplier
TM2500 Gas Turbine Enclosure	Omnidirectional Point Source at 4m a.g.l.	105	Equipment supplier
TM2500 Air Inlet Filters & Shell	Omnidirectional Point Source at 5m a.g.l.	104	Equipment supplier
TM2500 Attenuated Combustion Exhaust (Open Cycle)	Omnidirectional Point Source at 6.1m a.g.l.	126	Equipment supplier
TM2500 Attenuated Combustion Exhaust (Closed Cycle)	Omnidirectional Point Source at 6.1m a.g.l.	103	OTSG Exhaust supplier
Auxiliary and BOP Equipment (per LM6000 unit)	Omnidirectional Point Source at 2m a.g.l.	98	Equipment supplier
Acoustically Treated Transformer (per unit)	Omnidirectional Point source at 3m a.g.l	93	NEMA empirical method (Quieted Transformer 140MVA)
Air Cooled Condenser Array	Horizontal area source situated 10m a.g.l	105	Based on experience and data from previous projects

a.g.l.- above ground level

The noise data assumes a standard level of noise mitigation that is typically included in the proposed type of generation unit as that is the data provided by the supplier. These sound emission levels should be considered maximum permissible values for equipment as the design progresses to ensure that the environmental effects are no worse than stated in this assessment.

10.4.3 Noise Sensitive Receptors

Nearest Residential Areas

Table 10-6 below lists the closed 24 residential areas and their proximity to the site. The locations of the residential receptors are shown on Figure 10-1. As discussed in other chapters within this ESIA, the closest residential areas are approximately 2 km from the power plant sites and significant operational noise sources. In addition, there are a small number of kiosks and a caretaker located nearby that will be relocated as part of the project.

All of the receptors in the nearby residential areas would be classified as Ghanaian EPA zone type A, which is the most sensitive to noise and for which the most stringent permissible noise levels are prescribed. The uses located in closer proximity to the site are located in an industrial area with high existing noise levels.

Table 10-6 : Modelled Sensitive Receptor Locations

Receptor Description				Location (UTM Zone 31N Coordinates)	
Reference	**Location**	**Direction from PPS1/2**	**Distance from PPS1/2 (km)**	**E (m)**	**N (m)**
1	Residential	NNW	2.8	167656	630814
2	Residential	N	3.8	168512	632187
3	Residential	N	4.2	169257	632681
4	Residential	N	3.9	169748	632296
5* (new)	Informal dwelling	NNW	0.13	169731	628557
6** (new)	Commercial worker accommodation	SSE	0.25	169889	628216
7	Residential	NE	2.7	171196	630251
8	Residential	NE	2.6	171296	630098
9	Residential	NE	3.4	172059	630390
10	Residential	NE	4.0	172561	630560
11	Residential	ENE	4.5	173369	630115
12	Residential	E	4.0	173121	629327
13*** (new)	Informal dwelling	NW	2.06	170376	628953
14	Residential	SE	2.6	171558	627355
15	Residential	SE	2.2	170957	627159
16	Residential	S	2.2	169758	626419
17	Residential	S	3.1	169184	625374
18	Residential	S	3.8	168005	624842
19	Residential	SSW	3.2	167477	625773
20	Residential	SW	2.9	167081	626516
21	Residential	WSW	2.7	166775	627275
22	Residential	W	2.8	166427	628178
23	Residential	W	3.1	166136	628842
24	Residential	NW	3.4	166134	629881

Notes: Following completion of the original ESIA (2015), it was determined during the subsequent site visit and ESIA amendment 1 that some of the originally considered locations are not in fact residential dwellings. Relevant receptor numbers have been transferred to the following newly identified receptors:

** Receptor 5 is the Stage 2 site residential dwelling which is due to be relocated by the land owner before Stage 2 construction commences and therefore has been scoped out for stage 2 calculations. It is likely that the resettlement will take place prior to operation of Stage 1. However, the receptor has been included to confirm related impacts in the event that there are any delays to resettlement by the landowner.*

*** Receptor 6 is a workers' residence in the commercial premises adjacent to the south of PPS1.*

**** Receptor 13 is a newly established residential dwelling, which will be resettled as part of EPL's Stage 2 Abbreviated Resettlement Action Plan (ARAP), prior to operation of Stage 1. This receptor is therefore not included in the assessment.*

Other Potentially Sensitive Receptors within the THIA

The power plant, tank farm and the neighbouring industrial/commercial facilities (including existing power stations) are all located within the THIA and are considered to be heavy industrial land uses (GEPA Zone E).

Although located in a heavy industrial area, it was confirmed during 2016 consultations with the site owners that these single storey buildings are used for overnight accommodation for up to 18 factory workers. The company indicated that the workers are residing in these on the site during short- to medium-term (up to 18 month) contracts. Therefore, consideration has been paid to the potential for sleep disturbance due to noise at this location.

Therefore, in addition to the residential receptors detailed in Table 10-6, the assessment considers the potential for noise impacts at the JQ factory workers' accommodation buildings, located approximately 150m to the south of PPS1.

As noted above, the following potentially sensitive receptors were also identified during the ESIA process. However, these receptors will be relocated to areas that will not be adversely affected by noise from the project (either as part of EPL's resettlement activities or by the landowners of the Stage 2 site):

- Informal kiosks/businesses along Valco Road and on the Stage 2 site located adjacent to the tank farm site, between the tank farm and Stage 2 site – some of whom were identified as residing in those kiosks overnight at least temporarily; and,
- A man identified as the caretaker of the eastern part of the Stage 2 site, and his family.

Given that these receptors are scheduled to be relocated, they are not considered further in the noise assessment. The socio-economic chapter considers these uses and includes appropriate resettlement/livelihood restoration planning activities.

It is noted that EPL has had ongoing consultation and engagement with all of the above receptors since late 2016. EPL will continue engagement with these parties as part of ongoing general stakeholder / community engagement activities and/ or as part of the resettlement or livelihood restoration process, as appropriate.

During the 2017 site visits, it was also identified that a new informal residential dwelling has been established since the 2016 site visits and socio-economic surveys for the Stage 1 ARAP. It is located approximately 200m east of the tank farm site, between the Top Archive and Glas Brown Company facilities. This dwelling is not within the project footprint and was not identified during previous project survey phases as it is newly established. However, the dwelling could be impacted by significant operational noise levels during Stage 1a.

Given the timing of the dwelling's establishment, it is considered that EPL is not obliged to resettle these dwellings and they are not considered in this noise assessment. However, EPL will continue to engage with the residents during the Stage 2 ARAP to share information on the likely project-related noise levels and the project timeline. If appropriate, and acceptable to the residents, EPL will include the dwellings in the Stage 2 ARAP. This is discussed further in the socio-economic assessment (Section 20).

10.5 Impacts Assessment

10.5.1 Construction

The construction works are estimated to generate noise levels in the range 83-87 dB L_{Aeq} at a distance of 10 m and therefore personal hearing protection should be worn by construction workers working in the vicinity of noisy machinery. However, given the separation distances of 2.2 km to the nearest residential dwellings, the construction noise levels are not predicted to exceed 40 dB L_{Aeq} at residential noise sensitive receptors for any significant duration.

All buildings within 2.2 km of the power plant sites and tank farm construction works are within an industrial zone and the relevant GEPA guideline value of 70 dB(A) applies. Construction noise levels are predicted to be lower than 70 dB(A) at distances greater than 60m from the main site and tank farm construction works, and therefore not significant.

Buildings within 60m of the tank farm construction works are identified commercial/industrial facilities, which are considered to have a low sensitivity to noise. This low sensitivity to construction noise, together with the temporary nature of the construction works, means that it is not expected that construction noise would give rise to significant impacts at these receptors.

There are various industrial receptors in the vicinity of PPS 1 and PPS 2 which may contain noise sensitive uses associated with the commercial / industrial land use, such offices along with some existing kiosks/businesses on the Stage 2 site. Any such receptors that lie within 60m of the construction works at any one of the two plants and tank farm sites could potentially experience noise levels above 70 dB(A) at certain times during the construction process, and could therefore experience adverse noise impacts. However, any such impacts would be of short duration and during the day. It is also assumed that all permanent buildings will be designed to account for the heavy industrial surrounding land use and the Stage 2 site kiosks and residence are scheduled to be relocated.

Construction of the pipeline will also occur within the industrial zone. Noise associated with the construction of the pipeline is expected to be moderate, and will only impact receptors for a short duration, and will therefore not be significant.

The noise impact from construction activities is therefore assessed as being negligible at all receptors.

10.5.2 Operation

Impacts at nearby residential areas

The noise levels due to the operation of Stages 1, 1a and 2 of the Project have been predicted using a 3D noise model prepared in Cadna/A. The predictions are for receptor points 4m above ground, which can be taken to be the approximate height of a second storey window. Values have been rounded to the nearest integer value, which is an appropriate level of accuracy given the input data and calculation methodology.

Contour plots showing the predicted noise levels are presented in Figures 10-2 to 10-4 and noise levels at the various residential receptors are presented in Table 10-7.

Table 10-7: Predicted Noise Levels due to Project, dB LAeq

Ref.	EPA Zone	EPA Night Limit	IFC Limit	Assessment Threshold	Predicted noise levels $L_{Aeq,T}$		
					Ph. 1a	Ph. 1b	Ph. 2
R1	A	48	45	45	44	31	32
R2	A	48	45	45	41	29	30
R3	A	48	45	45	40	28	29
R4	A	48	45	45	41	29	30
R7	A	48	45	45	**48**	33	35
R8	A	48	45	45	**48**	34	36
R9	A	48	45	45	44	30	32
R10	A	48	45	45	42	29	30
R11	A	48	45	45	40	27	28
R12	A	48	45	45	42	27	29
R14	A	48	45	45	**49**	31	33
R15	A	48	45	45	**51**	33	35
R16	A	48	45	45	**50**	36	37
R17	A	48	45	45	44	31	32
R18	A	48	45	45	39	26	27
R19	A	48	45	45	40	27	29
R20	A	48	45	45	40	28	30
R21	A	48	45	45	42	28	31
R22	A	48	45	45	40	27	30
R23	A	48	45	45	41	29	30
R24	A	48	45	45	40	26	28

As Table 10-7 demonstrates, the predicted noise levels are below the assessment threshold noise levels at the majority of the nearest identified residential receptors.

However, during the temporary operation of the PPS1 plant in open cycle mode during Stage 1a (i.e. prior to the conversion of the TM2500 to closed cycle operation), the calculated levels exceed the IFC limit of 45 dB(A) at five receptor points (i.e. R7 – R8 to the north east, and R14 – R16 to the south).

In determining whether this exceedance constitutes a significant noise impact at identified receptor points the following has been considered:

- The predicted noise levels are between 1 and 6 dB above the IFC limit. This difference is only considered to be marginal. For instance a change in level of 3 dB is considered to only just be perceptible in outdoor environments.

- As the model does not account for the screening provided by buildings between the sites and the local receptors, the results are likely to be higher than would occur in practice and therefore this assessment is conservative.
- There are a number of other industrial/commercial facilities between the site and the receptors in question, including the Aksa HFO power plant, located 800m to the north east of PPS 1. These facilities are likely to produce significant noise emissions, closer to the receptors, which may be greater than the residual noise levels from PPS 1 during Stage 1a.
- The calculations are undertaken in accordance with ISO9613-2, and represent the worst case possible noise levels at receptors, which would only under the following conditions:
    - When the receptor is directly downwind of the sources; and,
    - When there is a mild temperature inversion (i.e. the air temperature increases with height), such that noise is refracted down towards the ground.

  These conditions are unlikely to occur for the majority of the time.
- The predicted noise levels only exceed the General EHS Guideline criteria for Stage 1a. This exceedance would therefore be temporary, during the 12 month Stage 1a operational period. After Stage 1a, the permanent levels would be significantly lower in combined cycle mode.

The source responsible for the exceedance during Stage 1a is the TM2500 exhaust when operating in open cycle mode, which already includes a noise attenuator in the design. The cost associated with further reducing the noise from the exhaust has been investigated and is not considered proportionate to the temporary and marginal exceedance of the noise limit.

Taking these factors into consideration, it is not considered that the temporary and marginal potential exceedance of the noise criteria would represent a significant noise impact at local receptors.

The noise modelling indicates that the relevant criteria for industrial areas in the Ghanaian EPA regulations can be met at relevant industrial / commercial noise receptors surrounding the development (e.g. offices associated with neighbouring power generation facilities). The equipment will be specified to ensure that these limits are not exceeded due to noise from the development.

The overall impact from operational noise at residential areas is therefore assessed as not being significant.

Impacts at site boundary

The results of the noise model indicate that the noise levels at the site boundary during Stages 1b and 2 would meet the GEPA noise criterion for heavy industrial areas of 70 dB(A).

The calculated levels at the site boundary during Stage1a are higher than the 70 dB(A) limit, principally due to the TM2500 exhaust when operating in open cycle mode. However, this is not considered to be significant for the following reasons:

- The noise levels from the TM2500 exhaust stacks at the site boundary have been calculated using omnidirectional point source using the procedures outlined in ISO9613-2. However, in reality, the majority of the sound energy from the exhaust stack would be radiated vertically. Therefore the modelled noise levels are conservative and actual noise levels at the site boundary are likely to be significantly lower than the predicted values.
- Noise levels are only predicted to exceed the limit during the temporary Stage 1a open cycle operational period. After Stage 1a, the permanent levels would be significantly lower in combined cycle mode.
- Consideration has been paid to the closest sensitive receptors (i.e. the JQ factory workers accommodation buildings and the kiosks on Valco Road). These locations are discussed in the following paragraphs.

Impacts at JQ factory workers accommodation buildings

The noise model indicates that noise levels at the northernmost of the JQ factory workers accommodation buildings would range from approximately 65 – 75 dB(A) during Stage 1a, as a result of the combustion exhaust levels in open cycle mode. A noise contour plot showing the noise levels at JQ factory workers accommodation during Stage 1a is shown on Figure 10-5.

During Stages 1b and 2a, the noise levels would be expected to reduce to between 50 – 60 dB(A) due to the sound reduction associated with the addition of the OTSG and steam turbine – the recovery of heat by the OTSG results in a reduction in velocity of exhaust gas compared with the original TM unit stack, with consequent reduction sound levels.

Based on observations made during a site walkover and discussions with senior management from the JQ packaging factory, it is identified that the workers' accommodation buildings are fitted with air conditioning units. Therefore windows are normally closed and would not be opened to provide ventilation air during sleep.

Based on an estimated reduction of 25 dB(A)[2] provided by the façade of the buildings with closed windows, the predicted internal noise levels are estimated to be 40 – 50 dB(A) during Stage 1a, and between 25 – 35 dB(A) during Stages 1b and 2.

Based on guidance provided by the WHO and BS8233, internal noise levels are considered to meet a 'good' standard for sleeping in some parts of the JQ factory workers accommodation buildings during Stages 1b and 2. In other parts of the building a 'reasonable' standard would be met. No additional design or other mitigation is therefore considered to be required for Stage 1b and Stage 2.

However, during Stage 1a, internal noise levels would significantly exceed the WHO recommended threshold for sleep disturbance, and therefore significant noise impacts would be expected at this location. Accordingly, mitigation measures are proposed to manage the noise impacts on the JQ factory buildings during Stage 1a.

[2] This figure is based on professional judgement. This is considered likely to be sufficiently conservative for a building with windows, unless there are significant un-attenuated gaps in the building façades.

Impacts at Kiosks on Valco Road

The noise modelling exercise predicts that the EPL project-derived noise levels in the vicinity of the Valco road kiosks would be approximately 55 dB(A) for Stage 1a, reducing to 40-45dB(A) for Stage 1b and Stage 2. This noise level is similar to or less than baseline measurements taken in the project area in 2015.

It is therefore considered unlikely that the project will result in significant operational noise impacts at this location for the following reasons:

- There are existing significant noise sources adjacent to the kiosks (Centuo Steel and Valco Aluminium works and traffic on Valco Road) which are likely to result in baseline noise levels of similar to, if not greater than those predicted by the model.
- There other potentially significant noise sources (the TOR installation and VRA power plants) are located similar distances as the proposed project from the kiosks which are also likely to contribute to elevated baseline noise levels.
- The model is conservative in that it does not include any of the buildings located between the site and the kiosks, which would further reduce any noise impacts.

10.6 Mitigation

General

The noise data assumes a standard level of noise mitigation that is typically included in the proposed type of generation units, and includes the following mitigation:

- Silencers (attenuators) on the gas turbine air intakes;
- Silencers (attenuators) on the bypass/HRSG system; and,
- Steel turbine enclosures.

JQ factory workers accommodation buildings

In order to reduce noise levels during Stage 1a at the JQ factory workers accommodation buildings, the attenuation provided by a temporary barrier immediately to the north of the buildings has been investigated.

The effectiveness of a noise barrier is determined by the 'path length difference' it introduces to the noise path between the noise source and receiver. This 'path length difference' is the extra distance that the sound has to travel with the introduction of the barrier.

A barrier that would screen the accommodation buildings from the exhaust stack mouths, and would introduce a path length difference of 2 metres, would result in a reduction in noise of at least 15dB within the accommodation buildings. This amount of reduction would be sufficient to avoid sleep disturbance during Stage 1a within the JQ factory workers accommodation buildings.

It is considered that a potential cost effect way of installing such a temporary barrier could be the placement of shipping containers to north of the JQ factory workers accommodation buildings. It is estimated that a height of approximately 7.8m (i.e. the height of three ISO shipping containers) could introduce the required path length difference of 2 metres, providing the containers were located in close proximity (i.e. within approximately 5m) of the northernmost accommodation building. With such a barrier in place, the overall impact from operational noise at the JQ factory workers accommodation buildings would be considered as not significant. Figures 10-5 and 10-6 show the noise levels at the JQ factory workers accommodation during Stage 1a with and without a barrier in place.

In the event that a barrier (as above or of other construction type) is not feasible, EPL will work with JQ Packaging to investigate other options to manage the temporary Stage 1a noise impacts.

10.7 Summary

Noise levels at identified receptors during the construction phase of the project are expected to remain below the relevant WBG/IFC and EPA criteria.

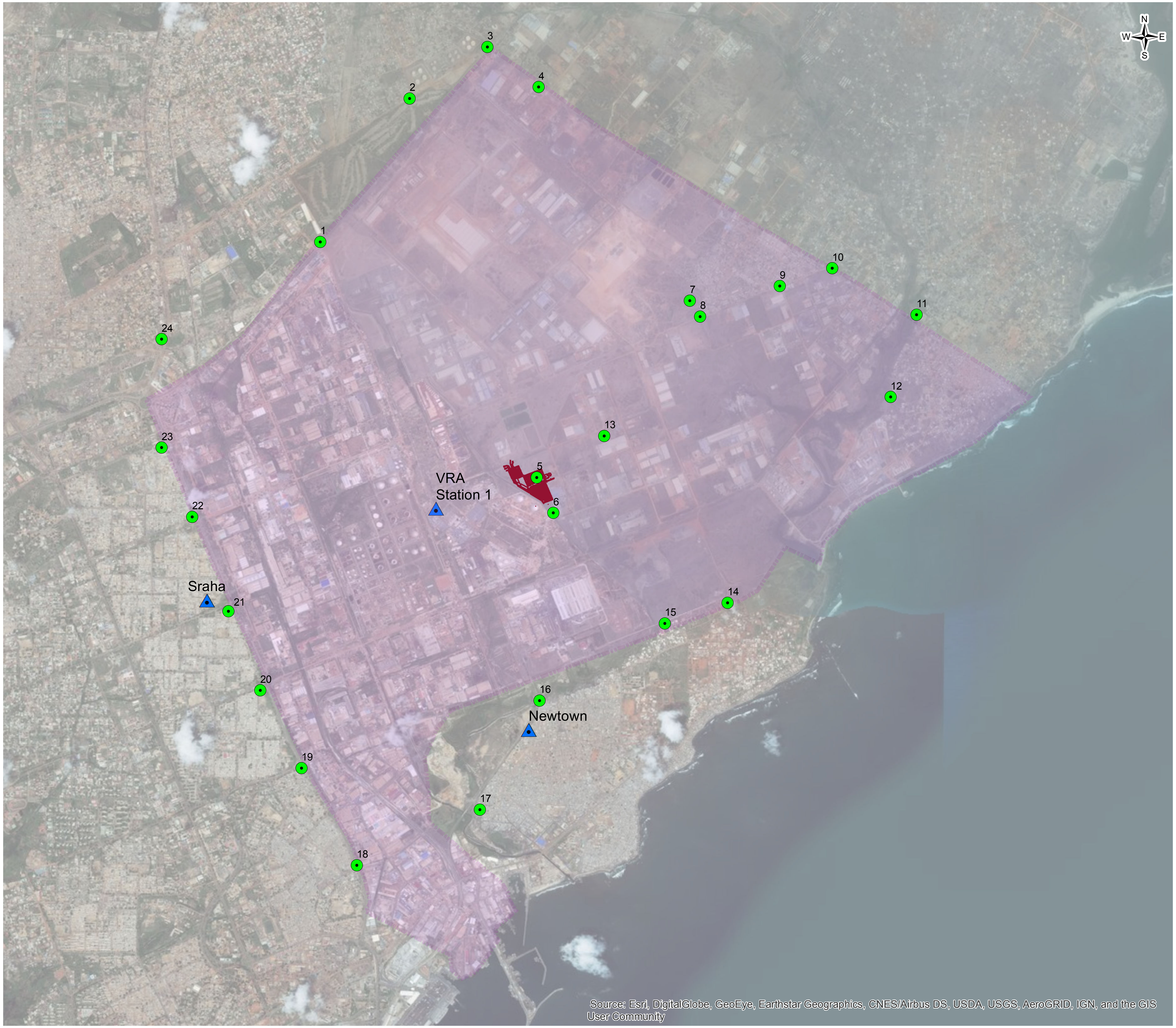
There is the potential for construction phase impacts at any noise sensitive buildings such as offices or kiosks within 60m of the construction works. However, any such impacts would only occur for the limited duration of the construction period, and will be generally be highly intermittent as a function of the nature of construction activities ongoing at any one time.

Although there is the potential for temporary and marginal exceedance of the EHS Guideline noise criteria at a limited number of residential receptors during Stage 1a, this is not considered likely to represent a significant noise impact.

At the JQ factory workers accommodation buildings, noise levels would significantly exceed the WHO recommended threshold for sleep disturbance during Stage 1a, and therefore significant noise impacts would be expected at this location. However, with a suitable temporary barrier in place, a reduction in noise levels sufficient to avoid sleep disturbance effects could be achieved. In the event that a barrier is not feasible, other measures will be investigated in full co-operation with the JQ factory management.

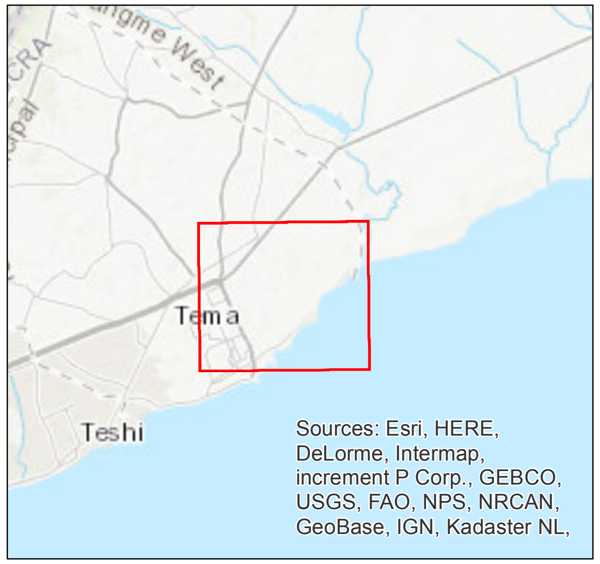
Therefore, with the mitigation measures described in Section 10.6, noise impacts that may occur as a result of the project are not considered to be significant.

FIGURE 10.1



Receptor calculation points
TEMA Heavy Industrial Area (THIA)
Noise monitoring locations
Site Layout

0 500 1,000 1,500
Metre



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Receptors and Noise Monitoring Locations

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Client No.		
Drawing No.	Figure 10.1	

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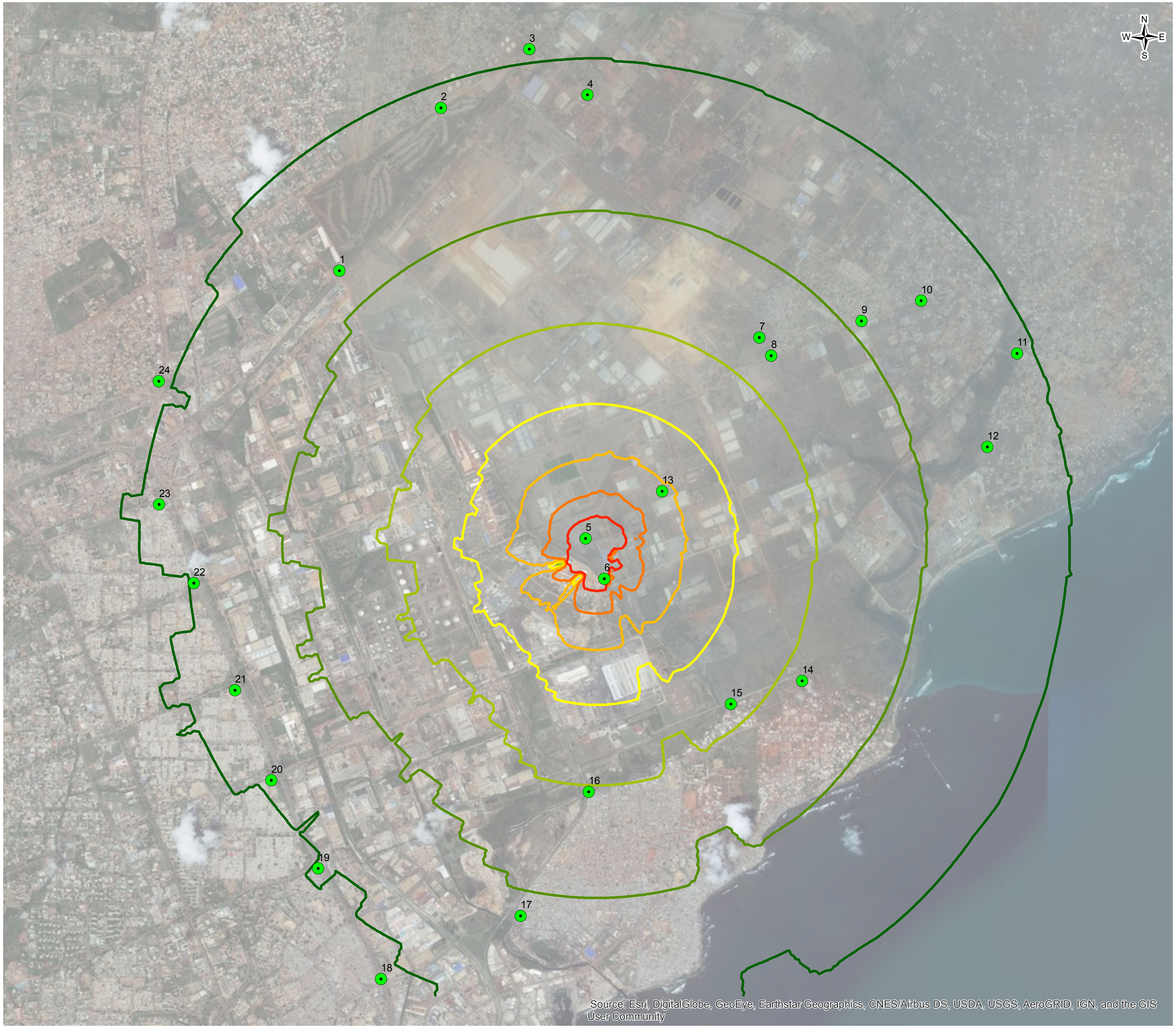


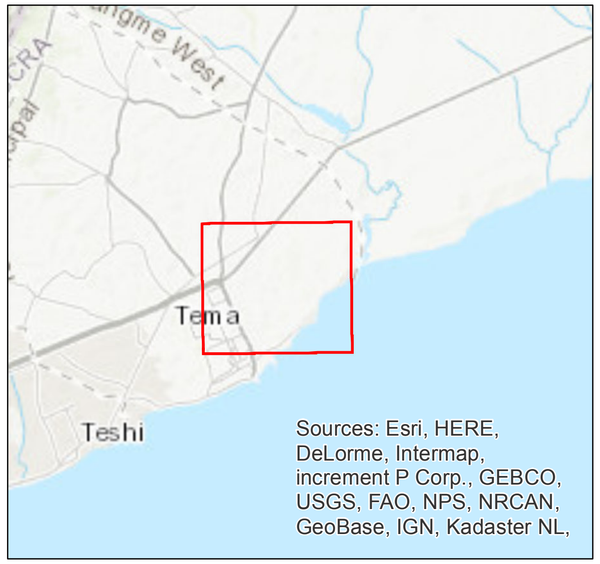
FIGURE 10.2

Stage 1A

Noise Level, dB(A)

- 40
- 45
- 50
- 55
- 60
- 65
- 70
- Receptor calculation points

0 500 1,000 1,500 Metre



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Drawing Title

Predicted Noise Levels
Stage 1A

Drawing Status

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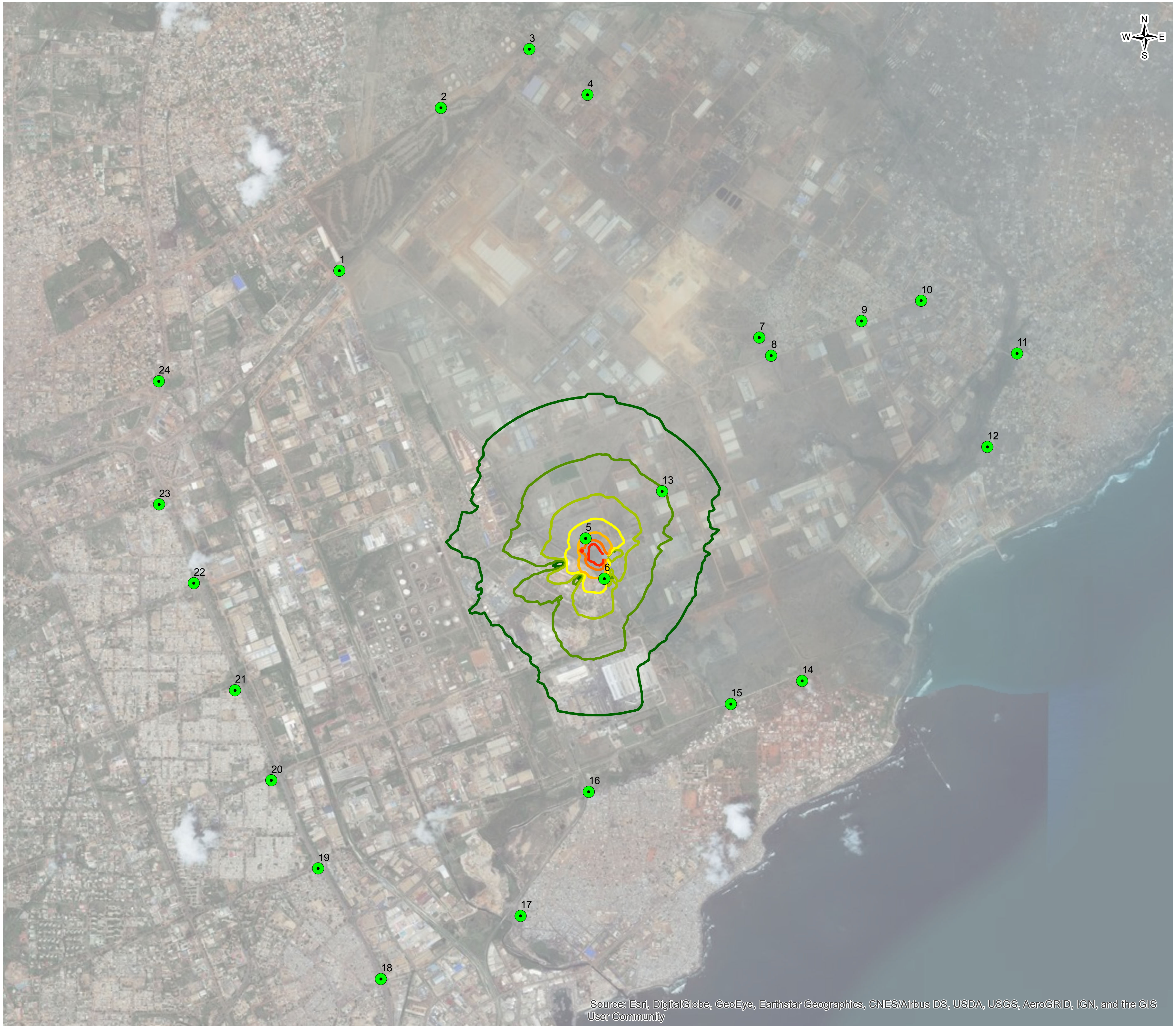


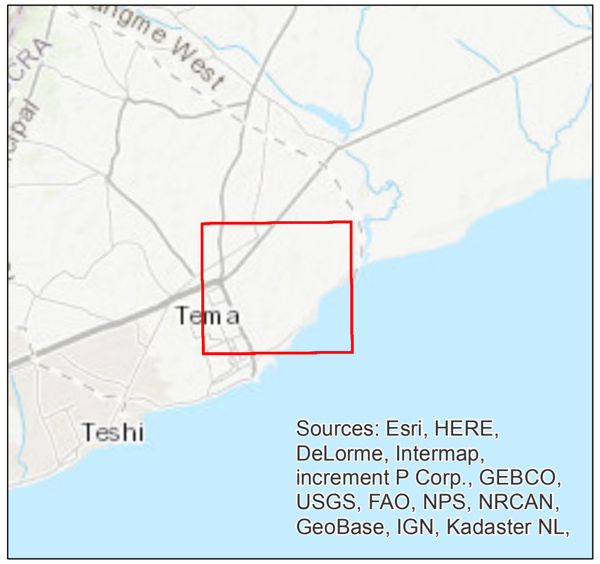
FIGURE 10.3

Stage 1B

Noise Level, dB(A)

- 40
- 45
- 50
- 55
- 60
- 65
- 70
- Receptor calculation points

0 500 1,000 1,500 Metre



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Drawing Title

Predicted Noise Levels
Stage 1B

Drawing Status

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Jacobs No.	60K28902	
Client No.		
Drawing No.	Figure 10.3	

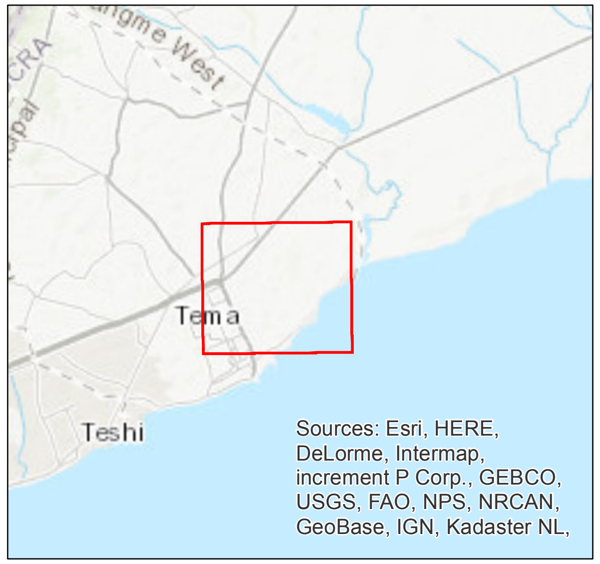
FIGURE 10.4

Stage 2

Noise Level, dB(A)

- 40
- 45
- 50
- 55
- 60
- 65
- 70
- Receptor calculation points

0 500 1,000 1,500 Metre



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Drawing Title

Predicted Noise Levels
Stage 2

Drawing Status

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Drawing No.	Figure 10.4	

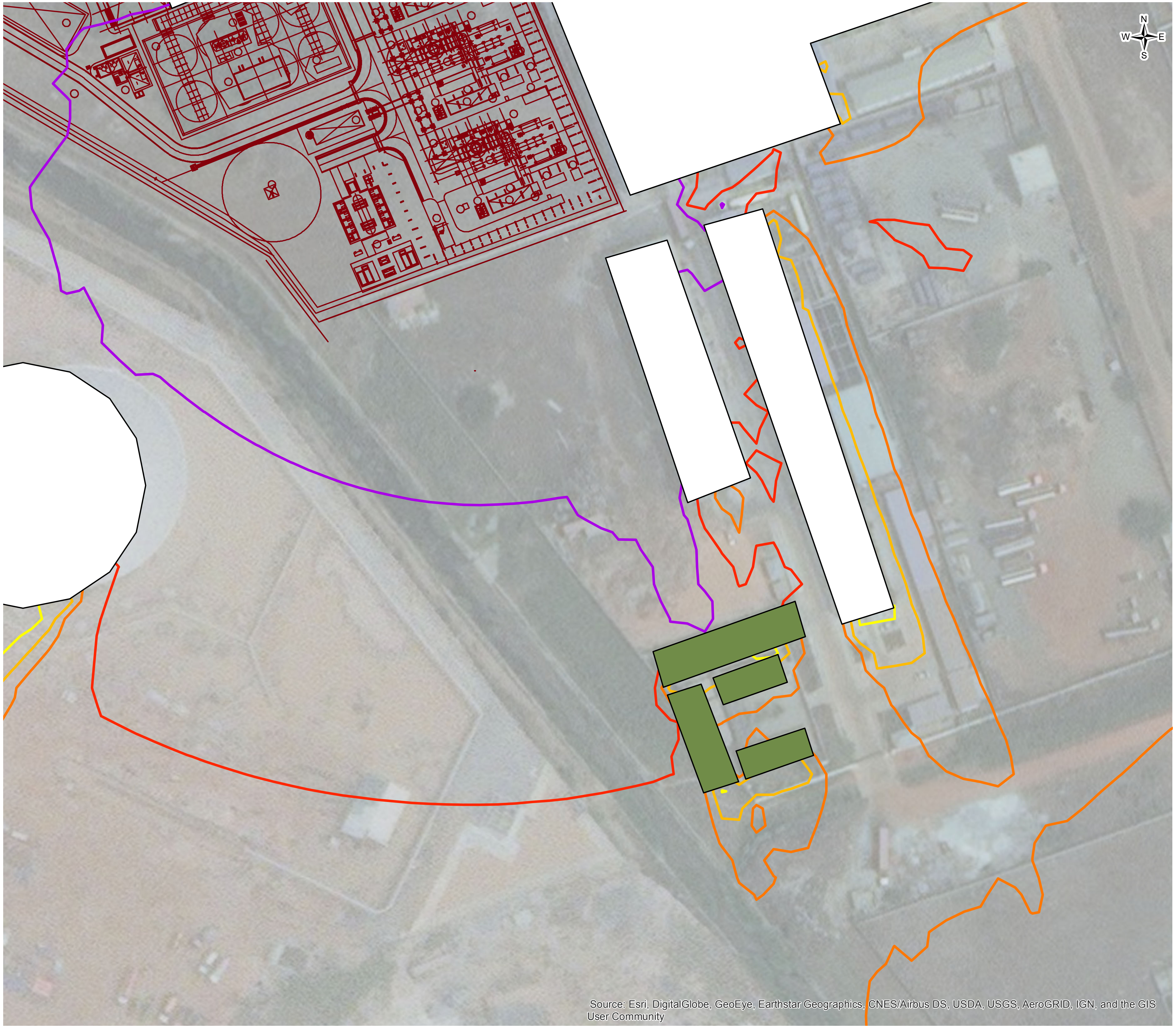


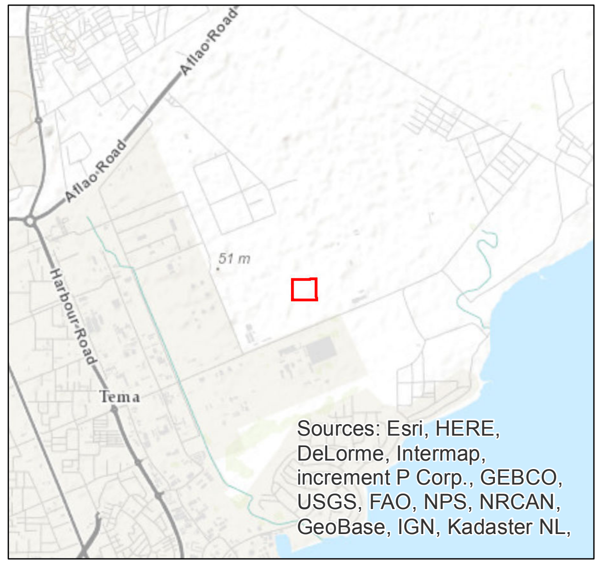
FIGURE 10.5

Stage 1A

Noise Level, dB(A)

- 40
- 45
- 50
- 55
- 60
- 65
- 70
- 75
- Buildings
- JQ Factory Workers Accommodation
- Site Layout

0 20 40 60 Metre



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Drawing Title

Predicted Noise Levels
Stage 1a
JQ Factory Workers Accommodation
Without Barrier

Drawing Status

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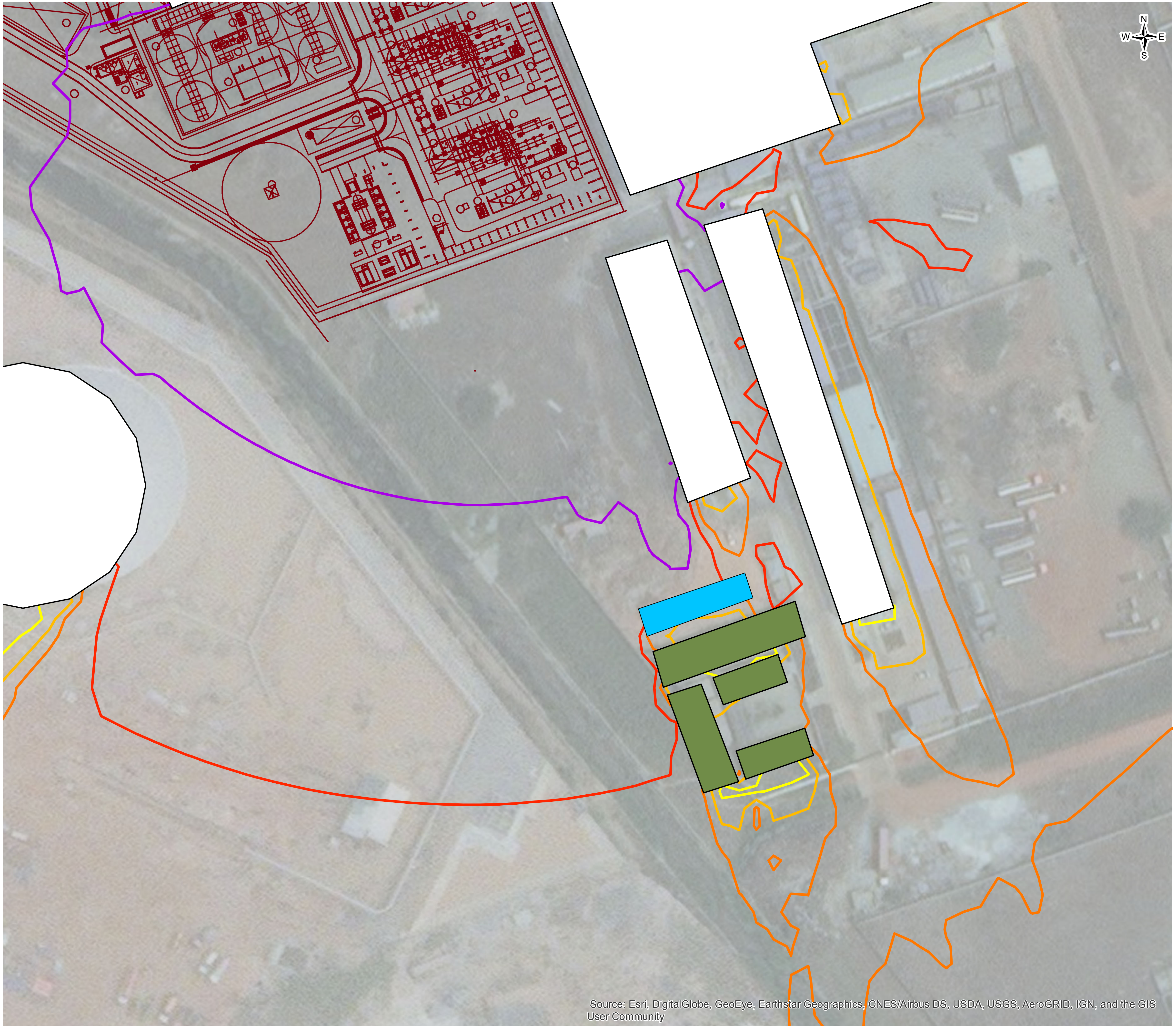
Drawing No.	Figure 10.5	

FIGURE 10.6

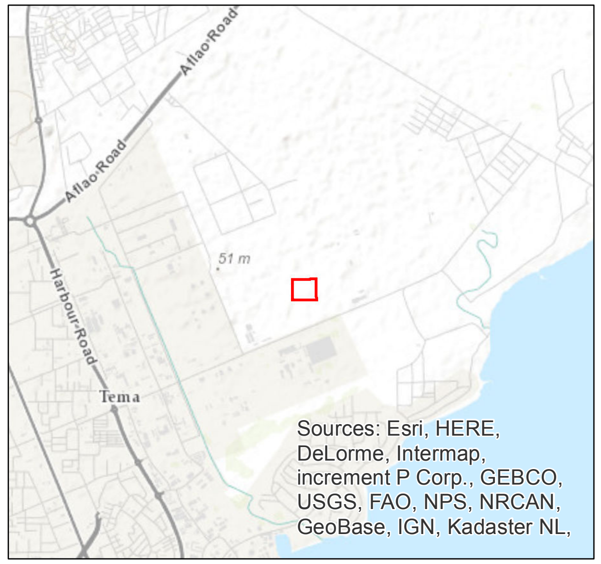


Stage 1A

Noise Level, dB(A)

- 40
- 45
- 50
- 55
- 60
- 65
- 70
- 75
- Buildings
- JQ Factory Workers Accommodation
- Example Barrier
- Site Layout

0 20 40 60 Metre



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Drawing Title

Predicted Noise Levels
Stage 1a
JQ Factory Workers Accommodation
With Barrier

Drawing Status

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Client No.		
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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Section 11 – Air Quality

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration		Rev No
August 2015	First issue		0
June 2016	Updated following changes to plant designs and extension of power plants onto two plots		1
	Section No.	***Change***	
	Wherever relevant	Reference to “power plant site” changed to reflect revised plan involving two power plant sites (PPS1 and PPS2).	
	11.1	Updated details of the development and status of baseline assessment.	
	11.2.2	Updated details of the development sites, construction phases and operating scenarios assessed for impacts to air.	
	11.3.2	Updated details of the development	
	11.5.3	Updated details of baseline assessment, stack height design and methodology for calculation of NO_x to NO_2 based on a site specific approach	
	11.5.4	Details of other power plants updated	
	11.6.2 and 11.6.3	Presentation of new assessment results based on the design changes and revised scenarios defined for the assessment.	
	11.7.2	Confirmation of actions taken during detailed design to reduce impacts and update to mitigation plan.	
	11.8	Updated conclusions	
	Figures	Updated figures with new modelling results.	
Aug 2017	ESIA amendment issued to Ghana Environment Protection Agency, incorporating details of further project design changes, including:		3
	Section No.	***Change***	
	Wherever relevant	Revisions regarding changes to site configuration and updated development stages. Inclusion of diesel fuel oil (DFO) scenarios in the assessment.	
	11.4	Addition of ambient criteria relevant to firing on DFO	
	11.3	Inclusion of DFO emissions data	
	11.6	Updated impact assessment including details of numerical cumulative impact assessment.	
	11.7	Updated mitigation	
	11.8	Updated conclusions	
	Figures	Updated contour plots	

Contents

Figures and Tables

11 Air Quality

11.1 Introduction

The following Section provides an assessment of the potential air quality impacts associated with the proposed Ghana Bridge Power Project during its construction and operation and provides relevant mitigation measures associated with the construction phase. The operational phase of the project will give rise to nine new emission points to air, over a three stage development programme (Stage 1a, 1b and Stage 2). A detailed description of the project is provided in Section 2 (Project Description).

This section includes the following:

- An outline of the scope of the air quality assessment including modelled scenarios, potential sources of emissions to air and key pollutants of concern during the construction and operational phases;
- A brief description of the assessment methodology;
- A study of the potential air quality impacts during the construction phase and each operational phase;
- Proposed mitigation measures; and,
- Predicted residual impacts, summary and conclusions.

Baseline air quality information is provided in Section 7.6. Additional technical information detailing the modelling undertaken is provided in Appendix B of this ESIA, the Air Quality Technical Appendix. The assessment presented in this section incorporates baseline data collected in 2015 and 2016.

11.2 Outline of Scope

11.2.1 Overview

An assessment of emissions to air has been undertaken to determine the potential air quality impacts of the power plant element of the proposed Project. The potential for adverse emissions to air from the liquefied petroleum gas (LPG) pipeline and tank farm are not considered here as associated risks will be managed through implementation of Good International Industry Practice (GIIP) for pipeline and tank farm construction and operation.

This assessment has been undertaken using an internationally recognised dispersion modelling technique. Concentrations of pollutants emitted by combustion processes associated with the project have been predicted at sensitive locations within the vicinity of the proposed site. The predicted concentrations have been compared to relevant ambient air quality guidelines specified for the protection of human health. There are no identified sites of ecological importance close to the proposed site, so no further assessment of ecological effects is considered.

11.2.2 Proposed Staged Development

The power plant will be constructed and operated from two sites (Power Plant Site 1 – PPS1 and Power Plant Site 2 – PPS2) over two development stages to provide a total net electrical output of 424 MW. It is understood that the use of LPG will be utilised until Natural Gas (NG) is made fully available. In the event of a disruption to LPG supply, it may be necessary to utilise Diesel Fuel Oil (DFO) as a fuel. Therefore, this assessment considers the impacts when the plants will be fuelled on LPG (comprising 90% propane and 10% butane), and scenarios for firing on DFO or a combination of periods on LPG and DFO. The sulphur content of the DFO is given as 0.3% in the fuel specification provided by EPL.

The development phases, over a 33 month period, are described below.

Power Plant Site 1:

Stage 1a – approximately 145 MW net, operational from May 2018

At completion of Stage 1a, five TM2500 turbines at 50Hz in open cycle mode will be installed, operating on LPG at maximum output. It is envisaged that operation will take place 9 months from Notice to Proceed.

Stage 1b – approximately 57 MW net, operational from August 2019

Stage 1b will involve fitting Once-through Steam Generators (OTSGs) to each TM2500 Gen8 turbine with emissions exiting from the OTSG stack location of each turbine. A steam generator will also be added in Stage 1b. Seven additional plant structures will be added to the site during Stage 1b and include the five OTSG units, the air cooled condenser (ACC) structure and steam turbine building.

Power Plant Site 2:

Stage 2 – approximately 222 MW net, operational from May 2020

At completion of Stage 2, four LM6000 PC Sprint turbines with Heat Recovery Steam Generators (HRSG) fitted to each LM6000PC Sprint turbine in closed cycle mode will be installed, operating on LPG at maximum output. A steam generator will also be added in stage 2. Additional plant structures will be added including the ACC structure and steam turbine building.

It is anticipated that the proposed plants will convert from LPG to NG within five years of Phase 4 commencing operation.

The scenarios considered in this assessment to cover these phases are outlined below:

- Scenario 1 – Development Stage 1a (operational for approximately 15 months):

  five x TM2500 LPG-fired turbine plant operating in open cycle mode; and,

  five x TM2500 DFO-fired turbine plant operating in open cycle mode;

- Scenario 2 – Development Stage 1b:

  five x TM2500 LPG-fired turbine plant fitted with OTSGs operating in combined cycle mode;

five x TM2500 DFO-fired turbine plant fitted with OTSGs operating in combined cycle mode;

- Scenario 3 – Development Stages1b and 2 (finalised plant development operational January 2020):

  Stage 1b and Stage 2: five x TM2500 LPG-fired turbine plant fitted with OTSGs operating in combined cycle mode and four x LM6000PC Sprint LPG turbine plant fitted with HRSGs operating in combined cycle mode; and,

  Stage 1b and Stage 2: five x TM2500 DFO-fired turbine plant fitted with OTSGs operating in combined cycle mode and four x LM6000PC Sprint LPG turbine plant fitted with HRSGs operating in combined cycle mode;

- Sensitivities Scenarios (4-6) - The results of Scenario 3 for both LPG and DFO were used to calculate the plant emissions for the following sensitivity scenarios for LPG / DFO operational mixes:

  - 1 month operation on DFO and 11 months operation on LPG;
  - 3 month operation on DFO and 9 months operation on LPG;
  - 6 month operation on DFO and 6 months operation on LPG; and,
  - Year-round operation on DFO.

- Natural Gas (NG) Scenario (7): As for Scenario 3 (Stage 1 and Stage 2 plants), except that all plants are fired on NG once available (expected within 5 years of development completion). The modelling results from Scenario 3 operation on LPG will be scaled to reflect emissions from 100% NG combustion.

Specific additional modelling was not required for scenarios 4-7.

Detailed plant specifications with regard to emissions are presented in Table 11-1. Further detailed information is provided within Appendix B of this ESIA, the Air Quality Technical Appendix.

It is noted that, whilst the emissions parameters are known for Stage 1, the Stage 2 parameters may be subject to change prior to the commencement of construction as part of the detailed design process. In the event of such changes, the amended specification data will be reviewed. Should the revised criteria be considered likely to result in significant additional adverse impacts associated with air emissions, the air quality modelling assessment will be revisited at that time to support the revised design process.

Table 11-1: Emissions Parameters for Ghana Bridge

Source Description	Centre point		Stack Height	Stack Internal Diameter	Exhaust Gas Efflux Velocity	Exhaust Gas Volumetric Flow		Exhaust Gas Temp	Emission Concentration [1]				Emission Rate			
									NO_x	CO	PM_{10}	SO_2	NO_x	CO	PM_{10}	SO_2
	E (m)	N (m)	(m)		(m/s)	m^3/s (actual)	Nm^3/s [1] (reference)	°C	mg/Nm^3				g/s			
Stage 1a: 5 x TM2500 LPG turbine plant operating in open cycle mode																
TM2500 S1a-1	169800	628478	30	2.80	34.1	210	72.3	543.7	152	100	N/A		11	7.23	N/A	
TM2500 S1a-2	169812	628449														
TM2500 S1a-3	169824	628419														
TM2500 S1a-4	169836	628390														
TM2500 S1a-5	169848	628361														
Stage 1a: 5 x TM2500 DFO turbine plant operating in open cycle mode																
TM2500 S1a-1	169800	628478	30	2.80	34.0	209	74.2	547.3	152	100	50	58	11.3	7.42	3.71	12.08
TM2500 S1a-2	169812	628449														
TM2500 S1a-3	169824	628419														
TM2500 S1a-4	169836	628390														
TM2500 S1a-5	169848	628361														
Stage 1b: 5 x TM2500 LPG turbine plant operating in combined cycle mode																
TM2500 S1a-1	169789	628479	30	2.29	25.9	106	72.1	140.6	152	100	N/A		11	7.21	N/A	
TM2500 S1a-2	169801	628449														
TM2500 S1a-3	169814	628420														
TM2500 S1a-4	169826	628391														
TM2500 S1a-5	169838	628362														
Stage 1b: 5 x TM2500 DFO turbine plant operating in combined cycle mode																
TM2500 S1a-1	169789	628479	30	2.29	25.9	106	74.3	141.4	152	100	50	114	11.3	7.43	3.72	12.08
TM2500 S1a-2	169801	628449														
TM2500 S1a-3	169814	628420														
TM2500 S1a-4	169826	628391														
TM2500 S1a-5	169838	628362														

Source Description	Centre point		Stack Height	Stack Internal Diameter	Exhaust Gas Efflux Velocity	Exhaust Gas Volumetric Flow		Exhaust Gas Temp	Emission Concentration [1]				Emission Rate			
									NO_x	CO	PM_{10}	SO_2	NO_x	CO	PM_{10}	SO_2
	E (m)	N (m)	(m)		(m/s)	m^3/s (actual)	Nm^3/s [1] (reference)	°C	mg/Nm^3				g/s			
Stage 2: 4 x LM6000 PC SPRINT LPG turbine plant operating in combined cycle mode																
LM6000 PC-SPRINT P3-1	169709	628543	40	2.75	22.1	131.5	91.4	95	152	100	N/A		13.9	9.1	N/A	
LM6000 PC-SPRINT P3-2	169686	628534														
LM6000 PC-SPRINT P3-3	169663	628525														
LM6000 PC-SPRINT P3-4	169640	628515														
Stage 2: 4 x LM6000 PC SPRINT DFO turbine plant operating in combined cycle mode																
LM6000 PC-SPRINT P4-1	169709	628543	40	2.75	22.5	151.4	98.4	145	152	100	50	184	15.0	9.8	4.92	16.82
LM6000 PC-SPRINT P4-2	169686	628534														
LM6000 PC-SPRINT P4-3	169663	628525														
LM6000 PC-SPRINT P4-4	169640	628515														

Note 1: Expressed at reference conditions: 273K, 101.3kPa, dry and 15% oxygen content.

Note 2: Effect diameter and velocity presented to take into account the silencer within the stack.

Note 3: It is noted that the WBG/EHS Guidelines for thermal power plants will be updated in late 2017. Review of the proposed changes indicates that there will not be a significant change or noticeable effect regarding the emissions criteria provided above.

11.3 Emissions to Air

11.3.1 Construction Phase

During the construction phase there is the potential for air quality impacts as a result of combustion emissions from construction related vehicles on and off site, and also from nuisance dust.

Given the relatively limited scale of the development, the maximum number of on-site vehicles and mechanical plant for any one day during all construction phases is anticipated to be low. As such, and given the short term temporary nature of construction emissions, the impacts from their emissions to air (tailpipe and generator exhaust gases) are not considered further in this assessment. Further details on the expected road traffic movements associated with the construction of the project are provided in Section 19, Traffic and Transport.

As with any construction site, dust may be generated as a result of earthworks and construction. Internal site traffic moving on un-surfaced roads within the development site may cause sufficient mechanical disturbance of loose surface materials to generate dust, particularly during the dry season. The proposed development includes the following main components which have the potential to generate dust:

- Preparatory earthworks to allow the construction of the power plant including, clearing of vegetation, soil stripping and stockpiling;
- Bulk earthworks including site grading and excavation work; and,
- The construction of the main components of plant including establishing and preparing concrete foundations for major plant and buildings, the construction of buildings and installation of equipment.

Construction activities with the potential to emit dust are generally short term. Often emissions are not continuous and fluctuate depending on the source, type of activity being undertaken and prevailing weather conditions. The dust generated from these activities is generally comprised of coarse particles which result in localised effects.

11.3.2 Operational Phase

The proposed power project will result in nine new emission points to air once the plant is fully operational. The new emission points will be phased in and have the potential to affect local air quality.

From May 2020 onwards the main sources of emissions to air are associated with the operation of the TM2500 and LM6000PC Sprint turbines in combined cycle mode.

The main pollutants associated with the combustion of LPG are oxides of nitrogen (NO_x), carbon monoxide (CO) and carbon dioxide (CO_2). These pollutants are described below:

- **Oxides of nitrogen** – NO_x produced from gas turbines comprise nitric oxide (NO) and nitrogen dioxide (NO_2) – the proportion of NO and NO_2 within the exhaust gas varies but typically NO is the predominant species and comprises approximately 95% of the emitted NO_x at release. For LPG and NG combustion, NO_x emissions are produced during combustion (i.e. the reaction of natural gas with air). NO is potentially less harmful than NO_2 and it is NO_2 that is associated with adverse effects upon human health. NO in the exhaust gas is oxidised in the atmosphere to form NO_2. However, the reverse process converting NO_2 to NO also takes place in the atmosphere.

- **Carbon monoxide** – CO emissions are a measure of combustion completion as higher values of CO indicate more incomplete combustion or less oxidation of CO to CO_2. CO can cause harmful health effects by reducing oxygen capacity of haemoglobin in blood and hence oxygen delivery to the body's organs and tissues.
- **Carbon dioxide** – CO_2 is one of the major greenhouse gases under the United Nations Framework Convention on Climate Change. The proposed project will primarily use LPG and then convert to NG, a less carbon intensive fossil fuel to generate electricity. This ensures that the least amount of CO_2 is generated per unit of energy. CO_2 is not considered in this assessment as it has no direct health effects. Implications of CO_2 regarding climate change are considered in the greenhouse gas emissions assessment provided in Section 18.

In addition to the above pollutants, the main pollutants associated with the combustion of DFO are sulphur dioxide (SO_2) and fine particulate matter.

- **Sulphur dioxide** – SO_2 primarily arises from anthropogenic activities and more specifically combustion of fuels containing sulphur and sulphur compounds. SO_2 is emitted in negligible quantities during the combustion of natural gas but generally at higher concentrations for liquid fuels which have a higher sulphur content. SO_2 can affect pulmonary function and lead to respiratory symptoms.
- **Particulate matter** – Fine particulate matter such as PM_{10} (particulate matter with aerodynamic diameter of 10 microns or less) or $PM_{2.5}$ (particulate matter with aerodynamic diameter of 2.5 microns or less) although emitted in negligible quantities during the combustion of natural gas, is emitted in higher quantities during the combustion of liquid fuels such as DFO. The range of potential health effects from exposure to PM_{10} or $PM_{2.5}$ is broad, but it predominantly causes respiratory and cardiovascular system problems..

The IFC "Environmental, Health and Safety Guidelines for Thermal Power Plants"[1] specify emission concentration guidelines for a range of electricity generating combustion plants. Those applicable to the proposed plant are shown in Table 11-2.

[1] International Finance Corporation, Environmental Health and Safety Guidelines for Thermal Power Plants, 2008

Table 11-2: IFC Air Emission Guidelines for Combustion Turbines for Thermal Power Plants Greater than 50 MWth

Fuel Type	NO_x Concentration (mg/Nm^3)		Dry Gas, Excess O_2 Content (%)
	Non-degraded Air-shed (NDA) / Degraded Air-shed (DA)		
Fuels other than natural gas	152	NDA	15
Natural Gas (NG)*	51	NDA	15

**It is anticipated that the proposed plant will operate solely on NG within 5 years of the commencement of plant operation and is included for reference for scenario 4.*

These emission guidelines make provision for the current state of ambient air quality surrounding the proposed site, by means of categorising the receiving atmospheric environment as either a "non-degraded air-shed" (NDA) or a "degraded air-shed" (DA), with the following definitions:

- NDA – if all national legislated or applicable IFC (e.g. World Health Organisation (WHO)) air quality standards are complied with; and,
- DA - nationally legislated air quality standards are exceeded or, in their absence, if WHO Ambient Air Quality Guidelines or other internationally acceptable standards are exceeded significantly.

In this case, the same emission standard applies for both DA and NDA for NO_x emissions. Based on the existing air quality monitoring within the vicinity of the proposed site (see Section 7.6), the area would likely be designated as a NDA.

The TM2500 and LM6000PC Sprint turbines will be designed to meet the IFC emission standard for NO_x set out in Table 11-2 for LPG (fuels other than natural gas) and NG. NO_x can be controlled by modifying operational parameters of the combustion process. The combustion temperature and air to fuel ratio will be monitored to ensure operations are controlled at optimum proportions so as to minimise the production of NO_x. Water injection will be integral to the plant design for NO_x control.

The generation of CO will also be kept to a minimum by optimally maintaining the required air to fuel ratio so that complete combustion occurs. Although no emission standards are specified by the IFC for CO, emissions will be minimised through the process controls described above and are expected to be less than 188 mg/Nm^3, as guaranteed by the manufacturer for Phases 1– 4. It is assumed that an emission limit of 100 mg/m^3 can be achieved running on NG for Scenario 7. For example, this would comply with UK emission limits for NG[2].

For DFO-firing, the sulphur content of the LCO for the Ghana Bridge Project is approximately 0.3 % so this complies with the more stringent requirement for degraded airshed set out in

[2] Environment Agency – Combustion Activities (EPR 1.01) , March 2009.

Table 11-2. The emissions of particulates for the Ghana Bridge Project firing on DFO are anticipated to be within the limit specified for a non-degraded airshed (i.e. less than 50 mg/Nm^3).

11.4 Assessment Criteria

11.4.1 Ambient Air Quality Guidelines

Ghanaian standards for air quality have been established via the Environmental Protection Agency (EPA) (Standards for Industrial/facility discharges into Water Bodies and Water Courses, Standards for Air Quality and Standards for Noise) Regulations 20 and are presented in Table 11-3. The current WHO (2000) ambient air quality guidelines are also presented. Only NO_x (as NO_2) and CO are pertinent in this assessment. It should be noted that the Ghanaian AAQG are applicable at defined locations, classified as 'Industrial' or 'Residential'. The WHO guidelines are applicable to the protection of public health. Air quality guideline concentration values are defined for each pollutant for specific averaging times, and are values which should not be exceeded in any given year.

The results of the dispersion modelling were assessed against the relevant Ghanaian EPA standards for a 'Residential' location for each of the assessment pollutants; where these are not available, the relevant WHO ambient air quality guideline was used. In this case, the EPA standards were supplemented with the WHO ambient air quality guidelines for annual mean NO_2. The maximum predicted 'off-site' results from the gridded model were also assessed against the relevant EPA standards for an 'Industrial' location.

Table 11-3: Ambient Air Quality Standards

Pollutant	Standards & Guidelines (µg/m³)			
	Averaging Time	EPA		WHO Guideline
		Location	Time Weighted Average (TWA)	
Nitrogen dioxide (NO_2)	1 hour	Industrial	400	200
		Residential	200	
	24 hours	Industrial	150	-
		Residential	60	
	Annual	-	-	40
Carbon monoxide (CO)	1 hour	-	30,000	30,000
	8 hour	-	10,000	10,000
Sulphur dioxide (SO_2)	10 minute	-	-	500
	1hr	Industrial	900	-
		Residential	700	-
	24hrs	Industrial	150	20 Interim (1) 125 (2) 50
		Residential	100	
	Annual	Industrial	80	-
		Residential	50	
Particulate matter (PM_{10})	24hrs	-	70	50 Interim (1) 150 (2) 100 (3) 75
	Annual	-	-	20 Interim (1) 70 (2) 50 (3) 30
Particulate matter ($PM_{2.5}$)	24hrs	-	-	25 Interim (1) 75 (2) 50 (3) 37.5
	Annual	-	-	10 Interim (1) 35 (2) 25 (3) 15

The IFC guidelines specify the following approach to significance for an air quality assessment:

"Projects with significant sources of air emissions, and potential for significant impacts to ambient air quality, should prevent or minimize impacts by ensuring that:

- *Emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines (see Table 11-3); and,*
- *Emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards. As a general rule, this Guideline suggests 25 percent of the applicable air quality standards to allow additional, future sustainable development in the same air-shed."*

The significance of an air quality impact will be determined by whether there is a predicted exceedance of prescribed air quality guideline values. Where appropriate, the determination of the process contribution against the ‘significance threshold’ of 25% of the guideline value will be considered in the context of the incremental addition to the existing ambient concentrations.

11.5 Assessment Methodology

11.5.1 Overview

This air quality impact assessment considers the impact on human health associated with the emissions to air from the combustion of LPG and DFO during operation as well as the displacement and subsequent dispersion of dust during the construction of the proposed plant.

11.5.2 Construction Phase

Due to the temporal and varying nature of pollutant emissions associated with construction activities, use of quantitative techniques such as dispersion modelling is not appropriate. The potential impacts during the construction phase are derived through consideration of construction site activities, proximity of sensitive receptors and the prevailing weather conditions, and are described in detail in Section 11.6. The recommended mitigation measures required to reduce any potential impact to negligible or low levels are set out in Section 11.7.

11.5.3 Operational Phase

The relevant air quality impact assessment criteria have been identified following a review of the standards and established guidelines for the protection of air quality for the relevant pollutants.

A review of ambient air quality data for Tema (collected during the ESIA baseline), including sampling for NO_2, SO_2 and particulates, was undertaken in 2015 to understand the baseline air quality (see Section 7.6). In addition, further monitoring of NO_2 and ozone was undertaken between April 2016 and November 2016. This includes a consideration of the location and nature of existing sources of air emissions in proximity to the proposed site.

To assess the likely air quality impacts from the proposed plant, modelling has been conducted. Air dispersion modelling using appropriate air dispersion modelling software is an internationally accepted tool that can be used to determine if the design and location of emission sources are adequate to protect air quality surrounding the proposed site.

This determination is made by comparing the maximum predicted dispersion modelling results at appropriate locations to the ambient air quality guideline stated in the applicable government regulations or other international standards. As such, if the predicted dispersion modelling results are within the air quality limits and the plant contribution is within acceptable thresholds, the plant design is assumed to be acceptable for regulatory approval.

For this assessment, it was decided to apply the UK Atmospheric Dispersion Modelling System (ADMS) version 5.2 dispersion modelling software. ADMS is listed as appropriate for assessing “more complex and refined models” in the IFC “Environmental, Health and

Safety Guidelines: Environmental, Air Emissions and Ambient Air Quality"[3] guidance document.

The dispersion modelling procedure for assessing the operation of the project is summarised as follows.

- Information on the design of the proposed site including site layout, stack location, design of the proposed gas turbines and relevant emissions data was obtained from Early Power Limited. Details of the buildings and structures on site were also obtained and the buildings module in ADMS was used to account for the effect of site buildings on the dispersion of pollutants.
- A stack height of 30m has been specified for the TM2500 turbines when operating in open cycle mode (Stage 1a). It is noted that the stage 1a stack is a temporary arrangement and before an OTSG will be installed within 15 months, also with a 30m stack (Stage 1b). For the LM6000PC Sprint units in closed cycle mode (Stage 2), a stack height of 40m has been used for the HRSG.
- Five years of hourly sequential meteorological data (2009, 2010, 2013, 2014 and 2015) from the nearest meteorological station (Accra) was used for this assessment. It should be noted that annual hourly sequential meteorological data was unavailable due to low data capture for some years.
- No formal established community residential areas are located within the Tema Heavy Industrial Area (THIA). The nearest formal community areas are located approximately 2km from the site. However, during consultations in 2016, it was confirmed that a number of workers are housed on site in commercial premises adjacent (to the south of) the Stage 1 site. In addition, the owners of two of the kiosks located along the original pipeline alignment were confirmed as residing at least part time in the kiosk. One informal (abandoned) residential dwelling was identified on the proposed tank farm site in 2015, but has since been removed. The above receptors were considered as part of the Stage 1 Abbreviated Resettlement Action Plan (ARAP) for the project.
- During the site visits for the 2017 ESIA amendment, residential receptors were identified on the Stage 2 site, though these will be relocated by the land owner. It has also been identified that owners of some of the kiosks located along Valco Road (approximately 900m to the south of the power plant sites) may also reside at least part time in their kiosks. Furthermore, a new informal residential receptor has been identified 200m east of the tank farm site, which has been established since the 2016 ESIA amendment. This receptor was established after the surveys for the 2016 ESIA amendment and surveys and may have been established after the cut-off date for the ARAP. This is also likely to be relocated and is discussed further in Section 20.
- Sensitive receptors surrounding the proposed site have been included in the modelling and concentrations of pollutants at these locations predicted, as discussed below. These represent individual residential properties within communities that border the

[3] International Finance Corporation, Environmental, Health and Safety Guidelines: Environmental, Air Emissions and Ambient Air Quality, 2007

Tema industrial zone, plus the location of worker accommodation in the adjacent commercial premises. As well as at discrete receptor locations, concentrations have been modelled on a receptor grid with 50m spacing, covering a 10km x 10km grid square centred on the proposed site to enable the generation of contour plots of the predicted ground level concentrations of the modelled pollutants. This also enables the maximum 'Off-site' concentrations to be estimated.

- The dispersion model was run (with the above information) for each scenario on LPG and DFO-firing and for each meteorological year. The predicted concentrations of the released substances (NO_x and CO for LPG and NO_x, CO, SO_2 and particulates for DFO) generated at ground level. The maximum modelled concentration at any of the sensitive receptor locations for any of the five years of meteorological data was reported. All combustion sources are assumed to run at 100% load continuously for the year.
- Concentrations of NO_x were converted to NO_2 as per the conversion method devised by Janssen et al[4]. This approach has been used to calculate a specific maximum conversion rate at various distances from the source to give more realistic concentrations of NO_2 due to emissions of NO_x from the modelled combustion units. More detail is presented in Appendix B (the accompanying Air Quality Technical Report).
- The respective modelled concentrations of pollutants due to turbine emissions from LPG and DFO firing were combined with appropriate background concentrations for the area. For Scenario 4, the predicted concentrations from Scenario 3 firing on LPG were scaled to reflect the change in emissions concentration as a result of firing on NG. The scaled results were combined with background concentrations and assessed accordingly.
- Modelled concentrations were assessed against the relevant ambient air quality guidelines, taking the current background levels into account.
- Cumulative modelling of other recent or proposed power plants in the airshed was also completed, as discussed in Section 11.5.4 below.
- A sensitivity analysis was also undertaken looking at different scenarios of worst case, emergency operation on DFO in the event of a significant disruption of the supply of LPG. This is presented in Section 11.6.3.

Table 11-4: Modelled Sensitive Receptor Locations

Receptor Description *				Location (UTM Zone 31N Coordinates)	
Reference	Location	Direction from site	Distance from site (km)	E (m)	N (m)
1	Residential	NW	3.20	167656	630814
2	Residential	NNW	3.96	168512	632187
3	Residential	NNW	4.27	169257	632681
4	Residential	N	3.85	169748	632296

[4] L.H.J.M. Janssen, J.H.A. Van Wakeren, H. Van Duuren and A.J. Elshout, A Classification of NO Oxidation Rates in Power Plant Plumes Based on Atmospheric Conditions, Atmospheric Environment Vol. 22, No. 1, pp. 43 – 53, 1988

Receptor Description *				Location (UTM Zone 31N Coordinates)	
Reference	Location	Direction from site	Distance from site (km)	E (m)	N (m)
5* (new)	Informal dwelling	NNW	0.13	169731	628557
6** (new)	Commercial worker accommodation	SSE	0.25	169889	628216
7	Residential	NE	2.28	171196	630251
8	Residential	NNE	2.22	171296	630098
9	Residential	NE	2.97	172059	630390
10	Residential	NNE	3.47	172561	630560
11	Residential	ESE	3.93	173369	630115
12	Residential	SE	3.43	173121	629327
13*** (new)	Informal dwelling	NW	2.06	170416	628859
14	Residential	SSW	1.73	171558	627355
15	Residential	SSW	2.03	170957	627159
16	Residential	S	3.14	169758	626419
17	Residential	S	4.03	169184	625374
18	Residential	W	3.55	168005	624842
19	Residential	WSW	3.34	167477	625773
20	Residential	WSW	3.25	167081	626516
21	Residential	WSW	3.39	166775	627275
22	Residential	W	3.69	166427	628178
23	Residential	W	3.94	166136	628842
24	Residential	NW	3.20	166134	629881

** Receptor 5 is the Stage 2 site residential dwelling which is due to be relocated by the land owner before Stage 2 construction commences and therefore has been scoped out for stage 2 calculations. It is likely that the resettlement will take place prior to operation of Stage 1. However, the receptor has been included to confirm related impacts in the event that there are any delays to resettlement by the landowner.*

*** Receptor 6 is a workers' residence in the commercial premises adjacent to the south of PPS1.*

**** Receptor 13 is a newly established residential dwelling, which will be resettled as part of EPL's Stage 2 Abbreviated Resettlement Action Plan (ARAP), prior to operation of Stage 1. This receptor is therefore not included in the assessment.*

A complete description of the dispersion modelling methodology, turbine emissions data, study inputs, uncertainties and assumptions are provided in Appendix B of this ESIA, the Air Quality Technical Appendix.

11.5.4 Cumulative Effects

There is a number of existing industrial plant within 3km of the proposed site. The emissions from the majority of existing plants are assumed to be accounted for within the ambient background concentrations. These plants will not be considered further for cumulative effects.

Emissions within the local airshed from plants commissioned since the 2016 monitoring period or from planned new plants and plant changes/expansions which will be commissioned prior to the EPL project, have the potential to cumulatively increase the overall pollutant air concentrations within the airshed.

Relevant identified power plant facilities within the project airshed are summarised in Table 11-5..

Table 11-5: Identified New or Proposed Power Plant Facilities (Including future Expansions)

Facility Type	Existing / Proposed Capacity	Fuel Type	In Operation (start date)	Approximate Distance from PPS1	Direction (from PPS1 / PPS2)
Trojan Power Ltd – Tema III	56 MW	Gas	When gas available (2016)	115m	WSW (PPS2)
CENIT / VRA TTP1 CCGT Expantion	220 MW	LCO/ Gas	Combined cycle expansion proposed, but no further details	0.6km	SW (PPS2)
VRA Station 3 upgrade	42 MW	Gas / Diesel	14 MW commissioned, others built	0.005	SW
Cenpower Kpone Independent Power Plant	350 MW	LCO / Diesel / Natural Gas	No (2017)	2.5	E
Sunon-Asogli Power Plant Phase 2	360 MW	Natural Gas / LCO	Yes (Unknown) New units may operate on LCO	3.4	E
AKSA Heavy Fuel Oil (HFO) Power Plant	200 MW	HFO	Yes (2017)	~0.8km	NNW
Karpower Ship	225 - 450 MW	HFO	225MW operating 2016 (new 450MW ship late 2017)	~5 km	SW (PPS1)

Notes:
The operation of gas-fired plants is intermittent as limited by availability of gas.

Since the 2016 air quality monitoring period, two new plants have been rapidly commissioned – AKSA HFO Power Project, located 800m northeast of the site and the Karpower HFO ship-based power plant, located in Tema Harbour. Information from the Ghana EPA indicates that a new 450MW ship is under consideration for Tema, though it is currently not confirmed whether the Karpower ship expansion will proceed. The larger ship capacity assumed for purposes of conservative assessment.

It is also understood that the Sunon-Asogli expansion project is either commissioned or pending commissioning once fuel is available. Recent press reports[5] at the time of writing

[5] http://allafrica.com/stories/201705291138.html

indicate that the Sunon-Asogli company is planning operate on LCO whilst gas is unavailable for operation.

The Cenit Power and VRA plants plan to co-venture to increase their power capacity by 110 MW each to a combined output of 440 MW with the addition of steam turbines on the existing plant. Emissions will not increase, but the buoyancy of the plume will be lower which is likely to impact dispersion. However, this would be expected to be managed through use of a taller stack on the associated HRSG.

Quantitative data for the proposed plants was requested at various times during consultation activities and is the subject of on-going engagement with other operators. However, despite a number of attempts to obtain the required technical information, no significant data was provided by the time of this latest iteration of the ESIA air quality assessment.

The potential for cumulative impacts has therefore been assessed quantitatively using assumption based on information from project ESIAs (for Cenpower and Aksa HFO Project) and, in the absence of the ESIA (e.g. for Sunon-Asogli and Karpower HFO Project) assumptions based identified publically available information about the plant capacities and fuel types, and site observations.

11.6 Assessment of Impacts

11.6.1 Construction Phase Impacts

The level of dust generation and dispersion is dependent upon a number of factors including:

- The type of construction activities taking place;
- The occurrence of hot, dry weather;
- The prevailing wind speed and direction; and,
- The mitigation measures adopted.

The potential for dust to be generated during the construction phase will be short-term and temporary in nature within the vicinity of the proposed site. Sensitive receptors downwind of the prevailing wind direction, i.e. to the north and northeast, would typically be most susceptible to dust emissions.

The closest residential receptors in the formal community areas are located in Tema New Town approximately 2.2km from the proposed site. The closest informal residential receptors are located on the Stage 2 site (to be relocated by the land owner) and workers' accommodation on the commercial premises adjacent to PPS1. A further residential dwelling, established since the commencement of the ESIA, has been identified 200m east of the tank farm site. This is likely to be relocated as part of the Stage 2 ARAP. There are also offices on some of the adjacent commercial premises and kiosks located close to the sites, though these are likely to be moved as part of the Stage 1 or Stage 2 ARAP.

Construction dust has the potential to cause human health impacts and annoyance through soiling. Because of the large particle size of dust generated; however, it is unlikely that this risk will have an effect beyond 200m of site activities or up to 500m along designated haul routes (due to the entrainment and potential re-suspension of material). As the Tema Heavy

Industrial Area is of low sensitivity for human health impacts, the dust emissions are unlikely to cause a significant impact other than short-lived nuisance effects at nearby buildings.

Unsurfaced roads and open ground are existing sources of dust in the area, and it is unlikely that construction works will give rise to significant additional effects since the nature of disturbance is similar. The unmitigated impacts are therefore assessed as being negligible as only low, localised impacts are predicted.

In the event that visual monitoring finds that dust emissions are unacceptable on the site during certain meteorological conditions (e.g. a hot dry period with high winds), construction will be tailored or additional mitigation put in place to ensure that dust emissions due to the construction works reduce to acceptable levels. Mitigation measures are discussed further in Section 11.7.1.

11.6.2 Operational Phase Impacts

Introduction

The results in Table 11-6 to Table 11-8 presents the maximum pollutant concentrations at 'residential' receptor locations as a result of emissions to air from the proposed plant, for each development stage and scenario considered. The results presented are the maximum concentrations for any of the five years of meteorological data included in the assessment for LPG and DFO.

The following information is presented within the results tables:

- Ambient Air Quality Guideline (AAQG). The EPA AAQG for "Residential" locations has been applied to sensitive receptor locations. The EPA AAQG for "Industrial" areas is applied to offsite locations which are not residential. Where no EPA AAQG exists, the WHO AAQG has been applied (as indicated within Table 11-3);
- Process Contribution (PC), the maximum modelled concentration of the substance at sensitive human receptors due to emissions from the proposed plant as per scenario modelled;
- Predicted Environmental Concentration (PEC), the maximum modelled concentration at sensitive human receptors due to process emissions combined with the background concentration; and,
- PC and PEC as a percentage of the appropriate AAQG.

The full results for each assessed sensitive human receptor and the modelled grid are presented in the Technical Appendix.

Table 11-6: Maximum Predicted Annual Mean NO_2, SO_2, PM_{10} and $PM_{2.5}$ Concentrations at Sensitive Receptors for all Modelled Scenarios

Scenario	NO_2					SO_2					PM10					$PM_{2.5}$				
	AAQG (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC/ AAQG (%)	PEC/ AAQG (%)	AAQG (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC/ AAQG (%)	PEC/ AAQG (%)	AAQG (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC/ AAQG (%)	PEC/ AAQG (%)	AAQG (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC/ AAQG (%)	PEC/ AAQG (%)
Scenario 1: 5 x TM2500 LPG turbine plant operating in open cycle mode																				
Stage 1a	40	0.48	22.38	1.20%	55.95%	50					20					10				
Scenario 1: 5 x TM2500 DFO turbine plant operating in open cycle mode																				
Stage 1a	40	0.48	22.38	1.20%	55.95%	50	3.6	8.3	7.21%	16.6%	20	1.2	188.7	5.8%	943%	10	1.2	45.3	11.7%	453%
Scenario 2: 5 x TM2500 LPG turbine plant fitted with Once Through Steam Generators (OTSGs) operating in combined cycle mode																				
Stage 1b	40	0.82	22.7	2.06%	56.8%	50					20					10				
Scenario 2: 5 x TM2500 DFO turbine plant fitted with Once Through Steam Generators (OTSGs) operating in combined cycle mode																				
Stage 1b	40	0.85	22.75	2.12%	56.87%	50	10.6	16	21.2%	32%	20	3.2	190.7	16.0%	954%	10	3.2	47.3	31.9%	473%
Scenario 3: Stage 1b (LPG fired) and four x LM6000PC Sprint LPG turbine plant fitted with HRSGs operating in combined cycle mode																				
Stage 2	40	1.58	23.5	3.95%	58.7%	50					20					10				
Scenario 3: Stage 1b (DFO fired) and four x LM6000PC Sprint DFO turbine plant fitted with HRSGs operating in combined cycle mode																				
Stage 2	40	1.50	23.4	3.76%	58.5%	50	12	17	24%	34%	20	3.2	190.7	16.0%	954%	10	3.2	47.3	31.9%	473%

The maximum concentrations predicted on the grid are within 350 m of the proposed power plant, between the plant and the next set of substantial buildings located to the northeast within the Tema Industrial Area.

For annual mean NO_2 concentration, the process contribution is less than 25% of the AAQG for all scenarios and fuel types. The PEC is below the AAQG in all cases as well.

For scenarios where diesel is used as fuel, for the annual mean SO_2 concentration, the PC is always less than 25% of the AAQG, and the PEC meets the AAQG. For PM_{10}, the annual mean concentration is less than 25% of the AAQG, but because of the elevated background levels, the PEC exceeds the AAQG. For $PM_{2.5}$, the PC is greater than the AAQG, and again the PEC exceeds the AAQG. It should be noted that it has conservatively been assumed in this case that all particulate emissions are in the form of $PM_{2.5}$.

Table 11-7 Predicted Maximum Modelled 1-hour and 24-hour NO2 Concentrations and 10 min and 24-hour SO2 Concentrations at Sensitive Receptors for all Modelled Scenarios

Scenario	NO_2										SO_2									
	1hr NO2 AAQG (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC/ AAQG (%)	PEC/ AAQG (%)	24hr NO2 AAQG (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC/ AAQG (%)	PEC/ AAQG (%)	10 min SO2 AAQG (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC/ AAQG (%)	PEC/ AAQG (%)	24hr SO2 AAQG (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC/ AAQG (%)	PEC/ AAQG (%)
Scenario 1: 5 x TM2500 LPG turbine plant operating in open cycle mode																				
Stage 1a	200	6.34	50.1	3.17%	25.1%	60	2.20	46.0	3.67%	76.7%										
Scenario 1: 5 x TM2500 DFO turbine plant operating in open cycle mode																				
Stage 1a	200	5.47	49.3	2.73%	24.6%	60	2.30	46.1	3.83%	76.8%	500	102	113	20.5%	22.6%	20	15.8	26.5	79.2%	132.2%
Scenario 2: 5 x TM2500 LPG turbine plant fitted with Once Through Steam Generators (OTSGs) operating in combined cycle mode																				
Stage 1b	200	10.3	54.1	5.16%	27.1%	60	3.21	47.0	5.36%	78.4%										
Scenario 2: 5 x TM2500 DFO turbine plant fitted with Once Through Steam Generators (OTSGs) operating in combined cycle mode																				
Stage 1b	200	10.6	54.4	5.30%	27.2%	60	3.91	47.71	6.52%	79.5%	500	181.2	191.8	36.2%	38.4%	20	43.5	54.1	217%	270%
Scenario 3: Stage 1b (LPG fired) and four x LM6000PC Sprint LPG turbine plant fitted with HRSGs operating in combined cycle mode																				
Stage 2	200	21.1	64.9	10.5%	32.4%	60	6.48	50.3	10.8%	83.8%										
Scenario 3: Stage 1b (DFO fired) and four x LM6000PC Sprint DFO turbine plant fitted with HRSGs operating in combined cycle mode																				
Stage 2	200	20.0	63.8	10.0%	31.9%	60	6.42	50.2	10.7%	83.7%	500	303.6	314.2	60.7%	62.8%	20	51.6	62.2	258%	310.8%

For 1-Hour and 24-hour average NO_2 concentrations, the process contribution is less than 25% of the AAQG for all scenarios and fuel types. The PEC is below the AAQG in all cases as well.

When running on diesel, for the 10-minute average SO_2 concentration, the PC is less than 25% of the AAQG for Stage 1a and 1B, but is greater than 25% of the AAQG for Stage 2. The PEC is less than the AAQG in all instances.

For the 24-hour average SO_2 concentration, the PC is greater than 25% of the AAQG for Stage 1a, but for Stage 1B and Stage 2, the PC exceeds the AAQG. The PEC exceeds the AAQG for all scenarios.

Table 11-8 Predicted Maximum Modelled 24-hour PM10 and PM2.5 Concentrations and 1-hour and 8-hour CO Concentrations at Sensitive Receptors for all Modelled Scenarios

Scenario	CO 1hr					CO 8hr					PM_{10} 24 hr					$PM_{2.5}$ 24 hr				
	AAQG (μg/m^3)	PC (μg/m^3)	PEC (μg/m^3)	PC/ AAQG (%)	PEC/ AAQG (%)	AAQG (μg/m^3)	PC (μg/m^3)	PEC (μg/m^3)	PC/ AAQG (%)	PEC/ AAQG (%)	AAQG (μg/m^3)	PC (μg/m^3)	PEC (μg/m^3)	PC/ AAQG (%)	PEC/ AAQG (%)	AAQG (μg/m^3)	PC (μg/m^3)	PEC (μg/m^3)	PC/ AAQG (%)	PEC/ AAQG (%)
Scenario 1: 5 x TM2500 LPG turbine plant operating in open cycle mode																				
Stage 1a	30,000	51.2	331	0.17%	1.10%	10,000	20.5	301	0.21%	3.01%	50					25				
Scenario 1: 5 x TM2500 DFO turbine plant operating in open cycle mode																				
Stage 1a	30,000	61.5	342	0.21%	1.14%	10,000	21.1	301	0.21%	3.01%	50	4.9	379.9	9.8%	760%	25	4.9	93.1	19.6%	372%
Scenario 2: 5 x TM2500 LPG turbine plant fitted with Once Through Steam Generators (OTSGs) operating in combined cycle mode																				
Stage 1b	30,000	105.5	386	0.35%	1.29%	10,000	70.0	350	0.70%	3.50%	50					25				
Scenario 2: 5 x TM2500 DFO turbine plant fitted with Once Through Steam Generators (OTSGs) operating in combined cycle mode																				
Stage 1b	30,000	109.0	389	0.36%	1.30%	10,000	72.3	352	0.72%	3.52%	50	13.5	388.5	26.9%	777%	25	13.5	101.7	53.9%	407%
Scenario 3: Stage 1b (LPG fired) and four x LM6000PC Sprint LPG turbine plant fitted with HRSGs operating in combined cycle mode																				
Stage 2	30,000	184	464	0.61%	1.55%	10,000	95	375	0.95%	3.75%	50					25				
Scenario 3: Stage 1b (DFO fired) and four x LM6000PC Sprint DFO turbine plant fitted with HRSGs operating in combined cycle mode																				
Stage 2	30,000	178	458	0.59%	1.53%	10,000	83	363	0.83%	3.63%	50	15.6	390.6	31.1%	781%	25	15.6	103.8	62%	415%

For CO, for the 1-hour and 8-hour average concentrations, the PC is less than 25% of the AAQG and the PEC is less than the AAQG for all scenarios.

When running on diesel, the PM_{10} and $PM_{2.5}$ 24-hour average concentrations are less than 25% of the AAQG for Stage 1A, but are greater than 25% of the AAQG for stages 1b and Stage 2. Given of the high particulate matter background, the PEC exceeds the AAQG in all instances.

11.6.3 Sensitivity Analysis for Partial Operation on DFO

A sensitivity analysis has been undertaken in which the effects of running the plant on diesel for 1, 3 and 6 months of the year (and LPG for the rest of that year) are calculated in addition to the data derived above for year-round operation on DFO.

It should be noted that because the peak concentrations for the 10-minute, 1-hour, 8-hour and 24-hour averaging periods are driven by the meteorological conditions during the relevant periods, the predicted peak concentrations of these short duration averaging are identical for the plant running on diesel, no matter how long the plant is using diesel.

The main impact will therefore be seen on the annual average concentrations, and the combined total contribution is calculated by using the appropriate fraction of the LPG and diesel annual mean concentrations, scaled by the fraction of time the plant uses each fuel. This analysis is presented in Table 11-9.

Table 11-9: Sensitivity Analysis of Running Scenario 3 (Stage 1b and Stage 2) for 1, 3, 6 Months and Year-round Operation on DFO

Sensitivity	Scenario	AAQG ($\mu g/m^3$)	Background ($\mu g/m^3$)	PC ($\mu g/m^3$)	PEC ($\mu g/m^3$)	PC/ AAQG (%)	PEC/ AAQG (%)
NO_2	Annual mean - 1 month diesel	40	21.9	1.90	23.8	4.75%	59.50%
	Annual mean - 3 month	40	21.9	1.88	23.8	4.71%	59.46%
	Annual mean - 6 month	40	21.9	1.86	23.8	4.64%	59.39%
	Annual mean – all year	40	21.9	1.5	23.4	3.76%	58.5%
PM_{10}	Annual mean - 1 month diesel	20	187.5	0.91	188.41	4.54%	942.04%
	Annual mean - 3 month	20	187.5	2.72	190.22	13.61%	951.11%
	Annual mean - 6 month	20	187.5	5.44	192.94	27.22%	964.72%
	Annual mean – all year	20	187.5	3.2	190.7	16.0%	954%
$PM_{2.5}$	Annual mean - 1 month diesel	10	44.1	0.91	45.0	9.07%	450.07%
	Annual mean - 3 month	10	44.1	2.72	46.8	27.22%	468.22%
	Annual mean - 6 month	10	44.1	5.44	49.5	54.44%	495.44%
	Annual mean – all year	10	44.1	3.2	47.3	31.9%	473%
SO_2	Annual mean - 1 month diesel	50	5.3	1	6	2%	12%
	Annual mean - 3 month	50	5.3	3	8	6%	16%
	Annual mean - 6 month	50	5.3	6	11	12%	22%
	Annual mean – all year	50	5.3	12	17	24%	34%

Because the emission factors for NO_2 and CO are very similar for both LPG and diesel, there is very little difference in annual impacts from the use of the two fuels. The use of diesel introduces particulate emissions, but in this case, the PC is less than 25% of the AAQG, but because of the high background the PEC exceeds the AAQG for both PM_{10} and $PM_{2.5}$.

Regarding the short term limits, because the short term average peak concentrations remain the same as for running 100% of the time on diesel, the same commentary applies as before, namely that exceedances may still be seen for 24-hour SO_2 and PM concentrations at each of the partial DFO operating scenarios.

11.6.4 Running on Natural Gas

When natural gas becomes available, plant emissions will consist of NO_2 and CO. Emissions will be reduced, since the emission factors for natural gas for NO_2 and CO are 33% and 50% of those for LPG respectively. The air quality calculations will scale proportionately, so lower impacts will be seen.

11.6.5 Cumulative impacts analysis

Four key external power plants have been identified in the vicinity of the project, for inclusion in the cumulative impacts assessment. These are identified in Table 11-10.

Table 11-10 External Power Plant included in the Cumulative Analysis

Power plant	Fuel	Stack height	Rated Power	Emission rates			
				NO_X	SO_2	CO	PM_{10}
			(MW)	g/s	g/s	g/s	g/s
Sunnon Asogli – Gas / LCO	LCO	45	360	99.3	620.7	20.7	8.3
Aksa HFO Plant	HFO	70	187	88.7	296.4	9.4	23.4
Cenpower	LCO	45	340	74.0	462.8	15.4	6.2
Karpower Ship*	HFO	45	470	223.0	745.0	23.7	59.0

*Information from the Ghana EPA indicates that a new 450MW ship is under consideration for Tema, though it is currently not confirmed whether the Karpower ship expansion will proceed. The larger ship capacity assumed for purposes of conservative assessment.

Emissions are estimated using US EPA AP42 emission factors and are based on the fuel and power rating of the plant. A key assumption to be noted is that no mitigation on the emissions has been assumed which makes this assessment conservative.

In addition, at this stage it is not uncertain as to whether the Karpower ship expansion will indeed proceed. Therefore, for further conservative consideration, the larger ship capacity has been assumed.

As can be seen, emissions are between 10 and 100 times greater than for this project. The overall effect is to significantly elevate the background levels in the airshed. The background data collected so far were measured prior to the commissioning of most of these schemes and as such will not include the contributions from them.

Because the background concentrations of particulate matter are already very high, the impact of these other plant on the background will not be as great.

The annual mean concentrations of NO_2 and SO_2, in the airshed are predicted to be ~30 and 20 μg/m^3, respectively. It can be seen from the results above that this will still not result in an exceedance of the NO_2 AAQG for the PEC even using this higher background. However, the predicted cumulative 24-hour average SO_2 concentration (~100 μg/m^3) suggests that the entire region will exceed the AAQG.

The air quality technical appendix presents the results of the analysis done which gives the predicted maximum offsite concentrations for Scenario's 1 – 3; confirming the above conclusion. As this is the maximum on the grid, residential receptors have not been re tabulated as the results would be lower.

Whilst this is not a detailed assessment and contains a number of approximations and conservative assumptions, this is likely to add further weight to arguments against the use of diesel (AAQG are exceeded "even more" in these circumstances).

The next phase of the monitoring program will inform this debate further and should be timed according to the confirmed commissioning and operation of these external plants, especially the commissioning of the larger Karpower power ship generating capacity.

11.7 Mitigation and Monitoring

11.7.1 Construction Phase

Specific construction management mitigation measures with regard to impacts on air quality are included within the ESMP presented in this ESIA report.

The following mitigation measures are recommended and should be adopted where practicable and necessary during the construction phase:

- Plant and equipment will be designed and used in a manner which minimises dust generation;
- Dampening (using water or some other environmentally benign dust-suppressant material) of un-surfaced areas, soils and spoil may be undertaken to prevent dust re-suspension during hot, dry weather conditions with relatively high wind speeds;
- Careful location, grading and management of stockpiles of soil and similar materials will be undertaken to prevent wind-blow or taken off-site;
- Sealing and / or re-vegetation of completed earthworks will be undertaken as soon as reasonably practicable;
- Where possible, site roads will be surfaced early in the construction programme – with vehicle speeds limited to an appropriately low speed to minimise re-suspension of dust from surfaced and un-surfaced roads;
- Regular cleaning of surfaced roads and maintenance of un-surfaced roads will be undertaken to reduce off-site transport of soils and to avoid dust generation;

- Lorries will be sheeted during transportation of friable construction materials and spoil and wheel wash facilities made available during adverse conditions;
- Drop heights will be minimised during material transfer activities, such as unloading of friable materials; and,
- Positioning and movement of construction equipment will be undertaken in a manner which minimises dust generation.

With regard to combustion emissions from on-site plant and machinery, the following should be considered:

- Diesel powered construction equipment and vehicles will be well maintained to minimise exhaust emissions; and,
- Idling reduction awareness activities for onsite diesel powered equipment and mobile vehicles.

Implementation of the monitoring and mitigation plans will ensure that the impact, which was already considered to negligible based on its local and short-duration nature, will be reduced even further.

In addition to the construction-related impacts, the ambient air quality monitoring programme discussed below may need to commence during the construction phase.

11.7.2 Operational Phase including Mitigation of Cumulative Impacts

The following measures have been acted on during detailed design to further assess and reduce potential impacts, including cumulative impacts, to air quality:

- Refinement of the stack design and stack height to minimise impacts to residential areas; in particular, improved dispersion of emissions has been achieved by the conversion of the TM2500 units to combined cycle results where the heights of the final discharge stacks have increased from 15.3m to 30m;
- Extension of ambient air baseline monitoring of NO2 and ozone (to enable derivation of a local conversion ratio from NO_x to NO_2) for a further six months between April 2016 and November 2016 to provide a more robust baseline;
- Additional engagement with the operators of other proposed plants at Tema to collaborate on assessment and management of cumulative impacts to the air-shed.

Mitigation measures already included within the design will be integral to the design and operation of the proposed plant. These include:

- The use of modern combustion technology and effective combustion to minimise the generation of NO_x and CO emissions and to meet appropriate emission standards;
- The use of water abatement as an integral part of the plant design to reduce NO_x emissions from the turbines operating in open cycle mode;
- The use of a low-sulphur fuel, (i.*e*. LPG, low sulphur DFO and ultimately NG);

- Appropriately designed stacks and stack height to ensure adequate dispersion of emissions to air;
- Continuous Emissions Monitoring Systems (CEMS) will be installed on the exhaust stacks to monitor the emissions of the relevant pollutants and associated emissions parameters in accordance with the appropriate monitoring and reporting requirements of the EPA. Provision shall be made for manual sampling of pollutants where required. Sampling points and safe access to the monitoring points shall be designed into the plant; and,
- Because of the dynamic emissions context and rapid development within the airshed, it is recommended to undertake an extended monitoring programme in the locality. Monthly diffusion tubes should be deployed on a continuous basis, with analysis for NO_X and SO_2. Timings should be according to the confirmed commissioning and operation of these external plant, especially the commissioning of the larger Karpower power ship generating capacity (although a continuous programme should pick up the step changes in levels anyway). Particulate monitoring is a complicated process, and in light of the current knowledge of a likely very high background, and considering that EPL will only be running on DFO for temporary back up use, there may not be significant value in implementing a programme to look for variations due to emissions from other plants.

11.8 Summary and Conclusions

This assessment has considered the potential for construction impacts associated with e.g. emissions of dust during the construction phase, and operational impacts associated with emissions of NO_2, and CO, SO_2 and particulates from the proposed plant during each stage of development on local air quality.

The potential impact due to emissions from road traffic or mobile plant during the construction and operational phases is considered to be negligible. The implementation of recommended mitigation measures will further reduce the low risk of dust impacts surrounding the proposed site during construction.

The assessment of operating emissions follows the accepted approach for international ESIA of application of national guidelines (or WHO ambient air quality guidelines where national guidelines are absent) regarding acceptable impacts on human health and worse-case operational scenario and assumptions. The assessment was based on conservative assumptions as it is likely there will be down time for maintenance and the predicted concentrations are based on continuous operation throughout the year.

Results when operating on LPG:

- The proposed plant is predicted to result in increases in NO_2 and CO concentrations at the closest downwind 'residential' locations within the Tema district area when operating on LPG. However, the predicted process contributions for all pollutants and averaging periods are below the 25% of the respective AAQGs for all operating scenarios on LPG. On this basis, the plant complies with the IFC requirements for non-degraded air-sheds (IFC, 2007).
- Improvements in the plant design, including the use of taller (30m) stacks for Stage 1a and incorporation of heat recovery on the TM2500 units, has substantially reduced the predicted impacts in comparison to earlier design iterations.
- Predicted emissions from the project on LPG under the cumulative modelling scenario also shows predicted process contributions for all pollutants and averaging periods are below the 25% of the respective AAQGs for all operating scenarios. On this basis, the plant complies with the IFC requirements for non-degraded air-sheds (IFC, 2007).

Result for DFO operating scenarios and LPG/DFO sensitivity scenarios:

- The 10-minute average SO2 concentration, the PC is less than 25% of the AAQG for Stage 1a and 1B, but is greater than 25% of the AAQG for Stage 2. The PEC is less than the AAQG in all instances.
- For the 24-hour average SO2 concentration, the PC is greater than 25% of the AAQG for Stage 1a, but for Stage 1B and Stage 2, the PC exceeds the AAQG. The PEC exceeds the AAQG for all scenarios.
- The PM10 and PM2.5 24-hour average concentrations are less than 25% of the AAQG for Stage 1A, but are greater than 25% of the AAQG for stages 1b and Stage 2. Because of the high particulate matter background, the PEC exceeds the AAQG in all instances.
- A sensitivity analysis has been undertaken for operation on DFO for 1, 3 and 6 months of the year (and LPG for the rest of that year). As peak concentrations for the 10-minute, 1-hour, 8-hour and 24-hour averaging periods are driven by the meteorological conditions, associated peak concentrations of these short duration averaging are identical for the plant running on diesel, no matter how long the plant is using diesel. Therefore exceedances will still be seen for 24-hour SO_2 and PM concentrations.
- The main impact will be seen on the annual average concentrations. As the emission factors for NO_2 and CO are very similar for both LPG and diesel, there is little difference in annual impacts from the use of the two fuels. The use of diesel introduces particulate emissions. In this case the PC is less than 25% of the AAQG, but because of the high background the PEC exceeds the AAQG for both PM_{10} and $PM_{2.5}$.

Results for cumulative modelling scenario:

- The cumulative modelling scenario considered the plants now in operation since the most recent baseline monitoring data was collected, and also those predicted to be commissioned prior to the EPL project.
- Whilst the assessment necessarily had use a number of assumptions and is therefore conservative, emissions from those projects are predicted as between 10 and 100 times greater than EPL's emissions and results indicate that the airshed is likely to be degraded for particulates and the 24-hour average SO2 concentration by the time the EPL project is operating (if it is not already so).
- This is adds further weight to arguments against the use of diesel as a main operational fuel as AAQG are exceeded "even more" in these circumstances. However, the cumulative results annual mean concentrations of NO_2 and SO_2 will still not result in an exceedance of the NO_2 AAQG for the PEC even using this higher background.

The predicted concentrations of NO_2 and CO are significantly lower than LPG operation when the project is running on natural gas. The reduction in pollutant emissions as a result of converting from liquid petroleum gas to natural gas is 66% for NO_2 and 47% for CO. The predicted concentrations are well within the relevant AAQGs and the process contributions are lower than the 25% threshold specified by the IFC. For this phase of the project, the impact is considered to be reduced to negligible / minor.

For contingency operation on diesel, it may be appropriate to make use of the WBG/IFC interim targets for SO_2 and $PM_{2.5}$ 24-hour average AAQG. These are the emissions parameters which show potential AAQG problems when running on diesel, since the predicted PCs are above 25% of the most stringent WHO AAQG adopted.

In the WBG EHS Guidelines, the guidance states that "interim targets are provided in recognition of the need for a staged approach to achieving the recommended guidelines", with no further guidance on their actual application.

The EPL project is investing significantly in LPG infrastructure. It is also the final goal of the project to ultimately power the station with natural gas, which will be compliant with the most stringent of the IFC standards and not emit SO_2 or particulate matter. Whilst waiting for the NG supply to mature, the plant will be powered with LPG, which has the same characteristics as NG, though higher emission factors, but will still meet the IFC AAQGs.

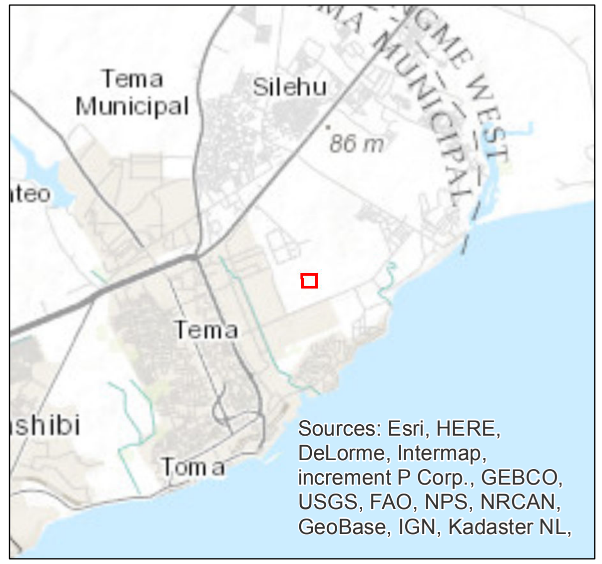
It is possible that, in the interim period prior to gas operation, prolonged operation on DFO may be required due to interruption in LPG supply. Given that risks in LPG supply market are outside of EPL's control, as a contingency measure in the event that LPG supply fails, it is suggested that the plant should be permitted to run on DFO as an interim measure to maintain generation.

This is predicted to lead to exceedance of 25% of the AAQG at the most stringent levels for SO_2 and $PM_{2.5}$, but it is considered that the situation should be recognised as an interim one *en route* to the natural gas ideal. The use of the IFC interim guidance levels (125 µg/m^3 for SO2 and 75 µg/m^3 for PM2.5 24-hour average) for these pollutants may allow the plant to meet the 25% of the interim AAQG.

FIGURE 11-1

Legend

- Proposed Onsite Buildings
- Stage 1 a - TM2500 Emission Point to Air (OCGT)
- Stage 1 B - TM2500 Emission Point to Air (OCGT)
- Stage 2 - LM Emission Point to Air (CCGT)
- Indicative Site boundary



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	22/07/2017	Revised generator operation	DA	GW	GW	MM

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Client

Early Power Ltd

Project

Ghana Bridge Power Project ESIA

Drawing Title

Emission Points to Air and Proposed Site Layout

Drawing Status

Scale @ A3	1:1,500	DO NOT SCALE
Jacobs No.	60K36301	
Client No.		
Drawing No.	Figure 11-1	

FIGURE 11-2

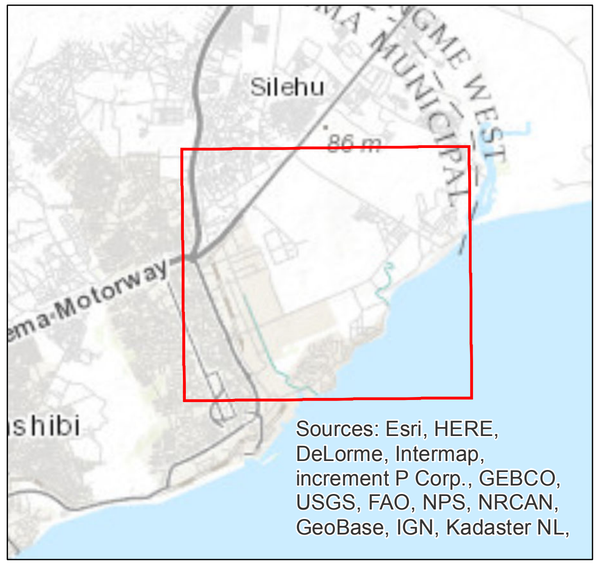
Legend

Indicative Site boundary

Residential Receptors

Air Quality Monitoring Locations

Sensitive receptor locations 5 and 6 will be removed on Stage 2 and therefore have been scoped out of Stage 2 analysis.



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	22/07/2017	Revised generator operation	DA	GW	GW	MM

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Ghana Bridge Power Project ESIA

Drawing Title

Sensitive receptors and baseline monitoring locations

Drawing Status

Scale @ A3	1:30,000	DO NOT SCALE
Jacobs No.	60K36301	
Client No.		
Drawing No.	Figure 2	

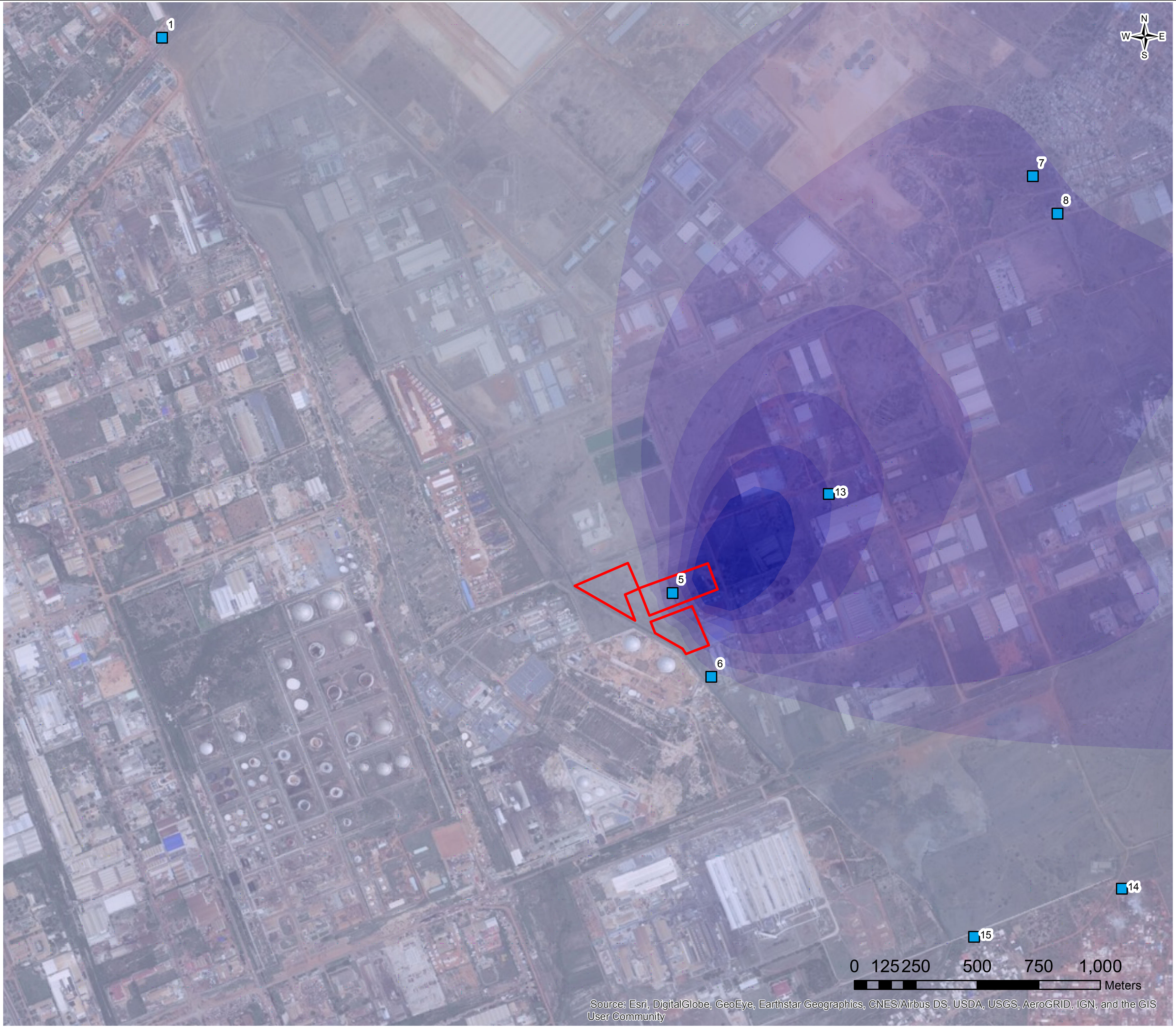


FIGURE 11-3

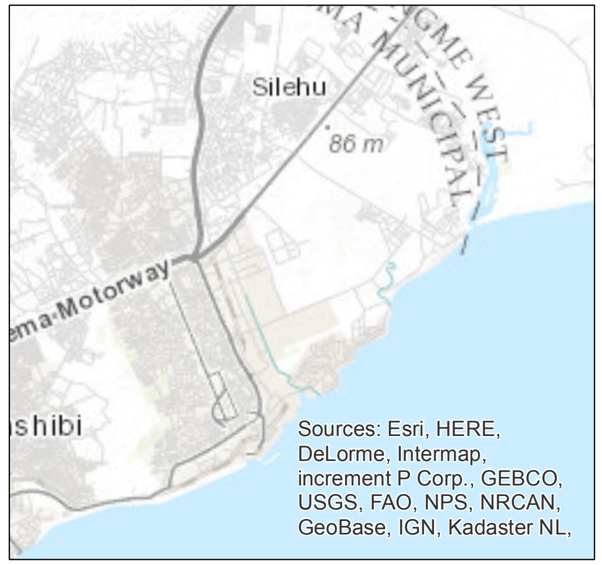
Legend

- Indicative Site Boundary
- Residential Receptors

Annual Mean NOX (µg/m3)

- 0 - 5
- 5 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- > 50

Sensitive receptor locations 5 and 6 will be removed on Stage 2 and therefore have been scoped out of Stage 2 analysis.



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Drawing Title

Annual Mean Nitrogen Dioxide Process Contributions for Scenario 3 (Fully operational Stg1 and 2 Plant) – DFO and LPG operation

Drawing Status

Scale @ A3	1:15,000	DO NOT SCALE
Jacobs No.	60K36301	
Client No.		
Drawing No.	Figure 11-3	

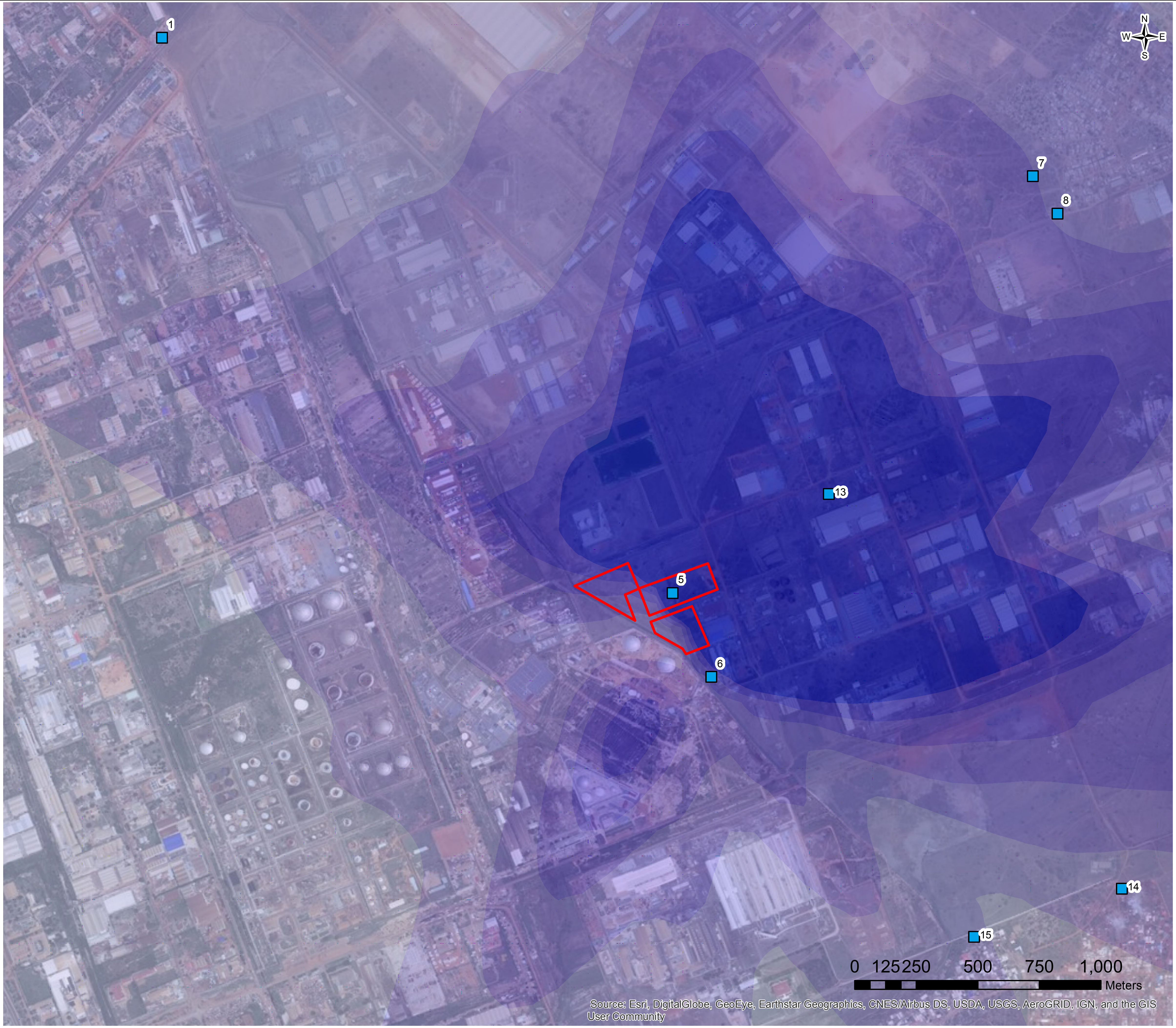


FIGURE 11-4

Legend

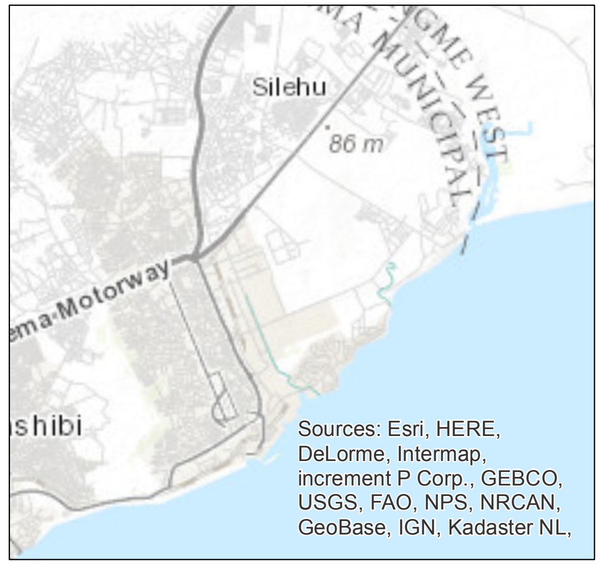
Indicative Site Boundary

Residential Receptors

24-hour Mean NOX (µg/m3)

0- 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
> 60

Sensitive receptor locations 5 and 6 will be removed on Stage 2 and therefore have been scoped out of Stage 2 analysis.



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
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Project

Ghana Bridge Power Project ESIA

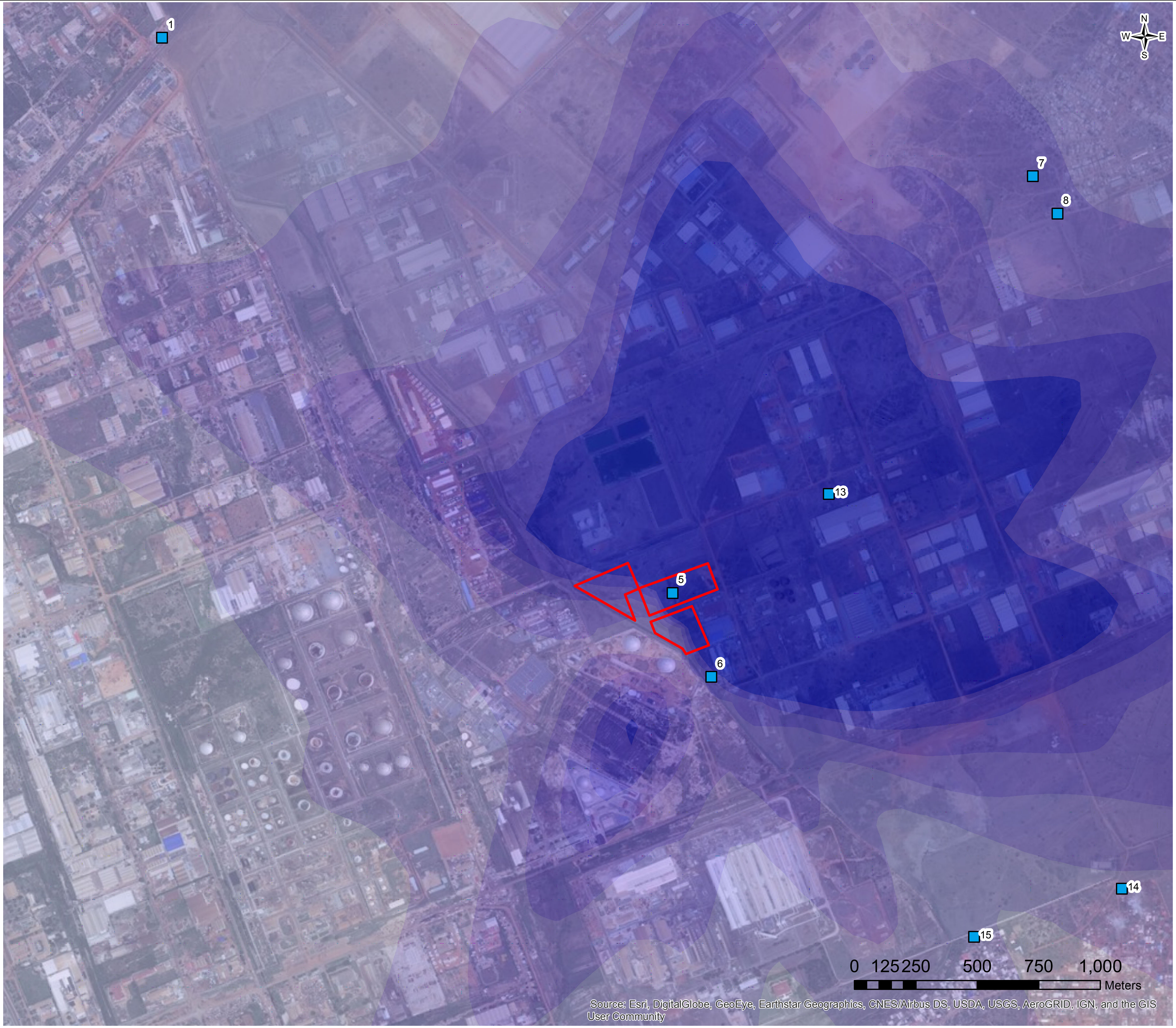
Drawing Title

24-hour Mean Nitrogen Dioxide Process Contributions for Scenario 3 (Fully operational Stg1 and 2 Plant) – DFO and LPG operation

Drawing Status

Scale @ A3	1:15,000	DO NOT SCALE
Jacobs No.	60K36301	
Client No.		
Drawing No.	Figure 11-4	

FIGURE 11-5



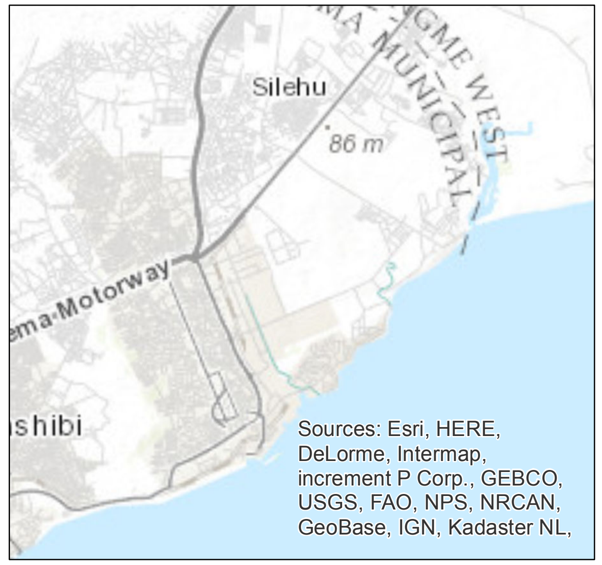
Legend

- Indicative Site Boundary
- Residential Receptors

24-hour Mean SO2 (µg/m3)

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- > 60

Sensitive receptor locations 5 and 6 will be removed on Stage 2 and therefore have been scoped out of Stage 2 analysis.



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Ghana Bridge Power Project ESIA

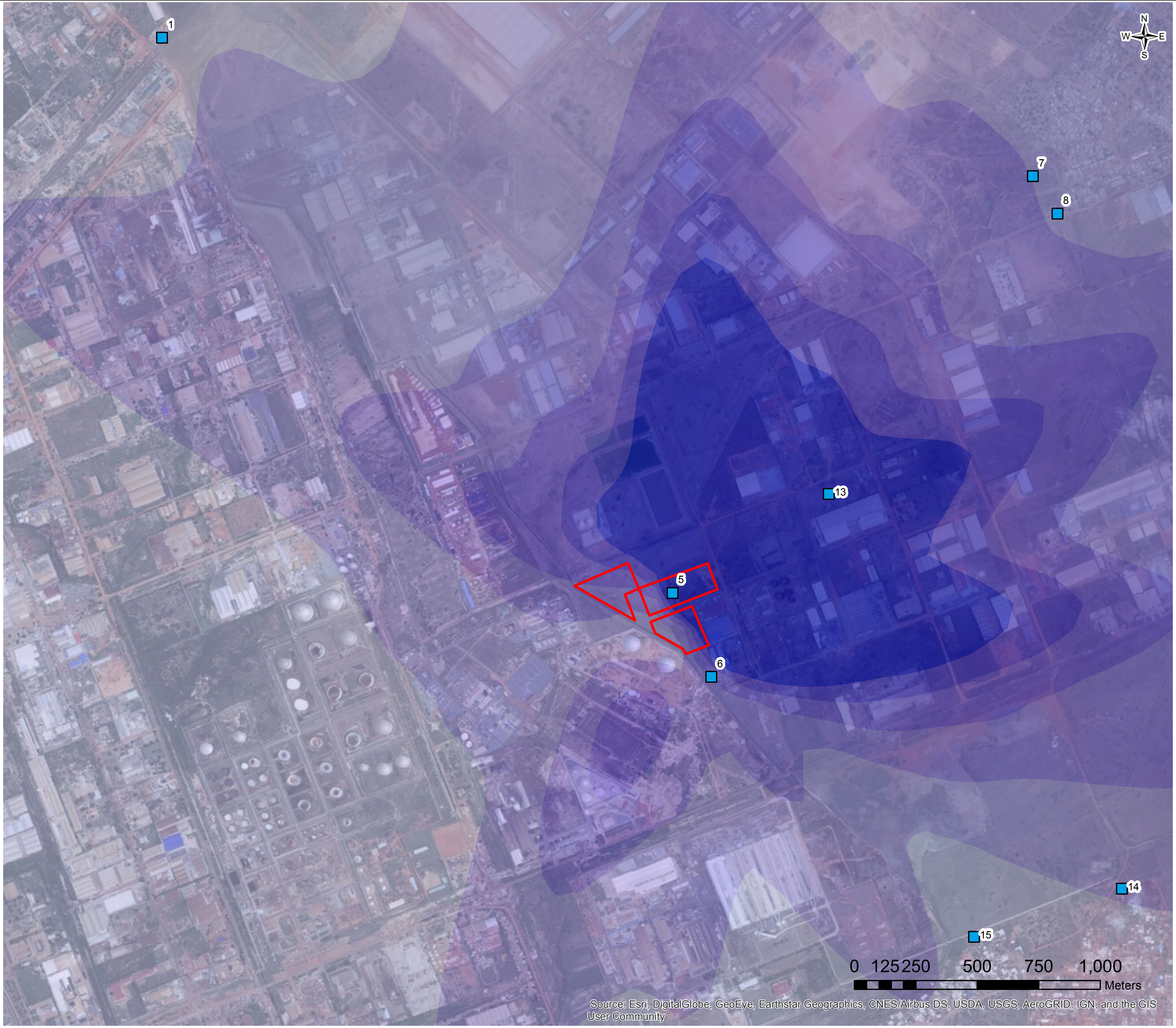
Drawing Title

24-hour Mean Sulphur Dioxide Process Contributions for Scenario 3 (Fully operational Stg1 and 2 Plant) – DFO operation

Drawing Status

Scale @ A3	1:15,000	DO NOT SCALE
Jacobs No.	60K36301	
Client No.		
Drawing No.	Figure 11-5	

FIGURE 11-6



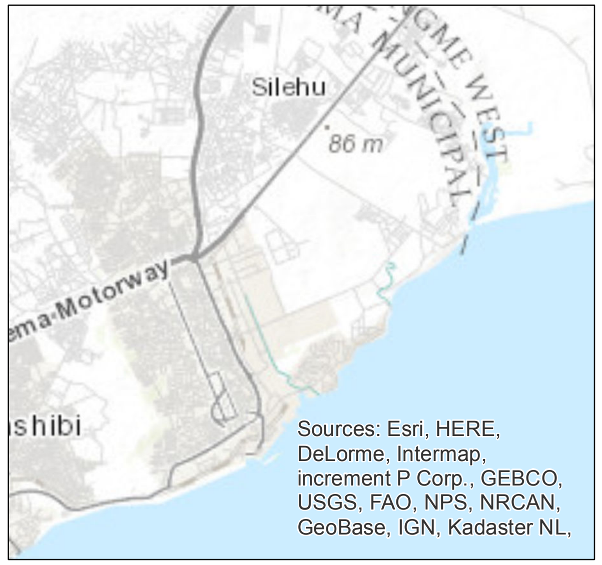
Legend

- Indicative Site Boundary
- Residential Receptors

24-hour Mean PM2.5 (µg/m3)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- > 25

Sensitive receptor locations 5 and 6 will be removed on Stage 2 and therefore have been scoped out of Stage 2 analysis.



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Client

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Project

Ghana Bridge Power Project ESIA

Drawing Title

24-hour Mean Particular Matter (2.5) Contributions for Scenario 3 (Fully operational Stg1 and 2 Plant) – DFO operation

Drawing Status

Scale @ A3	1:15,000	DO NOT SCALE
Jacobs No.	60K36301	
Client No.		
Drawing No.	Figure 11-6	

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Environmental and Social Impact Assessment

Section 12 – Landscape and Visual Assessment

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration		Rev No
Sep 2015	First issue		0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency		1
June 2016	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating the following changes:		2
	Section No.	***Change***	
	Wherever relevant	Reference to “power plant site” changed to reflect revised plan involving two power plant sites (PPS1 and PPS2).	
	Wherever relevant	Corrections to spelling, grammar and other changes for consistency. Abbreviated terms provided in full at first usage.	
	12.2	Additional details on sources of landscape and visual impact from water storage tanks and pipelines	
August 2017	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating the following changes:		3
	Section No	***Change***	
	12.6	Amendment to Figure 12-1 to show revised site location configuration	

Contents

Figures and Tables

12 Landscape and Visual

12.1 Introduction

This Section assesses the potential effects of the project on the landscape resource and visual amenity within the study area adopted for the Landscape and Visual Assessment (LVA).

The assessment addresses the following issues:

- Impacts on the landscape resource;
- Impact on the perception of the landscape; and
- Impacts on visual amenity.

Landscape impacts are changes on the landscape resource and perception of the landscape, and differ from visual impacts, which relate to the appearance of these changes and the resulting impact on visual amenity.

12.2 Sources of Landscape and Visual Impact

A detailed description of the project is provided in Section 2. In regards to potential landscape and visual impacts, the key components of the project comprise:

- Two liquefied petroleum gas (LPG) power plants including gas TM and LM turbines, with emission stacks and Heat Recovery Steam Generators (HRSGs) with stacks;
- Air cooled condensers;
- Steam turbine buildings and water storage tanks;
- New LPG, diesel and water pipelines (routed in combination with existing pipework above ground or new pipeline routes underground); and
- Tank farm for LPG storage.

Underground elements of the development are not considered in this section.

12.3 Methodology and Approach

The methodology and approach to the LVA is based on guidance provided in the following publications:

- 'Guidelines for the Assessment of Landscape and Visual Impacts', Third Edition, The Landscape Institute with the Institute of Environmental Management and Assessment (2013); and
- 'Landscape Character Assessment: Guidance for England and Scotland', The Countryside Agency and SNH (2002).

The assessment aims to:

- Identify systematically all the potential landscape and visual impacts of the proposed development;
- Take account of proposed mitigation measures;
- Predict and estimate the magnitude of impacts; and
- Assess the significance of effects of these impacts in a logical and well-reasoned fashion.

The assessment describes the changes in the character and quality of the landscape and visual resources that are expected to result from the proposed development. It covers both landscape impacts i.e. changes in the fabric, character and key defining characteristics of the landscape; and visual impacts, i.e. changes in available views of the landscape and the significance of those changes for people.

In assessing landscape impacts, the potential direct impacts on the fabric of the landscape are considered, together with the potential impacts on the perception of landscape character. The latter depends on a number of factors:

- The nature of the landscape character type, including factors such as the nature of views and sense of enclosure;
- The extent of the potential visibility of the proposed development (e.g. the extent of the development seen);
- The proportion of the character type with potential visibility; and
- The distance to the proposed development.

Viewpoint analysis has been carried out to identify and evaluate the potential impacts on, and visual amenity arising from, the proposed development at specific representative locations in the study area. The viewpoints selected are considered to be representative of the spectrum of receptors in the study area, located at different distances, directions and elevations relative to the proposed development.

The extent of the study area to the proposed development is determined through evaluation of the scale, context and likely visibility of the proposed development. The extent of the study area can be refined or extended as a greater understanding of the proposed development is established. The study area adopted for this assessment has extended to a 5km radius.

12.4 Assessment Criteria

The aim of the environmental assessment is to identify, predict and evaluate potential landscape and visual impacts arising from the proposed development. Identified impacts are quantified wherever possible; however, the nature of landscape and visual assessment requires an element of interpretation using professional judgement. In order to provide a level of consistency to the assessment, the prediction of magnitude and assessment of significance of the residual landscape and visual effects have been based on the following pre-defined criteria.

12.4.1 Landscape Sensitivity

The sensitivity of the landscape is not absolute and varies according to the nature and value of the existing landscape, the nature of the proposed development and the type of change being considered. The determination of the sensitivity of the landscape resource to change associated with the proposed development is defined as High, Medium or Low and is based on professional interpretation of a combination of parameters as defined in Table 12-1.

Table 12-1: Definition of Landscape Sensitivity

Sensitivity	Parameters
High	Landscape with important components, usually of particularly distinctive Character and high quality, susceptible to relatively small changes and for which mitigation would be difficult or not possible. Some less destinctive or lower quality landscapes may also fall into this category where characteristics are such that mitigation of negative changes would be difficult.
Medium	Landscape with characteristics reasonably tolerant of changes or for which mitigation is likely to be possible. These landscapes may be of high quality or of distinctive character but will usually be relatively ordinary and moderately valued.
Low	A less distinctive or relatively poor landscape with few features of quality or interest, potentially tolerant of substantial change and with scope for mitigation of any negative changes.

In some instances, a landscape with important components and high quality may be of a lower sensitivity as a result of its potential tolerance to change and opportunities for mitigation, e.g. a variable landform or high levels of tree cover. Conversely a landscape with few features of interest may be of a higher sensitivity because it is vulnerable to a particular type of change.

12.4.2 Visual Receptor Sensitivity

The sensitivity of visual receptors is based on an interpretation of a combination of parameters as follows:

- The location of the viewpoint;
- The context of the view;
- The activity of the receptor; and
- Frequency and duration of the view.

Visual receptor sensitivity is defined as High, Medium, Low or Negligible as shown in Table 12-2, below.

Table 12-2: Definition of Visual Receptor Sensitivity

Sensitivity	Parameters
High	Residents; strategic recreational footpaths, cycle routes or rights of way, whose attention may be focused on the landscape; important features with physical, cultural or historic attributes; picnic areas.
Medium	People travelling through or past the landscape on local roads, train lines or other transport routes.
Low	People engaged in outdoor sports or recreation (other than appreciation of the landscape), commercial buildings or commercially engaged pedestrians, whose attention may be focused on their work or activity rather than the wider landscape; people travelling through the landscape on major roads e.g. motorways.
Negligable	Views from heavily industrialised areas.

12.4.3 Determination of Magnitude of Change

The magnitude of change (or impact) arising from the proposed development, to the landscape or visual resource, is described as Substantial, Moderate, Slight or Negligible based on the interpretation of a combination of largely quantifiable parameters.

Definitions of magnitude are given within Guidelines for Landscape and Visual Impact Assessment (3rd Edition 2013). Table 12-3, below provides the definitions for magnitude of change used for the purposes of this assessment. These may be positive or negative changes.

Table 12-3: Definitions of Magnitude of Change to the Landscape Resource

Level of Magnitude	Definition of Magnitude of Impact
Substantial	Total loss or major alteration to key elements / features / characteristics of the baseline conditions such that post development character/composition of baseline would be fundamentally changed.
Moderate	Partial loss or alteration to one or more key elements / features / characteristics of the baseline conditions such that post development character/ composition/ attributes of baseline would be partially changed.
Slight	Minor loss of or alteration to one or more key elements / features/ characteristics of the baseline conditions. Change arising from the loss / alteration would be discernible but underlying character / composition of the baseline condition would be similar to pre development circumstances / patterns.
Negligible	Very minor loss or alteration to one or more key elements/ features / characteristics of the baseline conditions. Change barely distinguishable, approximating to the “no change” situation.

For change experienced at visual receptors, change to a view or setting, the parameters are as follows:

- Distance of the viewpoint from the development;
- Duration of impact;
- Angle of view in relation to main receptor activity;
- Proportion of the field of view occupied by the development;
- Background to the development; and,
- Extent of other built development visible, particularly vertical elements.

These are also assessed within the range of Substantial, Moderate, Slight or Negligible change, as shown in Table 12-4 below, and can be adverse or beneficial:

Table 12-4: Definitions of Magnitude of Change to the Visual Amenity

Level of Magnitude	Definition of Magnitude of Impact
Substantial	Where the scheme would cause a significant change to the existing view.
Moderate	Where the scheme would cause a noticeable change to the existing view.
Slight	Where the scheme would cause a barely perceptible change to the existing view.
Negligible	Change barely distinguishable, approximating to the "no change" situation.

12.4.4 The Significance of Effects

The significance of any identified landscape or visual effect is assessed as Major, Moderate, Minor or Negligible / No impact. These categories are determined by correlating the landscape or visual sensitivity of the resource with the predicted magnitude of change, as illustrated by the following matrix (Table 12-5).

Table 12-5: Correlation of Sensitivity and Magnitude of Impact to Determine the Significance of Effects

Landscape/Visual Sensitivity	Magnitude of Change			
	Substantial	Moderate	Slight	Negligible
High	Major	Major/Moderate	Moderate	Moderate/Minor
Medium	Major/Moderate	Moderate	Moderate/Minor	Minor
Low	Moderate	Moderate/Minor	Minor	Minor/None
Negligible	Moderate/Minor	Minor	Minor/None	No Impact

Where the landscape or visual effects have been classified as Major or Major / Moderate, this is considered to be a significant impact. It should be noted that significant impacts need not be unacceptable, or necessarily negative, and may be reversible. The potential impacts associated with the proposed development are referred to as adverse, neutral or positive in the text where applicable.

The matrix is not used as a prescriptive tool, and the methodology and analysis of potential impacts at any particular location must make allowance for the exercise of professional judgement. Thus, in some instances a particular parameter may be considered as having a determining impact on the analysis.

12.5 Assessment of Effects upon Landscape Character Type

The assessment of effects on the LCT is provided below.

12.5.1 Industrial Land LCT

The project is located within an industrial area on a low lying brownfield plot within the VRA LCT. In regard to landscape character, the project can be said to be located within the 'Industrial Land LCT' characterised by the industrial buildings, sheds, lay down areas and tank farms. To all sides beyond a distance of approximately 2km, the industrial land is surrounded by low rise housing and commercial development.

There will be direct effects on a small portion of the Industrial Land LCT only, resulting from the construction and operation of the project. The project will consolidate and reinforce the industrial characteristics of the LCT, which is perceived in the context of the existing infrastructure including pipework. The LCT is of no or very limited landscape or amenity value.

In this regard the magnitude of change of the character of the LCT will be slight and the resulting effect will be minor which in the context of this assessment is not significant. This effect will endure for the lifetime of the project until decommissioning.

12.5.2 Residential LCT

There are no direct effects on the Residential Land LCT as a result of the project and effects will be indirect in nature only.

The project will exert very limited influence on the character of the Residential Land LCT, which surrounds the Industrial Land LCT. This is a function of its distance from the Residential Land LCT (in excess of 2km) and the context in which the project will be viewed, which comprises existing industrial buildings and infrastructure. The magnitude is therefore considered to be slight.

In this regard the magnitude of change on the character of the Residential Land LCT will be negligible and the resulting effect classified as minor/none, which in the context of this assessment is not significant.

12.6 Assessment of Effects upon Visual Receptors

The assessment is supported by Figure 12-1 showing the site location and visual receptors.

12.6.1 Assessment of Views from Residential Areas

In views from the surrounding residential areas, including Kpone, Tema and Tema New Town, the project will be viewed as a new grouping of industrial structures within the middle of the existing industrial buildings and infrastructure. These views will be typically experienced by properties on the fringe of the neighbouring residential areas at a distance of approximately 2 km, visibility reducing with increasing distance owing to the screening by intervening buildings. Viewed in the midst of the existing industrial structures, or in close association with the existing pipework in regard to the proposed sections of pipe, the project will exert limited influence on the existing visual amenity.

In this regard, the magnitude of change to views from the high sensitivity surrounding residential areas will be negligible, resulting in effects that are moderate/minor or less. In the context of this assessment these effects are not significant.

12.6.2 Assessment of Views from Roads and Railways

The project is likely to be visible to some extent from distributor roads surrounding the industrial area including Valco Road, Harbour Road, and the N1 (Accra to Alfao Road). Views of the project from these routes are likely to be partial and intermittent, the project viewed within the industrial area and exerting limited influence on visual amenity.

In this regard, the magnitude of change to views from the medium sensitivity principle roads in the vicinity of the project is likely to be negligible and the effects minor or less. In the context of this assessment these effects are not significant.

Views of the project from the Accra/Tema railway are likely to be similar to those of experienced from the roads and the effects on visual amenity not significant.

12.7 Conclusions

The project is located within an existing industrial area and will not significantly alter the character of it. In regard to visual amenity, the project will be viewed within the midst of the existing industrial developments and, seen in the context of the existing industrial structures, will have only a minor effect on the visual amenity experienced from the surrounding residential areas and transport routes. The resulting effects from the project are not likely to be significant in the context of the assessment and no mitigation is required.

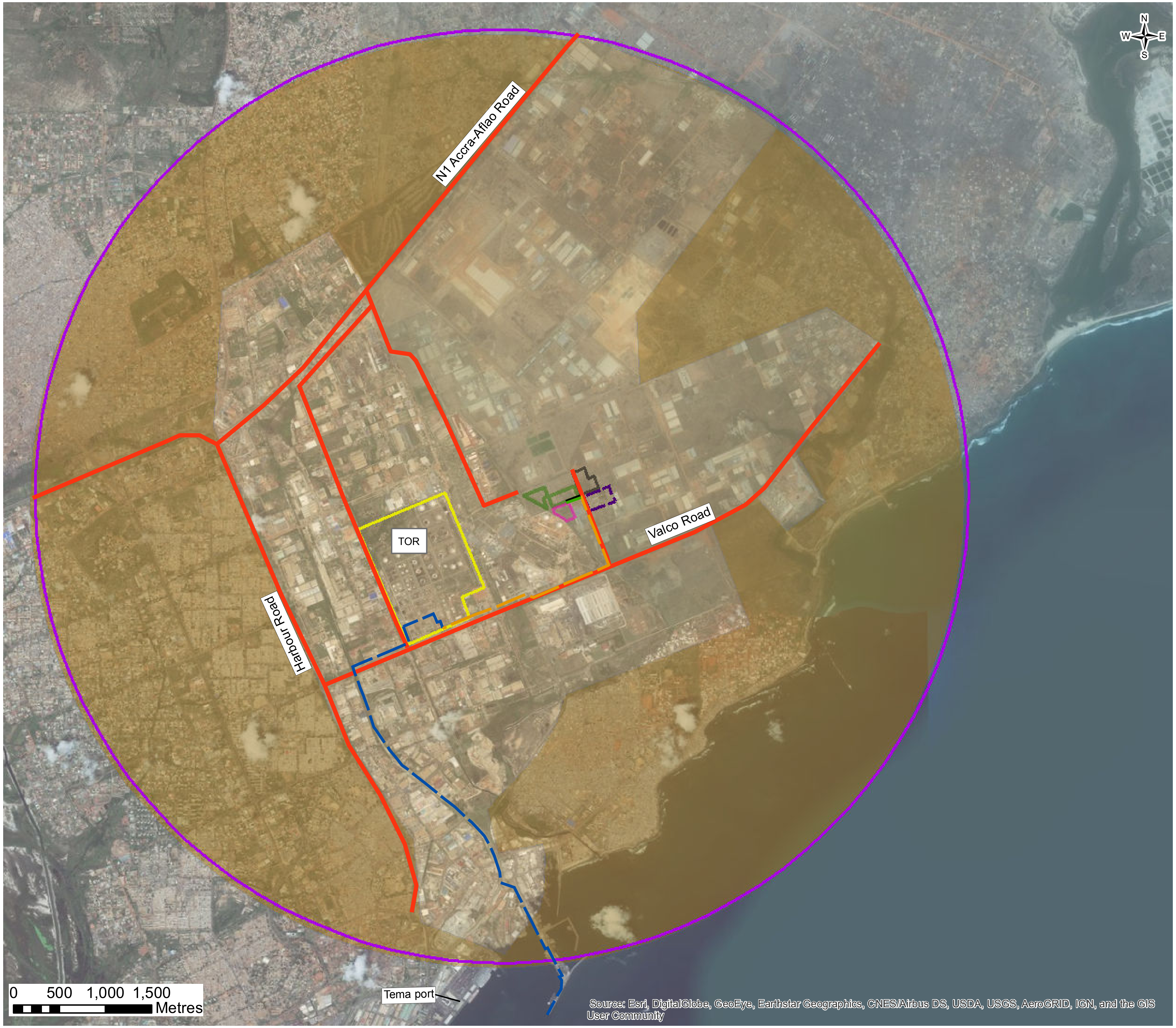

FIGURE 12.1

Legend

- 12 " LPG Pipeline (Overground)
- 12 " LPG Pipeline (Underground)
- 8 " LPG Pipeline to Site (Underground)
- Diesel Pipeline
- Roads
- Ghana Bridge Power Plant Site 1
- Ghana Bridge Power Plant Site 2
- Diesel Tank Farm
- LPG Tank Farm
- Tema Oil Refinary
- 5km Study Area
- Industrial Land
- Residential

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
1	17/07/2017	Initial Issue	PW	RS	LR	JPW

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Project
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Drawing Title
Landscape and Visual Assessment Study Area

Drawing Status

Scale @ A3	1:40,000	DO NOT SCALE
Jacobs No.	60K36301	
Client No.		
Drawing No.	60K36301/LVA/12_1	

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Ghana Bridge Project ESIA

Environmental and Social Impact Assessment

Section 13 – Flood Risk

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration		Rev No
Sep 2015	First issue		0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency		1
June 2016	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating the following changes:		2
	Section No.	***Change***	
	Wherever relevant	Reference to "power plant site" changed to reflect revised plan involving two power plant sites (PPS1 and PPS2).	
	13.5	Update to status of further work and mitigation measures	
August 2017	ESIA amendment including updated Flood Risk Assessment		3
	Wherever relevant	Locations of the two power plant sites (PPS1 and PPS2) and LPG pipeline route.	
	13.3 to 13.7, 13.10 and 13.11	Addition of a numerical flood risk assessment with associated updates to various sections, including conclusions and mitigation	

Contents

Figures and Tables

13 Flood Risk

13.1 Overview

Whilst flooding issues have been observed in other parts of the Tema region (west-Tema), it is noted that an internet literature search, consultations with the Ghana EPA, local authorities (Tema Development Corporation (TDC), Tema Metropolitan Authority (TMA) and Kpone-Katamanso District Authority (KKDA) and anecdotal information from local stakeholders to the project site, did not identify any evidence of historical flooding in the vicinity of the project sites.

However, good international industry practice (GIIP) is that all possible sources of flooding for a given site should be reviewed and considered as part of the development process, in addition to the consideration of future potential flood risks for example as a result of continued urbanisation or potential climate change impacts.

13.2 Potential Sources of Flood Risk

While a wide number of specific flood mechanisms exist, typically many of these can be easily discounted in this setting. Table 13-1 summarises a range of potential risks, the possibility that these may be relevant to this site and those which have been further assessed. Figure 7-1 of the Environmental Baseline, Section 7, shows the regional hydrological context and nearby river catchments.

Table 13-1: Screening of Potential Flood Sources

Flood Source		Pathway	Consider further
Tidal	Storm surge coinciding with high astronomical tide (HAT)	Tidal ingress up minor watercourses	Yes
	Wave action	Wave run up on the coast leading to overtopping flow into the river/port area	Yes
Fluvial	Dzorwulu River	River is remote from the site and separated by high ground	No
	Dechidaw River	River is remote from the site and separated by high ground	No
	Watercourse 1	River is remote from the site and separated by high ground	No
	Watercourse 2	High fluvial flows exceeding channel capacity	Yes
	Watercourse 3	River is remote from the site and separated by higher ground	No
	Site development	Loss of flood storage arising from changes in site levels	Yes
		Changes in flood conveyance resulting from development within the floodplain and changes to the channel of Watercourse 2.	Yes
Groundwater	Shallow groundwater	Ingress in excavations and below ground	Yes

Flood Source		Pathway	Consider further
		structures	
Pluvial including overland flow	Intense rainfall	Ponding on flat areas during intense storms	Yes
	Overland flow	High land to the north of the site	Yes
	Drainage Infrastructure	Existing foul and storm water drains	Yes
Other / artificial	Reservoirs	Dam failure	Yes

13.3 Assessment Methodology

The scoping flood risk assessment (FRA) undertaken for the original (2015) ESIA was largely qualitative and based on desk based sources. That assessment included a review of:

- The environmental context of the development, including:
    - the site terrain, topography based on Shuttle Radar Topography Mission (SRTM) data;
    - climate and rainfall patterns;
    - geology and soils, hydrogeology and hydrology;
    - tidal data;
    - records of historical flooding; and,
    - a site walkover.

The scoping FRA concluded that a more detailed assessment was required for the fluvial flood risk associated with Watercourse 2. As such, a hydraulic model of Watercourse 2 was constructed using data from a focussed cross-sectional survey and limited topographical survey data from the proposed power plant sites (PPS1 and PPS2) and tank farm sites. A discussion on the methodology used to estimate the flood risk to the site from Watercourse 2 is detailed in Section 13.9.

The following sections (Section 13.4 – Section 13.8) present the assessment of risks at the power plant and tank farm development areas. Flood risks to the pipeline route are considered separately, in Section 13.9.

13.4 Tidal Impact Assessment

This section considers the impact assessment from tidal flooding; specifically, from storm surge coinciding with highest astronomical tide (HAT). As discussed in the baseline section (Section 7.2), the action of a storm surge can increase sea levels along the coast locally by as much as 2m. If this coincides with a large spring tide, still water levels off the coast would be approximately 2.9m above mean sea level. With wave action, this increases the potential level of inundation to 4.9m above mean sea level.

The Fifth Assessment Report (AR5) of the United Nations Intergovernmental Panel on Climate Change (IPCC) concluded that global mean sea level will continue to rise at a rate very likely to exceed current rates (3mm per year[1]). Other recent work[2] suggests that the total average sea level rise by the end of the century could be as great as 1.2m. Local changes in land elevation would also need to be factored in to provide a local estimate of likely sea level rise along the coast local to the site.

Assuming that local land formation is relatively stable, this would mean that towards the end of the power station's development life, peak tidal flood elevations could be around 6.1m above the current mean sea level. This would mean that based on current land elevations, the power plant sites and tank farm would be at a negligible risk of inundation from a storm surge event. However, the risks posed to the Tema Oil Refinery (TOR) jetty will be greater from this type of event which could have impacts on fuel availability and plant operation.

High tides during periods of high fluvial flows have the potential to increase the risk of flooding in coastal areas. However, there is a fall of approximately 12m between Watercourse 2 adjacent to PPS1 and assumed maximum tides. Therefore, the backwater effects of high tides are likely to be negligible.

13.5 Fluvial Impact Assessment

13.5.1 Purpose of the Hydraulic Modelling

The original FRA concluded that it would be highly unlikely that the two major watercourses in the area, the Dzorwulu River and Dechidaw River, would pose a significant impact to the site, given the distance between them and the power plant sites. Two minor catchments, Watercourse 1 and Watercourse 3, were also considered unlikely to pose significant impact due to the presence of higher ground between the watercourses and the power plant site.

However, the FRA did raise concern over Watercourse 2, which drains a relatively small, but potentially responsive urban catchment. As such, the hydraulic modelling and further discussion in this Section, and the updated FRA are specifically focussed on Watercourse 2.

The previous FRA included a qualitative assessment on Watercourse 2 using the Manning's formula[3] and the rational method for determining catchment flows. Using the Manning's formula allowed only a basic estimate for channel capacity based upon the channel gradient, channel roughness coefficient (Manning's N value) and channel dimensions, which were estimated from satellite imagery.

The limitations of this methodology meant that a more robust estimate of the flood risk from Watercourse 2, using a hydraulic model, was advisable. A technical appendix (Appendix C – Flood Risk) contains the detailed methodology used for the FRA.

The hydraulic modelling aimed to predict the peak water level within the modelled river reach for the 1% Annual Exceedance Probability (AEP) flood event, which is equivalent to the 1 in

1 Nerem, R. S. et al. (2010). "Estimating Mean Sea Level Change from the TOPEX and Jason Altimeter Missions". Marine Geodesy **33**: 435–446.

2 http://nca2014.globalchange.gov/report/our-changing-climate/sea-level-rise, accessed 16/01/2015

3 Manning R. (1891). On the flow of water in open channels and pipes. Transactions of the Institution of Civil Engineers of Ireland, 20, 161-207

100-year flood. Additional modelling was also done to consider a 1 in 1000 year event (0.1% AEP) and sensitivity scenarios to consider potential increased flood flows due to potential effects of climate change or increasing urbanisation within the catchment.

The model considers risks to PPS1 and PPS2 only. The tank farm site elevation is sufficiently greater than the power plant sites that it was not considered to be at risk from potential watercourse flooding, and therefore was not included in the modelling assessment.

13.5.2 Overview of the Modelled Area

A single hydraulic model was constructed to understand the flood risk from Watercourse 2 to the power plant sites. The model covers approximately 3.5km, with the upstream extent of the model approximately 1km upstream of PPS2. The model extents were chosen to ensure all significant hydraulic structures along Watercourse 2 were incorporated into the model.

The model was then used to design the specification for a cross-sectional survey, which was undertaken along the same 3.5km reach of Watercourse 2. The cross-sectional survey also included three minor tributaries to Watercourse 2. The modelled reach of Watercourse 2 is illustrated in Figure 13-1 below. The model does not account for any existing or proposed storm water drainage on the sites.

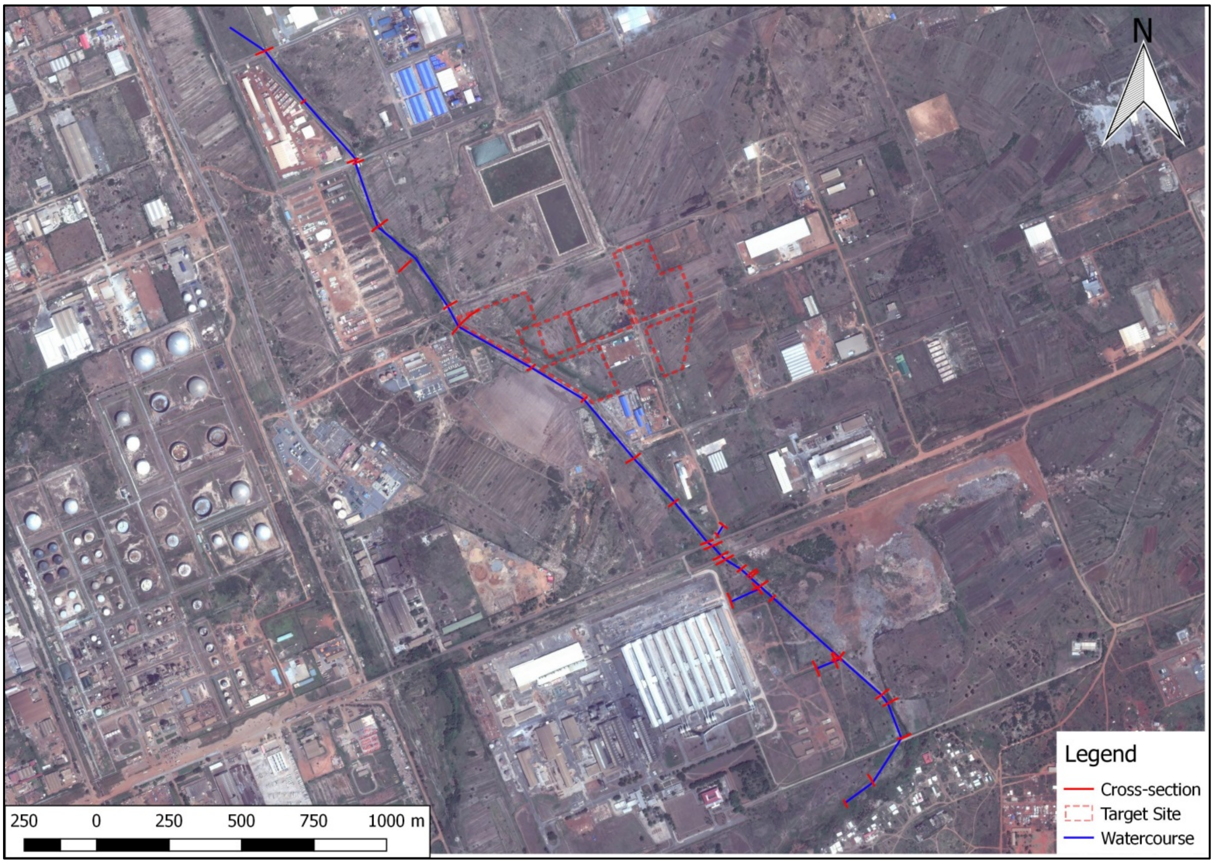

Figure 13-1: Modelled area

13.5.3 Hydrology of the Modelled Area and Summary of Model Scenarios

The target site is a small ungauged catchment undergoing relatively rapid urbanisation. The approach taken to estimate the design 100-year flood hydrograph was to use the US Soil

Conservation Service (SCS) unit hydrograph method. Outputs from this were then scaled for other flood scenarios.

Although the SCS method was developed in the USA, it has been widely applied around the world. It requires the following input data and parameters, the derivation of which is described in subsequent sections:

- Catchment area (km2);
- Design rainfall depth (mm), and storm profile;
- SCS Curve Number;
- Catchment time of concentration (tc);
- Peak rate factor; and,
- Base flow (m3/s).

Catchment Area

The catchment for the Watercourse 2 reach adjacent to the target development site was delineated from the ASTER GLOBAL digital elevation model (DEM). The DEM has a horizontal resolution of 30m. The catchment area to the proposed development was estimated to be 6.47 km2 (Figure 13-2).

Contributions from additional downstream sub-catchments were also required for the hydraulic representation of the Watercourse 2 channel. These are also indicated in Figure 13-2; and their flood contributions were obtained via areal scaling of the hydrograph determined for the principal target catchment. The area of the target catchment and the downstream sub-catchments are given in Table 13-2.

Table 13-2: Model Catchment Areas

Catchment	Area (km^2)
Target	6.47
Tributary 1	0.40
Tributary 2	0.12
Tributary 3	0.07
Residual	2.53

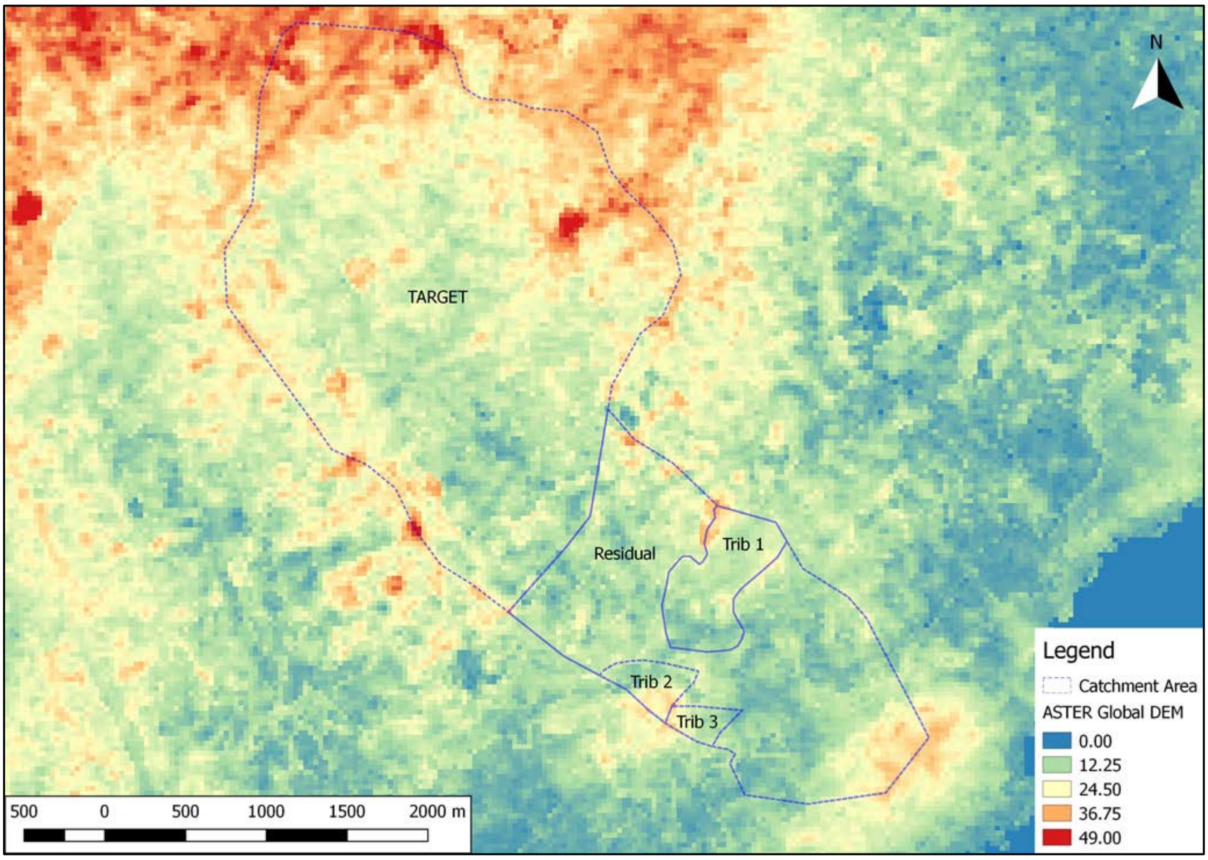

Figure 13-2: Catchment Boundaries

The peak baseline flows used in the hydraulic model for the 1% AEP and 0.1% AEP events are shown in Table 13-3 along with the locations where they were estimated. In addition to the baseline flows for each event, a sensitivity scenario was also undertaken using 'upper' bounds of estimated channel flows to account for potential increases in flood flows due to the effects of climate change or increasing urbanisation of the catchment.

Further details on the technical methodology for the assessment are detailed in Appendix C – Flood Risk.

Table 13-3: Data Used to Build the Hydraulic Model

Inflow	Description	1% AEP Peak Flow (m^3/s)		0.1% AEP Peak Flow (m3/s)	
		Baseline Flow Scenario	'Upper Flow' Sensitivity Scenario	Baseline Flow Scenario	'Upper Flow' Sensitivity Scenario
Watercourse 2	Inflow estimated at location directly downstream of proposed power plant site.	132.0	152.0	155.8	175.8
Tributary 1	Inflow estimated for small tributary of Watercourse 2 at chainage 679m,	8.2	9.4	9.7	10.9

Inflow	Description	1% AEP Peak Flow (m^3/s)		0.1% AEP Peak Flow (m3/s)	
		Baseline Flow Scenario	'Upper Flow' Sensitivity Scenario	Baseline Flow Scenario	'Upper Flow' Sensitivity Scenario
Tributary 2	Inflow estimated for small tributary of Watercourse 2 at chainage 1049m,	2.5	2.9	3.0	3.4
Tributary 3	Inflow estimated for small tributary of Watercourse 2 at chainage 679m,	1.5	1.7	1.8	2.0
Residual catchment	Flow distributed laterally along Watercourse 2 between power plant site and d/s extent of model.	51.6	59.5	60.9	68.8

Research[4] undertaken on catchments within the USA, China and IAHS Catalogues 41, allowed the derivation of the following regression curves to estimate maximum flows for catchments of particular area:

Drainage basins under $100km^2$: Flow = 90A
Drainage basins over $100km^2$: Flow = 850A0.357

Where: A = Area (km^2)

Using these formulae, at $6.47km^2$ the envelope gives an upper bound of $582m^3/s$ for watercourse 2, approximately 4 times greater than the sensitivity flow estimated.

13.5.4 Model Results

1% AEP Flood Event and Sensitivity Scenario

The 1% AEP flood event was routed through the hydraulic model representing Watercourse 2 and its three tributaries. Results for the 1% AEP event are as illustrated in Figure 13 3. Results of the 1% AEP sensitivity scenario flood extent are illustrated in Figure 13-4.

The flow paths from the 1% AEP event are shown on Figure 13-5 and a long section which displays predicted flood water elevation and left and right channel bank elevation is shown in Figure 13-6.

[4] Herschy, R (2000) The Worlds Maximum Observed Floods. The Extremes of the Extremes: Extraordinary Floods (Proceedings of a symposium on held at Reykjavik, Iceland. July 2000). IAHS Publ. no. 271. 2001.

The flow paths from the 1% event can be broadly considered to apply to all of the modelled scenarios. Likewise, the areas on the long section which show overtopping will also apply to the higher flow scenarios.

Figure 13-3: 1% AEP Indicative Flooding Extent at Ghana Bridge Power Plant Site

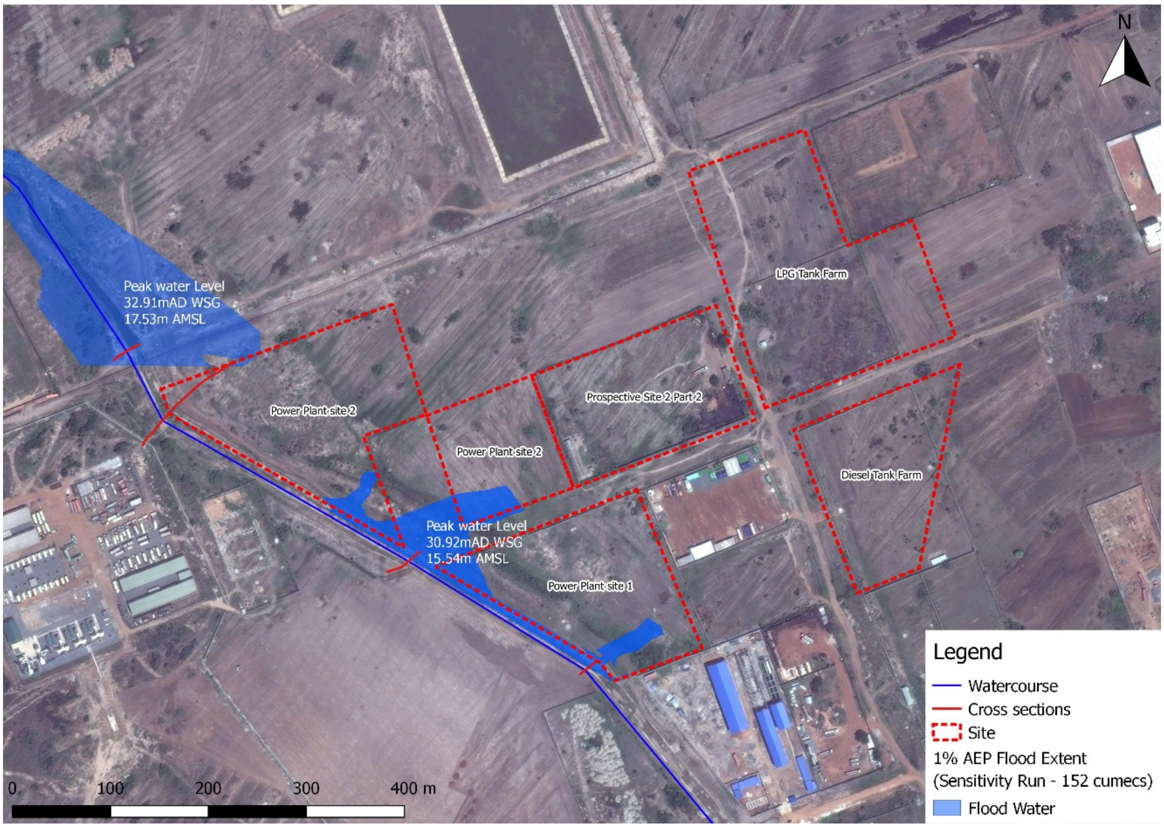

Figure 13-4: 1% AEP Sensitivity Indicative Flooding Extent at Ghana Bridge Power Plant Site

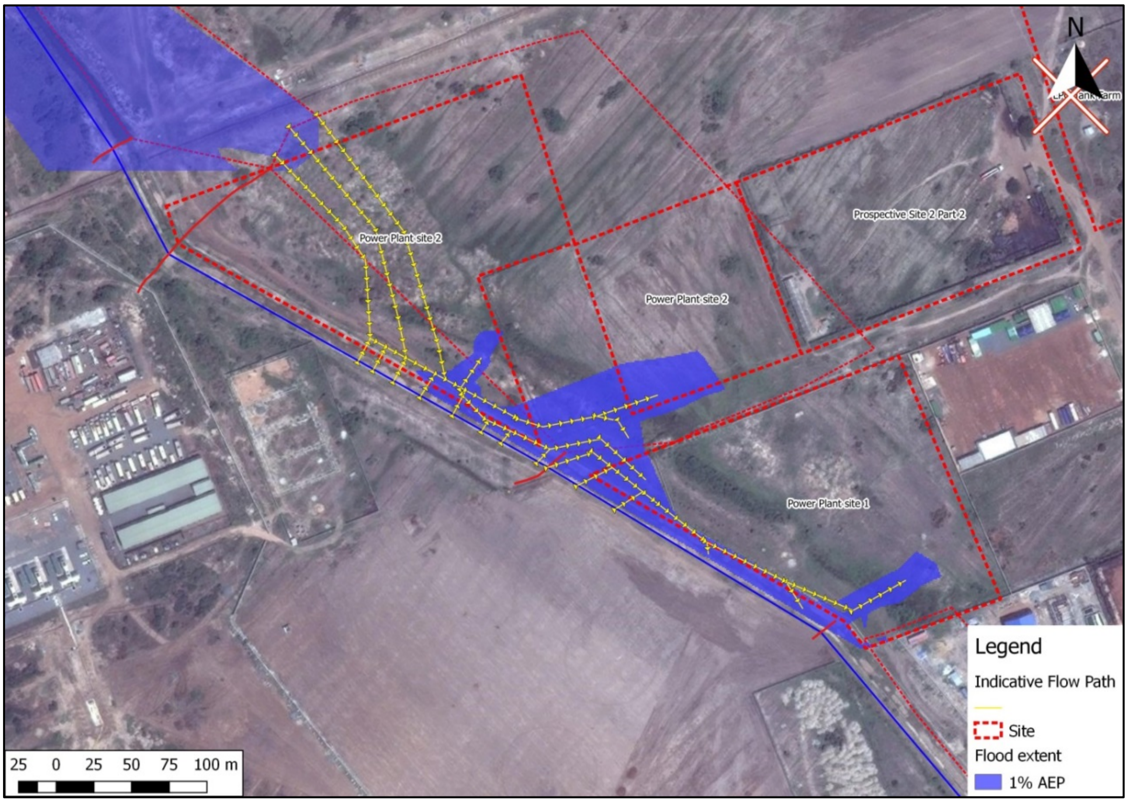

Figure 13-5: Indicative flow path for 1% AEP flood event

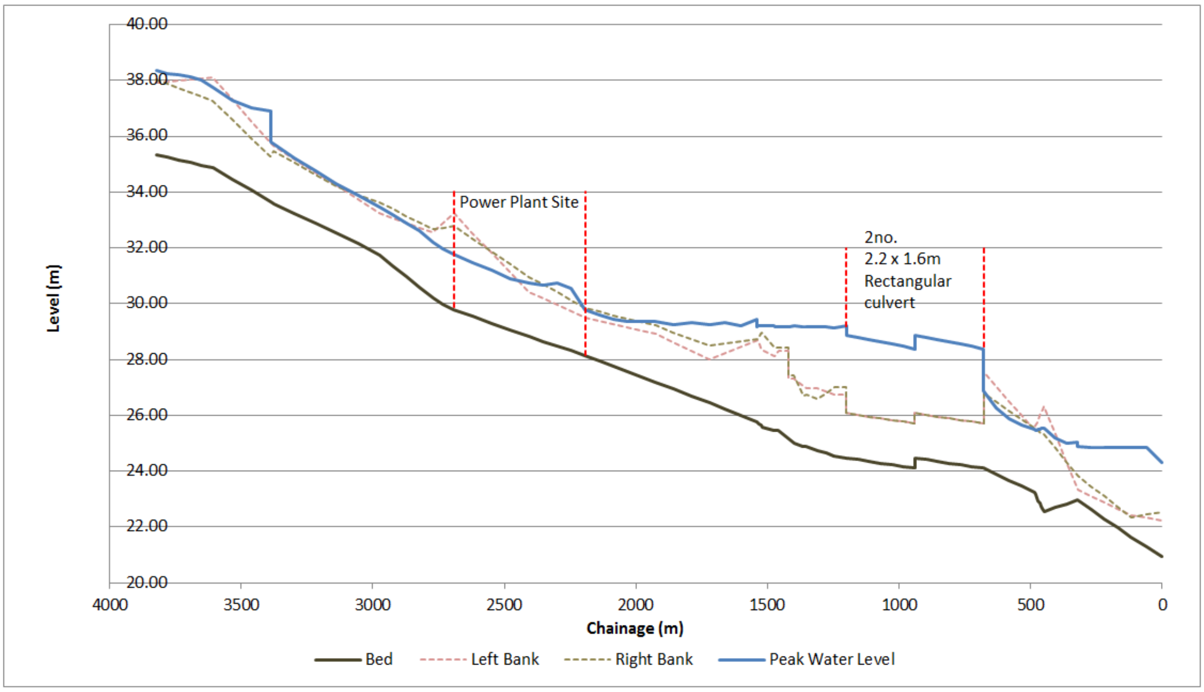

Figure 13-6: Long section of Watercourse 2 showing 1% AEP peak water level

Results indicate that, small areas of both PPS1 and PPS2 may be susceptible to flooding from Watercourse 2 during a 1% AEP flood event. However, the results also indicate that the flood flows from upstream of PPS2 may flow across part of the western portion of PPS2, from the northern boundary.

The 1% AEP model results were interrogated to identify the causes of the predicted minor flooding at the power plant sites. As illustrated by the long-section in Figure 13-6, approximately 1km downstream from the power plant sites, the storm drain is culverted beneath Valco Road and the minor road which runs parallel to the south side of Valco road. Immediately to the south, and adjacent to the Valco Aluminium works site, the dimensions of the drain are reduced by more than 50%, as illustrated in Photograph 13-1.

Photograph 13-1: Watercourse 2 Capacity Reduction and Double Barrelled Culvert Entrance (view from upstream, facing south)

This reduction in capacity means that the double barrelled 2.2m x 1.6m rectangular culvert is predicted to not have sufficient capacity to convey the 1% AEP flood flows. A significant head loss is therefore predicted at the culvert which causes water to back up at the inlet.

A combined flow of 19m^3/s is conveyed through the two rectangular culverts with the remaining flow of 135.7m^3/s overtopping the culverts as floodplain flow (67.4m^3/s comes directly from Watercourse 2, whilst the remaining 68.3m^3/s by-passes the culverts along the left and right floodplains).

Figure 13-6 shows that the raised peak water level resulting from the head loss at the double barrelled rectangular culvert is felt as far upstream as the power plant sites.

However, Watercourse 2 also overtops its left bank upstream of PPS2 (maximum flow of 13.8m^3/s). A proportion of this flood water re-enters Watercourse 2 before the two power plant sites; however, because of the flood water level in the upper flood plain, approximately 9000m^3 of flood water flows overland across a low elevation area within the western portion of PPS2, before re-joining Watercourse 2, though some of the water is retained within a small area of the southwest corner of PPS2.

Watercourse 2 also overtops its left bank between chainage 2289m and 2145m, with an additional 8000m^3 of water entering the area between PPS2 and PPS1. This water flows in to the area between PPS2 and PPS1, breaching a small area along the southern boundary of the PPS2 land areas. Approximately 14,500m^3 then flows across a small area in the northwest corner of PPS1, back into the storm drain.

Further south along the boundary of PPS1, the model predicts that a Watercourse 2 again overtops its left bank and potentially breaching the site boundary. The water is generally predicted as flowing in a south easterly direction parallel to the watercourse. The majority of this water re-enters Watercourse 2, apart from in an anomalously low area close to the southern boundary of PPS1.

The predicted peak water levels within the low lying areas of the power plant sites for the baseline 1% AEP flood event and 1% sensitivity scenario, respectively, are 30.73mAD and 30.92mAD (WSG84) (equivalent to 15.35m and 15.54m AMSL).

However, with regard to the predicted water flows across the western portion of PPS2, the key consideration is the water level within the upper flood plain, which is 32.83m and 32.91m AD (WSG84) (17.45m and 17.53m AMSL) for the 1% AEP baseline and 1% sensitivity scenario, respectively.

Whilst it is understood that the design of the power plants will include appropriate perimeter cut off drains and internal storm drainage, it is considered that raising sensitive infrastructure (including as access roads and foundations) at the site to a level 600mm above the predicted peak floodwater levels would be advisable to reduce the risk to the power plant.

For a 1% AEP flood event, consideration of the predicted sensitivity scenario flood levels (to allow for potential climate change and urbanisation effects) would require the following finished levels for sensitive infrastructure:

- PPS1 – 31.52mAD (WSG84) (equivalent to 16.14m AMSL); and,
- PPS2 – 33.51mAD (WSG84) (equivalent to 18.13m AMSL).

0.1% AEP Flood Event and Sensitivity Scenario Results

In line with GIIP, the baseline model was also run using the 0.1% AEP flood event (equivalent to the 1 in 1000 year return period) which has a peak flow of 156 m^3/s at the proposed power plant sites.

As with the 1% AEP event, a sensitivity run was then undertaken in which the peak 0.1% AEP flow was increased by an additional 20m^3/s (to account for effects of potential climate change and increasing urbanisation) resulting in a peak flow of 176m3/s at the proposed power plant site.

Figure 13-7 and Figure 13-8 illustrate the predicted flood extent and associated flood water levels for both the baseline 0.1% and 0.1% AEP sensitivity flood events.

Figure 13-7: 0.1% AEP Indicative flooding extent at Ghana Bridge Power Plant Site

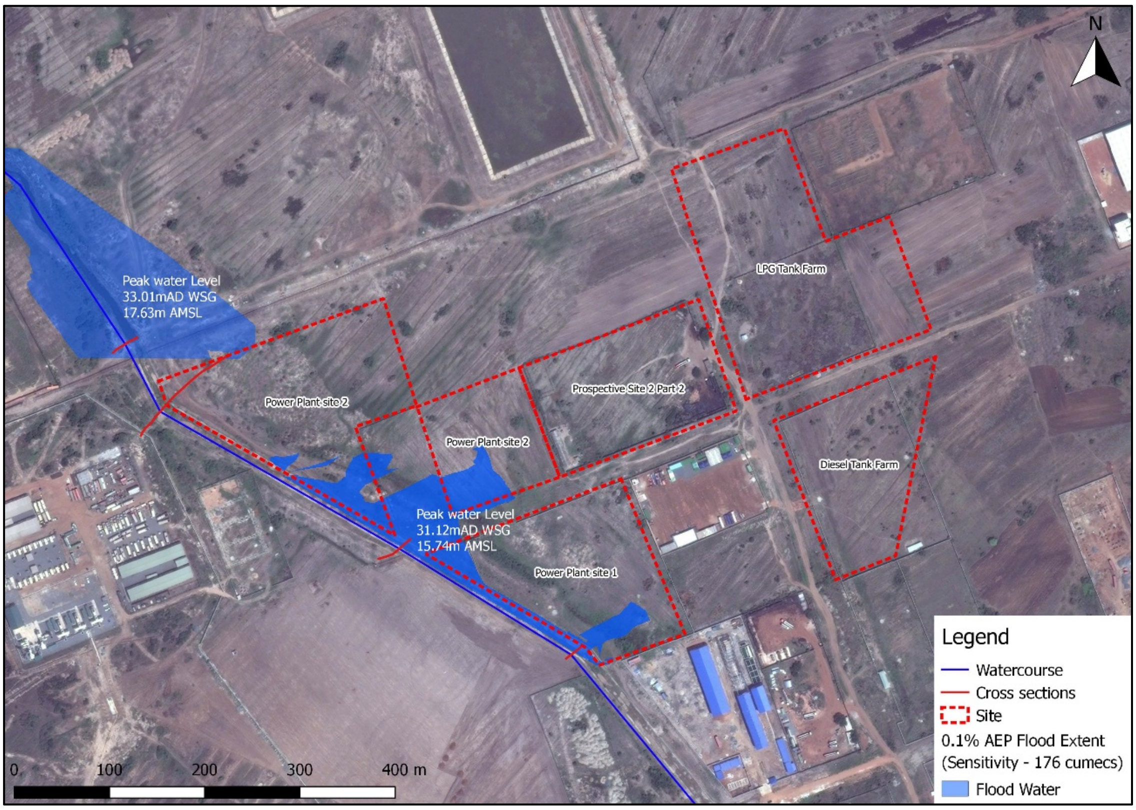

Figure 13-8: 0.1% AEP Sensitivity Indicative flooding extent at Ghana Bridge Power Plant Site

It is noted that the flow paths and location of bank overtopping are the same as those for the 1% AEP flood event (see Figure 13-5), but with correspondingly increased flow volumes.

For the 0.1% AEP event and 0.1 sensitivity scenario, the predicted peak water levels within the low lying areas of the power plant sites, are 30.95m and 31.12m AD (WSG84) (equivalent to 15.57m and 15.74m AMSL). The predicted flood level within the upper flood plain is 32.92m and 33.01m AD (WSG84) (17.54m and 17.63m AMSL) for the 1% AEP and 1% sensitivity scenario, respectively.

Again, whilst appropriate perimeter cut off drains and internal storm drainage will be included, to protect against a 0.1% AEP event, sensitive infrastructure (including as access roads and foundations) should be raised to a level 600mm above the predicted peak floodwater levels.

Using the predicted 0.1% sensitivity scenario flood levels would require the following finished levels for sensitive infrastructure:

- PPS1 – 31.72mAD (WSG84) (equivalent to 16.34m AMSL); and,
- PPS2 – 33.61mAD (WSG84) (equivalent to 18.23m AMSL).

Model Assumptions and Limitations

The accuracy and validity of the hydraulic model results is heavily dependent on the accuracy of the hydrological and topographic data included in the model. While the available information has been used in the most appropriate way to represent the fluvial flooding mechanisms, there are uncertainties and limitations associated with the model.

Efforts have been made to assess and reduce levels of uncertainty in each aspect of the modelling process. The assumptions made are considered to be generally conservative for modelled water levels at the proposed power plant sites, further floodplain survey is likely to result in predicted model water levels to be lower than those detailed in this report.

Channel roughness has been assigned using the best available information (survey data and aerial photography), it has been assumed that Watercourse 2 will remain dredged throughout the life of the power plant, as has been evidenced during the ESIA period, and therefore EPL should confirm with KKDA/TDC that this maintenance will continue indefinitely. The roughness values are based on available guidance (Chow, 1959).

Hydraulic coefficients for structures have been applied using available guidance within the Flood Modeller software. The dimensions of the structures have been based on detailed survey measurements and photographs. It is assumed that the structures are not blocked in any way and will be maintained as appropriate.

It has been assumed that the downstream boundary condition is free discharge without any downstream control. This is deemed appropriate as the boundary is sufficiently downstream of the proposed site location.

Flood plain representation is the biggest uncertainty associated with the model. Topographic data was collected for the modelled reach of the Watercourse 2 and spot levels are available at the two power plant sites. However, detailed topographic data was not available for the wider upstream and downstream catchment so the triangulated irregular network (TIN) model for the floodplain representation was based on limited topographical data for the wider catchment.

This limited representation of the floodplain results in a more conservative model as flood water which would generally be able to extend out further into the catchment floodplain is prevented from doing so by the model. This results in higher predicted peak water levels that would likely occur in reality. If required, the model could be refined following topographical survey of the entire reach of the modelled watercourse and catchment. This would most likely result in lower predicted peak water levels at the power plant sites; however, this activity may be considered onerous in the context of the predicted minor flood risk, given the conservative approach taken for the modelling.

Finally, the model does not account for the use of site storm drainage. It is considered that appropriate perimeter and internal site storm drainage would likely convey a significant proportion, if not all of the flood waters in the unlikely event that a 1% AEP event would result in backing up of flood water to the power plant sites (given the above limitations of downstream topography assumptions).

Summary of Modelling Results and Recommended Finished Levels

The fluvial flood risk assessment predicts that, in the absence of mitigation, for a 1% or AEP flood event, small areas of both PPS1 and PPS2 may be at risk of minor flooding. This is due to a combination of insufficient downstream capacity of the storm drain to convey flood flows and Watercourse 2 overtopping its left bank both upstream of the power plant sites and along the boundary of the sites. Associated flows and water levels will be increase as would be expected for a 0.1% AEP event.

Whilst there is inherent uncertainty in any modelling exercise, the modelling results are considered conservative. This is particularly with regard to representation of the upstream and downstream flood plain which could be refined if a survey of the wider downstream catchment were undertaken; with the likely result being a reduction in predicted flood extent and flood levels. However, this extensive level of survey may be costly and, given the conservative model assumptions and inherent uncertainties within the modelling process, the benefits of increased accuracy as a result of additional survey may not be significant. The model also does not consider the effect perimeter and internal site storm drainage which would further mitigate potential flood risk.

The predicted peak flood water levels for all scenarios are summarised in Table 13-4 along with the existing maximum and minimum site elevations at the power plant sites for additional context.

Table 13-4: Predicted Peak Flood Levels for 1% and 0.1% and Existing Site Elevation

Elevation or Flood Criteria (mAD)	Datum	Power Plant Site 1	Power Plant Site 2	Upstream Floodplain
Maximum Existing Ground Level	WSG84	35.58	34.48	N/A
	Ghana Grid	20.2	19.1	N/A
Minimum Existing Ground Level	WSG84	29.27	30.29	N/A
	Ghana Grid	13.89	14.91	N/A
1% AEP Flood Event	WSG84	30.73	-	32.83
	Ghana Grid	15.35	-	17.45
1% AEP Sensitivity	WSG84	30.92	-	32.91
	Ghana Grid	15.54	-	17.53
Finished level to address 1% AEP event	WSG84	31.52	33.51	-
	Ghana Grid	16.14	18.13	-
0.1% AEP Flood Event	WSG84	30.95	-	32.92
	Ghana Grid	15.57	-	17.54
0.1% AEP Sensitivity	WSG84	31.12	-	33.01
	Ghana Grid	15.74	-	17.63
Recommended finished level (0.1% event)	**WSG84**	**31.72**	**33.61**	-
	Ghana Grid	**16.34**	**18.23**	-

Notes: For PPS2, the predicted peak water level within the upper flood plain was used to determine the recommended finished level, rather than the water level within predicted low lying areas of inundation.

To support a conservative approach to flood risk management, it is recommended that sensitive infrastructure within the site is raised by 600mm above the predicted peak water level for the appropriate design scenario. If designing for a 0.1% AEP (1 in 1000 year) event, this would require finished levels of 31.72m AD (WSG84) (16.34m AMSL) for PPS1 and 33.61m AD (WSG84) (18.23m AMSL) for Stage 2. It is recommended that site raising is accompanied by the use of appropriate perimeter and internal site drainage.

In addition, given the continued development within the THIA, it is recommended that EPL engages with KKDA and TDC with regard to the potential risks highlighted here and long term planning of storm drainage within the catchment. We recommend that this discussion includes both confirmation of the drainage maintenance regime and also consideration of the design capacity of the storm drain and double barrelled culvert to the south of Valco Road.

With consideration of the above assessment, the unmitigated flood risk at the site could result in effects of local to district level sensitivity and medium magnitude, with corresponding minor to minor / major significance. With application of the proposed mitigation, the significance is assessed as minor to negligible.

13.5.5 Potential Changes in Fluvial Flows as a Result of Climate Change or Other Developments

According to USAID (2011)[5], modelling projections of rainfall among seven representative meteorological stations in Ghana gave mixed and inconclusive results, lacking consistency and predicting decreases and increases in rainfall across stations. Precipitation changes for Accra (located less than 30km from the power plant location) ranged from a 52% decrease to a 44% increase in wet season rainfall by 2080. The variability between the models' precipitation predictions is similar to the inter-annual variability currently experienced in the region.

Given the lack of clarity regarding future changes to rainfall totals, intensity and seasonal distribution, predicting the potential change in rainfall and associated impact on fluvial flows is not possible at this time. However, it would be prudent to assume that they may potentially increase incrementally over the lifetime of the proposed development either due to anthropogenic climate change or due to changes in land use in the catchment upstream of the site.

Anthropogenic changes in this context primarily concern increasing impermeable surface area as a result of continuing development within THIA. This is likely to result in more rapid run off and potential for more rapid streamflow response or other changes in the catchment's response to rainfall events.

Any potential incremental increase in flows could hypothetically exacerbate risk fo flooding from Watercourse 2 predicted by the conservative modelling exercise presented above. However, it is considered that the proposed design mitigation (site raising and perimeter and appropriately sized internal site storm drainage) – which is based upon use of the 0.1% AEP sensitivity scenario results - should be sufficient to mitigate the theoretical risk of climate change and/or additional development-related incremental increases in flood flows.

Associated potential impacts are therefore assessed as negligible given the above mitigation. However, it is recommended that EPL engages with KKDA and TDC with regard to the long term planning of storm drainage within the catchment and how this has/will consider the continued development within the THIA and potential for long term, climate change-related, incremental increases in rainfall.

13.5.6 Sub-catchment 2b

There is currently no data on the precise route of flows within this catchment. Analysis of the SRTM topography data indicates that the tank farm is located in a shallow valley with the land rising up by approximately 3m to the east and west of this element of the site. Therefore, based on this topography, surface flows would converge to form a flow pathway running through, or very close to the proposed tank farm site.

The area has been heavily modified through development of the THIA with walled cadastral boundaries and access roads and some associated storm drainage. No natural drainage channels are present. Observations during site visits indicate that surface flows during the

5 USAID (2011) Ghana Climate Change Vulnerability and Adaptation Assessment

wet season in the vicinity of the tank farm and this tend to be intercepted by and channelled down the local site access roads, particularly where there is no formal storm drainage.

The modelling assessment presented above has demonstrated that there is no fluvial flood risk to the tank farm site from the nearest significant water feature (the storm drain). The remaining risk within this sub-catchment is therefore pluvial flooding during the wet season, which is discussed below.

13.5.7 Impacts on Fluvial Flood Risk away from the Sites

The following section considers potential impacts from the Project on fluvial flood risk away from the development sites themselves. The power plant sites are located adjacent to the main flood conveyance route within the Watercourse 2 catchment. Protecting the site from flood risk will involve raising the power plant sites above the predicted flood levels as described above.

This could however have an impact on the flood risk locally through two key mechanisms. These are:

1) Reduction in flood conveyance – The raising of land within an area that acts to convey flood waters will mean that under flood conditions, water will not be able flow as rapidly downstream. This can cause water to back up upstream of the site, potentially resulting in deeper and/or more frequent flooding upstream.
2) Loss of flood storage - The raising of land within the floodplain will mean that under flood conditions the low lying areas of land within the sites will no longer available to store flood waters. This water will therefore be displaced which will increase flood depths on land that is adjacent to or downstream of the site..

Given the limited extent of the predicted flooded areas within sites, and conservative model assumptions used, the proposed raising of the development sites is not expected to have a noticeable impact on the flood conveyance of Watercourse 2 or result in a significant loss of flood storage within the catchment.

However, given the continued development within the THIA, it is recommended that EPL engages with KKDA and TDC with regard to the long term planning of storm drainage and flood risk within the catchment.

Site Access Routes

The primary site access route is via Valco Road. Therefore, there is a risk an extreme flood event may restrict access to the site via Valco Road.

At the Valco Road crossing, the upstream predicted peak water level for the 1% AEP flood event is 29.44mAD. Survey data indicates that the bridge deck level at the Valco Road crossing is 28.98mAD (WSG84).

The resultant peak water flood depth is estimated to be 440mm above the road level. For the “upper flow” sensitivity simulation, the predicted peak water level at Valco Road is estimated to be 29.565mAD which equates to a peak flood depth of 585mm. Head loss occurs at the structure which results in downstream peak water levels that are slightly lower than the upstream water levels: 29.197mAD and 29.295mAD or the 1% AEP baseline and “upper flow" scenarios, which equates to a max flood depth of 217mm for the 1% AEP baseline flood event and 315mm for the "upper flow" event. These levels will increase further under the 0.1% AEP flood event.

The model results therefore predict that access to the site via Valco Road could be constrained during a significant flood event. However, as discussed above, the modelling results are necessarily conservative given the inherent uncertainties in flood risk modelling. Also, in the unlikely event of a flood event significant enough to flooding of Valco road it is possible to access the site via high ground from the main Tema road to the north. This route is not expected to be at risk from flooding as it effectively follows a catchment boundary.

Planning for site access and egress, including emergency response, should therefore consider the potential for flood related closure of the Valco Road access and confirm the alternative route from the high ground to the north.

13.6 Groundwater Considerations

Given the relatively flat topography and generally low permeability of the underlying geology, issues associated with a high water table are not anticipated. However, if any deep excavations or below ground facilities are proposed, the hydraulic properties of the soils and shallow geology should be investigated as part of the design process. Once this is understood, appropriate precautions in terms of tanking and pumping may be required to control groundwater levels and ingress rates. This is, however, a matter of design and the risk of groundwater flooding is considered to be negligible.

13.7 Pluvial Impact Assessment

13.7.1 Flows from Off-site

Rainfall intensities recorded in the Greater Accra area of Ghana are often high, as would be expected given the tropical climate. As detailed in Appendix C, rainfall intensity duration frequency (IDF) curves developed for Tema indicate that rainfall intensities in excess of 100mm/hr can be expected during short duration storms with an annual exceedance probability of 10% or less. Storms of this intensity are likely to frequently exceed the infiltration capacity of soils during the wet season. They may also exceed the capacity of local artificial drainage systems, resulting in water ponding in depressions or behind obstacles to flow, or overland flow.

The power plant sites and the tank farm have areas of higher ground to the north. As discussed in 13.5.5, whilst the SRTM topography data indicates that the tank farm is located in a shallow valley, observations on site confirm that there are no natural drainage features and that rainfall-derived accumulations of water tend to accumulate on and/or drain via the local site access roads in areas where there isn't formal storm drainage. Most of the land parcels within the THIA also tend to be walled, which will further act to constrain overland flows in the area.

It is likely that, in its natural state prior to development of the THIA, concentrated flows of surface water may have been routed across the area local to the proposed development sites. In the current developed state, it is clear that the altered runoff regime is heavily influenced by the configuration of access roads, walls of the land parcels and existing storm drainage (where this is present). The likelihood of significant external overland flows crossing the sites is therefore likely to be low given the factors discussed above.

However, the altered runoff regime is instead likely to result in a significantly increase flows along the site boundary and access roads with associated increased risk of erosion of roads and site boundary features including fencing and site entrance driveways, if not properly mitigated. This type of erosion was noted on the site access road, to the south of the site and north of Valco Road, during the June 2017 site visit. Due to a lack of appropriate roadside storm drains, significant ponding appeared to have resulted in erosion of the recently re-graded access road producing relatively deep depressions. The volumes of water present may also have been associated with the recent clearance the tank farm site and lack of formal drainage at that time.

Accordingly, appropriately designed site perimeter drainage and internal site drainage are recommended to ensure that risks from wet season pluvial flooding or erosion are appropriately managed. Given the observed issues with erosion, EPL may wish to install formal roadside drainage for the areas immediately adjacent to the site, which should be connected to the main storm drain unless another feasible design solution can be confirmed. The project may wish to assume from an operational stand point that the local authority has insufficient budget to maintain the drains in the vicinity of the site and include periodic maintenance within the project cost plan.

The unmitigated potential impacts due to pluvial flooding, overland flow and associated erosion are considered to have local sensitivity and low magnitude.

13.7.2 Management of Site Runoff

In most areas of the development sites, construction will involve replacing bare or vegetated ground, that previously allowed some infiltration of rainwater, with impermeable coverings such as roofs and hardstanding. Under storm conditions the development will therefore increase peak rates of runoff from the site unless the drainage system is designed to prevent this.

As discussed above, any such increase in runoff rates has the potential to exacerbate flood risk along the drainage systems and watercourses into which these flows are directed. Good practice requires that in areas where there is no risk of contamination, site design seeks to minimise increases in impermeable area through the use of permeable surfacing (i.e. gravel / hard-core) with runoff from roofs and hardstanding directed to these permeable areas to encourage infiltration.

In addition, unless it can be confirmed that the receiving drainage systems downstream have been designed to accommodate the predicted flows from the entire development area (by a detailed drainage survey), the onsite drainage system should be designed to store and attenuate any residual increase in flows. This will ensure that there is no increase in peak runoff.

13.8 Artificial (Dam Breach) Risks

The Ashaiman and Dawhenya Reservoirs have been constructed on the Dzorlulu and Dechidaw rivers respectively. Whilst the catastrophic failure of these dams would be a major cause of flooding in Tema, based on the catchments derived from the SRTM data, it appears unlikely that the development sites would be impacted. No reservoirs or other artificial water features have been identified upstream of the site and the risk from this source is considered to be negligible.

13.9 Risks to the Pipeline

The pipeline routes from the TOR jetty to the tank farm and power plant sites will generally have a low sensitivity to flooding, with the exception of the TOR jetty, which is likely to be vulnerable to tidal surges. However, during June 2017 consultations with the TOR, representatives from TOR environmental, health and safety team indicated that sections of the above ground TOR ROW (where it culverts beneath an abandoned railway line) are vulnerable to pluvial flooding.

The team indicated that this flooding may have been a causal factor in degradation of pipelines which later leaked and caused at least two fires (most recently in 2010). Whilst the TOR team confirmed that subsequent inspection and preventative measures have been put in place, proposed further measures have not been implemented due to funding availability.

The pipe route is also proposed to cross Watercourse 1 in the vicinity of TOR, a small drain adjacent to Sentuo Steel and the storm drain (Watercourse 2) by the eastern end of the Valco Aluminium works.

The key risk posed to the pipeline by flooding is that erosion caused by flooded water courses could wash away the foundations of supports for an above ground pipeline. The crossings also have the potential to constrict flows and increase the potential for blockages. Impact from debris during periods of high flow could potentially damage the pipeline if it is not designed and constructed appropriately.

It is noted that the pipeline crossing for storm drain (Watercourse 2) has already been completed in the form of an underground crossing which mitigates risk at this location. A detailed assessment of the remaining crossings is beyond the scope of this assessment. However, at detailed design stage, consideration should be given to routing pipes underground in the vicinity of remaining watercourses to avoid any constriction of flows and risks to the supporting structures. Alternatively, crossings should provide at least 0.6m freeboard between the top of the watercourse bank and the soffit level of the crossing and be designed to be resilient to impact from debris.

In addition, the discussions with TOR should be progressed to identify the flood-prone rail culverts along the TOR ROW which may have contributed to previous safety issues. EPL should investigate the conditions at these locations and consider if it can contribute to improving either the drainage at these locations in partnership with TOR. These discussions should be included in ongoing general safety discussions with regard to community health and safety along the TOR ROW (discussed further in Section 20).

13.10 Summary

Whilst flooding issues have been observed in other parts of the Tema region (west-Tema), no evidence of historical flooding in the vicinity of the project sites has been identified. However, GIIP requires that all possible sources of flooding are considered as part of the development process, including potential future risks for example as a result of continued urbanisation or potential climate change impacts.

The most significant potential flood sources and mechanisms are considered to be:

1) Fluvial flooding along Watercourse 2 associated with backing up of the stormdrain due to capacity of culverts 1km downstream of the power plant sites; and,

2) Surface water runoff / overland flow (pluvial flooding) following intense rainfall events.

The development also has the potential to exacerbate flooding elsewhere adjacent to and downstream of the site, through:

1) Proposed land raising reducing flood conveyance along Watercourse 2, which could exacerbate flooding on and upstream of the site;

2) Land raising resulting in a net loss of flood storage, potentially increasing flood severity in areas adjacent to and downstream of the site;

3) Potential increases of storm flows due to upstream development of the catchment when increased run off from new impermeable areas may increase risk of downstream flooding; and,

4) Potential to flood Valco Road, inhibiting the main site access route.

The flood risk assessment results are summarised as follows:

- The conservative modelling assessment undertaken for Watercourse 2 predicted a minor fluvial flood risk to small localised areas within PPS1 and PPS2. The output from the model could be further refined with detailed topographic or LIDAR survey of the wider catchment (which would likely lower the predicted flood water levels); however, given the scale of survey and the inherent uncertainty in flood risk modelling, the associated costs may not reflect sufficient benefit to the project.

- Given the conservative modelling assumptions and the implementation of recommended mitigation (raising the site by 600mm above the predicted upper flood scenario levels at PPS1 and the upper flood plain levels for PPS2, and use of appropriately designed perimeter and internal site storm drainage), the unmitigated fluvial flood risk to the project is assessed as minor/major. However, with the proposed mitigation, this is assessed as minor to negligible.

- In the current developed state, the surface water runoff regime is heavily influenced by the configuration of access roads, walls of the land parcels and existing storm drainage (where this is present). Whilst significant overland flows entering from outside the sites are therefore unlikely, the altered runoff regime is instead likely to increase risk of erosion of access roads and site boundary features, without appropriate mitigation. Evidence of this issue was noted during the June 2017 site visit where ponding and erosion have occurred most likely due to a lack of appropriate roadside storm drainage and the recent clearance of the tank farm. The unmitigated potential impacts due to pluvial flooding, overland flow and associated erosion are considered to be local sensitivity and low magnitude. However, with the proposed mitigation, this is assessed as negligible.

- Although significant fluvial or pluvial flooding is not anticipated, flood risk in general is likely to incrementally increase over time as a result of continued development within the THIA area and Watercourse 2 catchment upstream of the project. This may theoretically be exacerbated by potential climate change-related impacts, though this cannot be predicted with any certainty. However, with application of the design mitigation above, any potential impacts associated with these factors should be appropriately managed, and are assessed as negligible.
- Given the limited extent of the predicted flooded areas within sites, and conservative model assumptions used, the proposed raising of the low lying areas within the development sites is not expected to have a noticeable impact on the flood conveyance of Watercourse 2 or result in a significant loss of flood storage within the catchment with respect to a potential 1% AEP event.

Considering the above, without mitigation measures, the magnitude of the overall flood risk for construction and operational activities is assessed as medium and could potentially result in local to district level effects. The overall significance of the unmitigated effect of the power plant development is therefore assessed as minor / major.

13.11 Mitigation Summary

There are a number of mitigation measures recommended to complete the assessment of flood risk and support the resilience of the development to identified potential current and future risk issues.

- The design of the development should be prepared with due consideration of the potential issues discussed in this report. The following summarises the recommended design mitigation and or supporting actions (e.g. consultation): In order to consider the implications of a 0.1% AEP flood event, with an additional allowance for potential climate change and urbanisation-related increases in flows, sensitive infrastructure should be raised to 600mm above the predicted peak water levels for ‘sensitivity’ scenario flood event. As such, unless further assessment is done to refine the results of the FRA, the sites and/or sensitive infrastructure should be raised to a minimum of:
  - PPS1 - 31.72m AD (WSG84) (16.34m AMSL); and,
  - PPS2 - 33.61m AD (WSG84) (18.23m AMSL).
- Installation of perimeter and on-site storm drainage infrastructure of sufficient capacity to accommodate predicted wet season overland flows and any potential increase in flows due to future development in the catchment and potential climate-change related increases in rainfall;

- Planning for site access and egress, including emergency response, should therefore consider the potential for flood related closure of the Valco Road access and confirm the alternative route from the high ground to the north;
- The project may wish to consider installation of formal roadside drainage for areas immediately adjacent to the site, which should be connected to the main storm drain unless another feasible design solution can be confirmed. The project may wish to assume from an operational stand point that the local authority has insufficient budget to maintain the drains in the vicinity of the site and include periodic maintenance within the project cost plan.
- Consultation by the EPC contractor with TDC, TMA and KKDA authorities to determine which body is responsible for management of the drainage networks in the vicinity of the project, to ensure that the drainage maintenance programme will continue indefinitely. Consultation should also discuss the long term management of drainage and potential flood risk, with respect to increasing development and the potential flood-related issues associated with the capacity of the culvert to the south of Valco Road;
- Avoid increasing site runoff or displacing storm flows onto other adjacent developed sites unless the receiving systems have been specifically designed to accommodate these flows. This may require design of storage and attenuation capacity within the site drainage system to prevent an increase in peak runoff;
- At locations where the above-ground section of the pipeline crosses streams, use directional drilling to go beneath streams, or provide at least 0.6m freeboard between the top of the watercourse bank and the soffit level on pipeline crossings; and,
- If above ground pipelines are used at watercourse crossings, pipelines should be designed to be resilient to impact from debris in the event of high flows/flooding of the watercourse(s).

Following consideration and implementation of the above mitigation measures, the magnitude of flood risk is assessed as low/medium and the significance of the effect is assessed as negligible to minor. The EPC contractor should ensure its design is reviewed by a competent hydrologist or flood risk engineer to confirm that the issues highlighted have been adequately addressed.

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Section 14 – Climate Change

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration		Rev No
Sep 2015	First issue		0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency		1
June 2016	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating the following changes:		2
	Section No.	***Change***	
	Wherever relevant	Reference to “power plant site” changed to reflect revised plan involving two power plant sites (PPS1 and PPS2).	
	Wherever relevant	Corrections to spelling, grammar and other changes for consistency. Abbreviated terms provided in full at first usage.	
	14.5.2	Update to the routing and source of fuel supplies.	
	14.5.4	Update to details of the raw water supply.	
	14.5.5	Additional details on the location of power plant site 2.	
	14.6.4	Clarification on the suggested security of water supply review.	
August 2017	ESIA amendment issued to Ghana Environment Protection Agency, incorporating details of further project design changes, including:		3
	Wherever relevant	Revised locations of the two power plant sites (PPS1 and PPS2).	
	Wherever relevant	Updates for consistency with the updated Flood Risk Assessment (Section 13).	
	Wherever relevant	Incorporation of latest available published baseline data.	
	14.5	Revision to assessment findings	
	14.6	Revision to proposed mitigation	
	14.7	Revision to conclusion and recommendation	

Contents

Figures and Tables

14 Climate Change

14.1 Introduction

Identifying potential climate events and hazards is necessary to assess the potential sensitivity and ultimate vulnerability of the Project based on the climate profile.

This assessment differs from the others, as the concern in this instance is the potential for impact of external forces on the plant components and its ability to perform in the required manner over the Project life.

14.2 Potential Sources of Climate Change Impact

Climate events and hazards can be categorised as follows:

- *Climate events* include heatwave, frost, extreme rainfall, freezing conditions, hail, damaging winds, rainfall deficits and cyclonic storms; and,
- *Climate hazards* include river and/or coastal flooding, bushfire, crop failure, water supply restrictions, landslips and coastal storm erosion events.

14.3 Assessment Methodology

14.3.1 Climate Change Projections

Climate change projections are generated using general circulation models (often referred to as global climate models or GCMs), which simulate the ocean, atmospheric and land surface processes that influence global climate. The models are run under historical conditions and with scenarios representing long-term sequences of future greenhouse gas emissions.

Climate change projections are useful tools to guide decision-making about climate risks. They indicate the expected trend in climate variables under various emissions scenarios and the likely magnitude of change. Their reliability varies, with global projections being more certain than regional projections, and temperature projections being more certain than those for rainfall.

Changes in average conditions are also more certain than changes in extremes. While climate model projections have improved in recent years, some important climatic influences, including the El Niño Southern Oscillation events (which influences the West African Climate), are currently not well represented (although the most recently released United Nations Intergovernmental Panel on Climate Change (IPCC) Assessment Report 5 (AR5) does include El Niño effects in its modelling).

The detailed climate baseline for Ghana is presented in Section 7.4. Ghana has a tropical climate characterised by prevailing high temperatures and variation in the amount, duration and seasonal distribution of rainfall. There are two main seasons; the wet and dry seasons. Variations in temperature both annually and daily are quite small. Throughout the year, maximum temperatures are around 30°C, dropping three or four degrees during the brief respite between rainy seasons, with minimum temperatures of around 23°C. The coolest time of year is between June and September when the main rainfall occurs. The humidity is constantly high, at about 80%.

14.3.2 Project Vulnerability to Climate Change Hazards

The vulnerability of the project components to flood risk under climate change scenarios has been determined as described in the flood risk assessment (FRA), presented in Section 13.

The vulnerability of the project to temperature change has been undertaken as a qualitative assessment for this ESIA submission.

The vulnerability of the project utilities and infrastructure to changes in temperature, flooding and storm events has been undertaken as a qualitative assessment.

The impact of the project on local environmental and social vulnerability has been undertaken as a qualitative assessment.

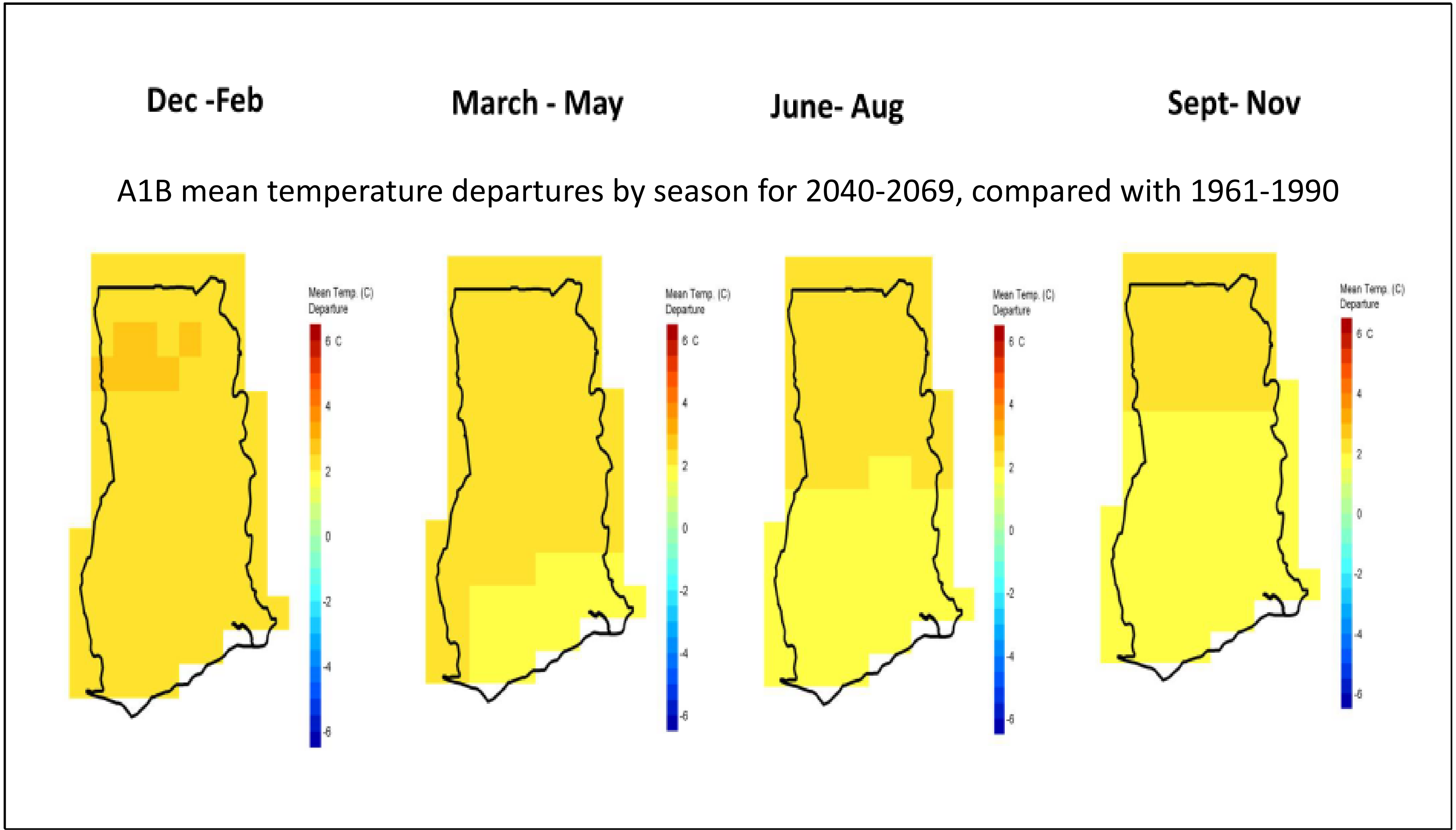
14.4 Predicted Climate Change and Climate Change Events

14.4.1 Temperature Change Predictions in Ghana

GCMs generally agree on the trend for temperature changes, which are predicted to increase markedly more in the northern region of Ghana than in the south, where the Project is located. Ghana's third communication to the UNFCCC (2015) reports projected national mean temperatures increasing 3.8% by 2040 (1.02°C), 5.6% in 2060 (1.5°C), and 6.9% by 2080 (1.8°C).

Figure 14-1 shows future (2040-2069) changes in average temperatures, compared with 1961-1990 measurements, taken from Climate Wizard (http://www.climatewizard.org). The predicted changes are taken from the Ensemble Average of GCMs for the Medium A1B Scenario.

Figure 14-1: Projections of Changes in Future Average Temperatures by the 2050s using Ensemble GCMs at the Medium Emission Scenario



(Source: Climate Wizard)

USAID's Ghana Climate Change Vulnerability and Adaptation Assessment (2011) states that all projections indicate substantial increases in the frequency of days and nights that are considered 'hot' in the current climate. However, the models vary widely in the degree of increase they predict.

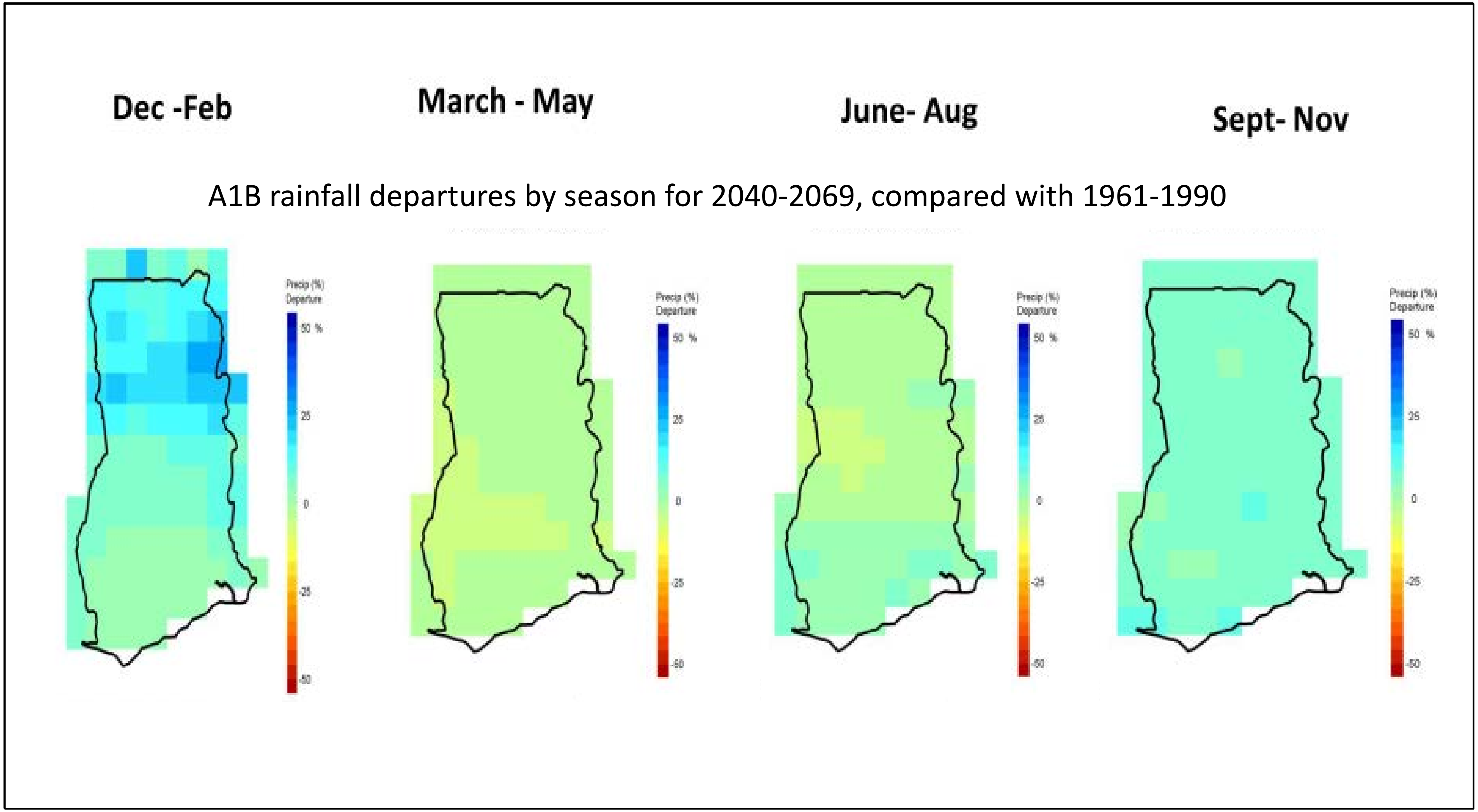
Although the projected mean temperature increases more rapidly in the interior regions of Ghana than near the coast, the projected changes in the daily temperature extremes ('hot' and 'cold' days and nights) in Ghana are largest in the coastal areas.

14.4.2 Rainfall Change Predictions in Ghana

There is little agreement in the literature on future precipitation amounts or seasonality changes. However, it is considered that the warming of the air and the oceans will increase extreme precipitation (i.e. the amount of rain in the 1% Annual Exceedance Probability event will increase).

Figure 14-2 below shows predicted change in precipitation in the 2050s, relative to 1961-1990 measurements, taken from Climate Wizard (http://www.climatewizard.org). The predicted changes in precipitation are taken from the Ensemble Average of GCMs for the Medium A1B Scenario. These show changes in precipitation that are highly variable both geographically and seasonally. There is up to a predicted c.25% increase in precipitation during December to February, up to c.15% increase in September to November, and between -10% and 10% change between March and August, based on these climate scenarios.

Figure 14-2: Projections of Changes in Future Annual Average Rainfall by the 2050s using Ensemble GCMs at the Medium Emission Scenario



(Source: Climate Wizard)

According to USAID (2011) ensemble modelling, projections of rainfall among seven representative meteorological stations also gave mixed and inconclusive results, lacking consistency and predicting decreases and increases in rainfall across stations. Precipitation changes for Accra (which is located less than 30km away) ranged from a 52 percent decrease to a 44 percent increase in wet season rainfall by 2080.

The variability between the models' precipitation predictions is similar to the inter-annual variability currently experienced in the region. The projections tend to indicate a decrease in January to June rainfall and an increase in July to December rainfall.

14.4.3 Sea Level Rise

The oceanography of the West African region is influenced by the meteorological and oceanographic processes of the South and North Atlantic Oceans.

Ghana’s third National Communication to the IPCC predicts that the sea level around Ghana is likely to rise 5.8cm by 2020, 16.5cm by 2050, and 34.5cm by 2080.

The Fifth Assessment Report (AR5) of the IPCC (IPCC, 2013) concluded that global mean sea level will continue to rise at a rate very likely to exceed current rates (3 mm per year). Global mean sea level rise for 2081–2100 relative to 1986–2005 is predicted to be in the range of 0.26m to 0.98m (IPCC 2013). However, this period is likely to be beyond the design life of the project infrastructure.

14.5 Assessment of Vulnerability to Climate Change Events and Hazards

Based on the following vulnerability assessment, mitigation measures have been proposed. These are presented in Section 14.6.

14.5.1 Flood Vulnerability

The FRA (Section 13) assesses the flood risk to the project, from fluvial, pluvial and tidal sources. No significant flood-related risks were identified for the tank farm site.

Rainfall related surface accumulations and flows into and within the power plant and tank farm sites will be addressed through appropriately designed perimeter and internal storm drainage which will be sized to accommodate a reasonable increase in rainfall intensity due to climate change. However, site visit observations indicate that nearby site access roads may have minor issues from pluvial flooding if appropriate storm drainage is not installed.

The conservative numerical modelling assessment undertaken for the Watercourse 2 catchment (see Figure 7-1) predicted a minor fluvial flood risk to small localised areas within PPS1 and PPS2. The FRA concludes that the flood risk posed to the proposed power plant sites is unlikely to be significant, but is likely to increase incrementally over time, as a result of both climate change and changes to land use within the catchment upstream of the site.

The FRA also included suggested mitigation measures to protect the LPG pipeline at water crossings in the event of flooding. Climate change-related changes in flood flows are not expected to significantly increase risks to the pipeline given the mitigation proposed in the FRA.

14.5.2 Tidal and Wave Flood Risk

Ghana Bridge Power Plant Sites

Taking account of the sea level rise projections in the IPPC 5th Assessment report, the FRA has concluded that there would not be a significant risk of inundation of the power plant sites from a storm surge event exacerbating sea levels along the coast.

The FRA found a negligible risk of 'backwater effects' (fluvial flows that have the potential to increase the risk of flooding in coastal areas) as there is a fall of approximately 12m between Watercourse 2 adjacent to the power plant sites and assumed maximum tides.

The flood risk report also found the risk of flooding due to wave actions (up to 2 m above still water level) not to be significant at the sites, again given the elevation and distance from the coast.

Tema Oil Refinery Jetty and Pipeline

The plant will use LPG sourced via a pipeline from the existing TOR Jetty to the TOR site, through to the new tank farm and power plant sites for at least the first 5 years of the project life, at which point it may switch to using natural gas. The coastal location of the TOR jetty leaves the jetty and lower reaches of pipeline at increased risk of tidal and wave flooding.

Significant storm surges could damage the jetty and accompanying LPG pipeline which could impact on fuel availability and plant operation. Based on the IPCC 5th Assessment Report, Global mean sea level is currently rising at a rate of 3mm per year, a 25 and 50 year operational period could see rises of 75mm and 150mm, respectively. This range is considered unlikely to significantly increase the existing level of risk to the jetty from storm surges.

14.5.3 Temperature Change Vulnerability

Based on projections from Ghana's third communication to the UNFCCC (2015) and detailed in 14.4.1 above, temperatures are expected to change by 3.8%, 5.6% and 6.9% by 2040, 2060 and 2080, respectively. Thus, by the end of the project lifetime, average temperatures may potentially have increased by between 1.02°C and over 1.8°C.

This increase is not expected to have a significant impact on engine performance; however, efficiency does decrease slightly in relation to increasing ambient temperature. The impacts of ambient temperature change on a CCGT installation may be more pronounced than for other types of fossil fuel power plants due to the significant air intake for a CCGT. As ambient temperature increases, the heat rate of the turbine increases and the output of the turbine decreases.

Early Power Ltd may wish to re-run performance curves for efficiency and output in order to calculate the effects of temperature increase on the cost model. Although there may be an increase in the lifetime cost of generation, this is considered unlikely to be significant.

14.5.4 Utilities and Infrastructure Vulnerability

The identified information regarding climate change indicates that incremental changes in temperatures, rainfall events and therefore associated flood risk may occur in the future. There is a risk that these changes could impact on a project's key infrastructure requirements (water, energy, transport infrastructure and communications) should these be identified as vulnerable.

Given that Ghana has rapidly transitioned to mobile telephone communications network, it is not considered that an interruption in land linked communications would prevent physical communication for project workers, for example from a safety perspective, regardless of the cause. Assessment of the wider vulnerability of Ghana's commercial communications network is beyond the scope of this study.

Internal 'site load' energy requirements for the project will be provided by its own power plants. On the assumption that appropriate design and operational risks are appropriately managed, there should not be any future risk to the project associated with climate change.

Access Roads

Flooding of local roads could restrict movement of site staff which could impact on the construction and operation of the facility. The FRA indicates that there may be a minor risk of flooding to the site under a 1% AEP flood event. Such an event may also theoretically result in flooding of the main site access road (Valco Road), in the vicinity of the storm drain.

In the event of a significant flood event on the storm drain, the site will be protected through the design mitigation proposed in the FRA and can be accessed from the north where the land is elevated and is not expected to be at risk of fluvial flooding.

Water Supply

The project requires reasonably significant operational water quantities including for demineralised water for make-up to the steam / water cycle and for the control of the emission of oxides of nitrogen (NO_x) in the flue gases from each gas turbine. However, as the plant will be air cooled, this puts significantly less strain on local water resources than, for example one through or hybrid cooling which require orders of magnitude greater quantities of water.

In order to provide such water, the project has included provision for raw water storage tanks, with a three day supply buffer between the supply and plant use.

The raw water will be provided by the Ghana Water Company (GWC) municipal reticulation network. GWC is the national water supply and treatment company. Information from the GWC website[1] indicates that water supply for the Tema area is primarily provided via a pipeline from the Kpong Headworks and the significant water reserves of the Kpong Dam - one of the three Volta River dams which collectively form the largest man-made lake in the world. Whilst Ghana has experienced droughts in the past which have reduced lake water levels and curtailed power production from the dams, a literature search did not identify evidence that water supplies to Tema were significantly affected.

GWC is contracting to provide water to the project and has provided assurance that this supply can be provided without affecting supplies to other water users. Given the scale of the water resource available, it considered unlikely that there will be an issue with actual

[1] http://www.gwcl.com.gh/tema.html

water availability at source. Risks to the project are more likely to be potential water supply disruptions as a result of accidental pipeline damage or GWC maintenance-related interruptions. This risk has been considered as part of the project design process and is a factor in determining the 3 day on site storage.

Whilst it is recognised that predicted variations in rainfall patterns and intensity may occur as a result of climate change, the scale of the Volta River reservoirs is such that it is likely to buffer any change. It is therefore considered highly unlikely that any such changes would result in a noticeable impact on project water supplies and the associated the risk to project is therefore considered negligible. However, as discussed in the FRA chapter, it is recommended that EPL engages with KKDA and GWC to highlight the risks of climate change-related rainfall changes to promote the discussion of long term adaptation measures.

14.5.5 Local Environmental and Social Vulnerability

All aspects of the project infrastructure are located within the Tema Heavy Industrial Area. PPS1 lies within brownfield land approximately 225m east of the TTPC. PPS2 is located immediately north of PPS1, separated by a strip of land c.25m wide. The tank farm site lies in brownfield land approximately 30m east of PPS2 and 150m north-east of PPS1. The power plants and tank farm sites will be the subject of long lease agreements with the existing owner/leaseholder on a willing transaction basis. The sites are situated within a heavily industrialised area, with facilities particularly densely located to the east and west. To the north and south there are some areas of unoccupied land further afield.

There are no residential areas within 2km of the project sites and no direct impacts on those communities are predicted. It is possible that raising of the development sites may result in a small increase in the risk of flooding to surrounding properties without appropriate mitigation. However, appropriate drainage design mitigation measures are proposed in the FRA to effectively manage associated risk.

As detailed in 14.5.4, EPL has confirmed with GWC that water supply for the project can be provided without adversely affecting supplies to existing water users.

It is considered unlikely that the potential changes in temperature or rainfall events will result in significant additional project-related risks to the surrounding environment. In any case, conventional construction mitigation and additional design mitigation included in this ESIA would address any risk.

14.6 Mitigation

Significant climate change-related issues are not anticipated for the project. Given the above assessment, it is considered that specific mitigation for climate change issues is not required on the condition that the mitigation measures presented elsewhere in this report (particularly for the FRA) and in the project Environmental and Social Management Plan (ESMP) are implemented.

Regarding the sensitivity of the Project to temperature change, Early Power Ltd may wish to re-run performance curves for efficiency and output in order to calculate the effects of temperature increase on the cost model. EPL may also wish to consider the inclusion of operational management actions such as coinciding maintenance shutdowns with periods of high temperatures which might otherwise impact on plant efficiency, although this may be difficult to achieve in practice.

14.7 Conclusions and Recommendations

Whilst a number of potential impacts have been highlighted as part of the climate change assessment, associated project risks are not considered to be significant on the condition that the mitigation measures presented in this ESIA are implemented.

It is not suggested that a detailed climate change risk assessment is undertaken. However, it is recommended that the issues highlighted in this assessment are captured in the project risk register. In addition, it is recommended that EPL engages with local authorities and GWC to highlight the risks of climate change and associated impacts on utilities and to promote climate change adaptation activities in long term planning.

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Section 15 – Ecology

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration		Rev No
Sep 2015	First issue		0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency		1
Jun 2016	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating the following changes:		2
	Section No.	***Change***	
	15.3	Mitigation measures / comments updated	
August 2017	ESIA amendment issued to Ghana Environment Protection Agency, incorporating details of further project design changes, including:		3
	Section No.	***Change***	
	Wherever relevant	Text additions / edits to reflect an additional baseline survey for revised project locations, comprising PPS2 and the revised routing of the LPG fuel delivery pipeline.	

Contents

15 Ecology

15.1 Introduction

Details of the baseline ecology of the development area and surroundings are provided in Section 7.8 and, field survey reports are provided in Appendix D. Due to earlier iterations of the ESIA reflecting the locations of the project sites at those times, the survey results are contained within three separate survey reports: C1, C2 and C3. Survey data for the current project locations are provided in the reports as follows:

- C1: LPG tank farm area;
- C2: PPS1 (formerly PPS2[1]); and
- C3: PPS2, and the LPG pipeline route.

15.2 International Guidelines and Standards for Assessment

National and international legislation and guidance relevant to this assessment are detailed in Section 5 of this ESIA report. The assessment has been undertaken with reference to the following:

- Ghana Wildlife Conservation Regulations (1971) LI 685 (as amended);
- Environmental Assessment Regulations 1999 (as amended);
- Environmental Protection Agency Act, 1994; and
- International Finance Corporation (IFC) Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources.

Ghana is also a signatory to a number of International Environmental Conventions that will apply to the assessment including:

- United Nations Convention on Biological Diversity (1994);
- Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention) (1971);
- Convention on the Conservation of Migratory Species of Wild Animals (1988);
- Convention on the Trade in Endangered Species (CITES) (1973); and
- African Convention on the Conservation of Nature and Natural Resources (1968).

15.3 Site context

Ghana is a country with an extremely rich biodiversity component, with 83% of Ghana's species located within its forests. The site has been deemed of poor biodiversity importance. There are no nationally or internationally protected sites within 5km of the site.

[1] The current PPS1 site was formerly known as PPS2, prior to the change to the current site configuration. The ecology baseline report for that site was undertaken during the previous phase of ESIA work and therefore the wording reflects the previous site configuration and refers to PPS2.

The nearest site of ecological importance is the Sakumo Lagoon Ramsar[2] site, which bounds the western end of Tema, approximately 6km west of the power plant site. The Sakumo Lagoon is fed by the Ashaman Dam which lies approximately 7.5km north-west of the project site.

The the Sakumo Lagoon Ramsar site is also the nearest IBA and KBAis 25km away. The nearest Global 200 site is the Eastern Guinean Lowland Forest, the boundary of which is approximately 20km away at the nearest point to the site.

15.4 Data collection

Baseline data collection included a desk-based review of existing ecological information, and field surveys carried out in August 2015, June 2016 and May 2017. Additional survey during the dry season was not considered to be required as the surveys undertaken did not indicate that migratory species of nature conservation interest were likely to enter the site during the dry season. The information gathered was supplemented with interviews with members of the local community.

Species groups for which positive results were identified were: mammals, birds, reptiles and invertebrates, as well as habitats. Baseline data collection methods are results are provided in Appendix D, and results are summarised in Section 7.8.

Parts of the project sites and much of the LPG pipeline route support little or no vegetation, due to their industrial nature or surroundings. Data collection was therefore necessarily more intensive where the structure and composition of habitat present was greater.

15.5 Assessment Methodology

In considering potential impacts on ecological receptors, consideration was given to IFC Performance Standard 6 (PS6) *Biodiversity Conservation and Sustainable Management of Living Natural Resources* (IFC, 2012), the content of which was guided by the Convention on Biological Diversity.

Typically, impact assessment considers in detail those ecological receptors which are:

- important and/or subject to some form of legal protection; *and*
- potentially vulnerable to significant impacts from the proposed development.

15.6 Impact Assessment

As detailed in Section 7.8.6, three species are listed as Threatened (“Vulnerable” or above) on the IUCN Red List may be present within the vicinity of the site: the hooded vulture, (*Necrosyrtes monachus*), the straw-coloured fruit bat (*Eidolon helvum*), and the chaff flower (*Achyranthes sp.*). A small number of other species have Partial Protection under the Wildlife Conservation Regulation of Ghana, which relates to hunting only.

Based on the distance to protected sites, the project will have minimal impact on the overall biodiversity of Ghana. The magnitude of predicted construction and operational effects on

[2] Ramsar sites are wetlands of international importance designated under the Ramsar convention, 1971.

ecology are *low*. The significance of the effect is predicted to be *negligible*. The mitigation measures outlined below are recommended to ensure that there are no residual impacts from development activities.

15.7 Mitigation

The following measures are proposed to minimise potential impacts:

- Construction work should begin during the dry season. Since some species that visit the area are likely to move out of the area during this period, works are likely to have less impact on the wildlife of the area than if undertaken during the wet season.
- The project should consider carrying out clearance activities during the periods outside the breeding season. This will prevent impacts on any species that may select the few thickets in the area for breeding site. On the power plant sites, if clearance is done right after the farming activities and the area is not left to grow back before clearing, no impact is expected since the farming already disturbs the wildlife.
- The Neem tree:
    - The Neem tree is invasive and any individuals identified on site should not be encouraged to spread. The EPC contractor should include measures to prevent this in the construction phase. An action to produce an invasive species management plan is included in the ESMP.
    - The disposal of the Neem tree and any seeds should be done with care and certain pesticides can be used to support the eradication of the plant.
- No further mitigation for birds or the Chaff flower is required. The Chaff flower may be a species of some conservation importance and should be protected where possible. The population of the chaff flower should be monitored; this action will be included in the ESMP.

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Section 16 – Water and Wastewater

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration		Rev No
Sep 2015	First issue		0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency		1
June 2016	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating the following changes:		2
	Section No.	***Change***	
	Wherever relevant	Reference to "power plant site" changed to reflect revised plan involving two power plant sites (PPS1 and PPS2).	
	Table 16-1	Ghanaian limit for total chromium corrected.	
August 2017	No changes made to this section		3

Contents

Figures and Tables

16 Water and Wastewater

16.1 Introduction

The following section provides a discussion on water usage and discharges, and assesses the associated environmental impacts from the construction, operation and decommissioning of the project.

Water usage and wastewater is outlined in the project description, Section 2.9. Baseline data on surface waters near the development is provided in Section 7.1.4 with hydrogeology baseline data in Section 7.1.11.

16.2 Legislation and Standards

The IFC and Ghana EPA have compiled discharge standards for safe discharge of effluent to surface waters. The standards are outlined in Table 16-1, below. IFC standards for sanitary waste discharges are provided in Table 16-2. Ghana does not currently have equivalent standards at the time of writing.

Table 16-1: Relevant Ghanaian and IFC Water Quality Discharge Standards[1]

Parameter	Ghanaian limits for Thermal Power Plant	IFC EHS guidelines for Thermal Power Plants >50 MW
pH	6 – 9	6-9
BOD5 (mg/l)	50	-
Oil and Grease (mg/l)	5	10
Total Suspended Solids (mg/l)	50	50
Total Phosphorus (mg/l)	2.0	-
Colour (TCU)	200	-
COD (mg/l)	250	-
Chromium (total) mg/l	0.5	0.5
Sulphide (mg/l)	1.5	-
E. Coli (MPN/100 ml)	-	-
Turbidity (N.T.U.)	75	-
Cadmium (mg/l)		0.1
Lead (mg/l)	0.1	0.5
Nitrate (mg/l)	50	-
Copper (mg/l)	0.5	0.5
Iron (mg/l)	2	1
Zinc (mg/l)	2	1
Mercury (mg/l)	-	0.005

1 Note that for oil and grease the more stringent Ghanaian limit will apply. Where there are no Ghanaian limits or where IFC is more stringent, those of the IFC will apply.

Parameter	Ghanaian limits for Thermal Power Plant	IFC EHS guidelines for Thermal Power Plants >50 MW
Total residual chlorine	-	0.2 (a)
a) So called chlorine shocking may be preferable in certain circumstances. This involves using high chlorine levels for a few seconds rather than a continuous low level release. The maximum value is 2 mg/l for up to 2 hours not to be repeated more frequently than once in 24 hours, with a 24 hour average of 0.2 mg/l (the same limits will apply to bromine and fluorine).		

Table 16-2: IFC Indicative Values for Treated Sanitary Sewage Discharges

Pollutant	Unit	IFC Guideline Value
pH	pH	6-9
Biological Oxygen Demand	mg/l	30
Chemical Oxygen Demand	mg/l	125
Total nitrogen	mg/l	10
Total phosphorous	mg/l	2
Oil and grease	mg/l	10
Total suspended solids	mg/l	50
Total coliform bacteria	Most probable number / 100ml	400 (Not applicable to centralised municipal wastewater treatment systems which are including in the EHS guidelines for water and sanitation)

16.3 Water Use and Sources of Wastewater

16.3.1 Construction

The main water use during construction will be for hydrostatic testing of tanks and pipelines. Water will also be used for cleaning, consumption and sanitary uses.

The following wastewater streams will be generated during construction:

- Effluent from hydrostatic testing of storage tanks and pipelines. This water may be treated with chemical additives prior to use to prevent internal corrosion and which may be present as potential contaminants in the effluent; and
- Sanitary wastewater from construction workers welfare facilities.

In addition, accidental spillage may release substances directly into soil with infiltration into groundwater or surface waters.

16.3.2 Operation

Water use during operation will primarily be for process cooling and scrubbing of NO_x from the combustion plants. The cooling systems used however, are air-cooled systems which do not require significant quantities of water in comparison with hybrid or once through cooling systems. They will not require sea or river water intake or discharge infrastructure. Water will also be used for cleaning, consumption and sanitary uses.

The following wastewater streams will be generated during operation:

- Wastewater from demineralisation of potable water (necessary to meet purity requirements for plant use);
- Wastewater from the NO_x scrubbing plants;
- Steam / water circuit blowdown (water purged from the system to enable the concentration of various compounds in the circulating water to be maintained to limits prescribed by the Ghana EPA); and
- Sanitary wastewater from offices and worker welfare facilities.

Stormwater and surface water runoff from non-process areas will be discharged directly into a surface water course.

In addition, accidental spillage may release substances directly into soil with infiltration into groundwater or surface waters.

16.4 Assessment Methodology

Water use has the potential to deplete limited resources in water scarce areas. Wastewater may be contaminated with a range of pollutants that are harmful to people or the aquatic environment.

The methodology adopted for assessing the significance of effects is presented in Section 6.

Based on the baseline information reviewed and presented above, the sensitivity of the site and surrounding areas with respect to land and water quality is considered to be of “local” geographical context.

16.5 Impacts Assessment

16.5.1 Construction Phase

Water for construction use will be provided initially by tanker/other bulk container or temporary connection to the local VRA clean water tank until the Ghana Water Company (GWC) pipeline is constructed. The GWC has assured the project that an adequate supply is available and that supply to the project will not be detrimental to other water users.

Hydrostatic testing of storage tanks and pipelines will require the use of water and discharge of the effluent. Chemical additives may be added to the water to prevent internal corrosion and which may be present as potential contaminants in the effluent. If released directly into the environment, the contaminants could be harmful to aquatic receptors.

Sanitary wastewater will be generated during the construction work with temporary amenity facilities provided on site. There will be 200 workers present at peak times of construction activity. This wastewater is highly biologically active and very toxic in the aquatic environment, as well as to people, if released directly into a watercourse.

Other potential impacts to surface and groundwater during construction activities include the generation of sediment laden runoff, alteration of the hydrological flows of watercourses and the mobilisation or release of contaminants to watercourses and / or groundwater.

Spills during construction (and operation) could impact on groundwater. Similarly spills into, or in the direct vicinity of, surface water features could result in the pollution of these receptors as could storm water runoff from areas of land that are contaminated.

Given the nature of works and Good Industry International Practice (GIIP) construction mitigation which will be utilised, it is considered that construction impacts to water resource will be low and of a localised nature. However, the potential for wastewater from sanitary uses to pollute local watercourses, as well as potential risk of sediment releases, means that the unmitigated impact from the construction phase would be medium and has the potential to result in district level impacts. The significance of the effect of water use and waste water from the construction activities is therefore assessed as minor / major without mitigation.

16.5.2 Operational Phase

Water for operational use will be sourced via the GWC supply, as abstraction of groundwater was not considered to be a viable option. GWC has assured the project that an adequate supply is available and that supply to the project will not be detrimental to other water users.

Water use during the operational phase has been minimised by the selection of air cooling technology as described above.

Effluents produced during operation will include:

- Wastewater from demineralisation of potable water, which is likely to contain sodium bisulphite and an anti-scalant, with additions of acid or caustic soda as appropriate to provide the required near neutral pH;
- Steam / water circuit blowdown which is likely to contain residual chlorine, a biocide and an antiscalant;
- Wastewater from the NO_x scrubbing plants which are likely to contain ammonia, nitrate nitrogen and heavy metals; and
- Sanitary wastewater from offices and worker welfare facilities.

Should any of these effluents be released directly into a watercourse, they are likely to result in significant harm to aquatic organisms and potentially people who may come in contact with the water.

As in construction, there is the possibility that accidental spills of fuel, etc. could cause considerable contamination of watercourses. Surface water run-off could also become contaminated with sediment and oil, both of which would be harmful if discharged directly into a surface watercourse.

Given the nature of the operations, relatively low water usage, discharge characteristics and limited number of personnel at the site, it is considered that operation phase impacts to water resource and from wastewater discharge will be medium and of a localised nature. The significance of the effect of water use and waste water from the construction activities is therefore assessed as negligible / minor without mitigation.

16.5.3 Impacts Assessment for Decommissioning

Decommissioning impacts will be similar to those experienced during construction. Although water will not be required for hydrostatic testing, substantial water use may be required for decontamination and cleaning purposes.

16.5.4 Cumulative Impacts

The operation of the new power station infrastructure in a region where there is significant existing industrial operators, where new plants are scheduled to come on line in the future, where there is a growing population and where precipitation is declining, will potentially result in pressure on water resources and water scarcity.

Discharge of contaminated wastewater from the large number of industrial users could result in significant blight to the environment if uncontrolled.

The magnitude of any cumulative effects that the construction and operation of the development may have on water resource or water quality is assessed as high. The cumulative significance of effect of the development is therefore assessed as minor / major without mitigation.

16.6 Management and Mitigation of Impacts

16.6.1 During Construction

Construction phase impacts on the local water environment will largely be controlled through the application of GIIP construction methodology, including the adoption of the requirements of IFC General EHS Guidelines. This will include management of construction site drainage and appropriate sediment segregation / run off controls and appropriate control and storage of potential pollutants such as fuels or cementitious material used in the construction process.

Chemically treated wastewater from hydrostatic testing of storage tanks and pipelines will be minimised by pre-use tests to determine whether simple pH adjustment is sufficient. This would avoid the need for more environmentally aggressive chemicals. The Project also intends to avoid the use of dyes (e.g. fluorescein) in the test water. All discharges (including concentration of biofouling additives if required) will be assessed to ensure that the quality standards stated in Table 16-1 are met. Wastewater that cannot meet the quality requirements will be removed from site by tanker and disposed of at an appropriately licensed facility.

Sanitary wastewater will be collected in a series of septic tanks, which will be emptied on a regular basis. An authorized contractor will be assigned the responsibility of emptying the septic tanks and disposing of the wastewater in accordance with legal requirements.

Provision will be made for sufficient number of toilets to accommodate the number of workers present at any given time. Site rules will be implemented to ensure that workers use the facilities provided to avoid uncontrolled release of pollutants into the environment.

All workers will be trained in the handling, storing, and disposal of hazardous materials. Emergency procedures will be in place so that in the event of an accidental release the spill can be contained and effects mitigated. Emergency spill containment material and clean-up equipment will be distributed and stored in appropriate places so that any spill can be cleared up as quickly as possible to minimize any adverse effects.

With implementation of the proposed mitigation measures, it is considered that construction impacts to water resource and discharge of wastewater will be low and localised. The significance of effect of the construction activities is therefore assessed as negligible.

16.6.2 During Operation

The water supply for operations will be sourced as described.

The power plants will be air cooled and so will not require significant quantities of water in comparison with hybrid or once through cooling systems. They will not require significant water take and discharge infrastructure, minimising potential impacts.

The project includes waste water treatment plants which will treat the process wastewater to control the concentrations of various compounds to within the limits prescribed by the Ghana EPA and IFC. The resulting effluent will then be discharged via storm drains into the adjacent stormwater drainage system. Appropriate monitoring arrangements will be put into place to ensure that discharge effluent complies with the Ghana and IFC discharge quality standards.

Sanitary wastewater will be removed from the sites by tanker for off-site treatment and discharge.

As in construction, there is the possibility that accidental spills of fuel, etc. could cause considerable contamination of watercourses. GIIP precautions including adoption of the requirements of IFC General EHS Guidelines will be utilised to prevent accidents. Oil and fuel areas will be bunded. All workers will be trained in the handling, storing, and disposal of hazardous materials. In the event of an accidental release there will be emergency procedures in place so that the spill can be contained immediately. Emergency spill containment material and clean up equipment will be distributed and stored in appropriate places so that any spill can be cleared up as quickly as possible to minimize any adverse effects.

Any contaminated waste waters / storm waters following a spill, will be collected as far as possible and retained on site prior to being treated by the waste water treatment system or appropriate off-site treatment system and discharged.

With implementation of the proposed mitigation measures, it is considered that construction impacts to water resource and discharge of wastewater will be low and localised. The significance of effect of the construction activities is therefore assessed as negligible.

16.7 Conclusion

Impacts from water use and effluent discharge from the project's facilities have been assessed. Water use has been minimised through the selection of air-based cooling system as well as measures to be adopted to avoid the unnecessary use of chemical dosing. A number of mitigation measures are planned for management of wastewater to avoid harm to the environment, and where releases into the local watercourse are planned, to ensure that Ghana EPA and international water quality standards are met. These measures will reduce the significance of the effects from construction and operation to negligible / minor.

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Environmental and Social Impact Assessment

Section 17 – Solid Waste

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Sep 2015	First issue	0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency	1
June 2015	No changes to this chapter	2
August 2017	No changes to this chapter	3

Contents

Figures and Tables

17 Solid Waste

17.1 Introduction

This Section identifies the sources and types of waste that will be generated during the site preparation/construction and operational phases related to the project. An assessment of the environmental impact related to the generation of solid waste is also provided.

17.2 Legislation and Standards

Ghana is signatory to the following conventions regarding wastes:

- Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movements of Hazardous Wastes within Africa (1990).
- Rotterdam Convention of Prior Informed Consent Chemicals (1998).
- The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (2003).
- The Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matters, London (1972).

17.3 Waste Streams

17.3.1 Construction

A major component of construction wastes will be the generation of soil arisings from excavation and piling works. Other solid wastes generated in construction include:

- Building rubble;
- General construction waste, e.g. cement bags and waste concrete;
- Plastics;
- Electrical cabling;
- Empty oxy acetylene tanks;
- Scrap metals (mixed metals) including spent welding rods;
- Empty chemical containers;
- Packaging materials of cardboard and plastic;
- Fibreglass;
- Spilled oils and waste oils;
- Spilled oil clean-up materials;
- Paint;
- Waste wood;

- Paper;
- Domestic waste;
- Sewage effluent; and
- Grass/ vegetation from stripping.

Expected quantities of specific waste streams are not yet defined; however, in relation to the size of the project, it is likely that only a moderate amount of waste will be generated during the site preparation and construction phase. Some of the waste produced is likely to be classified as hazardous.

17.3.2 Operation

Once operational, there will be few significant sources of solid waste generated and the additional burden placed on the existing waste management infrastructure in the project area should be low.

The solid wastes could include:

- Domestic and commercial waste (cardboard, paper, pallets, packaging material from spares, waste printer cartridges, food wastes, dirty oil, etc.).
- Wastes produced during maintenance, including:
  - Sludge removed from oil separators;
  - Deposits removed from the HRSGs;
  - Scrap metals from maintenance; and
  - Miscellaneous wastes (e.g. air filters).
- Reverse osmosis membranes from the demineralisation plant (typical lifespan of 5 to 10 years).
- Solid hazardous and other wastes from water treatment in the RO plant including process ferric and lime sludges.
- Paper and plastic packaging materials.

17.3.3 Decommissioning

When the project is decommissioned, there will be potential for generation of significant quantities of hazardous and non-hazardous materials. It is likely that materials generated at decommissioning will include all of those mentioned above for the operation phase. There will also be arisings of building materials and components, equipment, fixtures/fittings, and other items that may be contaminated with hazardous residues and / or contain hazardous constituents. The decommissioning plan will aim to recover assets, recycle materials and minimise the need for solid waste disposal.

Additional waste may be generated from or include:

- plant cleaning and decontamination activities;

- miscellaneous demolition wastes;
- residues or stabilised waste from on-site treatment activities such as chemical treatment, incineration, fixing in solids (cementaceous backfills, refractory fixing, etc.);
- arisings from land remediation where end of plant clean-up of soil and groundwater contamination is required to prevent future risk to people or the environment.

17.3.4 Hazardous Materials (all phases)

A hazardous waste disposal agreement will be signed with the Tema Metropolitan Assembly and all such disposals will be supervised by the Plant Environmental Officer.

The table below provides a list of the expected hazardous waste over the project life cycle.

Table 17-1: Hazardous Waste Streams

Hazardous Waste	Project Phase		
	Construction	**Operation**	**Decommissioning**
Excavated materials which may contain heavy metals, hydrocarbons / other contaminants	X		
Paint associated with construction and maintenance activities.	X	X	
Empty chemical containers	X	X	X
Spilled treated and untreated oil	X	X	X
Waste oil clean up materials	X	X	X
Chemicals and greases	X	X	X
Batteries	X	X	X
Medicinal wastes	X	X	X
Scrap metals	X		X
Waste fiberglass	X		X
Waste ion exchange resins		X	
Spent water treatment filters		X	
Boiler chemicals for boiler water treatment		X	
Reverse Osmosis membranes		X	

Details of hazardous materials stored and used for the project are provided in the project description. Hazardous materials stored on the site include DFO. It is possible that accidental release of these and other materials (e.g. lubricating oils / grease / paint) could arise through construction and operational activities.

17.4 Assessment Methodology

The generation of solid wastes and potentially improper and/or indiscriminate disposal of solid waste in and around the project facilities are potentially adverse effects associated with the development. Likely sensitive receptors are considered to be:

- Uncontaminated surface and near surface soils;
- Controlled waters – surface water and groundwater;
- Ecological receptors; and
- Human receptors – ground workers, site workers and nearby communities.

The methodology adopted for assessing the significance of effects is presented in Section 6.

The impacts from management of inert wastes would be at a local level i.e. within 1km of the project site. Wider district or regional impacts are likely in relation to wastes that require off-site treatment, destruction or disposal to landfill.

For hazardous wastes it is possible that arrangements will need to be made to transport wastes further afield, and even possibly overseas dependent on the availability of suitable disposal contractors. As such the sensitivity of the site and surrounding areas with respect to land and water quality is considered to be of “district” geographical context.

Note that the impacts and management of accidental release of oily wastes are discussed along with wastewaters in Section 16.

17.5 Impacts Assessment

Without appropriate waste storage, handling and disposal there is a chance that environmental contamination could occur. This would represent a breach of environmental legislation on the basis that inappropriate waste management was taking place. Furthermore, in the case of hazardous waste, there could be long-term damage to human health or the receiving environment.

Potential impacts associated with the project activities are described below.

17.5.1 Construction and Decommissioning Phase Impacts

The following potential impacts associated with the generation, handling and disposal of solid waste during the construction and decommissioning phases have been identified:

- Contamination of soils by direct exposure to contaminated wastes and or migration of contaminants in surface run off or migration of contaminants such as oils/ hydrocarbons;
- Contamination of groundwaters through leaching of contaminants from waste materials which are not properly contained or illegally dumped;
- Contamination of surface waters through improper storage and disposal of wastes, either directly or by migration of contaminants in groundwaters;
- Harm to ecological receptors through improper waste disposal / illegal dumping of wastes in ecologically sensitive areas;

- Harm to ecological receptors through migration of contaminants leached from poorly managed waste materials and pollution of waterbodies;
- Human health impacts from direct contact with contaminated waste materials generated during excavation / piling and dredging;
- Human health impacts through contamination of surface waters and ground waters (drinking water) with implications for potential downstream fisheries and human consumption;
- Human health impacts from fugitive dusts generated from stockpiled waste materials;
- Human health impacts from fugitive dusts caused by transportation of waste materials;
- Visual impact from improper waste disposal/ illegal dumping of wastes;
- Impacts to sensitive receptors following accidental release / spillages of materials used during the construction process;
- Human health impacts from odours generated by waste materials;
- Human health impacts through inappropriate re-use of waste materials (note that it is not uncommon in countries such as Ghana for unregulated re-use of materials without necessary safety checks on their origin); and
- Unnecessary disposal of materials and use of natural resources.

The magnitude of potential harm from waste generation and management during construction and decommissioning is assessed as medium. The significance of the effect is therefore assessed as minor / major without mitigation due to the potential for district level impacts.

17.5.2 Operational Phase Impacts

The following potential impacts also apply to the operational phase of the project:

- Contamination of soils, groundwaters and surface waters following improper storage and disposal of wastes;
- Harm to ecological receptors through improper waste disposal / illegal dumping of wastes in ecologically sensitive areas or through migration of contaminants leached from poorly managed waste materials and pollution of waterbodies;
- Human health impacts following improper storage and disposal or re-use of wastes through contamination of surface waters and ground waters (drinking water) with potential implications for downstream water users, including potentially human consumption;
- Impacts to sensitive receptors following accidental release / spillages of waste materials used during operation;
- Human health impacts from odours generated by waste materials; and
- Unnecessary disposal of materials and use of natural resources.

The magnitude of harm from waste management during plant operations is assessed as medium to low. The significance of the effect is therefore assessed as minor / major without mitigation due to the potential for district level impacts.

17.5.3 Cumulative Impacts Assessment

The operation of the new power station infrastructure in an area where existing power stations operate and where others are scheduled to come on line in the future will add to the loading on district waste disposal facilities which may already be unsuitable to accept certain types of waste. There is a risk that the existing facilities will not be able to cope with the quantities and types of wastes that are being produced. An audit of the waste disposal facilities is required to be undertaken by the EPC Contractor and project operator prior to use of the facilities to ensure they are appropriate for use.

The magnitude of any cumulative effects that the construction and operation of the development may have on solid waste management is assessed as high. This assessment is conservative and has been made considering the known lack of disposal facilities for wastes and the problems faced by developing countries in appropriate waste management. The cumulative significance of effect of the development is therefore assessed as minor/major without mitigation. This may be an area where specific government policy and initiatives are required to ensure that adequate provision is available.

17.6 Waste Management and Mitigation Measures

The potential impacts from the generation and disposal of waste during the project life cycle have been recognised and good practice mitigation measures will be employed to minimise these. These are outlined below.

17.6.1 General Approach to Waste Management

A detailed waste management plan covering the entire project life cycle will be developed as part of the ESMP and will include the following the principles:

- Application of the waste management hierarchy (reduce, reuse, recycle and dispose);
- Handling and storage of wastes in a manner that prevents uncontrolled release to the environment;
- Segregation of non-hazardous and hazardous wastes; and
- Transfer and disposal of arisings and wastes in accordance with legal requirements.

Waste disposal contractors, treatment facilities and waste disposal sites will be audited prior to use to ensure they meet the required national regulatory, EPA and international IFC standards.

17.6.2 Additional Measures during the Construction Phase

Where possible, excavation arisings from construction (e.g. piling arisings and excavated materials) will be re-used on site. Where this is not possible (e.g. because of contamination or because they are geotechnically unsuitable) contamination will be neutralised utilising the services of suitable waste contractors and / or they will be disposed to a suitable disposal site.

Temporary storage of excavation arisings will be on impermeable membranes, which will also be used to cover temporary spoil heaps to prevent rain washing out contaminants. Rainwater collection bunds and trenches around the spoil heaps will be used as necessary.

Temporary containment measures will be provided for fuels and oils, including secondary containment (e.g. bunds and drip trays) and provision of drainage trenches where necessary, to prevent pollution entering soil, surface waters and groundwater.

All dry materials will be stored to minimise dust and wastage. Materials will be stored in containers where possible and all bagged materials will be stored on pallets and covered. Cement will be stored on original packaging pallets and within enclosed storage compounds where possible. If outside storage is required cement will be stored off the ground on pallets and covered with tarpaulin. No polluting materials will be stored in the vicinity of any watercourses.

Construction staff will be briefed in identification of potential contamination and hazardous materials (e.g. discoloured soils, fibrous materials, odours) that may be encountered during site preparation and ground breaking activities. If potentially contaminated soil/groundwater or suspect hazardous materials are encountered, the following measures will be implemented:

- Works will be stopped and the area made safe;
- Suspect contaminated spoil or hazardous materials will be segregated from other materials, covered and stored in an impermeable, bunded area, away from drains and watercourses;
- Suspect contaminated groundwater will be pumped into a suitable storage container, e.g. an IBC; and
- The suspect materials will be tested and disposed of via suitable waste disposal contractors.

17.6.3 Additional Measures during Operation Phase

An Environmental Control Officer / Manager (title to be confirmed) will be appointed to ensure the management systems are implemented correctly.

Detailed waste management procedures will be developed for the operational phase in accordance with the requirements of the Waste and Environmental Management Plans.

Permanent segregation facilities will be provided (e.g. separate receptacles for food wastes, plastics, metals). The receptacles will be clearly marked and suitable to hold the type of waste they will contain. There will be frequent emptying of waste receptacles and transfer to appropriate storage facilities on site and/ or transfer and disposal by suitable waste disposal contractors.

Waste storage will be within designated areas located on hard surfacing and covered where appropriate to ensure containment and prevent ingress of rain. There will be special provisions for the storage of any hazardous wastes and these will be segregated from non-hazardous wastes.

All storage areas will be regularly emptied and periodically cleaned and disinfected.

Staff will be fully trained in the handling and suitable disposal of waste streams and provided with PPE where appropriate.

17.6.4 Additional Measures for Decommissioning

The following additional measures are recommended at decommissioning:

- Consideration of decommissioning and optimisation of material re-use, recovery and recycling opportunities during detailed design;
- Development of a high level decommissioning plan while the plant is in operation and knowledge about the plant is readily available from operational personnel; and
- Pre-demolition audit and development of a bill of quantities of arisings to optimise management arrangements and minimise disposal requirements.

17.6.5 Accidental Releases

Accidental release / spillages may arise through activities during any phase of the project life cycle. In the event of an accidental release, measures will be put to contain and clean up released materials to prevent direct discharge to sewer, surface water or soil. Measures will be in place to contain these wastes and ensure they are appropriately treated and disposed.

17.6.6 Assessment of Impacts Following Mitigation

Following implementation of the mitigation measures identified above, the impacts from wastes during the project life cycle are expected to be negligible / minor. There will be residual impact from the use of landfill and natural resources.

17.7 Conclusions

Environmental effects are associated with the generation of solid waste and potentially improper and/or indiscriminate disposal of solid waste in and around the project site with implications for subsequent land contamination, visual impact and public health issues. Mitigation measures to reduce the occurrence of these effects included appropriate use of the waste hierarchy (reuse, recycling, and disposal), adequate provisions for storage and segregation of wastes and appointment of approved waste contractors for removal and disposal of wastes to an approved facility. More detailed waste management procedures will be developed prior to operation and the EPC construction contractor will implement a Waste Management Plan (WMP) for the construction phase.

A residual impact is inevitable given that waste will be generated throughout the lifespan of the project, however the implementation of recommended mitigation measures will ensure the significance of this effect is reduced.

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Section 18 – Greenhouse Gas Emissions

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration		Rev No
Sep 2015	First issue		0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency		1
June 2016	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating the following changes:		2
	Section No.	***Change***	
	Wherever relevant	Reference to “power plant site” changed to reflect revised plan involving two power plant sites (PPS1 and PPS2).	
	Wherever relevant	Corrections to spelling, grammar and other changes for consistency. Abbreviated terms provided in full at first usage.	
	18.4.2 & Fig 18-1	Updated information on the system boundaries, the project phases and operating conditions	
	18.4.3 & Tables 18-1 to 18-4	Updated calculations based on revised operating information	
	Table 18-5	Additional information	
	18.6.1	Updated assessment of impacts	
	18.9	Updated calculations and assessment summary	
August 2017	ESIA amendment issued to Ghana Environment Protection Agency, incorporating details of further project design changes, including:		
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	Wherever relevant	Amendments to development stages and inclusion of emissions resulting from the use of SF_6	
	Wherever relevant	Updated efficiency data for LM Units and updated calculations	
	Wherever relevant	Updated for inclusion of Paris Agreement details	

Contents

Figures and Tables

18 Greenhouse Gas Emissions

18.1 Introduction

Greenhouse gases (GHG) allow incoming radiation to pass through the atmosphere, but prevent much of the outgoing radiation from escaping the earth's atmosphere. It is now widely accepted that increasing concentrations of these gases in the atmosphere are leading to the accelerated warming of climates around the world. This is often referred to as 'global warming' or 'climate change'.

Numerous pollutants are known to contribute to global warming. Climate change is most closely associated with CO_2. CO_2 is the natural product released during combustion of carbon based fuels with the quantity released dependent on the carbon content of the feedstock. Although not in itself a toxic gas, it is widely accepted as being the most significant contributor to the 'global warming' effect due to the wide range of sources and overall contribution to the total volume of GHG in the atmosphere.

Other GHG are recognised in the Kyoto Protocol as the key gases associated with climate change[1]. Due to their relative physical properties, referred to as their Global Warming Potential (GWP), these gases have a more powerful greenhouse effect than carbon dioxide. CO_2 is considered to be the 'baseline' gas for GWP (GWP = 1) and the relative warming potentials of the other gases are normalised to the equivalent mass of CO_2 required to achieve the same warming effect; total greenhouse gases are therefore quantified in units of CO_2 equivalents (CO_2e).

Ghana's current generation capacity of 2,125 MW[2] comprises approximately 50% hydro and 50% thermal plants. The proposed project is an integrated LPG-to-power plant which it is anticipated will produce 424 MW of electricity from LPG initially and then from NG.

18.2 International Guidelines and Standards for Assessment

The International Finance Corporation (IFC) Performance Standard 3 (PS3) requires the project *"to promote the reduction of project related GHG emission in a manner appropriate to the nature and scale of the projects operations and impacts"*. In addition, the IFC Thermal Power Guidelines (2008) make recommendations to help avoid, minimise and offset carbon dioxide equivalent (CO_2e) emissions from new thermal power plants and present carbon emission performance guidelines for gas-fired thermal power stations. This enables comparison of the project performance against best practice guidelines.

Under PS3 there is a requirement, that, *"projects which are expected to produce more than 25,000 tonnes of CO_2e annually are required to quantify direct emissions from the facilities owned or controlled within the physical boundary of the project, as well as indirect emissions associated with the off-site production of energy used by the project."*

This is generally produced as a "carbon balance".

[1] United Nations Framework Convention on Climate Change 'basket of six' greenhouse gases are: carbon dioxide (CO2); methane (CH4); nitrous oxide (N2O); hydrofluorocarbons (HFCs): perfluorocarbons (PFCs), and Sulphure hexafluoride (SF6)

[2] http://citifmonline.com/2014/06/02/de-lighting-ghanaians-the-state-of-ghanas-power-sector/

Furthermore, the World Bank Group (WBG) Environmental Health and Safety (EHS) Guidelines for Thermal Power Plants (2008) promotes the importance of energy efficiency and reducing GHG emissions in relation to new thermal power plant.

Recommendations from the Thermal Power Plant EHS Guidelines that are applicable to the development to help avoid, minimise, and offset CO_2e emissions include:

- Use of less carbon intensive fossil fuels i.e. fuel containing less carbon per unit of calorific value e.g. gas is less than oil and oil is less than coal, or co-firing with carbon neutral fuels i.e. biomass;
- Use of combined heat and power plants where feasible;
- Use of higher energy conversion efficiency technology of the same fuel type/power plant size than that of the country/region average. New facilities should aim to be in the top quartile of the country/region average of the same fuel type and power plant size;
- Use of high performance monitoring and process control techniques, good design and maintenance of the combustion system so that initially designed efficiency performance can be maintained;
- Where feasible, arrangement of emissions offsets e.g. the Kyoto Protocol's flexible mechanisms and the voluntary carbon market, including reforestation, afforestation, capture and storage of CO_2 or other currently experimental options; and,
- Consideration of fuel cycle emissions and off-site factors, e.g. fuel supply, proximity to load centres, potential for off-site use of waste heat, or use of nearby waste gases as fuel.

18.3 Potential Sources of GHG Emissions

During operation of the plant, combustion sources (LPG and ultimately NG) will release carbon dioxide (CO_2) while vents and other fugitive emissions will lead to the release of other GHG.

The carbon balance aims to provide an overall GHG emissions balance, broken down by phase and source category in tonnes of carbon equivalent per year (tCO_2e), i.e. the balance seeks to quantify the emissions:

- From combustion sources;
- From vents, leaks and other fugitive emissions; and,
- Plant operational activities.

18.4 Methodology and Approach

The main greenhouse gas associated with thermal combustion is CO_2 and therefore CO_2 is the main focus of this assessment. Methane (CH_4), Nitrous Oxide (N_2O) and Sulphur hexafluoride (SF6) emissions have also been considered within the assessment as, whilst these gases are emitted in much smaller quantities than CO_2, their higher GWP means their impact can still be significant. It is not anticipated that any significant sources of the other main greenhouse gases outlined above will arise during the operation of the plant.

This carbon balance has been produced following recognised methodologies to provide an assessment of the emissions associated with the operation of the proposed power plant. In line with the World Resources Institute (WRI) Greenhouse Gas Protocol, the carbon balance is based on the principles of relevance, completeness, consistency, transparency and accuracy. Also, as set out in IFC Guidance Note (GN) 3[3], the assessment scopes includes direct emissions from within the physical project boundary and also consideration of any indirect emissions associated with the off-site production of energy used by the plant, should this be applicable.

The calculation considers all the key GHGs listed by the United Nations Framework Convention on Climate Change (UNFCCC) and, therefore, the results are presented in tonnes carbon dioxide equivalent (tCO_2e).

The emission sources considered comprise:

- Scope 1 – direct emission sources: stationary combustion; mobile combustion (transportation); process emissions and fugitive emissions;
- Scope 2 – indirect emission sources: consumption of purchased electricity, heat or steam; and,
- Scope 3 – other indirect/value chain emissions: upstream and downstream emissions associated with water supply and treatment, waste disposal, staff travel and embodied carbon in construction materials.

18.4.1 Systems Boundary: Temporal

The assessment has focused on emissions from the operation phase of the project. The operation phase focuses on the consumption of fuels (LPG and ultimately NG, with consideration of back up use of diesel fuel oil - DFO) and water throughout the plant's lifetime.

As the initial design lifespan of the power plant is 25 years, decommissioning would depend greatly on the environmental legislation and the technology available at the time.

18.4.2 Systems Boundary: Physical

For each of the temporal boundaries outlined above, a physical boundary has been applied defining the inclusion and exclusion of emission sources. Key emissions sources in Scopes 1 and 2 have been considered. Where it has not been possible to obtain data, this has been supplemented by recognised industry standard values e.g. from IFC GN3, or the data gap has been identified. A detailed description of the data gaps is contained in Section 18.5.3.

The system boundaries applied are shown in Figure 18-1 'Operation Phase' on the following page.

[3] International Finance Corporation World Bank Group Guidance Note 3 Resource Efficiency and Pollution Prevention (Paragraph 15) January 1, 2012

Figure 18-1: System Boundaries for Carbon Balance of Operation Phase

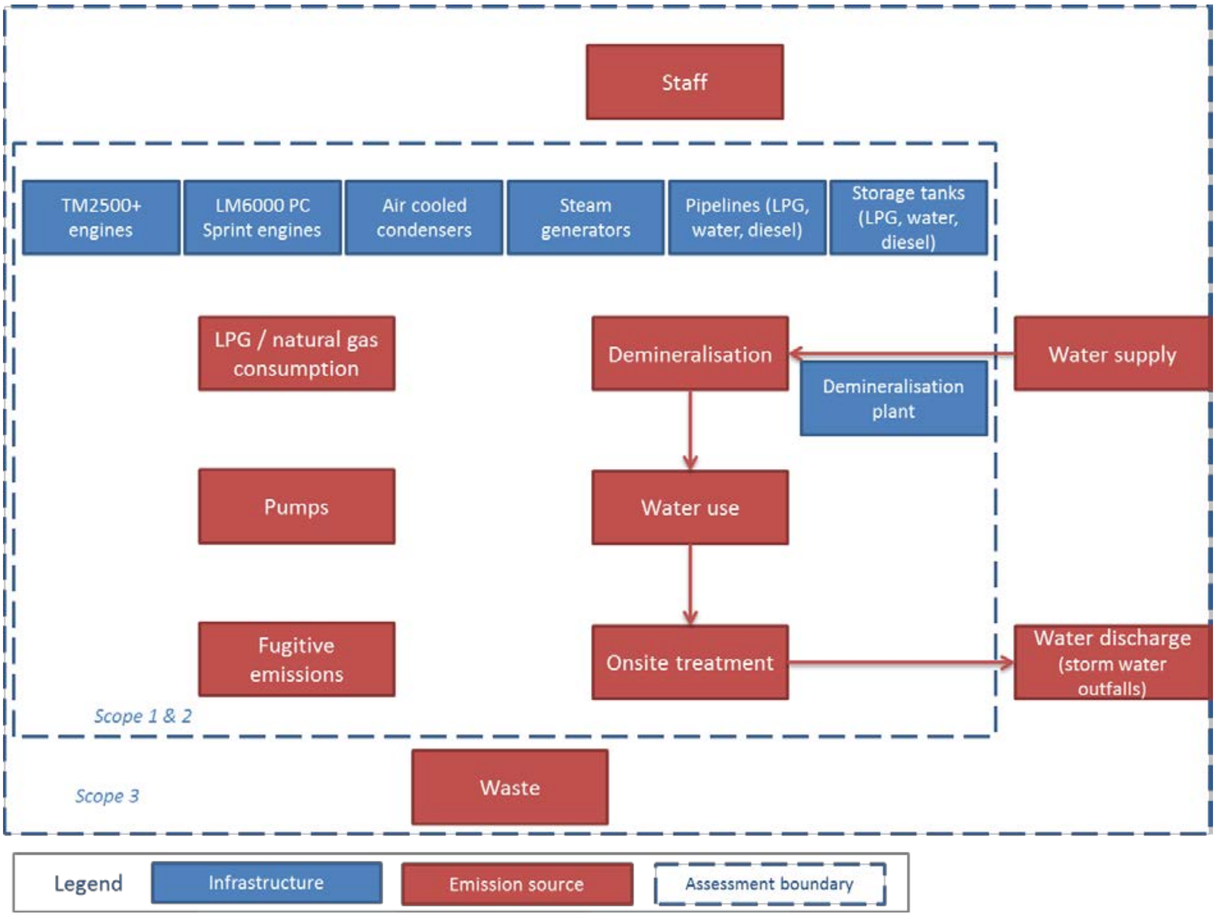

Figure 18-1 details the key emission sources for the operation phases including fuel consumption, water supply and treatment and fugitive emissions. A detailed breakdown of data explored is given in Section 18.5.3.

The operation phases will consist of different operating conditions that reflect the development of the power plant over two sites in three stages, and an additional scenario for operation on NG.

Table 18-1: Operating Conditions over Development Stages, including NG Scenario

Development Stage and Net Cumulative MW Output	Operational Date	Power Plant Site 1 (PPS1)	Power Plant Site 2 (PPS2)
1a (145 MW)	May 2018	5 x TM2500 in open cycle mode	-
1b (202MW)	Aug 2019	5 x TM2500 in combined cycle mode	-
2 (422MW)	May 2020	5 x TM2500 in combined cycle mode	4 x LM6000PC Sprint in combined cycle mode
2 NG (422MW)	2025	5 x TM2500 in combined cycle mode	4 x LM6000PC Sprint in combined cycle mode

- The heat recovery used on the TM2500 engines from Stage 1B in combined cycle will improve the efficiency from 33% to 46%[4]. This takes account of the benefits accruing from the addition of the once through steam generator (OTSG) and turbine.
- The heat recovery used on the LM6000 PC sprint engines in combined cycle will improve the efficiency from 37% to 49%[5]. This takes account of the benefits accruing from the HRSG and steam turbine.
- All auxiliary loads[6] will be met using electricity produced onsite.
- LPG is used for the first three operating conditions of the plant's operation with the aim being to replace it with natural gas within 5 years of completion of operating condition 4, if natural gas is made available to the project by the GoG. This has been modelled as operating condition 2 NG.
- Water supply is drawn from a connection to the GWC municipal reticulation network. Water is demineralised prior to use and demineralised water is stored onsite. Waste water is treated onsite in dedicated wastewater treatment plants. The resulting effluent is either re-used within the project or discharged to the storm water outfalls. Sanitary waste is collected in a septic tank (sewage treatment) before being pumped out and disposed of offsite by licenced contractor.

The assessment also does not consider the emissions associated with the exploration, preparation and transportation of the gas required for the plant, as these are not in direct control of the project. Emissions associated with exploration, preparation and transportation of fuel supplied to the plant, also known as 'well to tank' emissions, are deemed outside the assessment boundary.

18.4.3 Emission Factors Applied

The carbon emission factors used are from the IFC's Carbon Emissions Estimator tool.

18.4.4 Source Categories within the Systems Boundaries

The methodology applied has considered all significant sources of greenhouse gas emissions, summarised below.

- Operational fuel use including fuel input (LPG or natural gas, plus the use of diesel if the LPG supply is interrupted);
- Electricity consumption associated with the operation of fans, pumps, lighting and distribution panels, and air/oil separators;
- Transportation of fuel: pumps along pipeline;
- Waste disposal: flue deposits/scrubbing transportation and disposal);

[4] Data from Stage 1 EPC contractor guarantees.
[5] 4x LM6000 PC SPRINT (UDef - GE Match) 90p10b CCGT 2p HRSG STPFmatch STEffmatch (4750rpm) 129 mbara (PEACE match)
[6] These include fans, lighting and distribution panels, pumps (including for LPG pipeline) and air/oil separators

- On-site water use: water supply; wastewater treatment;
- Operation staff: commuting; and,
- Fugitive emissions: various e.g. refrigeration, process emissions.

18.5 Assessment Results

18.5.1 Absolute Emissions during Operation

The total direct carbon emissions arising from the plant depend on the amount of gas combusted, the combustion conditions and the specification of the gas, as well as the amount of fugitive emissions. Based on assumptions relating to the fuel composition, plant characteristics and gas leakage rates, the direct combustion emissions from the plant have been estimated as follows.

Table 18-2: Direct Annual Carbon Emissions

Operating condition	LGP			NG
	St. 1a (TMs OCGT)	St. 1b (TMs CCGT)	St. 2 (TMs CCGT; LMs CCGT)	St. 2 (TMs CCGT; LMs CCGT)
Direct annual carbon emissions ($tCO2_e$)	861,768	861,768	1,732,862	1,558,548
Direct carbon intensity (tCO_2e/MWh)	0.70	0.50	0.48	0.44

OCGT – Open cycle gas turbine
CCGT – Combined cycle gas turbine

If on-site electricity consumption (used for operational loads such as pumps and fans) and water consumption are included, then the total emissions increase slightly.

Table 18-3: Total Annual Carbon Emissions

Operating condition	LGP			NG
	St. 1a (TMs OCGT)	St. 1b (TMs CCGT)	St. 2 (TMs CCGT; LMs CCGT)	St. 2 NG (TMs CCGT; LMs CCGT)
Total annual carbon emissions ($tCO2_e$)	865,096	865,103	1,741,756	1,566,510
Total carbon intensity (tCO_2e/MWh)	0.70	0.50	0.49	0.44

18.5.2 Plant Performance

The IFC Thermal Power Guidelines (2008) present the typical carbon intensities of a range of types of plant and fuels. This allows direct comparison of the proposed plant with the standard for that type of plant (Table 18-4).

Table 18-4: Comparison with Performance Guidelines[7]

	Efficiency (% Net, LHV)	CO_2 (gCO_2/kWh)
EHS Guidelines values for CCGT plants (gas)*	54 - 58	348 - 374
EHS Guidelines values for Simple Cycle GT (gas)	36 - 40	505 - 561
Ghana Bridge power plants (LPG)	33.4 – 49.1	701 (Stage 1a) 503 (Stage 1b) 487 (Stage 2)
Ghana Bridge power plants (gas)	35 - 50	438

Notes: * EHS Guideline values reflect heavy duty gas turbines. However, the EPL project is using aero derivative engines to allow use of LPG, which contributes to lower than typical efficiencies combined cycle operation.

Power will be generated from Ghana Bridge power plant through a combination of simple open cycle and CCGT Gas Turbines. As would be expected, the results show that the proposed plant would perform above the typical efficiency range for simple cycle GT, but below typical efficiencies for CCGT mode. This is due to a combination of the use of aero-derivative engines (to allow operation on LPG) and the operating climate i.e. tropical location with very hot design conditions, rather than ISO conditions of cooler climates.

The EHS guidelines also allow for a comparison of the emissions performance of the proposed plant with the existing average emissions for the grid as a whole and the typical emissions performance of other specific thermal power generation methods (Table 18-5).

Table 18-5: Comparison of Typical Direct Emissions for Alternative Thermal Power Plants[8]

Source	Efficiency (% Net, LHV)	gCO_2/kWh	$mtCO_2$/yr
Ghana Bridge power plant: Development phase 1a (TMs OCGT) on LPG	33.4	701	0.87*
Ghana Bridge power plant: Development phase 1b (TMs CCGT) on LPG	45.8	503	0.87
Ghana Bridge power plant: Development phase 2 (LMs CCGT) on LPG	49.1	487	1.74
Ghana Bridge power plant: Development phase 2 (LMs CCGT) on gas	50.6	438	1.57
2015 grid electricity emission factor in Ghana	n/a	505[9]	

[7] World Bank Group Environmental, Health, and Safety Guidelines for Thermal Power Plants (2008)
[8] World Bank Group Environmental, Health, and Safety Guidelines for Thermal Power Plants (2008)

Source	Efficiency (% Net, LHV)	gCO_2/kWh	$mtCO_2$/yr
for all plants apart from wind and solar **			
Typical gas plant (CCGT)	54 – 58	348 - 374	4.2**
Typical oil plant (reciprocating engine)	40 – 45	449 - 505	5.5
Typical coal plant (IGCC)	46	760	8.7
Typical coal plant (Supercritical)	40	851	9.8

Notes:
* This is based on the proposed total capacity of 424MW
** Based on the IFC Emission Factors for gas power plants in Ghana
*** Electricty Company of Ghana Statistics (http://energycom.gov.gh/files/Energy%20Statistics_2015Final_1.pdf)

The above comparison shows that the proposed power plant results in higher emissions of CO_2 compared to a typical CCGT plant but lower emissions in comparison with other generating methods as a result of using a lower carbon intensity fuel. Emissions per unit energy produced from this plant in development phase 2 (TMs and LMs operating in combined cycle mode) using LPG will be broadly similar to the 2015 Ghanaian grid value provided by EPC. Following the change to natural gas, the EPL project emissions will decrease by approximately 10%.

18.5.3 Data Gap Analysis

As the project is still in the early stages of development, much of the data required to undertake a detailed carbon assessment is not yet available. Table 18-6 detail the data availability for the operation phase.

Table 18-6: Data Gap Analysis for Operation Phase

Operation	Emission Sources	Input Data Required	Data available
Power Plant			
Fuel in	Consumption of natural gas and LPG	Fuel flow (kW)	Yes
	Electricity consumption	Annual consumption (kWh)	Data available for auxiliary loads on engines No data on electricity consumption of the air-cooled condensers or the transformers
Transportation of fuel	Pumps for pipelines	Fuel type and quantity	Assumed to be electricity and included in the above
Compressed air system	Electricity consumption	Annual consumption (kWh)	No

[9] IFC carbon emissions estimator tool

Operation	Emission Sources	Input Data Required	Data available
Power evacuation	Electricity consumption	Annual consumption (kWh) of the step up transformers	No
Waste disposal (flue deposits/scrubbing system)	Material disposal	Material type/s and quantities End treatment e.g. landfill, recycling	No
	Transportation to disposal	Distance to treatment facility Mode of transport to treatment facility	No
On-site water use	Water supply	Quantity (litres/m^3)	Data available for water consumption by engines
	Transportation of water: pumps for pipeline	Fuel type and quantity	Assumed to be electricity and included in the above
	Wastewater treatment	Quantity (litres/m^3)	Amount assumed to be equivalent to the amount supplied
Operations staff	Commuting	Passenger km (total for all staff); mode of transport	No
Fugitive emissions	Various e.g. refrigeration, process emissions	Type and quantity	Leakage rate data available for SF6 used in from the hybrid switchgear
Gas Receiving Station and Pipelines			
Pump operation	Pumps	Fuel type (electricity, diesel) and quantity(annual consumption)	No
Water Demineralisation Plant			
Pump operation	Pumps	Fuel type (electricity, diesel) and quantity(annual consumption)	No
Operational fuel	Electricity consumption	Annual Consumption (kWh)	No
LPG Tank Farm and Pipeline			
Pump Operation	Pumps	Fuel type (electricity, diesel) and quantity(annual consumption)	No

18.6 Mitigation

It is recommended that, where practicable, the EPL evaluate technically and financially feasible and cost-effective mitigation options to reduce or offset project-related GHG emissions during operation of the project. Potential mitigation options are discussed in the following sections.

18.6.1 CCGT plant

In Stage 1b and Stage 2 two, the proposed plant will use CCGT technology. The fuel efficiency will therefore be improved through the use of heat recovery units that take the waste heat from the process and produce further energy via a steam turbine. When these gas turbines are operating in CCGT mode on LPG, net efficiencies of between 45.8% and 49.1% will be achieved.

Emissions per unit energy produced from the plant in Stage 2 will be broadly similar to the 2015 Ghanaian grid average for non-wind or solar power plants when using LPG and will reduce by approximately 10% when using natural gas. Energy produced by the plant will serve to reduce the grid average emission factor in the longer term.

Emissions of CO_2 are inevitable from thermal generation, but even slight modifications to the fuel specification can have material impacts on the overall rate of emissions from the plant. Until NG is available, the plant will be run using LPG. This fuel has a higher carbon emission factor than NG, which will be used for the remainder of the plant's operational lifetime. Emissions from the plant could potentially be reduced further by improving on the specification of the fuel to maximise the energy content, thereby reducing the amount of fuel required to generate electricity from the plant. Options for doing this are, however, limited.

It is recommended that emissions monitoring is undertaken for example, recording and estimating emissions based on the fuel specification (as it is combusted) and the amount combusted. This will help establish trends in the quality of the fuel being used and the efficiency of the combustion process.

18.6.2 Other Mitigation Options

Other mitigation options during the operational phase of the project may include:

Area	Mitigation options
Pumps & motors	• High efficiency motors • Variable speed drives or multi speed motors (depending on circumstances) • Motor load sensing for start/stop control
Lighting	• High efficiency lights (e.g. LEDs) • Motion and photo sensors • Use as much natural light as possible
Fugitive emission	• Periodic directed inspection and maintenance surveys using specialised equipment to detect and quantify leak • Prompt repair of any leakages
Waste	• Encourage reduction of waste through prevention and re-use • Recycle before considering other disposal routes
Water	• Encourage reduction in water use by staff • Fix water leaks promptly • Treat blow-down water for reuse

18.7 Reduction and Management of GHG Emissions

Some actions that could be considered to reduce and manage GHG emissions are as follows:

- Demand side measures to reduce need for new generation:

  Typically, a country's electricity sector is structured such that increased consumer demand is satisfied through the construction of new power plants or expansion of existing plant rather than through measures to reduce consumer demand. In some jurisdictions, for example California, power utilities are required to demonstrate that they have implemented comprehensive energy efficiency programmes with customers before they are permitted to develop new power plants.

  Encouraging large-scale energy conservation is a key strategy in the Ghana National Climate Change Adaptation Strategy[10]. However, in 2008, about 54% of households in Ghana had access to electricity, with rural access at only 24.9%, compared to 81% for urban households. As such, the main focus of Ghana's generation policy is likely to remain on increasing generation capacity for some time and therefore this option is not considered practical at this time.

- Make Provision for Potential Carbon Capture and Sequestration (CCS):

  Considerable effort is being made around the world to develop CCS schemes. Of the 13 operational projects in the world, only one demonstration project in the power generation sector (Canada) uses post combustion capture technology. In Africa, one CCS plant in Algeria uses pre-combustion capture as part of a gas processing facility. Nine plants are currently being built and 32 plants are planned in a number of countries, almost all of which are expected to receive explicit public subsidies. Given the current status of CCS in the power generation sector, the technology is not considered suitable for this project.

- Carbon Credits / Offsets:

  In a number of developed countries, large GHG emitters are participants in emissions trading schemes, under which they need to reduce GHG emissions to prescribed levels or face a penalty. Such participants can reduce emissions either directly (for instance, through biomass co-firing) or can purchase 'carbon credits' in the form of allowances from other scheme participants or emission reductions from projects in other countries. Participants in emissions trading schemes have clear market incentives to reduce their emissions as the penalty for non-compliance is typically much higher than costs of abatement or purchasing carbon credits.

  Ghana has signed up to the Paris Agreement and submitted its intended nationally determined contribution. Ghana has set a goal of reducing its business as usual emissions by 15% by 2030. It has recognised the need to improve the energy efficiency of its power plants and outlined that it expects the international carbon market to

[10] http://www.undp-alm.org/sites/default/files/downloads/ghana_national_climate_change_adaptation_strategy_nccas.pdf

contribute 16% of its total investment in climate change measures. It is recommended that the project keeps abreast of these developments and considers the potential for purchasing carbon credits if required.

Given the location and nature of the project, it is recommended that the project:

- Monitor, Calculate and Disclose GHG Emissions Annually

  For projects that are expected to produce more than 25,000 tonnes of CO_2e annually, the project is required to quantify direct emissions from the facilities owned or controlled within the physical boundary as well as indirect emissions associated with the offsite production of electricity used by the project. The project will quantify and disclose these carbon emissions annually in annual reports, as part of the project's commitment to meeting the requirements of IFC PS3.

- Develop GHG Targets for Environmental Management System:

  IFC PS1 requires the establishment of effective environmental and social management systems and PS3 requires the reduction of project GHG emissions. It is recommended that (a) the project's environmental management system include a target of reducing GHG emissions on an absolute and intensity basis; and, (b) GHG emissions be determined on an annual basis using the methodology described within IFC PS 3.

- Consider the possibility of utilising excess any excess heat:

  The project could investigate the potential for development of a District Heating scheme. As with all power plants, it is anticipated that there will be periods of time the plant will not be required to operate at full output and excess heat may become available. A District Heating scheme would be able to export any excess heat for the supply of space heating or district heating / water to any industrial/commercial/residential developments in close proximity. Additionally, where there is a demand for cooling, absorption chillers could be employed to generate a supply of cooling water. This could be used to pre cool combustion air or provide industrial or space cooling to businesses in the local area. However, this will be very much dependent upon local demand.

18.8 Cumulative Impacts

Details of surrounding land use and industries are provided in Section 1.2.2 and the surrounding industries are shown on Figures 1-3a and 1-3b in Section 1.

There are a number of existing power plants located within the Tema area including several within the VRA TTPC (see Table 1-1 in Section 1). There is also one other identified IPP project under construction and a new 450 MW Karpower HFO ship is understood to be replacing the existing 225 MW ship within Tema Harbour later in 2017, although this is not certain at this stage. . All of these projects will contribute GHG emissions. The close proximity of the plants within the Tema area offers opportunities for collaboration with potentially significant benefits to be achieved by the adoption emissions reduction measures cited above.

18.9 Conclusion

The assessment has quantified the emissions associated with operation of the EPL Ghana Bridge power plant. The direct combustion emissions from the plant relating to fuel consumption have been estimated at 1.74 million tCO_2e per year for the finalised development (Stage 2) when the TM2500+ and LM6000 units will operate in CCGT mode using LPG.

Once the plant is able to utilise natural gas, the direct combustion emissions will reduce to 1.56 million tCO_2e per year. Carbon intensity improves from 0.66 tCO_2e/MWh in the initial project phase to 0.42 tCO_2e/MWh when complete.

The power plant does not achieve the 54-58% efficiency guidelines cited for CCGT power plants within the IFC EHS Guidelines for Thermal Power Plants. However, this is because the project is using aero-derivative turbines (to allow operation on LPG) which have lower efficiency in CCGT mode, and also because the guidelines reflect ISO conditions in cooler climes and are not achievable in the equatorial climate within which the project is located i.e. an African location with very hot and humid design conditions.

The EPL Ghana Bridge power plant, in its final operating condition with natural gas will produce electricity at a carbon intensity broadly in line with the 2015 emissions factor data for Ghana (for non-solar or wind projects).

There are several ways to mitigate the GHG impacts of the new plant. It is recommended that measures are ‘built in’ to the design of the plant such as the use of low carbon materials and options to use excess heat. During the operational phase, GHG Targets for the Environmental Management System should include the recording of emission levels and identification of measures that can be taken to reduce them. Use of excess heat from the plant (and potentially other plants within TTPC) by surrounding industries should also be considered.

While the plant will increase the overall burden of emissions in Ghana, significant additional reliable power development will be required for many years to satisfy the increasing demand for electricity and further improve the quality of life and economic growth of the country. The use of CCGT technology allows the plant to provide a significant contribution to the base load electricity provision with a better than average emissions intensity.

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Section 19 –Traffic and Transport

EARLY POWER LIMITED

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Revision History

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	19.4.1	Update to values used in the description of construction vehicles and also tables 19-3, 19-4 & 19-5.	
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	Section No.	***Change***	
	19.4.1	Updates to reflect the revised site configuration and access routes. Inclusion of discussion of potential alternative access route.	
	Wherever relevant	Updates to reflect likely 36 month as opposed to previous 24 month construction schedule.	

Contents

Figures and Tables

19 Traffic and Transport

19.1 Introduction

This section evaluates the effects of the project on traffic and transportation. It identifies the potential effects of increased road and shipping traffic predicted during the construction and operation of the project. The significance of these effects is then assessed against recognised guidelines and cumulative impacts in association with other development projects considered. Where required, appropriate mitigation measures are recommended.

19.2 Traffic Assessment Guidelines and Local Governance

19.2.1 Assessment Criteria

The Institute of Environmental Management and Assessment (IEMA) 'Guidelines for the Environmental Assessment of Road Traffic' (Ref. 19-1) suggests that two broad principles be used as a screening process to focus the scale and extent of the assessment. These are:

- "include highway links where traffic flows will increase by more than 30% (or the number of heavy goods vehicles will increase by more than 30%); and,
- "Include any other specifically sensitive areas where traffic flows will increase by 10% or more."

Criteria for assessing the significance of the increases in traffic volumes as a result of the project are categorised in Table 19-1.

Table 19-1: Significance of Effects in Relation to Traffic Flow Increase

Magnitude	Increase in Traffic Flow
Major	Above 90%
Moderate	Between 60% and 90%
Minor	Between 30% and 60%
Negligible	Less than 30%

Where existing traffic levels are exceptionally low, any increase in traffic flow is likely to result in a predicted increase in traffic levels which exceeds these thresholds. Where this situation is identified it is important to consider any increase both in terms of its relative increase in respect of existing traffic flows, as well as the overall total flow in respect of the available capacity of the section of road being considered.

For example a 100% increase in traffic flow on a road which currently only carries 90 vehicles per day would potentially indicate a major significance effect, if it were considered simply, in terms of the IEMA guidelines, as detailed in Table 19-1. In reality, 90 additional vehicles spread throughout a day may be considered to be a fairly low impact.

In addition, a typical 6m wide road in the UK is capable of accommodating approximately 36,000 two-way vehicles per day, in accordance with notional capacities derived from guidance within the Design Manual for Roads & Bridges (DMRB) Volume 5, Section 1, Part 3 TA 79/99 'Traffic Capacity of Urban Roads'. (Ref.19-2). Therefore, such an increase would be unlikely to create major effects given the road's overall capacity. Table 19-2 refers to the link capacity relevant to the road network to be used for traffic generation of the project.

Table 19-2: Road Link Capacities

Road Type*	Road Type Description	Two-way Daily Flow (vehicles)
UAP 1	High standard single / dual carriageway road carrying predominantly through traffic with limited access.	48,960 (single carriageway) 172,800 (dual carriageway)
UAP 2	Good standard single/dual carriageway road with frontage access and more than two side roads per km.	48,960 (single carriageway) 172,800 (dual carriageway)
UAP 3	Variable standard road carrying mixed traffic with frontage access, side roads, bus stops and at-grade pedestrian crossings.	43,200
UAP 4	Busy high street carrying predominantly local traffic with frontage activity including loading and unloading.	36,000

* UAP – (Urban All Purpose)

A similar approach has been used for assessment of ship movements.

19.2.2 Local Governance

The Ghana Ministry of Roads and Highways is responsible for policy formulation, coordination and oversight, performance monitoring and evaluation of the sector in the following broad areas:

- Road Infrastructure Development and Maintenance; and,
- Road Maintenance Financing.

These functions are performed by the Road Infrastructure and Support Agencies as follows:

- Ghana Highway Authority is charged with the responsibility for the administration, planning, control, development and maintenance of trunk roads, ferries and related facilities in the country;
- Department of Feeder Roads (DFR) is charged with the responsibility for the administration, planning, control, development and maintenance of feeder roads and related facilities in the country; and,
- Department of Urban Roads (DUR) is charged with the responsibility for the administration, planning, control, development and maintenance of urban roads and related facilities in the country.

These authorities will also need to be satisfied that appropriate traffic management measures are in place.

19.3 Assessment Methodology

The road traffic impact of the project was assessed utilising the following approach:

- The road sections likely to be affected by the traffic associated with the project have been identified;

- The existing character of the road network has been determined;
- Existing traffic levels on the road network have been determined;
- The additional traffic generated by all phases of the project has been estimated; and,
- The effect of the additional traffic was assessed using the IEMA significance criteria.

The baseline data for road traffic used in the assessment is reported in Section 7.9.3.

The assessment of the impact from shipping associated with the project has been done on a qualitative basis.

An appropriate mitigation strategy was prepared to ensure that any potential traffic effects are kept to a minimum.

19.4 Impacts Assessment

19.4.1 Construction

Construction Vehicle Types, Numbers and Distribution on Road Network

During the 34-month construction phase, personnel will travel to and from the project by private car, light vehicles or minibus. Management staff are predicted to use private cars with general staff proposed to be transported to site by bus. In addition to these vehicles, the following Heavy Goods Vehicles (HGVs) will require access to the application site:

- HGVs delivering items such as aggregate and steel work;
- Low Loaders delivering steel work, pre-cast pile foundations, boiler components and turbine components;
- Road Tankers delivering items such as fuel and chemicals; and
- Ready mixed cement vehicles.

The traffic impact of the additional vehicles associated with the construction of the project can be categorised as:

- additional traffic volumes associated with the construction activities for the project travelling on the existing road network; and
- delays to non-development related journeys as a result of slow moving vehicles i.e. HGVs.

In order to assess a robust worst case scenario related to construction traffic, this assessment has considered all construction phases being undertaken simultaneously over a period of 24 months, in line with the previous iterations of this ESIA. This is the maximum length of each individual phase, rather than the 34 months currently proposed due to the staggering of the schedule, with PPS2 construction commencing in month 11 of the programme.

Maintaining the worst case assumption based on the previous schedule results in a higher level of daily traffic and a therefore a more conservative assessment.. Table 19-3 provides a summary of the traffic that will be generated throughout the course of a worst case 24-month construction programme.

As outlined in Table 19-3, the total number of offsite vehicle movements generated during the construction of the project is estimated to be 58,071 over the construction period. This figure includes 28,772 HGV movements and 29,298 car / light vehicle movements (referred to as Light Goods Vehicles (LGV)). This equates to an average of 39 HGV movements per day and an average of 39 LGV movements per day on the basis of a 24 month programme.

It is important to note that with the construction programme being a maximum of 34 months long, the increase in traffic associated with the construction activities will be a relatively short term, temporary impact.

Table 19-4 details the distribution of all project construction traffic passing each baseline traffic counter and the total traffic percentage increase during the busiest month of construction in order to highlight the worst case scenario. The same information for HGV traffic only is provided in Table 19-5. During the busiest month the project is predicted to generate an average of 40 HGV movements per day and an average of 43 LGV movements per day.

Table 19-3: Predicted Daily Vehicle Movements (Based on worst case 24 Month Schedule)

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	19	15	16	17	18	19	20	21	22	23	24
Monthly Vehicle Trips	2372	2383	2525	2534	2572	2549	2529	2524	2524	2534	2500	2483	2421	2317	2290	2327	2316	2395	2426	2395	2337	2286	2267	2267
No. of Days*	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
Average Total per Day	77	77	81	82	83	82	82	81	81	82	81	80	78	75	74	75	75	77	78	77	75	74	73	73
Average HGV Total per Day	39	40	40	40	40	39	39	39	39	39	39	39	39	38	38	38	38	38	38	38	38	38	38	38
Average LGV Total per Day	37	37	42	42	43	43	43	43	43	43	42	41	39	37	36	37	37	39	40	39	38	36	36	36

Table 19-4: Percentage Increase on Identified Links Due to All Vehicle Movements during Construction Phase

ATC Counter Location	Construction Traffic Passing this Link	% Increase in Total Vehicles During Worst Case Month 5
Harbour Rd between Tema Port and Harbour Rbt	All	0.3%
Harbour Rd between Harbour Rbt and Community Four Rbt	All	0.3%
Valco Road	All	0.8%
Access Road to Power Plant Site 1 (PPS1), Power Plant Site 2 (PPS2) and Tank Farm	All	6.7%

Table 19-5: Percentage Increase on Identified Links Due to HGV Movements during Construction Phase

ATC Counter Location	Construction Traffic Passing this Link	% Increase in HGVs During Worst Case Month 5
Harbour Rd between Tema Port and Harbour Rbt	All	1.2%
Harbour Rd between Harbour Rbt and Community Four Rbt	All	1.4%
Valco Road	All	2.3%
Access Road to Power Plant Site 1 (PPS1), Power Plant Site 2 (PPS2) and Tank Farm	All	17.7%

In terms of total traffic numbers, the construction of the project will have a negligible impact upon all assessed counter locations with the greatest predicted increase being 6.7% on the Access Road to the project Site.

With regards to HGV movements, the largest predicted percentage increase of 17.7% at the Site Access Road counter location represents a negligible impact on the road network in accordance with the criteria detailed in Table 19-1.

Moreover, the effects of construction traffic will occur over a relatively short period, therefore reducing the overall impact, and the existing road infrastructure is operating within capacity. Consequently, no significant environmental effects are predicted to arise from construction traffic generated by the project.

Severance

Severance is the perceived division that can occur within a community when it is separated by a major traffic route. Given that the minor impact due to an increase in HGVs occurs on an industrial access road it is predicted that the project will not result in severance impacts.

Driver Delay

Delays to drivers are generally caused at junctions and are only likely to be significant when traffic on the network is close to capacity. Based on the traffic count surveys on the local road network and the predicted increases detailed in Table 19-4, it is not anticipated that any of the key junctions around the site will experience significant additional delay due to construction traffic associated with the project and the effect will therefore be negligible.

Pedestrian Delay and Amenity

Pedestrian delay is closely related to traffic flow along a link and the increases in traffic flow as a result of the development are unlikely to result in any significant change to pedestrian delay.

Pedestrian amenity can be broadly defined as the relative pleasantness of a journey and could be affected by traffic flow, traffic composition, and separation from traffic. The minor increase in traffic flow from construction staff travel to and from the site is unlikely to result in any notable change to pedestrian amenity. Whilst it is acknowledged than there will be additional HGV trips associated with the construction phase, this is likely to be no more than 4 HGVs per hour over a 12-hour day and is therefore also not likely to have a significant impact on pedestrian amenity.

Overall the effect of the construction phase of the project on pedestrian delay and amenity is likely to be negligible.

Dust and Dirt

The effect of dust and dirt impacting on the local area and highway network is likely to be most keenly felt during the construction period. During this time, good management practices would be implemented, including wheel washing facilities for all departing vehicles and sheeting of HGVs carrying loads likely to shed debris. Such procedures should minimise the transfer of dust and dirt on to roads surrounding the site and any significant impacts arising. Further assessment of dust and dirt is included within the Air Quality Section 11.

Hazardous Loads

It is acknowledged that there may be hazardous loads associated with the construction of the project. In order to mitigate any potential adverse effects, the contractor will be obliged to submit plans for the safe transport of these loads to the relevant authorities i.e. DUR.

Shipping Traffic

There will be a negligible increase in marine vessel movements during the construction phase, with one shipment every 2 to 4 weeks required during mobilization and civil works to transport materials and equipment.

The current facilities at Tema Port handle all types of cargo including containerized cargo, dry and liquid bulk, iron/steel, machinery/equipment, palletized items and vehicles. The significant capacity of the national scale Tema port is sufficient to meet the project's requirements.

Potential Alternative Route to Site via Kpone Road

There is an alternative route that will potentially be used for traffic routing from Tema Port to site. This route is approximately 21km and involves routing further north on Harbour Road, along the Accra to Afloa Road and then south on Kpone Road then routing to site on minor roads. Traffic flow data was not available for the majority of the alternative route and therefore traffic increases cannot be quantified on each section of the route. The characteristics of the majority of the main roads on the alternative route are similar to those assessed above and therefore the same conclusions on the impact are applicable.

The characteristics of the minor roads on the alternative route are similar to the Access Road to site assessed above in Tables 19-4 and 19-5 and again it is predicted that the impact of the additional traffic on the alternative route minor roads will be comparable to those on the route via Valco Road.

Summary of Construction Traffic Impacts

The overall increase in road traffic arising from the project construction is assessed as negligible, although the increase in HGVs is considered to be minor. As the increases occur over a short term period of a maximum of 34 months and usage of the existing roads is relatively low, these increases are not considered significant.

Severance of communities, driver delays, pedestrian delays/amenity are not considered to be issues of concern as impacts are negligible. Any hazardous loads will be managed in conjunction with local transport authorities.

The increase in shipping traffic is also considered to be negligible.

19.4.2 Operation

Road Traffic

It is anticipated that the operational project will employ a total of 30-35 staff who will work on a shift pattern basis. The anticipated shift patterns and split of employees is as follows:

- Shift 1 – 14 employees – 0700-1600 hours.
- Shift 2 – 14 employees – 1500-0000 hours.
- Shift 3 – 7 employees – 2300-0800 hours.

Employees at the site are likely to be resident in the neighbouring settlements of Tema, Tema New Town and Kpone.

In addition to staff travelling to the site, there will be an occasional delivery from Tema Port. However, this is expected to constitute no more than 1 or 2 vehicles per day.

These levels of additional trip generation will be significantly lower than during the construction phase and therefore will be of negligible impact.

Shipping

There will be a negligible increase in marine vessel movements in the Tema port area during the operation phase, with three shipments per month for import of LPG.

19.4.3 Cumulative Impacts

During construction there is potential for cumulative impacts to occur with other proposed developments within the vicinity of the project. Depending on the confirmation of construction timescales for this project and proposed projects, a combined traffic management plan should be considered to ensure that there are no significant impacts on the local community and local road users.

Due to the low numbers of deliveries by ship, it is not anticipated that there would be any significant cumulative effects.

19.5 Management and Mitigation

It is recommended that the contractor liaise with the Ghana Highway Authority, the DFR and the DUR prior to start of construction.

Construction

The construction workforce will peak at approximately 200 workers per day during the construction period. There will not be any formal worker accommodation for the construction workforce as workers are expected to come primarily from the surrounding communities given the number of other power plant and fuel supply projects that have been constructed in the area. It is currently not known where the workers will reside, however, it is expected that buses will be provided to transport workers to and from the construction site.

Through the implementation of a traffic management plan for the site, HGV traffic movements will be managed and spread evenly over the working day to minimise on-site and off-site congestion.

Highway condition surveys and tracking analysis of abnormal loads at pinch points will also be undertaken if necessary. However initial views based on desktop analysis are that no issues will arise that cannot be mitigated accordingly.

To ensure timely supply of materials at construction, planning and scheduling of ship arrivals will take place in partnership with operators of Tema Port.

Operation

As outlined above, the operational site will employ only a small number of staff in comparison to the construction phase. Therefore, no operational mitigation is proposed.

To ensure timely supply of LPG during operation, planning and scheduling of ship arrivals will take place in partnership with operators of Tema Port.

19.6 Conclusion

Road and shipping traffic impacts from the project are expected to be negligible during both construction and operation. The construction impacts will be temporary and the road network has sufficient capacity to accommodate the marginal increase in daily traffic movements. It is important to note that this conservative assessment has shown that traffic increases are negligible even if the proposed construction phases are to be undertaken simultaneously over a 24-month period. In reality the levels of construction traffic on the roads each day will be lower than considered within this assessment due to the construction phases being staggered such that the phases will be completed over a slightly longer, 34-month programme. During operation traffic movements will be minimal, associated mainly with staff travel. Marine movements will also be negligible in the context of the operating Tema port.

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Section 20 – Socio-Economic Assessment

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration		Rev No
Sep 2015	First issue		0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency		1
June 2016	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating the following changes:		2
	Section No.	***Change***	
	Wherever relevant	Reference to "power plant site" changed to reflect revised plan involving two power plant sites (PPS1 and PPS2).	
	Wherever relevant	Corrections to spelling, grammar and other changes for consistency. Abbreviated terms provided in full at first usage.	
	20.1	Refers to June 2016 update.	
	20.3	Names of additional consulted stakeholders added, along with mention of concerns on cumulative impacts	
	20.4	Details added of consultations with potential Project Affected Parties in the project right-of-way as well as farmers cultivating PPS2.	
	20.5.1.1	Addition of Resettlement Action Plan (RAP).	
	20.5.2.1	Additional information on affected parties and intention to provide a RAP.	
	20.5.2.2	Additional information on affected parties and intention to provide a RAP.	
	20.5.2.4	Additional information on affected parties and intention to provide a RAP.	
	20.5.2.5	Addition of abandoned kiosk.	
	20.5.2.6	Intention to provide a RAP. Confirmation of existing farming activity to be addressed in LRP/RAP.	
	20.5.3.1	Update of project construction schedule. Bullet list at end of section limited to potential negative impacts since potential positive impacts are described earlier in the section.	
	20.5.3.3	Headings added to highlight section split between beneficial and negative impacts.	
	20.5.3.4	Measures to develop local community discrimination awareness programme and for Project Sponsor to consider moved into this section on Employment Impacts.	
	20.5.4.2	Assessment of impact to Community Health and Safety changed from moderate to major.	
	20.5.4.3	Measure to develop local community discrimination awareness programme and for Project Sponsor to consider deleted from this section on Community Health and Safety. Assessment of residual significance of impact to Community Health and Safety changed from minor to minor/moderate.	
	20.8	Addition of Abbreviated Resettlement Action Plan (ARAP).	

August 2017	ESIA amendment issued to Ghana Environment Protection Agency, incorporating details of further project design changes, including:		3
	Section No.	***Change***	
	Wherever relevant	Details of revised power plant site locations and modifications to the pipeline alignment.	
	20.2	Updates to reflect the outcomes of the June 2017 focus group representatives meeting	
	20.3	Updates to reflect additional May and June 2017	
	20.5	Updates to the impact assessment to reflect the impacts of the new Stage 2 site (Power Plant Site 2 - PPS2) and modified pipeline alignments	
	20.6	Updated to mitigation to reflect updated assessment findings	

Contents

20 Socio-economic Assessment

20.1 Introduction

The objective of the assessment conducted here is to determine the potential impacts of the project on social and economic factors that influence the socio-economic well-being of the communities where the project is proposed.

In order to measure the influence of the project on these factors, socio-economic baseline data was collected to establish existing characteristics of the community. The baseline data is presented in Section 8 of this report. The information is based upon the Social Baseline Studies prepared by Associated Consultants Limited in September 2015 and updated in June 2016 along with supplementary data collected between October 2016 and July 2017.

Figures 1-4a and Figure 1-4b in Section 1 show the locations of the communities and small businesses surveyed during baseline data collection. Additional details of community engagement are presented in Section 21 Consultation Process and within the Stakeholder Engagement Plan (SEP), which will be updated following the current amendment of this Environmental and Social Impact Assessment (ESIA). The baseline data collection included focus group discussions, stakeholder engagement meetings and discussions with individual small businesses, farmers, and kiosks in the vicinity of the developments.

This section presents a discussion of the potential positive and negative effects that could result from implementation of the project, including proposed measures to mitigate any potential negative impacts. An overview of findings is outlined in Sections 20.2 to 20.4 below. The socio-economic impacts assessment, including assessment of community health and safety impacts, and recommended mitigation measures are provided in Section 20.5. The cumulative impacts assessment is provided in Section 20.6. The legislation and standards applicable to the socio-economic assessment are provided in Section 5.

Originally, the project design developed in 2015 was planned for a single power plant site and tank farm site with no existing uses. The only directly impacted uses were along the pipeline route. In 2016, the design was refined to consider two sites (Power Plant Site 1 – PPS1 – and Power Plant Site 2 – PPS2) and similar supporting infrastructure.

The current project design and subject of this ESIA amendment includes a new PPS 2, with the site previously considered for PPS2 now forming PPS1. The liquid petroleum gas (LPG) supply pipeline route has also been slightly modified. The pipeline route has been modified twice during the 2017 amendment. The modifications focus on the section of the pipeline along Valco Road, between Tema Oil Refinery and the storm drain (Watercourse 2). The modifications centred on whether the pipeline should move to the south side of Valco Road or remain on the north side.

Based upon the original 2015 project design, the project was not predicted to result in any direct impacts on the nearest residential settlements located approximately 2km or more away from the site. Based upon the 2017 updates and the selection of a new PPS2 location, the nearest residential community districts remain unaffected.

However, some residential uses have been identified in the project vicinity, which is understood to be contrary to the planning zoning in the area. These parties are considered within this socio-economic assessment and the noise impact assessment (Section 10) as appropriate. The overall approach to this assessment, including baseline data collection has been designed to be commensurate with this, and to manage expectations within the communities with regard to project activities.

20.2 Focus Groups

Although the area is largely industrial, focus groups were conducted with representatives of each of the nearest communities including Tema New Town, Kpone, and the portion of Tema Community Areas located to the West of the project site in order to assess the potential impacts to the wider community. One focus group was conducted in 2015 for each of the potentially impacted communities including representatives from the youth, women and religious groups as well as identified community leaders in the communities. A second round of meetings with the same focus group representatives were conducted in June 2017, although for this phase, the groups were combined for a single event as part of disclosure activities for the ESIA amendment. The proceedings from the 2017 focus group representatives meeting are included in Appendix G2.

In addition, one-to-one interviews and socio-economic surveys were conducted with a selection of attendees from the focus groups from 2016 and 2017, as described below in sections 20.3 and 20.4.

Information presented below highlights the feedback that was given at each of the community focus groups respectively.

20.2.1 Kpone

A focus group discussion was held on September 3, 2015 and attended by 5 key community participants including religious leaders, an Assemblyman and a youth representative. The discussion was well balanced between the participants and conducted in Ga. Representatives of Kpone district also joined the 2017 focus group representative’s meeting.

A follow-up interview was also conducted with a local female business leader to ensure that women’s perspectives were captured. Challenges raised by the community included the inconsistency of community planning in the Kpone area as there are well-designed planning schemes for some areas and in other areas no planning schemes. This has led to haphazard development in most communities and other problems in the District such as:

- Building without development permits;
- Multiple land sales;
- Acquisition of land title problem; and,
- Encroachment on right of ways and public spaces.

Accessibility to roads is also generally poor and during the rainy season when most communities are not accessible due to the unpaved nature of the roads. However, there are ongoing collaborations by the District and the road authority to upgrade and open up most of the minor roads linking the communities. This has helped linked the communities to each other and also to other districts.

20.2.1.1 Community Profile

Historically, the main socio-economic activities of this community were described as fishing and farming. However, in recent times, both farming and fishing activities are declining. This has been a result of an increase in the population of the area as well as increasing estate development and industrial activities. Fishermen generally temporarily migrate in and out of the community as part of their fishing expeditions. There is also frequent migration into the community for industrial jobs. Community participants expressed a desire to maintain community rights to land for the use of future generations the desire to participate in all forms of development in the community that would that affect their lives.

The traditional authority is the community decision-making body composed of the traditional council which includes men, women and youth. The Kpone-Katamanso District Assembly (KKD) is responsible for all development related activities that affect the area. Kpone is generally a peaceful community with little conflict. However, clans have suffered some divisions as a result of the growing population.

Employment opportunities for locals are generally very low as most of the companies only employ locals as temporary factory hands. Another major challenge the community faces is the current decline in business for most companies located within the community which reduces the likelihood of community improvement projects. Politically the community faces challenges from outside authorities over political boundaries and associated revenue. The community regularly has contact and travel between Tema, Prampram and Dorwenya.

20.2.1.2 Community Health

According to the community leaders that participated in the focus group, there has been a recent increase in health problems especially among the youth which is believed to be due to environmental pollution from the surrounding industries. It is believed that cancer rates have risen and that the life span of youth in particular has been reduced as a result. A polyclinic and a privately owned health clinic are also located within the community.

20.2.1.3 Vulnerable Groups

The vulnerable groups within the community include Persons with Disability (PWD), orphans, widows and the elderly. Programs such as the Livelihood Empowerment Program, the District Assembly Common Fund for PWDs and HIV/AIDs programs have been put in place to assist these vulnerable groups.

20.2.1.4 Ethnic Make-up

Ethnic groups living in the community include the Akans, the Ewes, the Northern people and the Ga. In terms of numbers, the Ga are the most dominant group in the area, followed by the Akans, Ewes and Northners respectively. Active community organizations include the Fish Processors Association, the Fishermen Association, the Concerned Youth Association, the Dangbe Youth Association, the Hairdressers Association and the Association for the Aged.

20.2.1.5 Gender and Education

The role of women in the community is mainly split between vegetable farming and fish processing activities, and housekeeping and childcare. Previously, education among women was minimal, but in recent years women have begun to seek the higher education.

Approximately ninety-five percent (95%) of children are enrolled in school in the community according to focus group participants. Most community members complete at least basic primary education. However, as they progress to the secondary and tertiary levels, most of them drop out of school due to financial challenges. The community contains several primary schools that are privately owned, and a senior high school. One of the main goals of the local people of Kpone is to build and own a University in the area as part of championing education among the locals.

20.2.1.6 Youth

Youth groups are very active in the Kpone-Katamanso community. Currently, there are three main recognized youth groups operating in the area. These are namely: the Ga-Dangbe Youth Association, the Kpone Youth Association and the Concerned Youth Association. These youth groups champion the concerns of the youth of the community and involve themselves in all forms of decision-making that affect the youth.

20.2.1.7 Project Perceptions

Focus groups participants suggested that the Ghana Bridge Power Project would bring employment to the inhabitants of the Kpone community and would enable the community to have access to power and electricity. Members expressed general concerns about safety measures to be put in place during the construction of the project.

20.2.2 Tema New Town (Tema Manhean)

A focus group discussion was held on September 1, 2015 and attended by 14 key community participants including community traditional leaders, women leaders and youth representatives. The discussion was lively and conducted in a combination of Ga and English. The community was described as a mix of residential and commercial/industrial uses. Representatives of Tema New town also joined the 2017 focus group representative's meeting.

20.2.2.1 Community Profile

The industrialization of the area led to in-migration and resettlement across Tema, especially around the Harbour area. The main historic occupation in the Tema New Town area was fishing and farming. However, as with Kpone, farming and fishing activities in the area have dwindled due to industrialization. The traditional council is one of the main decision-making bodies in the community and consists of representatives from the various associations like the Canoe Owners Association, people involved in the fishing industry, women and youth groups. Locals are regularly in contact with the communities of Kpone, Teshie and Nungua for football matches and festivals organized between these communities.

Community inhabitants pride themselves on how industrialized and developed the community is. Inhabitants can boast of various industries and major companies such as

Tema Oil Refinery, Ghana Ports and Harbour (Ghana's main harbour), Ghana Textiles Limited as being located in the community. However, locals do not feel that industrialisation is without a cost to the community. For example, the local surface water features are believed to have become highly polluted due to the chemicals and sewage from industrial operations in the area. Focus group participants feel that this has adversely affected fishing activities which impacts local livelihoods. Participants also discussed a perceived decline in air quality due to industry.

20.2.2.2 Community Health

Sanitation in the Tema Manhean community is considered very poor. Most of the houses are built closely together, resulting in poor ventilation and an increase in diseases. During rainy seasons, illnesses like typhoid and cholera are predominant. There is also a clinic (St. John's Clinic) and a health post located within the community.

20.2.2.3 Ethnic Make-up

Although the town of Tema Manhean belongs to the native Ga people, in recent times it has become a more integrated community dominated by the Akans, Ewes and Ga-Adangbes. There are twenty-four clan houses in the community and many community members belong to several of these clan houses. This increased diversity and intermarriage reduces internal conflicts and helps promote unity in the area.

20.2.2.4 Vulnerable Groups and Local Associations

According to focus group participants, vulnerable groups in the community are mostly made up of the aged and unemployed youth. Associations and community organisations that can be found within the community include the Akyem Association, Milllionaire groups, Peace and Love group and Ghaba. These associations constitute welfare groups, musical groups and tribal groups. It was also noted that many girls drop out of school between the age of 10-12, rendering them potentially vulnerable.

20.2.2.5 Gender and Education

In the Tema Manhean community, women engage in fish processing, petty trading and market activities. According to the community leaders in most households, women are the breadwinners and are responsible for catering to many of the needs of their families. Even though fish processing is the primary industry that women are engaged in, they are also seen to play a role when it comes to conflict resolution and the organization of communal labour.

Approximately seventy percent (70%) of children in the community are reported to attend primary school. The community contains two primary schools and a senior high school. Community members also aspire to promote higher education among the youth and to improve the image of the Tema Manhean Community.

20.2.2.6 Youth

There is youth representation within the Traditional Authority of Tema Manhean. There are also several other youth groups found within the community and youth groups typically actively participate in development projects. Thus, they their support is considered important for the success of a local project. They also mobilize other youth for clean-up exercises and educational programs.

20.2.2.7 Project Perceptions

Participants expressed an expectation of increased employment direct and indirect as one of the main positive outcomes of the project along with the expectation that the project will help bridge the gap in the country's current power outage crisis.

However, participants expressed concern about air quality emissions from the project, traffic control, benefits distribution and any necessary safety precautions required to ensure community safety. They also noted concern that project-affected persons should be duly compensated.

20.2.3 Tema Communities 4, 7 And 9

A focus group discussion was held on September 4, 2015 and attended by 6 key community participants including Assemblymen, women leaders and representatives of key community organisations. The discussion was comprehensive and conducted in English. These Tema communities are generally urbanised and considered cosmopolitan in comparison to other more rural communities in Ghana.

Land ownership within these Tema Communities can be spread out under three main divisions: Traditional Authority, the Tema Development Corporation and the Tema Municipal Assembly (TMA). Although Tema is sub-divided into several communities, the township view themselves as one unified body. Representatives of Tema Communities 4, 7 and 9 also joined the 2017 focus group representative's meeting.

20.2.3.1 Community Profile

As an industrial hub, most of the economic activities in this area are industry related. Most community members work as industrial hands at companies such as the Tema Oil Refinery (TOR), Crocodile Matchet, Aluworks, Pioneer Foods and various others. Some community women are also engaged in trading, hairdressing, fish processing and dressmaking. A significant feature of the Tema Communities is that most of the women are operating their own restaurants and food establishments.

Poverty is on the rise in Tema due to the decline of industry and its accompanied redundancy. In the last four years since the power crisis, many in the community have lost their livelihoods. Infrastructure in this community is considered relatively good as roads are paved and the provision of services including: the sewer system, availability of electricity, toilet facilities and portable water are well managed. The availability of all these essential social amenities is believed to have promoted cleanliness and good sanitation. However, some of the existing infrastructure is now deteriorating and has become hazardous.

For example, the sewage system has exceeded its fifty-year life span without any repairs and is now broken down causing choked drains and spills. Also, access to transport in the area is high accompanied by associated traffic safety and congestion issues.

There are a higher number of internal conflicts noted within the community than Tema New Town or Kpone and there are also some disputes with other communities about political boundaries. There is a huge influx of migrants from all over Ghana to this area, especially from the northern-most part of the country into the Tema Community for the purpose of economic activities. According to participants, the high cost of living in Tema and congestion can be said to have led to some minimal migration out of Tema.

20.2.3.2 Community Health

Participants described a lot of environmental pollution in Tema as a result of the constant industrial activities in the township. They also felt that community members are gradually being affected by these pollutions and industrial emissions.

In particular, participants mentioned poor drainage and the prevalence of mosquitos in the area as a result. Aside from these, the community was described as facing the normal health challenges such as malaria and a periodic outbreak of cholera. Health facilities in the community include NaBita Hospital, the Tema General Hospital and several others.

20.2.3.3 Ethnic Make-up

Tema is an ethnically diverse area consistent with more cosmopolitan communities in Ghana. In terms of numbers, the Akans have the highest number of people living in the community followed by the Ewes, Northern people and Ga respectively.

20.2.3.4 Vulnerable Groups and Local Associations

Comparatively, the sites of Tema New Town were described as having more vulnerability in comparison to the Tema Communities where the presence of vulnerable groups is considered lower. Persons with Disability (PWD), orphaned children and widows make up the vulnerable groups in the Tema area. There are also political, religious, welfare and socially oriented groups found within the community. For example, there are Resident Associations, youth clubs, women organizations and some non-governmental organizations operating in the community.

20.2.3.5 Gender and Education

Participants noted the recent increase (approximately 60 percent) in the number of women as breadwinners for their families as men are losing their jobs in recent years. However, generally the roles of women in the community were still described as geared towards performing family welfare related activities such as childcare, housekeeping and catering for their households.

The number of school-going children is described as increasing in the community due to programs such as the School Feeding Program, Free Compulsory Basic Education and the shift school system (classes are run in shifts throughout the day to maximise the use of space). Most children in Tema were described as having a primary education.

However, in terms of secondary and tertiary education, the numbers drop drastically. Nonetheless, several youth go on to train in craftsmanship and trading. The community includes Data Link University College, GIMPA, Methodist University College, the Presbyterian University College.

20.2.3.6 Project Perceptions

Generally feedback from the focus groups discussion in this area included that recent community experience with similar projects has meant that the community is cautious due to unfulfilled expectations on other projects and concerns with safety issues.

They specifically expressed concern about the security on the existing pipelines at TOR in terms of general community safety. They also discussed the perceived need for a fire station on the project site as part of project safety measures. They were also interested in job creation and emphasised the need for follow through on community engagement and community improvement projects that could result from the project.

20.3 Stakeholder Meetings

In addition to the focus groups and other discussions, consultation was also conducted with businesses located adjacent to the project and in the surrounding approximately 1km, other existing and proposed power generation projects and major industrial institutions, as well as interviews conducted with the informal businesses located along the pipeline route and on the tank farm site.

Full details of the various stakeholders consulted to date are included in Section 21 and the project SEP.

20.4 Small Businesses / Kiosks within the Proposed Project Footprint

In addition to focus groups, interviews were conducted with identified Project Affected Parties (PAPs) in the project right-of-way.

As described above, the project footprint has been altered since original conception and development of the 2015 ESIA and 2016 Amendment. The 2015 design was planned for a single site with no existing uses. The only directly impacted uses were along the pipeline route. In 2016, the design was refined to consider what was then the PPS2 site (now PPS1 (which was being farmed)

The current 2017 design includes a different PPS2 with farming, commercial, and residential uses and a portion of the gas pipeline proposed for the project is now proposed to travel along the north side of Valco road, beneath the Ghana Oil Limited (GOIL) driveway and cross to the south side of the road before the Sentuo Steel Limited driveway.

As a result of this design change and project developments in the area, some new PAPs will be affected. Although it is noted that, as described in Section 1.2.4, the design as it currently stands will avoid a significant number of the kiosks located on the south side of Valco road, opposite Sentuo Steel (see Figure 1-4b).

Stage 1

Kiosk owners identified during the 2015-2016 consultation process within the project right of way generally consisted of food and drink vendors and a lottery kiosk. All of these parties generally reported having low incomes and business generally comes from the industrial workers in the community.

Most vendors expressed concern about disruption of business and potential livelihood loss associated with the project. Some of the business owners could be considered vulnerable as some reported very low income, at least one is a single woman supporting her family, and most were not from the area.

Not all of the vendors were able to be interviewed and one kiosk in the pipeline right-of way was confirmed to be abandoned, after repeated visits and based upon reports of the community. Several farmers were also identified currently cultivating what is now PPS 1. Crops include corn, peppers and okro. The farmers were unaware of the project prior to the ESIA consultations.

All of these parties were compensated and/or relocated in accordance with the Stage 1 Livelihood Restoration Plan (LRP) / Abbreviated Resettlement Action Plan (ARAP), prepared in March 2017.

Stage 2

For the current project design, in addition to the above impacted parties there was also some farmland identified in Power Plant Site 2 (PPS2), a 10 bedroom residence scheduled to be relocated by the land owner(s) prior to project construction in PPS2, two kiosks/businesses in PPS2, and some additional kiosks (up to 5) located along the new pipeline route, close to where it crosses to the south side of Valco Road, opposite Sentuo Steel.

20.5 Recent Encroachment in the Project Footprint and Wider Area

Since completion of the initial ARAP and its implementation, at least one new kiosk has set up opposite the PPS1 site entrance, within the Stage 2 / PPS2 land. Another has set up on the left side of the tank farm site entrance, outside of the project footprint. There are also several kiosks that have recently located on the road reserve between the PPS2 site and the tank farm site (on the opposite side of the road to the tank farm site).

These kiosks have all located in the project vicinity after the original baseline surveys and cut-off date from the Stage 1 ARAP was established and are therefore not considered to be the direct responsibility of EPL. However, EPL maintains ongoing communication with these kiosks and have informed them that they will need to move from their current location prior to construction.

In addition to these developments, a new residential dwelling has been identified approximately 200m east, between the Top Archive and Glas Brown Company facilities. This dwelling is not within the project footprint and was not identified during previous project phases as it is newly established. However, the dwelling could be impacted by operational noise of up to 60 dBA during Stage 1a per the results of the project noise.

Whilst EPL is not obliged to resettle these dwellings, they will continue to engage with the residents during the Stage 2 ARAP to share information on the likely project-related noise levels and the project timeline. Options for further support for the noise affected property may be considered by EPL depending upon the outcome of the initial consultations.

EPL may also, depending on discussions, provide further support in finalising the movement of the newly developed kiosks within the project footprint. In particular, EPL is considering helping to relocate the kiosk on the Stage 2 land, opposite the Stage 1 site entrance for safety reasons and in to deter other kiosks moving into the area.

In addition, given the influx of informal kiosk businesses in the project vicinity (and particularly the vulnerable situation identified for the kiosks along Valco Road), EPL is considering whether it is feasible to include some associated support initiatives within its Social Investment Strategy. To this end, interviews were conducted with all the kiosk owners on the south side of Valco road, including those that are at present avoided by the design.

20.6 Impact Assessment

20.6.1 Economic Displacement Impacts

Five farmers were actively using PPS1 in 2016. Five kiosks were also located along the proposed pipeline route and one kiosk within the tank farm site. There were also previous signs of an abandoned farm close to the previous pipeline route alignment, although it was ultimately confirmed that this farm was not located on the alignment.

All of these parties were relocated in accordance with the "Stage 1 ARAP" prepared for the project in March 2017.

In addition, three farmers are currently utilising portions of the "Stage 2" PPS2 site along with 2 kiosks/businesses. In addition, some commercial/food vendors along Valco Road were instructed to move and/or physically relocated by representatives from Tema District Council. Once EPL became aware of this issue, it immediately contacted TDC to halt this activity. Regardless of whether the pipeline route ultimately crosses through the former location of the effected kiosks, EPL now considers these as part of the project affected parties and will address the identified impacts to these parties through the Stage 2 ARAP process.

Surveys were conducted at each kiosk and with each farmer as part of the 2015 ESIA and subsequent amendments, with the most recent surveys in May-June 2017. None of the kiosks or farmers have legal land tenure, but some have been given permission by the adjacent businesses or land owners to farm or operate in their current location at least temporarily.

Nonetheless, these small businesses and farm land will be physically displaced by the project. EPL has developed an appropriate ARAP for the Stage 1 site and associated infrastructure in accordance with IFCPS5 including measures to address economic displacement and associated compensation and relocation, which will be updated to include all impacted parties prior to construction.

A Stage 2 ARAP is now being developed to address any additional economic displacement that would result from Stage 2 development and associated infrastructure. At the present time, it is expected that this will address the farmers identified on the Stage 2 site and up to 5 kiosks that were instructed to move by representatives from Tema District Council.

Although the number of kiosks and farm uses are few, economic displacement impacts will result from project development. Impacts of this nature can result in poverty and / or dislocation of individuals or communities, and the severance of extended support networks such as childcare. If not managed and mitigated appropriately, resettlement impacts can cause great controversy and result in significant public objections, time delays and considerable cost overruns for the project.

20.6.2 Associated Physical Resettlement Impacts

20.6.2.1 Construction and Operation

Along with experiencing economic displacement, at least two of the kiosk vendors on the original pipeline route and potentially some of the affected kiosks/businesses along Valco Road potentially impacted by the revised pipeline route consist of parties also residing at least part time in the kiosks along with family members. These vendors will (subject to confirmation of the revised pipeline route surveys) also be physically displaced by the project, both in terms of their location of work and residence.

For the kiosks along the original pipeline route, appropriate compensation and relocation measures to address physical displacement of the kiosks and compensation and relocation of the residents were completed by EPL as part of the Stage 1 ARAP, which was implemented prior to the commencement of PPS1 site preparation activities, in accordance with IFC PS5.

The Stage 2 ARAP will also contain measures to ensure that kiosks whose owners are identified as residing there are properly relocated in line with IFC PS5.

In addition to the impacted farmers and kiosks associated with the Stage 2 development and pipeline re-alignment, there are several parties currently residing in a house on PPS2. One family, including the ‘caretaker’ of the site (a relative of one of the land owners), have been living there permanently and the remaining residents are short term rental tenants. The rental tenants include some persons formerly farming part of the Stage 2 site and also some that are operating a nearby kiosk.

EPL understands that the rental tenants’ tenancy has been terminated at the time of writing and that the caretaker and his family are schedule to be relocated by the land owner prior to the execution of the land lease for the site with EPL.

In addition, EPL has communicated to the PPS2 land owners what its expectations are regarding the standards to be applied for resettlement of the residents. The ultimately implemented resettlement solution proposed by the land owners will be agreed with and monitored by EPL. In the event that and any additional actions are required to meet the requirements of IFC PS5, EPL will re-engage with the landowners in order to find a satisfactory solution, or any gaps will be addressed via a Supplemental Action Plan if required.

20.6.2.2 Assessment, Management and Mitigation

A total of 12 businesses and 8 farmers for both Stages of the project will be displaced by the project and need to be compensated and relocated accordingly. Although the socio-economic surveys established that the affected households do not include any indigenous groups, the Stage 1 ARAP identified that some of the PAPs considered for that assessment are economically vulnerable and will require further assistance to ensure that relocation does not result in further economic hardship. It is considered that this is also likely to be the case for at least some of the impacted Stage 2 parties.

A LRP/ARAP consistent with IFC PS5 was developed for Stage 1 and an additional Stage 2 LRP/ARAP will be produced in order that EPL can ensure that all affected parties will be appropriately compensated and / or relocated prior to the commencement of project construction.

20.6.2.3 Efforts to Avoid or Minimise Displacement

During the feasibility studies for this project, a total of three alternative sites were considered for the project: one in Tema and two alternative locations, one in Sanzule and one in Aboadze (both coastal areas to the west of Tema).

The alternative site considered in Aboadze is located approximately 200km to the west of the proposed site, but could be supported by existing infrastructure for several power plant projects in the area. However, the location of the project at this site would be likely to result in more significant and extensive environmental and social impacts due to the cumulative air quality, noise and socio-economic effects such as community health and safety and worker influx during construction from multiple existing plants in the area in combination with the proposed project.

The site at Sanzule, approximately 260km from Tema, was considered due to its proximity to the gas tie in from the offshore gas fields. However, a site walkover undertaken of the site identified that from an environmental and social perspective, this site was likely to be more challenging to develop than the currently proposed site.

Key reasons for this included the likely need for resettlement, proximity to a possible indigenous community, the site being located at or very close to sea level, and the lack of existing infrastructure in the area that will be needed to support the development such as transmission infrastructure and good quality road network to enable efficient construction.

An alternative site in Tema to the west of the proposed power plant development was considered, within the TTPC. This site, however, was considered less feasible due to its distance from the proposed tank farm and the extent of RoWs that would need to be secured for the required gas and water pipelines.

As part of the recent design changes, the project has refined the pipeline design in order to avoid affecting a significant number of additional kiosks along Valco Road through a change to the proposed re-alignment of the pipeline route.

20.6.2.4 Impact Significance

Economic and some associated physical displacement of 12 businesses and 8 farmers would occur as a result of the project, which will be permanent and considered to be a moderate adverse impact of medium magnitude and local geographical significance.

A Stage 1 LRP/ARAP consistent with IFC PS5 was developed including livelihood restoration measures, and resettlement measures for those residing in the kiosks, and including consideration of those considered to be severely affected and or vulnerable. The

Stage 2 LRP/ARAP will be developed to ensure that any additional affected parties are appropriately compensated and relocated prior to the commencement of project construction. In addition, resettlement of the residents from the PPS2 site will be reviewed by EPL and any additional actions required to meet the requirements of IFC PS5 will be addressed via a Supplemental Action Plan if required.

Impacts are expected to decrease following implementation of the LRP/ARAP through the benefits of compensation, relocation support and livelihood restoration measures.

20.6.2.5 Mitigation

As stated above, an ARAP was prepared for Stage 1 in March 2017 in line with the requirements of IFC PS5.

As the project boundaries have been modified since, a Stage 2 ARAP will be developed to ensure that all affected parties are appropriately compensated and relocated prior to the commencement of project construction in line with IFC PS5.

Development of the Stage 1 and Stage 2 ARAPs included / will include the following activities:

1. Collect census level data on affected parties including income and consider vulnerability of kiosk businesses;
2. Develop a system for compensation for crop loss on the site and potential livelihood restoration measures;
3. Develop appropriate measures, including compensation for resettlement of the inhabitants of the kiosks;
4. Continue consultation with the affected persons according to the requirements of IFC PS1 including the establishment of a grievance mechanism for the project that would be available to the local community;
5. Where determined as required by the outcomes of the above activities, provide training and livelihood assistance programs to the community including, for example, the potential to diversify, savings and credit opportunities, and business and enterprise training; and,
6. Monitoring of the effectiveness of the ARAP, including any livelihood restoration measures where appropriate.

With development of the Stage 1 and Stage 2 ARAPs, a commitment to adequate livelihood restoration has been made by EPL.

In addition, a plan and timeline resettlement of the residents from the PPS2 site by the land owners will be agreed with and monitored by EPL. Any additional actions required to meet the requirements of IFC PS5 will be addressed via a Supplemental Action Plan if required.

With implementation of the measures described above, the residual significance is expected to be reduced to minor adverse. In the long-term, impacts are expected to decrease and conditions to improve as a result of the ARAP and proposed mitigation, but would still be considered minor adverse as resettlement effects would be permanent.

20.6.3 Employment

Employment impacts arising from the construction, operations and closure phases of the project would include:

- Generation of direct employment by the project; and,
- Economic development created as a result of indirect employment by suppliers of goods and services to the project.

Direct employment created during construction is considered a beneficial effect of the project. A breakdown of employment by phase is provided below.

20.6.3.1 Construction

At the height of construction, 200 employees would be employed on-site, which would result in beneficial employment and indirect employment impacts for suppliers including goods and services providers for the project such as food vendors and building materials companies.

The construction period will last approximately 2 years commencing in quarter 3 of 2017. The majority of employment during construction is likely to be relatively short-term and significant employment opportunities for local communities may be limited due to the low levels of education, skills and limited experience and training opportunities that the local people have. This could result in a large percentage of the skilled and semi-skilled workforce being sourced on a temporary or permanent basis from outside of the local community. There is also the potential for women to be disproportionately affected as many of the construction jobs will be geared towards men.

At this stage in the project development, the origin of these workers is unknown. However, an influx of temporary employees to the community could also result in negative impacts on the local community by increasing the demand for housing and services and by exposing the community to security risks.

Coinciding with the influx of migrant workers is typically a raise in demand for goods and services during the construction period which can result in a rapid expansion in supply chain businesses operating in the area. This will result in increases in formal employment and informal labour. This expansion would likely result in additional migration into the area. The potential negative impacts that could arise from the presence of migrant and/or expatriate employees are comprised of:

- Inappropriate behaviour and lack of respect for local leadership and cultural norms on the part of expatriate workers;
- Conflict resulting in part from resentment by skilled nationals and local residents if they perceive that expatriates have been hired into jobs for which they are suitably qualified;
- Spread of transmissible diseases including HIV/AIDS both within the workforce and between the workforce and the local community;
- Resentment of non-local nationals by local residents if they are perceived to have taken jobs that could be successfully filled by local people, or due to non-integration with the local community;

- Increased local demand for consumer goods and housing resulting in financial hardship for local people; and,
- Increased pressure on infrastructure, services (such as healthcare) and roads, particularly with the establishment of informal settlements.

20.6.3.2 Operation

During project operations, employment impacts are considered to be largely positive. Permanent jobs would include 30-35 shift workers. Although it is not clear whether or not these jobs will be able to be sourced from the local community, the project will provide a source of long term primary and secondary employment and economic growth for the area.

Despite the considerable employment opportunities offered by the local power industry, local communities are limited in their ability to take advantage of them. The level and range of skills and applicable working experience available in the adjacent communities, particularly in rural areas, is limited by education and relevant skills training.

Without targeted training support from the project, the ability to acquire a position, and successful performance once hired, will favour experienced (skilled) personnel for professional roles, the majority of whom would likely come from abroad, but may also create conflict between in-migrants and the local population. This is also true on a broader level in Ghana, that there is a shortage of skilled technicians, professional engineers and operators who can adequately meet the labour market demand in the oil sector.

This may create the potential for resentment and lack of opportunity employment and training for youth in the community. In addition, as the demand for goods and services in the project area expands during the construction period, there will be a need for additional capacity, training and resources to address the daily commerce needs of the construction workers in particular informal businesses in the area.

20.6.3.3 Assessment, Management and Mitigation

Impact Significance

Beneficial Impacts

<u>Direct Employment</u>

The project will have a moderate beneficial impact on employment during construction and operations, both in the Project Area of Influence, in the wider geographical District. Construction and operational employment opportunities could be generated and providing potential opportunities for the local community. However, since at least some of these workers may come from outside the local area, the influx of migrant workers could result in minor adverse impact from the increased demand for services during the construction period which can result in growth challenges for the area.

As the project moves towards decommissioning and closure, there will be a subsequent decrease in the workforce requirements.

Indirect Employment

Plant staff and contractors will require numerous vendors, suppliers and service providers to meet the daily operating needs of the project together with the domestic needs of its employees. This could include goods and services include food vendors, laundry, supply of vehicles and transportation services, security patrols, as well as some construction equipment.

In addition, the project will induce secondary/tertiary economic activity due to the influx of migrants from outside the project's Area of Influence that will require housing, food, and other types of resources and services. There will be opportunities for utilising local goods and services for the project and related activities.

Typically, 3.2-3.5 jobs in service and supply sectors are created for each direct job generated by oil and gas projects.[1] At the local and regional levels this is likely to stimulate interest from local agricultural producers, as well as induce growth in other industries such as retail, hospitality, transportation, etc. This would be considered a minor beneficial impact.

Negative Impacts

- Conflict resulting from influx;
- Increased pressure on infrastructure, services and roads, particularly with the establishment of informal settlements; and,
- Inappropriate behaviour or loss of security in the project area as a result of influx.

20.6.3.4 Mitigation and Enhancement Measures

As a result of all of the above, it is important that the employment process is well managed and that the local community is able to actively participate. The following measures will contribute to this:

- Ensure a transparent hiring process is conducted help the community to understand strategic staffing decisions for the project to avoid conflict;
- A Construction Management Plan and procedures shall be designed to help to minimise land and community disturbance;
- Develop a Workforce Development Strategy – a commitment to maximize employment and skills opportunities for local people;
- Develop a training and skills programme to impart good international industry practice in the skilling of local people for construction and operational jobs; and,
- The Project Sponsor shall consider contributing to community improvement projects in the local area including community beautification and infrastructure improvement.

With the measures described above, the residual significance is expected to be moderately beneficial. In the long-term, employment impacts are anticipated to further improve as a

[1] MACROECONOMIC IMPACTS OF THE DOMESTIC OIL & GAS INDUSTRY, NPC, September 15, 2011 (PWC multipliers used).

result of the indirect impacts from the additional power generation and the targeted training and assistance programs for workers involved in construction and operation of the project.

20.6.4 Community Health and Safety Impacts

Health and safety impacts arising from the construction, operations and decommissioning are likely to include the following:

- Increased health and safety risks associated with the a pipeline failure along the above ground section of the LPG pipeline, including the following:
  - Unintentional impacts e.g. transport accidents from road vehicles, rail or aircraft;
  - Intentional impacts e.g. deliberate acts of vandalism, tapping into pipelines; and,
  - Other external factors e.g. earthquake.
- Increased risk of traffic hazards and incidents associated with the construction routes;
- Exposure to project-related hazards associated with construction, operational and decommissioning activities;
- Explosion risk from the LPG in pipelines and storage of LPG on site;
- Increased incidence of communicable disease;
- Community health impacts related to dust that will exacerbate existing or cause new conditions(e.g. respiratory, eye, skin diseases); and,
- Personal safety, security and well-being impacts associated with worker influx.

20.6.4.1 Construction and Operation

During construction, materials will be delivered to the site and during operations traffic flow is predicted to increase gradually. This would lead to an increase in the potential for other health related impacts associated such as increases in noise, dust, risk of accidents and exposure to hazardous materials. Project deliveries will be scheduled for daytime hours whenever possible due principally to safety reasons, but with the secondary benefit of noise reduction through the night.

The introduction of increased HGV traffic and general increasing traffic volumes presents a safety risk to the community and to workers. In addition, there will be the potential for increased road traffic accidents from increased construction traffic.

The LPG pipeline is proposed to be contained within an existing right of way that is exposed to the public. This existing pipeline and right of way is owned and operated by the TOR. As shown in Figure 8-2, whilst it does not run directly through any community areas, there are a number of road underpasses which are currently relatively poorly protected. This is particularly a danger for children in the community and is also a concern with the potential for risk of explosion in the area in the event of a vehicle collision.

The consequences of pipeline failure would likely result in either a jet fire (typically from impact) or an unconfined vapour cloud explosion due to delayed ignition. Tapping into pipelines may represent the highest potential intentional impact, with the impact limited to those in the vicinity. However, consultations with TOR in May 2017 identified that TOR has addressed a historical issue of fuel theft through the installation of security guard towers at 200m intervals along the pipeline and constant 24 hour walking patrols by the guards.

Consultations with TOR in May 2017 also identified that there have been two historical fires associated with pipeline failures on the TOR naptha line. Both were associated with rusting of the pipeline in locations where it passes under a culvert beneath a disused rail embankment. The culverts are liable to flood during rains. TOR confirmed that daily integrity checks are now undertaken along the full pipeline extent by the security guards and that remedial measures have been recommended for the culvert locations.

Given the medium overall security risk level currently reported in Ghana[2] and current lack of any active terrorism, the likelihood of such an event is currently considered very low.

Other potential external factors such as earthquakes or natural events do not represent a substantial risk to the project installation, due to the application of recognised international standards during design and construction. However, it is unclear to what standards the TOR pipelines have been constructed

Due to the routing of the pipeline above ground next to public roads with multiple crossing points, unintentional road vehicle impacts are likely to represent the biggest community health and safety risk associated with the LPG pipeline.

Emergency response for potential accidents will also be an important consideration. This is understandably a major public concern. Accidental gas leakages and explosion could lead to fire outbreaks which could result in the loss of human and aquatic life, property damage, and other serious health implications. Accidental release of and exposure to fumes and other toxic emissions emanating from the processing of the gas to generate power could result in respiratory infections to workers as well as residents around the project site. In the event of any explosions or leakages, fish and other aquatic organisms that are important to local livelihoods could also be affected. Appropriate health and safety standards shall be applied at the site to address any potential effects associated with accidents.

The influx of additional workers during the peak construction period may also facilitate increased incidence of teenage pregnancies, prostitution and criminal activities in the project area. Higher incidence of prostitution could in turn increase the prevalence of HIV/AIDS and other sexually transmitted diseases. No worker accommodation is anticipated to be developed as part of the project and workers are mainly anticipated to come from the surrounding Tema and Kpone communities. The EPC Contractor and project sponsors shall ensure that appropriate labour and working conditions and facilities are in place for the construction and operational workforce.

In addition to HIV and AIDs, the arrival of some workers from other regions at the height of construction and other in-migrants to the project area associated with secondary economic opportunities may also increase the risk of transmission of other communicable diseases. If HIV/AIDS increases in the region, there is a high probability that the risk of other associated diseases could increase. The local health system, would likely be impacted as the current patient care ratio is low and services could face a major increase in demand as a result of the influx.

Close living conditions, and large numbers of workers and in-migrants sharing sanitation and other facilities, as well as potentially poor hygiene practices, could also increase the risk of respiratory disease, as well as food and water-borne diseases (e.g. cholera, typhoid). In addition, dust from construction would exacerbate respiratory illnesses for workers. Personal safety issues are also a concern including threats to personal security and property as a result of unruly or disruptive behaviour by workers or other individuals new to the local area along with respect for local practices.

20.6.4.2 Assessment, Management and Mitigation

Community safety impacts from the exposed pipeline and increased roads and traffic, influx of workers increasing the risk of communicable diseases and safety risks and exposure to hazards would be considered a major adverse impact. Most of these effects would likely be short-term and localised and risks would be highest during the peak construction period. Children and other vulnerable people may be more susceptible to traffic risks as elderly, children, and those with existing health problems would likely be most susceptible to the community health risks. However, risks associated with pipeline safety would be more long-term.

20.6.4.3 Mitigation Measures

The following mitigation measures are recommended to reduce potential community health and safety effects:

- The project will be developed in line with Onshore Oil&Gas Environmental, Health and Safety guidelines. The proposed pipeline shall be coated and use cathodic protection to prevent corrosion and with SCADA. The depth of the pipeline shall be defined to ensure protection. Also the wall thickness could be redundantly designed (F factor redundancy).
- Work with TOR, TDC and Tema Metropolitan Assembly to encourage development of a pipeline safety management plan including pipeline markers to be installed to identify the pipeline rights-of-way, but not the exact location of the underground location; community awareness campaigns; and development of protections (crash barriers, guard posts and signage) on the road crossings. The project should obtain and review all TOR emergency planning documentation, including fire response for TOR and the pipeline and fire and spill response and control at the TOR jetty. Where any gaps are identified, these the project should engage with TOR in order to advocate for progressive improvements in the documentation.
- A Transport Management Plan shall be implemented for any construction traffic to reduce the potential for accidents.
- All project operations vehicles and contractor vehicles will have a speed limit set for travel through settlements and areas where there are no posted speed limits.

- A Worker Policy and Code of Behaviour shall be developed which includes guidance on visits, prescribed actions for conduct violations and a grievance mechanism for complaints.
- The EPC contractor shall involve external stakeholders (i.e. police or local authorities) in any on or off-site security incidents and ensure that appropriate incident response procedures are implemented.
- An HIV/AIDS awareness and prevention program shall be implemented to provide the community with tools and education materials to reduce the spread of HIV/AIDS.
- An important aspect of minimising the spread of communicable diseases within the community is worker health screening, particularly as many workers are local people. A worker health screening programme shall be developed and implemented during the peak construction period or at any time when workers on site number more than 100.
- Whilst currently not anticipated, any temporary worker accommodation plans if required in future will be developed according to international requirements under IFC Performance Standard 2 international requirements under IFC Performance Standard 2.
- First Aid and Safety training will be provided to workers and Community Emergency Response Plans will be developed and tested including consideration of workers and nearby residents in the vicinity of project-related traffic. These will include emergency response related to traffic accidents and potential releases of chemicals and other hazardous materials.
- Workers shall receive proper PPE and associated health and safety training including procedures for emergency response.

With the safety measures described above, the residual significance is expected to be reduced to minor/moderate adverse.

20.7 Cumulative Impacts Assessment

20.7.1 Cumulative Impacts

The project area is largely industrial, which could mean that the project may give rise to cumulative impacts when combined with other developments. This is likely to mean than similar community health and safety impacts from several sites in the project area simultaneously may exacerbate the overall level of risk.

This would indicate that although impacts are considered moderate and minor adverse individually, the combined effects of several similar projects is likely to increase the magnitude of the effects on the Regional level. This could mean increased risk of accidents, a larger community influx and associated risks and a larger displaced population.

In this context, the importance of proper stakeholder engagement and understanding of community concerns, and the provision of (where possible and appropriate) training and employment opportunities to community members becomes even more paramount.

The mitigation measures proposed above would ensure that impacts would be at worst, of adverse minor/moderate significance. However, careful monitoring of these measures and their effectiveness will be crucial to ensure that cumulative impacts are also moderate or minor adverse.

20.8 Conclusions

Overall adverse impacts associated with displacement (physical and economic), community health and safety would be counterbalanced by beneficial employment impacts of the project.

The number of informal businesses and residences to be resettled is small and there are a number of measures that can be implemented to increase the economic benefits of the project. Implementation of appropriate community health and safety measures if properly implemented would significantly reduce project effects and calm community concerns. Key aspects of all mitigation discussed here will be adequate community engagement and security of the LPG pipeline.

20.9 Follow on Work

The following key actions have/will be implemented by the project:

- Complete the final implementation step for the Stage 1 LRP/ARAP consistent with IFC PS 5 for those requiring livelihood restoration or physical resettlement as part of the project;
- Develop a Stage 2 LRP/ARAP consistent with IFC PS 5 for those requiring livelihood restoration or physical resettlement as part of the project;
- In the event that the resettlement process for existing residents on the Stage 2 site by the land owner is not considered sufficient by international standards, the project should develop a Supplemental Action Plan in line with requirements of IFC PS5 as required.
- Ongoing community consultation and information disclosure as required; and,
- Implementation by EPL and EPC Contractor of the above recommendations and mitigation measures within this assessment regarding community health and safety to meet the objectives of PS 2 and 4.

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Section 21 – Consultation

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration		Rev No
Sep 2015	First issue		0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency		1
June 2016	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating the following changes:		2
	Section No.	***Change***	
	Wherever relevant	Reference to “power plant site” changed to reflect revised plan involving two power plant sites (PPS1 and PPS2).	
	Wherever relevant	Corrections to spelling, grammar and other changes for consistency. Abbreviated terms provided in full at first usage.	
	21.2.2	Additional consultee information	
	21.3	Reference to additional table and consultations in June 2016. Addition of Table 21-4 – consultations held in June 2016. Update of stakeholders not identified / met with yet.	
	Table 21-4	ESIA phase consultation meetings held in June 2016	
August 2017	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating details of the revised project designs, including:		3
	Section No.	***Change***	
	Wherever relevant	Inclusion of stakeholder consultation and disclosure activities undertaken since issue of v2.	
	Wherever relevant	Text additions / edits to reflect the revised PPS1 and PPS2 locations and pipeline route.	

Contents

Figures and Tables

21 Consultation

21.1 Overview

A Stakeholder Engagement Plan (SEP) is under development for the project which sets out the approach to stakeholder and community consultation and disclosure for the lifecycle of the Ghana Bridge Power Project. The SEP is being developed in order to enhance the stakeholder engagement approach and procedures for the project.

The objectives of the SEP are to:

- Identify the Ghanaian legal framework for consultation activities and disclosure requirements, particularly in respect of those public consultation activities that are directly required under the local permitting process;
- Identify potential stakeholders in the area of influence, as well as relevant interested parties such as government agencies and other key stakeholders;
- Record all consultation activities, including those prior to the commencement of the ESIA process;
- Describe how concerns or grievances will be handled;
- Provide an action plan for further consultation during preparation, construction and operational phases of the Project, including details on appropriate formats and language for effective and culturally meaningful interaction with the community and identified relevant stakeholders; and
- Provide a disclosure plan, including the identification of any locations where relevant project documentation will be available locally and elsewhere, as well as languages to be used.

The SEP is a live document held by EPL and will be updated throughout the life of the project. Early Power has appointed KINA Advisory Ltd., who is acting as the project's corporate social responsibility representatives for the project. KINA Advisory Ltd will be taking forward development of the SEP for the lifecycle of the project.

The stakeholder engagement process is being used to inform the socio-economic assessment and the development and implementation of a Social Investment Strategy and Programme for the project. KINA Advisory Ltd. has been appointed to advise and assist in the development and implementation of a Social Investment Strategy (SIS) that is commensurate with the project activities and potential impacts, both positive and negative. The SIS remains in draft form at the time of writing.

The scope of consultation activities for this project was developed following advice from KINA Advisory Ltd., and with Associated Consultants Ltd., the Ghanaian consultants forming part of the ESIA team for the project. The scope of work is outlined in Section 21.2.2 and Table 21-2 summarises the stakeholder engagement activities undertaken to date and proposed throughout the ESIA process, including the work undertaken by KINA Advisory Ltd. The findings of the meetings held to date are provided in Section 21.3.

21.2 Project Specific Requirements

21.2.1 Overview and Rationale

To meet both national and international requirements, the affected and interested parties in the project need to be consulted at every stage of the ESIA process. The identified stakeholders and methods of engagement are detailed in the SEP.

As part of the standard ESIA process, community consultation would normally include a formal open public consultation event at both the scoping and final ESIA stages. In this instance, the formal public consultation event was omitted and replaced by focus groups. The strategic decision to forego a formal public consultation event and undertake a more informal approach to public consultation was based upon discussions with KINA Advisory Ltd. and Associated Consultants Ltd., and following informal communications with a representative of a leading IFI to discuss the approach. The proposed approach was then discussed and agreed with the EPA.

The key issues that informed this decision originated from the desire to engage in an appropriate level of community consultation for the socio-economic baseline without raising undue expectations amongst the nearest communities of extensive employment opportunities or social development initiatives that did not reflect the true scale of the project impacts and area of influence.

The formal public consultation event has been omitted for the following reasons:

- Given the industrial nature of the development location and the distance to surrounding communities (the nearest are over 2km from the power site), impacts to those communities will largely be indirect and no significant adverse impacts have been identified to the nearest community areas[1] as part of this ESIA.

- There is a significant level of social deprivation in the wider project area. Whilst EPL will develop a SIS, significant wide-spread public awareness of the project throughout the communities surrounding the Tema Heavy Industrial Area (THIA) may unrealistically raise expectations of disproportionate community benefits from the project.

- Undertaking public events would likely lead to levels of expectation that would not be commensurate with the scale of project activities and limited associated impacts. Extensive public engagement may therefore put inappropriate pressure on EPL to provide community benefits which are not in keeping with the limited impacts anticipated.

21.2.2 Scope of Consultation Activities

The scope of work completed for the community consultation process to inform the socio-economic baseline assessment was as follows:

- Initial desk-based socio-economic review;

[1] Displacement impacts on the small number of informal kiosks located along the pipeline route are considered separately and were not considered to represent impacts to the wider community areas (see Section 20 for further details).

- Collection of socio-economic data during stakeholder engagement meetings with nearby commercial business, representatives of the municipality and government institutions and community chiefs;
- Collection of socio-economic data through informal discussions with kiosk owners located along the pipeline route, farmer on Power Plant Site 2 (PPS1) and at proposed tank farm site;
- Focus group meetings in each of the surrounding community areas during (these include Tema New Town, Kpone and three communities in Tema); and,
- A focussed community consultation and disclosure event with representatives from the same communities as above. Rather than doing three separate focus group meetings, attendees from the different communities were invited to the same event.

Table 21-1 summarises the stakeholder engagement activities for the project.

Table 21-1: ESIA Stakeholder Engagement Implementation Timescales and Responsibilities

Activity	Timing of activities	Responsibility
ESIA Phase Engagement		
Draft ESIA disclosure on project website	Initially posted October 2015 (v1), subsequently updated to in 2016 (v2) and 2017 (v3).	Early Power
Individual meetings with stakeholders	Undertaken as necessary over the duration of the ESIA process to collect data and register concerns and opinions of stakeholders. Meetings will continue as required throughout the project development phase.	Jacobs Consultancy Early Power
Interviews with kiosk owners / road vendors	Undertaken as necessary over the duration of the ESIA process to collect data, inform the operators and inform the LRP. Following revisions to the pipeline route in 2017, additional kiosk operators were interviewed, although the final route selected avoids direct impacts on all but one vendor.	Jacobs Consultancy Early Power
Focus groups discussions with community representatives including vulnerable groups	Meetings undertaken within each of the three nearest communities to the project infrastructure. Representatives from the	Jacobs Consultancy Early Power

Activity	Timing of activities	Responsibility
	communities included: • Chief; • Village elders or community representatives; • Religious groups; • Women's groups; • Youth groups; and, • Fishing communities. Meetings undertaken as necessary over the duration of the ESIA process.	
Focussed community consultation and disclosure meeting	May 2017 Joint meeting with the communities nearest to the project infrastructure (Communities 4, 7, 9, Tema New Town, Tema East, Tema Manhean and Kpone) and the Tema Metropolitan Assembly. The purpose was to provide notification of changes to the project design and updated programme, disclose the findings of the draft ESIA, and collect updated socio-economic baseline data from a sample of attendees.	Jacobs Consultancy Early Power
Media communications	Newspaper adverts / radio communication for a minimum of three weeks to advertise draft ESIA disclosure and request comments. Newspaper (with nationwide coverage) notices after ESIA approval Radio (with nationwide coverage) announcements after ESIA approval in relevant languages. As requested or when press releases deemed relevant	Early Power
Production of Stakeholder Engagement Plan	First issue in December 2016. To be updated following latest ESIA iteration and associated consultation.	EPL Jacobs Consultancy

21.3 Stakeholder Consultation Meetings

A number of stakeholder consultation meetings have taken place throughout the ESIA process. Full details of the findings of these meetings are included within the project SEP. Findings of the meetings are summarised in Table 21-2 (meetings undertaken in February and March 2015), Table 21-3 (August 2015), Table 21-4 (June 2016) and Table 21-5 (May/June 2017). The formal screening documentation from the EPA is provided in Appendix E of this ESIA.

The format of meetings generally comprised introductions, followed by a project description (including phasing and timelines) and then a question and answer session regarding the ESIA approach with feedback from the stakeholder regarding the project and potential environmental and social issues. Where practicable and/or appropriate, the responses from consultation meetings have been considered in either the approach for the ESIA assessment or the mitigation measures included within the ESMP.

Table 21-2: Screening Phase Site Visit Meetings Held February and March 2015

Date	Stakeholder	Summary of Discussions
19/01/15	Various representative groups from Government of Ghana	Ministry of Power Advisor and various government groups represented at a kick off meeting for Emergency (Bridge) Power, the meeting focused on the delivery schedule for Emergency (Bridge) Power and support for Energy Commission, Power Purchase Agreement (PPA), Environmental Impact Assessment, site locations and interconnections for the project.
3/02/15	VRA Benjamin Sackey VRA TTPC Office	VRA operates Environmental Management System (EMS) for all its plants. It has noise and air quality stations and also collects additional ambient air quality data at certain locations. Electronic monthly data is available and can be provided upon formal request. ESIA for the TT1 expansion can also be provided. Social – No residential areas are located within 2km of the site. The nearest area is Kpone (where another VRA plant is about to be commissioned). Current ambient air quality is good, but dust is apparently an issue. VRA does not expect significant air quality issues on NO_x and SO_x, but PM10 may be an issue. Sentuo Steel located to southwest of the site and Tema Oil refinery is likely to be key cumulative contributor. Sentuo steel can only operate at night due to poor quality of emissions. TOR processes low Sulphur oil so does not cause major SO_2 issues in the air shed. There are four existing plants on the TTPC site and were details provided. Effluent is given limited treatment to gain correct pH and then discharged to surface storm drain east of the site. Farmers are known to farm around the drain downstream of the site, using the discharge as water for crops. Transport of equipment is very simple. Short stretch from port to the site. Municipal authority has standard procedures for this.
3/02/15	**EPA**	The EPA considered that because the project is temporary in

Date	Stakeholder	Summary of Discussions
	Director Badu- Yeboah Audrey Quarcoo Abena Ayensu EPA Training school, Amasaman	nature, located within the THIA area and in trailerised format, a full ESIA is not required by the EPA. EPA expects air emissions and (to lesser extent) noise to be key issues and modelling will be required. No social impact assessment or public consultation was required by EPA due to the site being within the existing VRA TTPC compound and THIA area and the distance to the nearest settlement. Jacobs indicated that whilst this is the case, the project will still need to do some form of community consultation and engagement to meet with the requirements of international standards. EPA indicated that the nature of RoW for pipeline may affect the extent of studies required. PPA status with ECG is also important for permit. EPA gave permission to commence baseline monitoring prior to getting formal go ahead for the ESIA to commence. Regarding cumulative impacts, EPA confirmed that Sentuo Steel has emissions issues, did previously operate at night and is under notice to install emissions reduction system. The EPA also noted that expansion was planned for the Trojan plant. EPA also noted that the project will require water storage tanks for back up, in event of GWC supply issues.
4/02/15	**VRA and TOR** TOR and TTPC	Team meeting with VRA and Grid co for formal site walk over and technical discussions, including environmental considerations. Similar meeting with TOR representatives for walk over of the section of the pipeline route within the TOR site.
03/03/15	Various TTPC	Team meeting with GRIDCo, ECG and VRA representatives for walk over the proposed area and technical review of connections.

Table 21-3: ESIA Phase Consultation Meetings Held in August 2015

Date	Stakeholder	Summary of Discussions
11/08/2015	**Ghana Water Company Limited (GWC), Tema** Mr Amidu Musa (Regional Distribution Manager)	The current design includes water supply to be provided by GWC. The following concerns were raised by the ESIA team regarding water supply to the project: 1. The availability of water to meet demand and the reliability of supply. 2. The negotiations/ ROW agreements required for the pipeline route and impacts associated with laying of pipes. In respect to the above Mr Amiidu Musa confirmed the following: 1. GWC holds sufficient capacity to meet the increased demands of the new power plant. The only envisaged shortages in supply would result due to power outages (which can stop pumps) or in maintenance

Date	Stakeholder	Summary of Discussions
		activities. It was recommended that the project included some backup water storage to ensure operations could continue should these circumstances arise. 2. The water pipes will be laid in a transmission line RoW belonging to GRIDCo which is not accessible for any other land use. There is no anticipated adverse impacts resulted from the laying of pipes. Permission has already been granted by GRIDCo for the laying of the water pipes.
11/08/2015	**GRIDCo** Mr. Kwame Owusu-Boadi (Snr Environmental Officer)	GRIDCo is the transmission company which will receive the power evacuated from the plant. GRIDCo were concerned that baseline air and noise data had been collected and that a robust ESIA was being undertaken. They were assured that an ESIA was being taken to EPA and international standards and this would be disclosed on the project website in due course. GRIDCo wanted reassurance that an occupational health and safety plan was being undertaken for the project to ensure safety of employees in operational phase. They were reassured that efforts to address health and safety will be created as actions in the ESMP which forms part of the ESIA.
11/08/2015	**VRA (TTPC)** Mr. Hans Ofedie (Environmental Officer)	VRA is a key project stakeholder as the power plant will be built within its TTPC. The project may share certain infrastructure, such as storm drainage and the project could potentially impact the TTPC from a noise, air quality and transport perspective. VRA provided information on current operations and indicated that an ESIA is available for the ongoing Station 2 expansion to a combined cycle plant. Concerns regarding the proposed Ghana Bridge Project included impacts of construction traffic and associated dust/noise impacts. It was confirmed that the ESIA was being undertaken to comply with international standards and would address these issues. VRA suggested that the plant site drainage should be direct to the storm drain behind the plant site (to the east), including treated effluent, rather than using exiting VRA facilities. Drainage to the offsite storm drain is currently anticipated in the project design. VRA requested sharing of air quality monitoring data in operational phase. They informed that Sentuo Steel Works has put up new extraction systems to minimise air pollution from their operations.

Date	Stakeholder	Summary of Discussions
12/08/2015	**Electricity Company of Ghana (ECG), Tema Region.** Mr. Mark Wiafe (Regional Manager) Various other ECG representatives	ECG provided information on its operations which is primarily to buy and sell electricity as the state-owned distributor. ECG were supportive of the project. Concerns raised included potential for disruption of ECG cables by the pipeline, concerns over LPG leaks and appropriate safety and security measures. These issues are considered within the ESIA in line with EPA and international requirements
12/08/2015	**Tema East Sub metropolitan Assembly** Madam Rita Damani (Tema East Sub Metro Director)	Tema East Sub metro is part of the TMA and its jurisdiction includes the project infrastructure locations. Their key activities include provision of socio economic infrastructure and services in the sub metro, ensure clean, safe and healthy environment and also to promote socio-economic activities in the sub metro, especially for the vulnerable and excluded. Socio-economic information on the area was provided including on some of the significant social challenges such as sanitation and employment Concerns regarding the proposed Ghana Bridge Project were mainly associated with traffic impacts during the laying of pipes, erosion and the treatment and disposal of effluent and wastes. These issues are all considered in appropriate chapters in this ESIA. It was requested that one month's notice prior to construction was provided so that traffic could be diverted from urban roads to minimise congestion. I was suggested that other permits may also be required from the other sub-offices in the TMA.
12/08/2015	**Tema Steel** I.V. Royal (Plant Manager) Madam Ellen Jonah (Human Resource Manager)	Tema Steel is a steel making company that is located close to the GridCo transmission installation, approximately 1km north of TTPC. The company is privately owned and has been in existence since 1964. The power outages affect their business because they are now producing under capacity and they asked if they could buy power directly from the project. The main concerns regarding the Ghana Bridge Project were air and noise pollution and wastewater treatment. They were assured that an ESIA was being undertaken to international standards and that appropriate mitigation and management to minimise impacts will be included in the ESIA.
14/08/2015	**VRA Kpone Thermal Power**	VRA KTPP is located approximately 7km north of

Date	Stakeholder	Summary of Discussions
	Plant (KTPP) Mr Seyram Dzefi (Health Safety and Environmental Officer)	the project site and is nearing completion of construction so as such it is unlikely to contribute in terms of cumulative impacts on air or noise (due to distance and prevailing wind direction) and transport. KTPP will produce 330 MW with Phase 1 (110MW) commissioned in October 2015 and Phase 2 (220MW) by January 2016. A third phase may also be added to provide 110MW. VRA KTPP has no specific concerns about the Ghana Bridge Project in relation to its own operations. However, general concerns and suggestions included: • Consider RoW acquisition with regard to potential for displacement of people. • Recommended the use of Continuous Emissions Monitoring (CEMS). • Water tank design should include deck storage for fire-fighting purposes. • During the transportation of project equipment and machines to site the following bodies should be contacted; MTTU(police) to escort transportation vehicles, GRIDCo, ECG and Vodafone to check if any cables along the route have to be pulled down to allow easy passage. Issues associated with pipeline displacement are considered in Section 20 of this document. EPL will consider the above suggestions as part of its design process.
17/08/2015	**Town and Country Planning Development (TCPD)** Accra Celestina Deku (Assistant Town Planning Officer) Patrick Apraku (Town Planning Officer)	TCPD is the national authority on developmental issues. Concerns regarding the project were mainly around effluent treatment and community safety. The ESIA team confirmed that the ESIA and project design will address these issues in line with EPA and international standards. TCPD suggested that the client consult with TCPD Tema region as they would be in a better position to answer most administrative questions.
18/08/2015	**EPA- Accra East Region** Tema Ebenezer Fiahagbe Regional Director Irene Opoku Hope Lomotey	EPA Accra East Region is the environmental authority responsible for the area where the project is located. The EPA are supportive of the project as they recognise it will help provide much needed power. The EPA provided information regarding surrounding industries. They informed us that Quantum Ltd had put in an application for a Permit to store Gas on the tank farm and that their application was under consideration. They also confirmed that Sentuo Steel had undertaken retrofitting of a dust collector/extraction system and

Date	Stakeholder	Summary of Discussions
		that this process was still ongoing. The EPA's concerns included the following: • Concern regarding the risk of concentrating generation in the TTPC area which could lead to significant power outages if there were a major accident in the enclave. The project will be designed and operated to international standards including rigorous safety requirements to mitigate this risk to as low as reasonably practicable. • Concern regarding pipeline construction impacts and risks to other users of the TOR RoW. Also that plant safety, environmental and community safety would not be compromised because of the rapid 'emergency' development of the project and that EPL should invest in adequate mitigation measures. This ESIA addresses these concerns in relevant chapters and the ESMP actions. It was suggested that all power companies within the TTPC coordinate to produce a Strategic Environmental and that companies with pipes in that corridor be consulted. The ESIA team confirmed that appropriate consultations were ongoing with TOR as part of the project development activities.
19/08/2015	**Tema Fuel Company** Andrews Baafi Owusu (Operations and Technical Director) Moses Delali Davudu (Technical and Operations Manager)	Tema Fuel Company (TFC) is located 600m south of the proposed plant site. TFC is privately owned and there are no plans for future expansions. TFC were supportive of the project and recognised the added stability it would bring to power supply for their operations. They are affected by weekly power outages mostly on Thursdays and Fridays resulting in expensive in-house generator fuel bills. Concerns regarding the proposed Ghana Bridge Project included risk of fire/explosions, and transport impacts and access restrictions to their installations during pipeline construction. Suggestions included deign to international standards regarding safety to reduce risk of explosions and ensuring that comprehensive consultation was undertaken with properties along the proposed pipeline route. The ESIA team confirmed that traffic studies had been conducted and that a traffic management plan would be developed in consultation with them and other stakeholders along the pipeline route. The ESIA and ESMP include safety requirements and mitigation measures in line with international standards.

Date	Stakeholder	Summary of Discussions
19/08/2015	**Ministry of Power** Solomon Adjetey Sulemana Abubakar Andrew Ashong Seyram Adabla	Ministry of Power is the national authority on production of power. The Ministry is supportive of the project as it will assist with Ghana National Energy Policy (Feb 2010) target of increased installed generation capacity to meet growing demands though IPP development. Their only comments on the project were that all EPA requirements were followed to obtain the necessary Environmental Permit.
19/08/2015	**Tema Metropolitan Assembly (TMA)** G. A. Tamakloe (Municipal Planning Officer) Ebenezer Fiahagbe EPA, Tema Regional Director Sam Okantey (Works Engineer) Edward Shardey (Public Health Officer) F.Y. Banduah (Director, Town and Country Planning Department)	TMA are the authority in charge of the Tema region. The TMA were supportive of the project as they appreciated the need to meet the power shortfall. They confirmed that the project is located in the THIA and that it is prohibited for people to farm or live in the THIA. TMA has recently inaugurated a committee to find ways to stop people from farming or living in the industrial area, but no plans were yet in place. No specific concerns were raised. The project will require a building permit from the TMA. The application will require supporting technical and environmental studies. The Department of Urban Roads under the Tema Metropolitan Assembly should be consulted to assist with traffic situation during the transportation of equipment.
20/08/2015	**Sentuo Steel Company** Mr Emmanuel Ayensu (Administrative Consultant) Jojo Nutakor (Corporate Affairs Manager)	Sentuo Steel is located adjacent to the southern end of the TTPC site, approximately 500m southwest of the plant site. It is a steel scrap processing plant which produces cast steel billets and rods. They are currently constructing a new plant and are about 90% to completion. They have a direct electricity offtake from VRA and are not on the ECG network. Concerns raised were generally regarding safety aspects of the project and risk of explosions given the siting of large number of power plants and fuel depots close to their site, as they run at high temperatures. It was confirmed that they had no issues regarding the laying of project pipes in front of their company but they expressed that care be taken so not to break or destroy any existing pipes. They informed that dust pollution had been an issue in the area. Sentuo Steel Company had installed new dust collectors (start of August) to their old plants in response to complaints about dust pollution

Date	Stakeholder	Summary of Discussions
		from neighbouring companies. It was also confirmed that construction of their new plant had been halted by EPA.
26/08/2015	**Tema East Submetropolitan Assembly** Follow up meeting with Madam Rita Damani (Tema East Sub Metro Director)	A follow up meeting was held between EPL, the ESIA team and Madam Damani to discuss the proposed community consultation and socio-economic baseline activities. Madam confirmed that Tema East jurisdiction includes Community 1, 4, 6, 7, 8, 9 and New Town, and the THIA. It was agreed that these areas could be consulted as two groups (Tema new Town, and the rest as one group). The focus group approach and basis for this were discussed and it was agreed that the group from should consist of at least a representative of the Chief, women, youth groups, church and the relevant council. Madam did not feel the communities would feel left out if they were not widely consulted. It was thought that whilst some community members would notice the development works, the project itself would not have a widespread influence on majority of the community.
26/08/2015	**EPA (Accra Headquarters)** Director Badu-Yeboah (Environmental Compliance)	A follow up meeting was held with the director to update on progress with the project and ESIA and to discuss the proposed community consultation and socio-economic baseline activities. The EPA will be pleased to receive the submission. EPA reiterated that based on the location and limited impacts of the project, it did not require a socio-economic assessment and formal public disclosure for the ESIA or a full-scale ESIA report. However, the EPA understands the need for socio-economic assessment and full ESIA report, including proportional community consultation, to meet with international requirements. The EPA had no objections to the proposed focus group approach for socio-economic baseline data collections. EPL confirmed it would submit the report and request a 'fast track' review.
27/08/2015	**Tema Development Corporation (Tema office)** William Roso (Chief Surveyor)	TDC is a government institution set up to assist in development of Tema. It is the end owner of large areas of land in Tema, including THIA, which it leases to business or individuals including the VRA. Mr Roso did not know about the project, but welcomes new power generation and is supportive of the project. He had no specific concerns about the project, but noted that many companies have requested RoWs in the area so these need to be considered by the project and EPL should contact TDC to ensure all ROWs are appropriate. From his own knowledge of working within TDC, the drainage network in Tema and around the project

Date	Stakeholder	Summary of Discussions
		site is extensive and he is not aware of any historical flooding issues. TDC can guide disposal of construction waste. He believes that generally in the project area there is not significant contamination as previously the land was farmed. He could not confirm if there is a landfill which could accept hazardous waste. There is a landfill to the east of the site, near Kpone.
27/08/2015	**Sunon Asogli Power (Ghana) Ltd.**	Cursory meeting with un-named administrative person. Requested formal meeting to be arranged.
27/08/2015	**Trojan Power Limited** **TTPC** Plant Manager	The plant manager confirmed that he was aware of the Ghana Bridge Project, but not of the status. He provided an overview of the currently limited operational status of the plant (operating on a gas / diesel mix with only around 50% of the machines operating at one time). He had no specific concerns about the Ghana Bridge project. He confirmed that Trojan had plans to expand their plant into vacant land adjacent to the south of the current engine buildings.
05/10/2015	**Energy Commission** Anthony Bleeboo (Deputy Director, Office Technical Regulations)	The Energy Commission regulate and manage the development and utilization of energy resources in Ghana. They also provide the legal, regulatory and supervisory framework for providers of energy in the country, specifically by granting licences for the transmission. Mr. Bleboo informed us that a provisional siting permit had been granted for the project. The permit would only be validated on receipt of an Environmental permit and Grid impact study from GRIDCo. He also did not foresee any unacceptable impacts from the project.
05/10/2015	**VALCO** Harrison Adu-Agyei (Manager, Power and Integrated Aluminum Business)	The VALCO aluminium installation is located about 1km south of the project. VALCO is an aluminum smelter with a 200,000 metric tons/ yr production capacity. The company employs about 2000 people. Currently, they are operating at 20% production capacity because of power availability. VALCO has plans to build a power plant close to Atuabo, which would enable operation at full capacity. They could then expand their production capacity by 360,000 metric tons/yr. At full capacity VALCO require 380MW to operate successfully but at the current 20% production capacity they only require 75MW. They must have a continuous supply of electricity (24 hours/day/7 days a week) because their operations can't be

Date	Stakeholder	Summary of Discussions
		interrupted. They are currently use 500kV generators to power their administration block and hospital. Mr Adu-Agyei stated that as the project area was already designated for power generation, he did not foresee any problems, although did express concern about potential leakages from pipes. He was assured these aspects are considered appropriately in the ESIA . He stated that the power generated by the project could not be used directly by VALCO as it would be more expensive than their current source (hydro power). However, he supports the project because the additional electricity generated from thermal power would mean that a greater proportion of the hydro-generated power would be available to industrial users.
05/10/2015	**Sunon Asogli Power (Ghana) Ltd.** Scott Zhang (Electric Engineer) Delali Amaglo (PRO) Emmanuel Edu (HSE Officer)	Sunon Asogli Power Ltd. is an operating power plant located in the Kpone District in the vicinity of the site. The company is jointly owned by Shenzhen Energy group Company Limited (60%) and China African Development Fund (40%). They have a installed capacity of 200MW on gas and employee approximately 150 personnel. The company plans to expand their installed capacity by 360MW. The company representatives do not anticipate any problems or impacts from the project, which they support as it will improve supply of electricity in Ghana.

Table 21-4: ESIA Phase Consultation Meetings Held in June 2016

Date	Stakeholder	Summary of Discussions
01/06/2016	**Sunon Asgoli Power Plant, Tema** Mr. Felix Quansar (Premier Resource Consulting) Environmental Consultant	The EPL project and project team was introduced. Details of the Sunon Asgoli Power Plant were confirmed as: Phase 1: Two x 100 MW gas-fired CCGT GE plants, currently shut down as gas supply was cut off Phase 2: Two x 180 MW gas-fired CCGT GE, under development with first plant recently commissioned. Total capacity: 560 MW Premier Resource Consulting prepared the ESIA. Monitoring of stack emissions, as well as ambient air quality and noise at four plant boundary locations, was initially undertaken by Envaserv Research Consulting Ltd using an AQM65 Compact Air Quality Monitoring Station. The project subsequently purchased their own mobile monitoring equipment. There were calibration problems in 2015, so the data collected in 2014 is considered to be more representative and this was provided by email. Modelling to predict the impact of stack emissions has been undertaken. Details of the modelling have been requested and promised.
02/06/2016	**VRA Station 3, Tema** Amos Osei-Adu,Julius Amesimeku, William Tawiah Station 3 Control Room Technicians	The EPL project and project team was introduced. Details of the VRA Station 3 Plant were confirmed as: Two x 400 MW and one x 300 MW gas & diesel-fired open cycle Siemens plants, currently shut down as gas supply was cut off. Only one of the 400 MW plants is currently commissioned, but all are built. Stack heights are ~15-18 m. Total capacity: 1100 MW Normal fuel is gas, with diesel to be used on an emergency basis only. The implementation of co-generation to provide steam is planned and space allowed in the plant layout. Monitoring of stack emissions is not required by the Ghana EPA, as the design specification is well below the relevant standards. No modelling to predict the impact of emissions has been undertaken.
02/06/2016	**Trojan Power expansion** Information collected from VRA	Details of the Trojan Power expansion were confirmed as:

Date	Stakeholder	Summary of Discussions
	personnel as above, site observations and internet search	Thirty-six (36) x 1.56 MW gas-fired Type 16V 4000 L32 gensets, shut down at time of visit as gas supply was cut off. Total capacity: 56 MW Project delivered by MTU Onsite Energy.
03/06/2016	**EPA (Accra Headquarters)** Kwabena Badu-Yeboah (Ag. Director of Environment Assessment & Audit Division)	Meeting attended by site visit party along with EPL personnel: Richard Wilcock, Kingsley Asare, Maanaa Stanley-Pierre Kingsley submitted a formal notification of the intention to submit an addendum report to the ESIA due to changes in the project design. The format of the proposed submission was discussed. It was agreed that: - sections which have been substantially modified will be re-issued in full as standalone documents, - a comprehensive listing of other changes will be provided. - the updated ESIA will be provided in full Six (6) hard copies of all documents to be provided. An electronic copy will be needed once the addendum has been approved. The submission date is 24th June. The EPA advised that a reduced fee for the submission will be possible, since full fees have already been paid. The cumulative impacts of operations within the industrial complex were also briefly discussed. The EPA would like to undertake a strategic assessment of the air quality impacts, but have no funding to do so at present.
03/06/2016	Frederick Danso, HSE Manager Cenpower Generation Company, Kpone IPP, Tema	The EPL project and project team was introduced. Details of the Kpone IPP Plant and construction status were confirmed as: Two CCGT GE electric frame 9E turbines with double pass NEM HRSGs, Siemens' steam turbine. Start up on diesel, operating on light crude oil (LCO) or distillate (TFO). Under construction; to be commissioned Qtr 3, 2017. Plant hopes to switch to gas supply from Qtr 2, 2018. Modelling of predicted impacts to air quality has been undertaken. As this indicated a possible exceedance of some of the air quality standards, further design work is underway to reduce the impact to acceptable levels. Sharing of project data was promised following receipt of a formal request from the project.

Table 21-5: ESIA Phase Consultation Meetings Held in May/June 2017

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
03/05/17	Marado Company Ltd Robert Adomako (Director) Land owner of western portion of Stage 2 site (including switchyard)	Marado Company Ltd ('Marado') acts as a products distributor for European companies, for products including medical equipment, business stationary and electrical security and banking services devices (ID cards, access cards). Its offices are located in Community 12 in Tema EPL provided an introduction to the project, including all infrastructure, timing and development phases, including current pre-NTP activities. The ESIA team then confirmed the two purposes of the meeting as consultation as the land owner and formal stakeholder. The team also enquired about the approach planned by Marado for relocating the farmers currently on the site, and the EPL's expectations regarding compliance with international standards. The team asked the director about concerns or issues with the development and also about the farmers that have been identified on the Marado-owned portion of Stage 2 site. The project has entered in to a long term land lease agreement with Marado, and the Director confirmed Marado is very supportive of the project. It originally wished to become a shareholder, but agreed a long lease instead. The director is aware of the farming on the site and has been in communication with the farmers to inform them about the leasing of the land and future development for EPL. The farmers are not relatives of the director or any other company member. There are 2 male farmers, along with relatives helping them. The names they have given to the land owner are Ali and Busanga. Farming has taken place for three years on the site. Farming only now continues in certain areas as the company has been trying to sell the land for many years. Marado confirmed it is pleased to support the project and does not have any concerns regarding E&S or other impacts associated with the development. It supports the project because power is very much needed in Ghana	N/A
03/05/17	Department of Urban Roads (DUR), Tema	DUR is located in the main Tema township, Community 21. This government agency's main mandate is to oversee the construction and maintenance of all roads within the Tema District with the exception of those within	The team confirmed that an ESIA has been completed and approved by NEMA and that this is currently

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
	Mr. Benjamin Bampoe (Director) Mrs. (Administration) Mr. Kingsley Donkor (Contracts Manager) Mr. Richard Amankwa (Maintenance & Supervision Manager)	Ashaiman and the main Tema highway (motorway). They also oversee roads within their neighbouring Kpone-Katamanso areas. The agency has only recently (2016) been devolved from decision making at main government level. A brief introduction was made about the project to the DUR team including the project's plans to drill beneath Valco Road and to place protective barriers adjacent to road crossings of the TOR pipeline RoW. The team requested confirmation of the procedure for the approval of the placement of concrete crash barriers for pipeline protection. The team also requested for maps of underground pipe network of proposed site areas so as not to impact existing drainage and pipelines of nearby companies. Unfortunately no such maps are available at DUR, Tema. The DUR team indicated that requirements for road crossings and road furniture placement include the submission of a traffic impact assessment to the DUR, Tema for approval (Road Crossing permit). Road Crossing fees are to be paid to the DUR, Tema for all road crossings and are charged per meter. Approval of all subcontractors for under-road drilling is to be done by DUR, Tema. Subcontractors must be included in the DUR's approved list of contractors. A letter is to be submitted in this regard with a profile of all contractors and subcontractors to be approved for 'no objection'. The 'no objection' letter would take less than a day to be processed. Clearances are to be checked from all relevant government departments (stakeholders) within the project area. Joint inspection/ inventory to be done with DUR, Tema to ensure road reservation boundaries. The Director expressed his agreement with project overall as he is of the opinion that power demand will increase in the near future with the increase of commercial and industrial activities in the area. Concerns: Local content percentage usually not satisfactory to the surrounding communities for similar projects. Also, community members would prefer direct contact to plant management.	undergoing amendment. The ESIA includes a transport assessment. With regards to local content, EPL has produced a Social Investment Strategy to be implemented as part of the project. This is geared to provide an appropriate level of support to local people in communities close to the site. As the project is designed to comply with both Ghana and international standards, it was confirmed that the human resources procurement process has significant local content requirements in line with IFC PS2. The team confirmed that the project will implement a grievance mechanism for the community to have direct contact with the plant's management team. EPL confirmed that it will notify DUR once notice to proceed has been issued and that its contractors will liaise with DUR in co-ordination with TDC regarding amendments to existing permits to allow for crash barriers/road crossings, regarding the proposed transportation routes and managing associated impacts, for example through implementation of the project's Traffic Management Plan.

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
		Inquired of any CSR actions to be implemented during the lifetime of the project. Inquired of traffic disruptions and appropriate diversions.	
03/05/17	Volta River Authority (VRA) Mr. Hans (Environmental Manager)	A brief update was given on the project changes and new sites, including regarding the ongoing pre-NTP works and proposed timing of post-NTP works. Mr Hans confirmed that comments and concerns have been previously provided on behalf of VRA in the form of meetings and responses to questionnaires during previous consultation rounds. The previous concerns were mainly regarding the proximity of the originally proposed EPL plant location to the existing VRA power plant(s). As the new EPL project plant sites are further away, these concerns are no longer relevant. He confirmed that the Trojan site is dual fuel but was formerly running on either LPG (liquefied petroleum gas) or compressed gas before it was shut down due to inadequate gas supply. Currently, only the diesel powered machines are in operation. There have however been about 4-5 fires in the last 6 months at the Trojan site. Capacity of VRA/Cenit Power is 2 plants of 110MW each, GE Frame 9 turbines. They currently operate in open cycle mode and there are plans for expansion to combined cycle mode. Mines Reserve Plant - 60 MW capacity, running on gas, though one unit is currently down. The whole station is to be decommissioned in 2019. New replacement stations are under consideration, possibly frame 9, but there are limitations due to the current available transformer capacities. These would also run only on gas. VRA performs hand held ambient air quality monitoring. They used to have a weather station and static air quality monitoring unit, but now use mobile hand-held units for testing due to lower operational costs and flexibility. They are willing to share data with EPL providing a letter is submitted per the request. It was explained that the ambient air quality data was to aid the shared responsibility in environmental air quality management of the area to which Mr. Hans agreed, reiterating that	EPL confirmed it is also committed to sharing information to protect the airshed. The team indicated it will submit an updated data request letter along with the notes of the meeting.

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
		it was the responsibility of all the companies in the area. The new Station 3 Seimens machines have a capacity of 49.5MW. However, they have not been commissioned as no gas is available for operation. VRA would use LNG if required quantities were available, but this is not yet possible. The VRA / Cenit power plants are currently running on LCO (light crude oil), diesel and gas. Operations have been curtailed as LCO supplies have been depleted. Station 3 has not been in operation since last year May (2016) due to lack of gas availability. Gas mainly reaches the Sunon Asogli Power plant but not enough to reach VRA. The Station 3 expansions run on a dual fuel system while the old Station 3 machines are gas only. Mr. Hans had no further comments or concerns different from what were previously noted. He is not aware of any flooding or records of historical flooding within this part of Tema within the past 10 years. He attributes this to the large storm drain between the VRA site and the EPL site which intercepts all runoff.	
04/05/17	Tema Oil Refinery Jetty GPHA (Ghana Ports and Harbour Authority) /TOR (Tema Oil Refinery) Jetty tour Mr. Isaac Kankam Boadu (Electrical Technician)	A tour of the TOR jetty was provided by security and technical start. An off-load of lube oil was in progress during the visit, therefore the team could not access the loading arm area. The jetty handles petrol, gas oil, RFO (Residual Fuel Oil), and naphtha (light and heavy) for import, distribution and also exportation from TOR. The 5 loading arms include: 6” loading arm for discharging LPG 10” line for refined products (inc. naptha) 6” mainline, and, 18” for RFO and crude oil. The arm is coupled with a manifold and petroleum products discharged to TOR. There are different arms for different products. They also have a booster station at TFC (Tema Fuel Company). EPL is planning to install a 12” loading arm to be discharged once a week. It is proposed to	EPL to formally request TOR EMP’s including emergency spill response and clean up, as well as fire procedures etc.

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
		replace the existing 8" LPG loading arm. For 7000/8000 metric tonnes, it usually takes an average of 3 days, a minimum of 2 days and a maximum of 4 days to discharge LPG continuously from a vessel. The maximum gas that can be discharged is 8000 metric tonnes due to the available capacity of their storage tanks. TOR has an environmental and safety management system including emergency response plans for spills and fire systems. Formerly they used a pigging system for cleaning the pipes and separating oil products. The current system however, involves washing with water then separation for oil pipelines, and 'air blowing' for gas pipelines. They drain oily contents into a sump and expel any remaining fugitive gas contents through a vent at sea level. Sump contents are loaded onto a truck for reprocessing at TOR. Firefighting is overseen/operated by Ghana Ports Authority and Ghana Fire Service, but there are fire lines and fire wardens in the operational staff. TOR Also incoming vessels have their own procedures which include the filling and exchange of lists of fire prevention and management equipment. This is done in order to know what each team has available. There has however been no major fire accident in over 10 years. The surrounding sea water is clean and clear with no sheen, no visible spills and smell of petroleum products.	
	20 20 Construction and Engineering (land owner of eastern section of Stage 2 site) David Kojo Anagbo (Director)	20 20 is an engineering and building construction company. The Stage 2 site land owned by 20 20 as a commercial investment. 20 20 was considering a number of other development scenarios before EPL contacted them regarding the project. EPL provided an intro to the project followed by the ESIA team, which confirmed the two purposes of the meeting as consultation as the land owner and formal stakeholder, and also with regard to confirmation about the approach planned for relocating the family living on the site and the small business, and the EPL's expectations regarding compliance with international standards for managing the relocation of the PAPs. Historically, Ghana was suffering from the 'Dumsor' ("off/on") issues, with power supply	EPL and the ESIA team committed to liaising with 20 20 going forward regarding the relocation/compensation process for the affected PAPs.

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
		and Mr Anagbo was personally affected at home and commercially through the cost of running generators. EPL then engaged with 20 20 regarding use of the land for Stage 2 of the proposed project and an agreement was reached in March 2017. 20 20 fully supports the project and has no concerns. 20 20 has been notified in regular discussion with EPL about the planned construction programme. The caretaker of the site is a close family member who lives on site with his wife and at least one child. He provides odd-jobs including building/masonary services for businesses in the area and does not actually 'work' on the premises. 20 20 also informally allowed a portion of the site to be used free of charge by a Small transport and distribution company – God Knows Enterprise. He has identified a place to relocate his business and 20 20 will provide assetance for the move. Mr Anagbo confirmed that God Knows may opt to move to Accra or move back to his village. EPL reminded Mr Anagbo of the clause in the land lease documentation regarding compliance with international standards. The team talked through the general requirements of PS5 and Mr Anagbo agreed to work together with EPL to ensure that an appropriate process would be put in place.	
04/05/17	J. Q. Packaging Limited Mr. Gary (Marketing Manager)	EPL provided a description of the project and provided notification of the proposed schedule including commencement of pre-NTP and pipeline activities. A brief recap of previously discussed plans for EPL's noise level measurements was provided. The ESIA team then explained the background to the monitoring and also gave an overview of the noise assessment that would be undertaken as part of the ESIA. The noise monitor was set up at the J.Q. living quarters, close to the nearest window facing the proposed EPL site. The block also serves as store room, but one male worker is currently residing there. Set up was completed at 2:25pm to be picked up on the following Saturday (06/07/2017) afternoon.	
04/05/17	Trojan Power Philip Taylor (Plant Manager)	EPL provided a description of the project and provided notification of the proposed schedule including commencement of pre-NTP and pipeline activities. The new expansion was installed in 2016/17,	N/A

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
		but is not operating. It is a Trojan and V Power joint venture with 50MW capacity. New regasification facilities are being built adjacent to the new expansion to deal with either liquefied NG or compressed NG (not confirmed) and will apparently be delivered by truck from the harbour. The first consignment apparently be delivered in June. Sunon Asogli will also use the LNG and has almost completed its regasification unit. Trucks will deliver via VRA compound entrance, not from the south although construction access will be from Valco Road through the Cirrus Oil Limited terminal. Trojan 1 previously used biofuel, but not currently available so now using diesel. 32 CAT engines provide approximately 25MW full capacity, but currently only 6 engines are running whilst other engines are being refurbished so likely output of ~5MW. Trojan 1 is planned to be replaced with 40MW repowering, comprising 4 x 10 MW gas engines. Trojan 2 is 20.8MW full capacity with 25 CAT engines. 16 engines running presently on diesel. A discussion was held on Stage 1 power cable RoW from Stage 1 site into GRIDCo switchyard. The Trojan construction workforce had recently cut through an electric cable as part of works for the LNG tanks. Trojan is supportive of the EPL project and does not anticipate any environmental or social issues associated with the project as it is located in the heavy industry zone and outside the Trojan company boundary.	
05/05/17	Cenpower KIPP Frederick Danso (HSE Officer)	EPL provided a description of the project and provided notification of the proposed schedule including commencement of pre-NTP and pipeline activities. Cenpower Kpone Independent Power Producer (KIPP) are constructing a large ~350MW CCGT plant with two Frame 9e GE turbines, HRSGs, steam turbine and once through seawater cooling system. KIPP provided a tour of their site to EPL and the ESIA team representatives. KIPP does not have any concerns about the project. Mr Danso is supportive of the EPL project and wishes to work collaboratively with regard to ambient air quality management	N/A

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
		issues. An information request letter was submitted again	
05/05/17	Aksa Energy Samuel (Aki) Essuman (Environment Manager)	EPL provided a description of the project and provided notification of the proposed schedule including commencement of pre-NTP and pipeline activities. The Aksa plant has a permit for 370 MW - 22 x Wartsilla reciprocating engines. However, only 3 of 4 phases (power houses) are currently constructed with 11 x 17MW units are commissioned and installed capacity at ~200MW. Whether the next phase proceeds depends on ongoing commercial discussions. Cooling is via radiators. Water is bowsered in, but pipeline to Ghana Water Company connection is in planning. There are currently 3 x 70m combined stacks. 7 units are connected to stacks currently with 4 in progress. The plant was commissioned at the beginning of April 2017. Aksa conducts monitoring through an on-site air quality meter including data for CO, NO2, SOx, PM1.0, 2.5 and PM 10. Aksa also has a weather station. Instrumentation is calibrated every three months. The EIA apparently includes assessments using a 90m stack and predicts grounding of plume concentrations at times 462 m in Blue Ocean Investments (Puma Energy aviation fuel). Currently the site has 70m stacks and no continuous emissions monitoring system (CEMS) is installed. Manual stack monitoring and wider community ambient monitoring is planned, but has not yet commenced. No hazardous waste has apparently been generated by the project yet. HFO apparently does not require in site treatment so sludge disposal is not an issue. Oily waste goes to Ecostar and inert solid waste goes to Zoom Lion. Mr Essuman is supportive of additional power projects in Ghana. He had the following questions/comments, How is EPL managing stakeholder and community consultation and how is EPL considering air quality. Suggestions: Geotechnical investigations should be undertaken as the ground conditions in the THIA can be difficult. He advised that H&S measures are strictly implemented as this can be a challenge in	The team confirmed that a comprehensive stakeholder engagement programme has been initiated by EPL. This includes community focus group meetings along with stakeholder engagement meetings such as this. The EPL project utilises LPG which is the cleanest fuel aside from natural gas and so the plant will contribute less significant air emissions than almost all the other plants in the air shed. Significant impacts from the project emissions were not predicted by the ESIA. Mr Essuman's suggestions are kindly noted by EPL and the

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
		Ghana. For waste management, he commented that it is important to use a registered local company to dispose of waste.	ESIA team. The team confirmed that the project will enforce an international standard EHS management system, which will include appropriate waste management and disposal protocols.
08/05/17	Kpone Katamanso District Assembly (KKDA) Mr. Vincent Yeboah (District Works Engineer)	KKDA is the local municipal authority for the portion of THIA which includes the plant and tank farm infrastructure and much of the below ground section of the pipeline. This includes the section of Valco Road where there are a number of informal kiosks (opposite Sentuo Steel) which could be impacted by the pipeline route if it is not possible to use the northern-most road reserve. The meeting was requested both as an updated consultation meeting, but also to discuss potential displacement issues and associated options in the event that the pipeline could not be routed on the north side of Valco road. Mr. Yeboah was present at the sod-cutting ceremony for the EPL project. The KKDA offices are adjacent to the Kpone Traditional Council. Its jurisdiction covers Kpone and Aburi area, sharing boundaries with Tema to the west, Dangbe West to the east and Akuapem South (Aburi area) to the north, and Gulf of Guinea to the south. KKDA provides planning / building permissions. It was noted that EPL obtained Stage 1 and tank farm building permit in February 2017 and the pipeline permit in April 2017. EPL provided an update on project progress, including notification of the likely timing of notice to proceed and summary of the pre-NTP works including the site preparation and the potential requirement to relocate the kiosks. For safety reasons, the kiosks would not be able to remain on the pipeline right of way after construction and so an alternative site would be necessary. Mr Yeboah wasn't fully aware of the latest pipeline route and appeared not to be aware that pipeline setting out had commenced. Mr. Yeboah advised that EPL should involve	EPL assured Mr Yeboah that it will involve KKDA in any potential discussions regarding potential displacement impacts and will share the existing ARAP prepared for Stage 1 of the project. The ESIA agreed that if relocation occurs, it should ideally be close to the existing site or other kiosks will move into the area to accommodate the supply need for local businesses.

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
		the assembly in any discussions the kiosk owners and that any stakeholder meetings should be held at the EPL premises if possible, rather than KKDA. Mr Yeboah confirmed that the kiosks do not have legal tenure for their site as they are located within the heavy industry zoned area and that they are likely to be moved in the future once a local solution is agreed. If required, any relocation should be close to the existing site so as not to disrupt the activities of the vendors and also help to retain their customer base in the adjacent industrial installations. Also that EPL consider construction of more formal (and tidier) structures for the kiosks on an alternative site to be agreed with KKDA and TDC. One potential relocation site was identified by KKDA adjacent to Sentuo steel, but further advice would be provided once a KKDA representative had visit the site. It was agreed that EPL would schedule a follow up meeting with KKDA to survey the existing area and suggest alternative sites for relocation. A discussion was held on appropriate methods for ensuring that, if resettlement of the kiosks is required, new kiosks cannot move on to the vacated site. Mr Yeboah suggested EPL could erect a fence or steel posts to prevent cars from parking along the road reserve area and therefore providing. KKDA would also use its inspection team to safeguard the area and handle any complaints about new encroachment. A separate discussion was then held on the permissions for roadside storm drainage. KKDA confirmed that drainage can be constructed within the path of the pipeline under the already provided permit; however, associated engineering drawings must be submitted to the KKDA. This includes future road designs. Opinions on the Project and concerns: Mr. Yeboah considered that granting of EPL's planning permits demonstrated KKDA support for the project. He considered that potential impacts to the area are progressive and so would likely not the seen immediately. He indicated KKDA formed a partnership with CenPower to collaborate for CSR activities and that any community activities should be designed to provide benefits to the wider	EPL confirmed that it is implementing a Social Investment Strategy (SIS) which is currently in draft form and would be discussed with KKDA going forward. The draft SIS currently includes actions such as support for local schools at Tema New town and youth training/scholarship opportunities. EPL also confirmed that the project will follow Ghanaian and international requirements regarding labour issues and local content. EPL requested an inventory of the KKDA youth / local workforce and their respective skills so that it could share this with its EPC contractor.

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
		KKDA jurisdiction. He enquired after employment opportunities and employment and noted that KKDA should be involved in the employment process to make more job opportunities more widely available to community members. Overall, he is happy about the project and also looks forward to the inception of the project as well as the involvement of the local work force in the project.	
09/05/17	Tema Oil Refinery (TOR) (Environmental and Safety Management Department) Seth Acheampong (Senior Safety Officer) Mark Quist (Environmental Services Manager) Mrs. Mary Kwafo (Senior Environmental Officer)	Meetings were held with TOR's environmental and safety team and also with the inspection team. A brief introduction was giving on the EPL project and the latest changes. EPL requested information on TORs operational monitoring and inspection activities along its pipeline RoW which EPL will be utilising. Also requested were copies of TORs management system documents, including fire and emergency response and whether any improvements to security were planned by TOR – particularly with regard to public access. TOR's Projects department is currently leading commercial discussions with EPL, but the Environmental department is aware of the project. The request for management plans should be by letter to the TOR managing director. It was confirmed that TOR has the following active product lines: 24" crude oil line; 18" Residual Fuel Oil (HFO); 14" gasoline; 10" gas oil / kerosene oil line; and, 6" LPG. TOR owns its RoW. It has security posts every 200m along the pipeline and the security guards do visual inspection of the pipeline. TOR also has an inspection department which routinely inspects the pipeline, including physical integrity. CCTV monitors were installed, but not working currently. There is not sufficient space for car/truck access down one of the lines. RoW technical inspections are annual (during March or April), including thickness testing. Visual inspections are continuous by security. Hydro tests are done on any repairs or new	EPL will issue a formal information request letter to TOR regarding for formal details on safety procedures, emergency response planning etc. EPL confirmed that the EPL permit from the

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
		lines in combination with visual inspections. Previous issues include diesel tampering and issues with crude oil line due to seawater (no further details provided). Various measures have been proposed to address these. The security posts were installed to stop the diesel tampering problem, which has been successful. Meetings are ongoing regarding further corrective works, but budgets are limited. TOR has had two significant fire accidents in the recent past. The most recent, in 2010, was a fire outbreak on the naptha pipeline caused as a result of a leak from a rusty section of the pipeline. Flooding during wet season promotes vegetation growth which obscured the pipeline. Naptha flowed on the water to an ignition source. The location is 200m south of the Valco Road behind the CPC (Cocoa Processing Company) premises. This area is one of the two hotspots on the line. A second fire occurred prior to this close to the PSC Shipping yard. At both locations the pipes run below the railway tracks. Apart from their exposure to the general public some of the pipes are positioned under railroad culvers. TOR would like some collaboration to elevate these pipes in order to avoid water contact under the road. Lighting along the corridor also requires improvement and CCTV cameras placed along the corridor are no longer functional. There remain 2 'hot spots' – the one behind CPC where the previous fire occurred and one is closer to the harbour by PSC Shipping Yard. Both are where culverts run beneath an old decommissioned rail road. They have proposed remediation works to improve these crossing, but these have not yet been implemented. The TOR representatives are supportive of the project and feel that power projects should be constructed in areas like Tema which are specifically zoned for the purpose. However, they noted the following questions/concerns: What is EPL's environmental permit status and how will the EPL plant be operated? There was a concern about possible limited LPG supply to the public consumers due to EPL's additional use of the product. Mr. Quist also enquired about the layout of the EPL plant, and whether exhaust gases and	EPA is in place and the plant would be operated in line with the permit conditions and international standards. EPL explained that the project is constructing a new LPG pipeline with double the existing 6" capacity which will be owned and operated by TOR. EPL will have its own LPG tank farm and is only utilising two of the TOR storage spheres. The project will therefore improve the existing LPG supply context in Ghana. The EPL project will also switch from LPG to natural gas in future further improving LPG availability. EPL observed that its plant sites are located beyond the existing VRA power plant complex and that the design of plant addresses associated air emissions and safety risks, as detailed in the ESIA. A sprinkler system for the spheres as well as full fire-fighting system for the plant sites and tank farm will be in place in line with Ghana fire service requirements and international standards. EPL is supportive of forming a working group with regard to the pipeline ROW safety issues and other issues which may emerge as part of the project.

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
		associated temperatures would be a risk to the TOR tank farms. He also asked about the fire and safety systems to be employed on the EPL tank farm. Mrs. Kwafo observed that EPL's presence was an advantage as it would increase the LPG supply capacity for TOR. They also asked if EPL's pipelines were ready. The pipes to be placed outside the TOR premises are ready but the pipes to be installed within the TOR plant are yet to reach Ghana. Mr. Quist suggested the formation of a TOR/EPL working group to handle arising issues. As the enclave grows, the safety risks also increase, particularly regarding road congestion due to tankers and access for emergency services. Proposals have been made to authorities for a dual carriage way to decongest the area, but these proposals are yet to be implemented.	
09/05/17	Tema Oil Refinery (TOR), Inspection Department Ebenezer Acquaah (Inspection Manager)	Follow on meeting to the above, held with the above H&S team present. Mr Acquaah confirmed that TOR in-house inspections are performed depending on the type of product. Lines outside the TOR plant (from the jetty to TOR) are checked annually. The department maintains the pipelines via visual checks for pipeline integrity as well as rust control, thickness checks, hydro checks for leaks and also makes replacements as and when they deem it necessary to do so. The team does walkovers from the jetty to TOR and from TOR to the jetty. This annual inspection is done by March/ April. The Inspections manger reiterated the need for an improved road network in the area and restriction of sensitive areas to the public. He also mentioned the historical issues with tampering with product lines and has proposed fencing, barriers etc. These recommendations are under consideration, but yet to be implemented due to financial constraints. He is supportive of the EPL project and agrees that a working group to discuss the ROW safety would be a good idea.	N/A
09/05/17	EPA (head office) Peter Akampa	EPL provided a brief update of project changes since last Environmental Permit update, including emerging issues and shared plans for updating the ESIA with associated consultation activities. PEL requested confirmation as to how the EPA wished to	EPL confirmed that it will issue the update letter to EPA as requested.

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
	(Permit officer – prepared EPL permit)	receive the updated ESIA. Mr. Akampae advised that a letter should be written to notify the EPA of changes and plans to reorganise the ESIA report. Plans for amendment would not affect the current environmental permit. Mr Akampe is very familiar with the EPL project as he prepared the EPA permit, though did not review the original ESHIA in detail. He considers that EPA is satisfied with the approach taken by the project as the permit was issued. Mr Akampae advised that he is not aware of any other new plants or expansions known to EPA for the Tema area, other than those already known to EPL (e.g. AKSA, Cenpower, Asogli, Trojan).	
21/06/17	GOIL (Ghana Oil) Mr. John Kojo Mensah (Depot Manager)	The team provided a brief update of project changes since the previous consultation, the planned updates to the ESIA, timing of the project development and particularly with regard to the potential pipeline route change which may require crossing the GOIL driveway, which could impact its business. Mr. Mensah said he was pleased to be of assistance and showed the Project team around the GOIL premises, including confirming the location of pipelines and connections to Tema Fuel Trade, and older connections to TOR. He reported that fuel supply from TOR has ceased due to issues with TOR plant and GOIL had therefore sought supply from Tema Fuel Trade. GOIL is planning a significant investment with refurbishment of the current site warehouse, installation of 3No. steel spheres for fuel storage, and purchase of more sprinklers and fuel tankers. Mr Mensah explained that GOILs Tema premises are the central storehouse for fuel tanks etc. for all stations and other distribution locations. They supply significant customers with fuel, including the president's office, and also store fuel for future purposes. GOIL is supportive of the project and did not having any concerns regarding EPL's upcoming excavations. The GOIL staff do not work on holidays and weekends and Mr. Mensah kindly requested that EPL carry out the works over a weekend – and preferably a long weekend. He is willing to work with EPL to schedule the dates and excavation pan when EPL is ready to do so.	21/06/17
21/06/17	Sentuo Steel	The team provided a brief update of project	21/06/17

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
		changes since the previous consultation, the planned updates to the ESIA, timing of the project development and particularly with regard to the potential pipeline route change which may require crossing the GOIL driveway, which could impact its business. A recap of earlier consultations with Sentuo Steel were discussed. Sentuo is concerned with the potential crossing of its driveway by the EPL pipeline as it was felt that Sentuo could be held responsible for care of the pipeline by TDC, given TMA and TDC have written to them severally concerning the upkeep of the frontage of their premises. Sentuo would require a written guarantee of safety and the assurance that that they would not be responsible for any care of the pipeline. Sentuo is also concerned that further new developments may result in requirements for its own plant to install additional emissions mitigation measures, as has apparently been required by EPA in response to issues with the VRA plant air intakes. Sentuo requested a written guarantee from EPL that it would not require them to undertake such actions in the future. As the Sentuo Managing Director is currently travelling, it was requested that a follow up meeting is held with EPL when the MD returns. No other concerns regarding the EPL project were presented.	
21/06/17	J. Q. Packaging Limited Mr. Gary (Marketing Manager)	The meeting was arranged to discuss and show Mr. Gary the results from the noise assessment and discuss potential mitigation solutions for the temporary impacts during Stage 1a. The ESIA team explained that the first phase of the project would be the noisiest, due to the operation of gas turbines without the ‘combined cycle’ steam generation component. This will be like the noise of small jet engines coming out of the top of the 30m exhaust stacks and the levels would likely be above guidelines for sleep disturbance at the JQ worker accommodation, without mitigation. Stage 1a will last for approximately 15 months. After this point, for Stage 1b and Stage 2, with the addition of steam turbine, the noise will not be of concern. The results were explained using the map of noise model data output for sound levels and also a	21/06/17

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
		drawing of the plant. The team proposed that shipping containers could be used to construct a temporary barrier ~9 high during Stage 1a, to reduce the noise to the worker accommodation. Modelling results were used to show how this would reduce the noise levels. Mr. Gary expressed no concerns with the proposed mitigation method and asked if JQ would need to buy the containers. The team suggested that containers may possibly be able to be rented as it would only be used for 15 months. Mr. Gary indicated that J. Q. Packaging would bear the cost for the containers and their stacking. However, he indicated he would need to discuss with his managing director. Overall he was in agreement about the process. He commented that he could not be certain about the loudness of the noise from the EPL site and whether the mitigation was appropriate until operations begin and they experience the noise for themselves.	
21/06/17	Tema Fuel Trade Ltd. Mr. Andrews Baafi Owusu (Director, Operations and Technical Services) Mr. Samuel Anim (Marketing Manager)	A brief introduction to the Project, latest changes and schedule was provided by the project. The team requested feedback on the potential pipeline route and also the possibility of relocating some kiosks on to a site proposed by KKDA, adjacent to Tema Fuel Trade. Mr. Owusu, mentioned that he was part of the committee with NPA that initiated the use of larger sized LPG pipes for fuel transfer from the TOR jetty. He commented that the kiosks along the proposed pipeline are illegal as they have no permits and so can be removed by the authorities. Fuel Trade staff do not patronise the wares of these vendors and apparently brought in the police some time ago to remove some kiosks. Mr. Owusu suggested that the site recommended by KKDA for the relocation of the vendors is under litigation between VRA and an original land owner. Fuel Trade also attempted to buy the land but was not permitted to do so. Mr. Owusu wanted to know the proximity of EPL to their premises as well as the temperature profile and indicated concern regarding the potential for emissions to impact the company's fuel tanks. Mr Owusu indicated that there had been	21/06/17

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
		violent altercations between his staff and Sentuo Steel in 2011. The development of the Fuel Trade Ltd. premises started in 2010 and was completed in 2013. Mr Owusu did not have any other concerns regarding the project.	
21/06/17	Environmental Protection agency (EPA) Mr. Kwabena Badu Yeboah (Acting Director - Environmental Assessment & Audit Division)	The purpose of the meeting was to give an update on the project's latest changes, development progress and schedule. Also in regards to emerging environmental and social issues (including the potential displacement of kiosks) and also to seek comment on how to proceed with the current revision of the ESIA. Mr. Yeboah advised that a letter should be written to notify the EPA of Project changes and plans to update the ESIA report. Mr. Yeboah asked, whether a location under consideration for the relocation of PAPs along the pipeline rout was an appropriate ROW. He also asked about the depth of the pipeline, to which Mr. Asare responded that it would be 1.2m or deeper depending on the slope of the area. Mr. Yeboah proposed there should be an appropriate project canteen on the EPL site or space for vendors. He indicated this should be for all installations as it's required by law. The fact that these are not installed by developers provides the market for the kiosks. The kiosks do not have legal tenure as they are located in the THIA which is zoned for heavy industrial use. In response to Mr. Asare's query regarding the process for ESIA completion, Mr. Yeboah advised only an addendum was needed. However, given the scale of the changes, requested a preference for submitting one complete revised document, which confirms in each chapter the areas of amendments, along with a cover letter which summarises the changes. It was estimated that the ESIA Draft final would be ready in 2 weeks and feedback from previously noted EPA comments will be included in the new report. Mr. Yeboah explained that the permit would remain in place. However, it will be reissued to reflect the project changes, but would still maintain the previous date of issue. He also confirmed that a letter should be written regarding the renewal of the permit about 2 months to expiration. The Project team reported that the issue	21/06/17

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
		concerning J.Q. Limited and noise levels from stacks during Phase 1a is being addressed through the ESIA noise assessment and mitigation has been identified and discussed with JQ in consultations. Mr. Yeboah added that J.Q. is not an EPA concern as the housing is illegal and should not be present in that area. The Project team reported that the Stage 2 site farmers and residents are to be relocated by the landowners, with EPL undertaking an assessment to consider compensation of remaining farmers. Also that EPL will monitor the resettlement done by the land owners. The team also disclosed an issue whereby TDC began to remove some of the kiosks from an area being considered for the potential pipeline route, but that EPL intervened to request that this ceases until the pipeline route is finalised (with the objective to avoid the kiosks). Mr. Asare requested confirmation that the remaining pipeline preparation and ultimately construction works could continue in the areas without any kiosks, which was agreed by EPA. However, EPA requested that a letter is to be written by EPL to seek approval from EPA for construction to continue in the location of the kiosks if this is ultimately required. Mr. Asare expressed concerns about the danger of possible explosions from leaks while vendors are situated on the lines. Mr. Yeboah answered that EPL should would work with TDC and communicate with the EPA Tema office to coordinate the process of relocating vendors in the event that kiosks are required to be moved. The ESIA team enquired about pollution from Aksa's plant site. Mr. Yeboah said he was aware that the plant is operating without connection to the stacks and that there had been actions taken already by EPA, with further action still to be taken. He reported that some companies have been shut down due to such pollution issues. There are plans to look at the airshed in that area (a strategic impact assessment) as well as individual companies' emissions. Mr. Yeboah reported that the existing 225MW Karpower ship is to be replaced by a 450MW power ship. The 225MW ship is to be sent to Takoradi when the new ship arrives at Tema. The new ship dimensions are 100mx300m. It	

Date	Stakeholder	Summary of Discussion	EPL / ESIA Team Response
		will run on HFO but can be switched to gas. The ship is under construction in Istanbul and will be completed by 15th July. The ESIA team described the potential flood risk at the THIA, specifically at the storm drain crossing of Valco Road. He explained that although drainage is the government's responsibility, important Project structures will be appropriately raised above the ground. The team also discussed the air quality issues and expectation that there remain no significant impacts from the project when operating on LPG. It was discussed that DFO modelling was being undertaken to look at potential impacts in the event of disruption to LPG fuel supply. The director noted this information.	

Whilst all efforts were made to consult with identified stakeholders, it has not yet been possible to arrange meetings with the following potential stakeholders:

- Cirrus Oil Terminals;
- Top Archive; and,
- Glas Brown Company.

EPL will continue efforts to arrange these meetings and gain feedback from these stakeholders.

21.4 Community Focus Group Meetings

Two rounds of focus group meetings have been held for the ESIA process, one in 2015 and a larger one with representatives from the previous focus groups for the latest amendment of the ESIA in June 2017.

Representatives were invited from the nearest surrounding communities. These include:

- Tema New Town;
- Kpone town; and,
- The metropolitan area of Tema, to the west of harbour road and west of the LPG pipeline. This area includes communities 4, 9 and 7 and the Sraha and Kortu-Gori districts.

Details of the focus group meetings and format are considered in the socio-economic assessment (Section 20) and will be included in the project SEP.

For the first round of meetings, two Ghanaian consultants from the ESIA team were present at each of the meetings along with EPL representatives, and an international consultant from the ESIA team was involved by teleconference facilities.

For the 2017 meeting, the international consultant was able to joined EPL and our Ghanaian partners to disclose the updated findings from the ESIA.

21.5 Engagement of kiosk owners/ vendors

Interviews (and socio-economic survey) were undertaken with the owners of the informal kiosks located within the original pipeline route alignment and tank farm site during the ESIA process. Details of the findings of these meetings are included within the socio-economic assessment, Section 20. They will also be included in the project SEP and these kiosks were included in the Stage 1 ARAP.

During design discussions regarding the Valco Road pipeline section, engagement (and socio-economic survey) was undertaken with the group of kiosks located opposite Sentuo Steel and Ghana Oil (see Section 20). The route ultimately selected (subject to detailed design survey) has been developed to avoid all apart from up to five kiosks. These will be considered in the Stage 2 ARAP as required. EPL will continue to engage with the remaining kiosks as part of the Stage 2 ARAP activities and is considering if it is feasible to include associated support initiatives within its Social Investment Strategy.

21.6 Summary and Conclusions

A comprehensive stakeholder engagement process has been undertaken for the purposes of the ESIA and will continue throughout the project lifecycle. The main issues and concerns of the local communities and other key stakeholders include:

- The delivery of jobs to the local community;
- The safety of the site and project infrastructure, including the pipeline; and,
- Cumulative impacts from the development.

These concerns have been considered in relevant studies within this ESIA. Key sections are the community health and safety discussion within the socio-economic assessment in Section 20, and also the air quality assessment in Section 11. Appropriate corresponding mitigation actions and / or management measures are included within the ESMP.

21.7 Actions

Stakeholder engagement will continue throughout the lifetime of the project in line with the requirements of the SEP. Implementation of the SEP will require the development of specific communications materials using culturally appropriate language and design aspects.

On-going discussion will continue between EPL, TMA, KKDA and the kiosk community representatives with support from the ESIA team and KINA Advisory to form agreements on what EPL can realistically provide as part of its SIS and how any issues can be managed.

The SEP, along with this ESIA and relevant construction phase related documentation (e.g. management plans etc, will be disclosed on the EPL website and hard copies will be held at the locations in the Tema/Kpone area (e.g. KKDA offices and Tema EPA office).

It is understood that KINA Advisory Ltd. will continue to act as internal advisor to EPL on development of a SIS and stakeholder / community engagement until full time, dedicated staff are appointed as part of the construction programme in line with the requirements of the ESIA / ESMP.

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Appendices

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Appendix A - Noise Technical Appendix

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration		Rev No
Sep 2015	First issue		0
Dec 2015	Issue of ESIA to Ghana Environment Protection Agency		1
June 2016	ESIA Amendment issued to Ghana Environment Protection Agency, incorporating the following changes:		2
	Section No.	***Change***	
	A-2	Updated with sound power levels provided by the supplier for the final design	
August 2017	ESIA amendment issued to Ghana Environment Protection Agency, incorporating details of further project design changes, including:		3
	A-3	Updated with baseline noise data at factory worker receptor	

Contents

Figures and Tables

Appendix A-1 Overview of Noise

Overview

Noise is defined as unwanted sound, and the normal unit of measurement is the decibel (dB(A)). Sound pressure levels range from the threshold of hearing at 0 dB(A) to levels of over 130 dB(A) at which point noise becomes painful.

Sound consists of vibrations transmitted to the ear as rapid variations in air pressure. The more rapid the fluctuation, the higher the frequency of the sound. Frequency is the number of pressure fluctuations per second and is expressed in Hertz (Hz).

The sensitivity of the human ear varies with frequency. To allow for this phenomenon, sound level meters are often equipped with a set of filters that modify the response of the sound level meter in a similar way to the human ear; these filters are referred to as the ‘A-weighting network’. The ‘dB(A)’ notation is used to indicate when noise levels have been filtered using the A-weighting network. It has been found that changes in noise level when measured in dB(A) correlate better with changes in subjective reaction than to changes in noise measured without using the A-weighting network.

Some common levels of noise on the A-weighted scale are given in Table A-1 below.

Table A-1: Common Levels of Noise

Sound Pressure Level (dBA)	Typical Environment	Average subjective description
140	30m from military aircraft takeoff	Intolerable
100	Underground station platform	Very noisy
90	Heavy lorries at 6m	Very noisy
60	Restaurant	Noisy
50	General office	Quiet
20	Background in TV studios	Very quiet

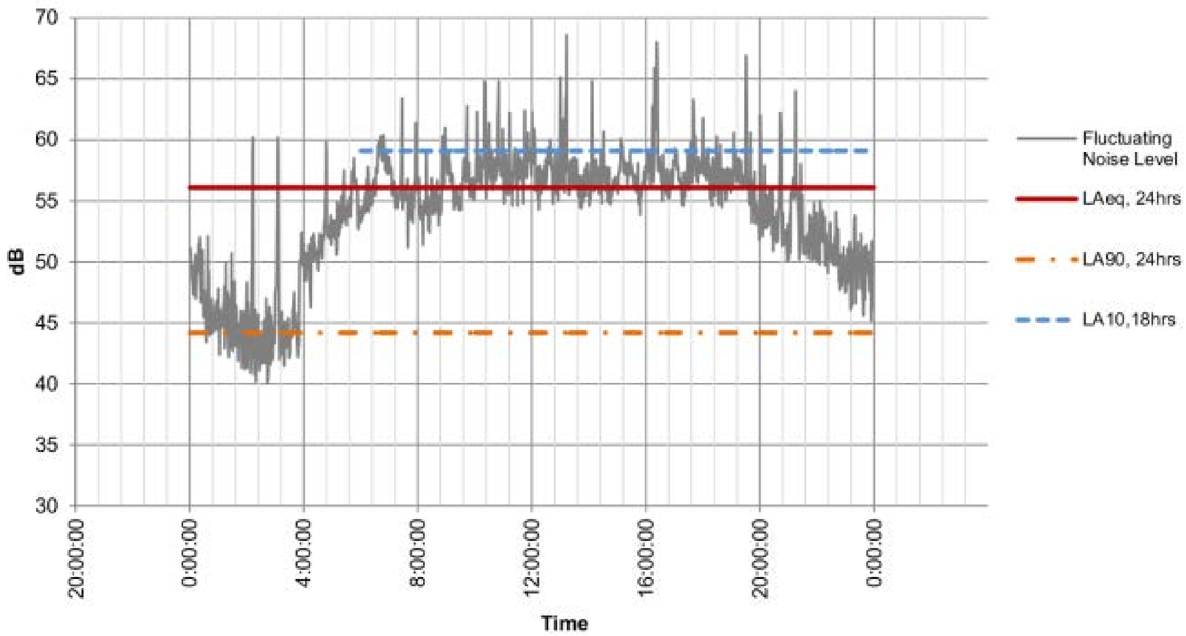
After Sharland,(1972)

Noise Descriptors

The subjective response to noise is dependent not only upon the sound pressure level and its frequency but also on its duration and the time of day it occurs. Noise levels fluctuate in response to events, for instance with aircraft passing overhead or changes in the quantity and speed of road traffic on nearby roads. For this reason environmental noise is often described in terms of an equivalent continuous sound pressure level, which can be thought of as a constant noise level over a time period (T) that contains the same sound energy as the fluctuating noise level. The notation for this noise descriptor is $L_{Aeq,T}$ and this concept is shown graphically in Figure 10A-1 below.

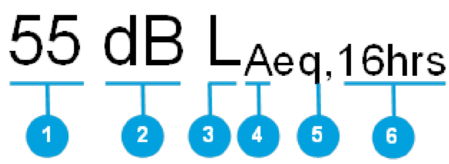
The $L_{A90,T}$ statistical noise parameter, which is defined as the level exceeded for 90% of the measurement period (T), is often used to describe background noise levels. This can be thought of as representing the underlying level of noise present during the quieter parts of the measurement.

Figure A-1 : Illustration of Statistical Noise Descriptors



Nomenclature

The nomenclature used to represent statistical acoustic quantities can appear complicated, however once understood it is logical and efficient. Take for instance the upper noise level recommended by the IFC noise level guidelines for residential, institutional and educational receptors of 55 dB $L_{Aeq,16hrs}$:



The above descriptor is comprised as follows:

1) The first part of the statistical descriptor identifies its numeric value. This value is usually given as a whole number or to one decimal place. Where values are given to one decimal place, this is normally required for compliance with a particular standard or convention, but it does not necessarily imply that the values are accurate to one decimal place.
2) The second group of characters indicate that the units of the noise descriptor are decibels.
3) The third grouping ('L') indicates that the quantity is a sound pressure level. Other less common quantities are sound intensity level (LI) and sound power level (LW).
4) The fourth grouping ('A') denotes that the sound pressure level is evaluated using the A-weighted filter network. There are two competing conventions regarding the position of this identifier, either immediately after the 'L' as shown in the example above, or alternatively in brackets following the units. Therefore whilst appearing different, 55 dB $L_{Aeq,16hrs}$ and 55 dB(A) $L_{eq,16hrs}$ are equivalent and may be used interchangeably. Which

convention is used is a matter of preference; however it is considered good practice to remain consistent within a document for the convenience of the reader.

5) The fifth grouping of characters identify the statistical index. In this example, the letters indicate that the quantity is in terms of the equivalent continuous noise level (eq), which has some similarities with the concept of an average noise level over a time period. Other common quantities include:
   - L_{DEN} which is the A-weighted equivalent continuous noise level, measured over the 24 hour period, with a 10 dB penalty added to the levels at night and a 5 dB penalty added to the levels in the evening to reflect people's extra sensitivity to noise during these periods.
   - L_{day} which is the A-weighted equivalent continuous noise level, assessed over an annual average daytime period (07.00-19.00).
   - $L_{evening}$ which is the A-weighted equivalent continuous noise level, assessed over an annual average evening period (19.00-23.00).
   - L_{night} which is the A-weighted equivalent continuous noise level, assessed over an annual average night-time period (23.00-07.00).
6) The sixth and final quantity shown after the statistical index is the duration over which the quantity is evaluated. This is typically represented in minutes or hours, e.g. 15min, 16hrs.

Decibel Addition

If the sound levels from two or more sources have been measured or predicted separately, and the combined sound level is required, the sound levels must be added together. However, due to the fact the decibel is a logarithmic value they cannot be added together using normal arithmetic.

Table A.2 below provides a quick guide to adding two sound levels together. First the difference between the higher and lower noise level must be calculated, and then the corresponding amount in the right hand side of the table must be added to the higher of the two noise levels.

Table A-2 : Guide to Decibel Addition

Difference between Noise Levels, dB	Amount to be added to Higher Level, dB
0	3
1	2.5
2	2.1
3	1.8
4	1.5
5	1.2
10	0.4
15	0.1

For example, when adding the values of 50.0 dB(A) and 55.0 dB(A) together, the difference between them is 5.0 dB(A) and therefore 1.2 dB(A) should be added to the higher value. The resulting sound level would be 56.2 dB(A).

Human Sensitivity to Change

Generally, a change of 3 dB(A) in fluctuating environmental noise is the minimum change perceptible to a human. However, there is research that suggests with respect to road traffic noise, immediately following a sudden change in traffic flow or road alignment people may find benefits or disbenefits when noise changes are as small as 1 dB(A). A change of 1 dB(A) is equivalent to an increase in traffic flow of 25% or a decrease in traffic flow of 20%. These impacts last for a number of years, however, in the longer term, perceived noise nuisance may tend towards the steady state level associated with the new source, which is generally lower.

Free-field and Façade Incident Noise Levels

Due to the effects of reflection, sound pressure levels measured close to large reflecting surfaces orientated near perpendicular to the direction the sound waves are traveling are higher than those that are measured away from reflective surfaces.

For sound propagation largely in the vertical direction (e.g. from an airborne aircraft towards the ground), the ground itself causes reflection. Unless stated otherwise, the airborne aircraft noise levels presented in this chapter include the effects of ground reflection, at a height of 1.5m above ground level.

For sound propagation largely in the horizontal direction (e.g. from ground operations), sound pressure levels measured 1m from a large solid, reflecting surface are termed 'façade incident' levels, whilst those measured at least 3m away from any reflective surfaces (other than the ground) are termed 'free-field'. Façade incident levels are typically up to 3 dB higher than free-field levels and therefore it is important to know the conditions under which a noise measurement or prediction has been undertaken. Unless stated otherwise, the noise levels presented in this chapter are free-field levels which do not account for the effects of reflection from building facades or other large vertical surfaces.

Potential Noise Effects

The operation of the equipment associated with the Project has the potential to lead to noise impacts at residences, schools, healthcare facilities and other nearby sensitive receptors.

Depending on the magnitude of the impact, and the activities being conducted at the receptor, the following effects may result:

- Small changes in behaviour such as turning the volume up, speaking more loudly, occasionally closing windows and a perceived reduction in quality of life.
- Material changes in behaviour such as avoiding certain activities during noisy periods, keeping windows closed most of the time, difficulty concentrating on tasks, reduced speech intelligibility and diminished quality of life.
- Health impacts such as annoyance, reduced cognitive performance, sleep disturbance (arousal, motility, sleep quality and reported awakening), the autonomous release of stress hormones, increased risk of hypertension (high blood pressure) and ischaemic heart diseases (including myocardial infarction).

Appendix A-2 Sound Power Levels Used in the Noise Model

Equipment	Octave band centre frequency									Sound Power Level, dB(A)
	31.5	63	125	250	500	1000	2000	4000	8000	
LM6000 Combustion Air Inlet Filters & Shell	112	111	107	110	104	100	94	91	85	106
LM6000 Turbine Enclosure	110	108	104	101	95	91	88	89	85	99
LM6000 Generator	107	107	111	104	95	101	100	100	89	107
LM6000 Combustion Exhaust (Open Cycle)	134	128	123	98	83	86	75	60	55	109
LM6000 Combustion Exhaust (Closed Cycle)	127	121	116	91	76	79	68	53	48	102
TM2500 Air Inlet Filters & Shell	114	117	111	107	100	93	95	92	89	104
TM2500 Turbine Enclosure	117	121	114	107	101	96	94	95	86	105
TM2500 Generator	116	119	110	106	100	94	91	88	94	103
TM2500 Combustion Exhaust (Open Cycle)	123	127	128	127	123	118	115	116	103	126
TM2500 Combustion Exhaust (Closed Cycle)	78	89	98	100	99	96	95	96	82	103
Auxiliary and BOP Equipment (per unit)	86	107	106	104	101	98	93	91	79	103
Acoustically Treated Transformer (per unit)	95	95	97	92	92	86	81	76	69	93
Air Cooled Condenser Array	106	109	109	106	103	99	96	93	85	105

Appendix A-3 Measured Noise Levels

Noise Measurement Results - VRA Station 1 210415						
Daytime Readings		**Sound pressure levels, dB**				
Time	**Duration**	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
21/04/2015 10:22	0:05:00	60.3	68.1	56.0	61.9	58.4
21/04/2015 10:27	0:05:00	59.2	65.0	54.9	60.8	57.3
21/04/2015 10:32	0:05:00	59.6	66.4	55.1	61.2	57.7
21/04/2015 10:37	0:05:00	58.8	63.7	55.2	60.3	57.1
21/04/2015 10:42	0:05:00	59.0	63.8	54.6	60.5	57.2
21/04/2015 10:47	0:05:00	58.7	64.4	54.6	60.3	56.8
21/04/2015 10:52	0:05:00	59.0	65.5	55.4	60.5	57.2
21/04/2015 10:57	0:05:00	59.5	67.6	55.4	61.4	57.3
21/04/2015 13:41	0:05:00	60.8	66.4	56.7	62.6	58.8
21/04/2015 13:46	0:05:00	60.0	66.2	55.0	61.7	57.9
21/04/2015 13:51	0:05:00	60.0	66.5	55.5	61.8	58.0
21/04/2015 13:56	0:05:00	59.6	64.9	55.9	61.1	57.8
21/04/2015 13:01	0:05:00	59.3	64.4	55.4	60.8	57.5
21/04/2015 13:06	0:05:00	59.5	65.2	55.5	61.2	57.6
21/04/2015 13:11	0:05:00	59.3	64.7	55.1	60.9	57.4
21/04/2015 13:16	0:05:00	59.6	65.3	55.9	61.2	57.6
21/04/2015 16:57	0:05:00	60.1	67.0	55.0	60.9	57.3
21/04/2015 17:02	0:05:00	58.6	64.3	54.8	61.6	57.1
21/04/2015 17:07	0:05:00	60.0	65.7	54.6	61.0	57.4
21/04/2015 17:12	0:05:00	59.7	62.3	56.1	60.5	57.2
21/04/2015 17:17	0:05:00	58.8	63.6	54.6	61.5	57.1
21/04/2015 17:22	0:05:00	59.4	63.2	57.6	61.3	56.6
21/04/2015 17:27	0:05:00	59.3	64.5	54.2	61.3	57.1
21/04/2015 17:32	0:05:00	60.3	66.7	55.3	61.3	57.9
Evening Readings		**Sound pressure levels, dB**				
Time	**Duration**	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
21/04/2015 19:05	0:05:00	61.1	65.3	56.4	62.6	58.9
21/04/2015 19:10	0:05:00	60.0	65.2	55.0	61.7	57.9
21/04/2015 19:15	0:05:00	60.8	65.5	56.4	61.8	58.0
21/04/2015 19:20	0:05:00	59.8	63.4	54.8	61.0	56.6
21/04/2015 19:25	0:05:00	58.7	63.6	55.4	60.8	56.5
21/04/2015 19:30	0:05:00	59.6	65.2	55.5	61.3	57.2
21/04/2015 21:36	0:05:00	60.5	64.4	57.6	63.6	57.8
21/04/2015 21:41	0:05:00	60.6	63.6	53.9	62.8	56.8
21/04/2015 21:46	0:05:00	61.7	68.2	54.5	63.9	58.5
21/04/2015 21:51	0:05:00	58.9	65.7	55.8	62.5	57.7
21/04/2015 21:56	0:05:00	59.6	63.6	56.2	60.8	57.3
21/04/2015 22:01	0:05:00	60.1	66.2	54.2	63.1	58.6
Night-Time Readings		**Sound pressure levels, dB**				
Time	**Duration**	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
21/04/2015 00:50	0:05:00	62.3	67.2	56.9	64.3	59.7
21/04/2015 00:55	0:05:00	61.8	66.5	54.0	62.8	57.8
21/04/2015 01:00	0:05:00	60.5	65.5	57.5	62.3	58.0
21/04/2015 01:05	0:05:00	58.7	64.7	56.9	61.9	57.7

Noise Measurement Results - VRA Station 1 210415						
21/04/2015 01:10	0:05:00	60.2	62.3	54.4	60.9	56.5
21/04/2015 01:15	0:05:00	59.7	65.1	53.8	62.4	57.8
21/04/2015 01:20	0:05:00	60.1	63.6	55.1	60.9	57.1
21/04/2015 01:25	0:05:00	58.6	64.1	54.7	63.1	58.6
21/04/2015 03:28	0:05:00	60.5	65.2	56.6	63.4	57.8
21/04/2015 03:33	0:05:00	60.3	65.6	55.1	62.6	57.7
21/04/2015 03:38	0:05:00	59.1	66.2	54.8	61.7	57.0
21/04/2015 03:43	0:05:00	58.8	64.7	56.0	62.8	57.7
21/04/2015 03:48	0:05:00	60.1	63.4	55.9	61.5	56.5
21/04/2015 03:53	0:05:00	59.2	64.3	54.5	62.1	57.2
21/04/2015 03:58	0:05:00	60.2	65.0	55.1	61.7	57.2
21/04/2015 04:03	0:05:00	58.5	64.2	54.3	61.8	57.8
21/04/2015 06:16	0:05:00	58.9	63.5	54.6	62.8	57.7
21/04/2015 06:21	0:05:00	60.2	65.2	55.6	61.7	57.8
21/04/2015 06:26	0:05:00	60.4	64.6	54.5	60.6	57.0
21/04/2015 06:31	0:05:00	59.2	63.8	55.4	61.6	57.7
21/04/2015 06:36	0:05:00	59.9	63.6	54.7	60.9	56.7
21/04/2015 06:41	0:05:00	60.5	64.2	55.3	62.4	57.7
21/04/2015 06:46	0:05:00	59.7	63.6	54.6	61.3	56.8
21/04/2015 06:51	0:05:00	59.8	64.3	54.6	62.3	57.8

Noise Measurement Results - VRA Station 1 220415						
Daytime Readings		**Sound pressure levels, dB**				
Time	**Duration**	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
22/04/2015 07:46	0:05:00	58.0	76.1	50.0	60.4	53.8
22/04/2015 07:51	0:05:00	57.8	83.2	50.4	62.1	53.5
22/04/2015 07:56	0:05:00	65.3	86.2	51.2	71.4	53.9
22/04/2015 08:01	0:05:00	61.6	73.5	48.7	64.1	52.5
22/04/2015 08:06	0:05:00	60.4	83.8	46.9	62.4	50.7
22/04/2015 08:11	0:05:00	60.6	74.8	52.0	62.1	54.8
22/04/2015 08:16	0:05:00	61.1	82.6	50.8	62.4	52.9
22/04/2015 08:21	0:05:00	65.7	88.5	52.1	70.6	54.4
22/04/2015 10:54	0:05:00	58.2	75.2	52.4	61.8	54.7
22/04/2015 10:59	0:05:00	60.3	82.4	50.4	61.1	53.4
22/04/2015 11:04	0:05:00	66.5	86.2	51.0	70.3	53.5
22/04/2015 11:09	0:05:00	61.1	78.5	48.6	63.1	53.5
22/04/2015 11:14	0:05:00	60.8	85.2	47.3	61.3	51.9
22/04/2015 11:19	0:05:00	59.9	76.1	51.2	63.0	54.7
22/04/2015 11:24	0:05:00	60.4	83.2	50.8	62.1	53.8
22/04/2015 11:29	0:05:00	65.3	86.3	51.2	71.1	54.6
22/04/2015 14:01	0:05:00	60.2	76.1	52.0	63.0	55.7
22/04/2015 14:06	0:05:00	61.0	82.2	51.5	31.1	54.5
22/04/2015 14:11	0:05:00	65.7	86.8	52.0	70.5	54.6
22/04/2015 14:16	0:05:00	61.6	79.1	49.7	65.2	53.0
22/04/2015 14:21	0:05:00	58.6	82.9	48.8	62.3	51.0
22/04/2015 14:26	0:05:00	59.0	75.1	53.0	61.9	56.1
22/04/2015 14:31	0:05:00	60.5	84.3	51.4	62.0	53.8
22/04/2015 14:36	0:05:00	65.5	86.8	52.3	71.4	53.5
Evening Readings		**Sound pressure levels, dB**				
Time	**Duration**	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
22/04/2015 20:44	0:05:00	61.8	84.0	52.4	62.6	53.9
22/04/2015 20:49	0:05:00	66.4	87.6	52.0	71.3	54.6
22/04/2015 20:54	0:05:00	61.3	79.0	49.8	64.6	53.0
22/04/2015 20:59	0:05:00	62.0	83.9	47.8	63.1	51.9
22/04/2015 21:04	0:05:00	60.9	77.6	53.1	62.0	55.9
22/04/2015 21:09	0:05:00	61.2	84.2	51.6	63.2	53.8
Night-time Readings		**Sound pressure levels, dB**				
Time	**Duration**	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
22/04/2015 00:03	0:05:00	50.3	70.7	41.5	53.8	44.9
22/04/2015 00:08	0:05:00	50.9	65.6	40.3	53.6	44.5
22/04/2015 00:13	0:05:00	53.3	80.6	40.9	53.4	43.8
22/04/2015 00:18	0:05:00	51.5	74.5	41.7	53.7	43.5
22/04/2015 00:23	0:05:00	53.4	80.3	41.7	56.8	44.9
22/04/2015 00:28	0:05:00	51.6	67.4	40.1	55.6	46.4
22/04/2015 00:33	0:05:00	55.4	71.2	42.0	58.6	45.1
22/04/2015 00:38	0:05:00	59.8	76.4	44.8	62.4	50.0
22/04/2015 02:55	0:05:00	50.4	67.9	41.2	51.5	42.6
22/04/2015 03:00	0:05:00	49.2	64.3	40.0	52.8	43.9
22/04/2015 03:05	0:05:00	54.9	81.2	41.9	54.6	44.7
22/04/2015 03:10	0:05:00	52.0	74.0	41.6	55.9	45.5

Noise Measurement Results - VRA Station 1 220415						
22/04/2015 03:15	0:05:00	53.9	80.3	42.8	56.3	45.0
22/04/2015 03:20	0:05:00	53.1	68.2	42.9	56.0	47.1
22/04/2015 03:25	0:05:00	54.1	72.3	42.9	60.1	46.2
22/04/2015 03:30	0:05:00	61.8	76.9	45.1	63.2	51.3
22/04/2015 05:33	0:05:00	52.7	67.3	38.4	51.9	43.2
22/04/2015 05:38	0:05:00	51.2	66.5	41.9	54.2	45.0
22/04/2015 05:43	0:05:00	55.1	82.6	42.9	55.7	45.5
22/04/2015 05:48	0:05:00	54.3	74.4	41.5	54.3	44.7
22/04/2015 05:53	0:05:00	52.6	79.5	40.9	55.8	43.7
22/04/2015 05:58	0:05:00	52.5	68.8	41.6	56.4	46.6
22/04/2015 06:03	0:05:00	54.4	71.9	41.5	57.6	45.7
22/04/2015 06:08	0:05:00	60.2	76.4	44.8	62.3	49.8

Noise Measurement Results - Sraha 210415						
Daytime Readings		**Sound pressure levels, dB**				
Time	**Duration**	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
21/04/2015 08:20	0:05:00	60.0	76.1	52.0	62.0	55.8
21/04/2015 08:25	0:05:00	60.9	83.2	50.4	62.1	53.5
21/04/2015 08:30	0:05:00	67.4	88.2	51.2	70.4	54.5
21/04/2015 08:35	0:05:00	60.8	78.2	49.7	64.1	52.5
21/04/2015 08:40	0:05:00	61.5	84.3	48.7	62.3	50.9
21/04/2015 08:45	0:05:00	60.0	76.1	52.0	62.0	55.8
21/04/2015 08:50	0:05:00	60.9	83.2	50.4	62.1	53.5
21/04/2015 08:55	0:05:00	67.4	88.2	51.2	70.4	54.5
21/04/2015 11:38	0:05:00	62.1	78.0	53.0	63.1	56.9
21/04/2015 11:43	0:05:00	61.7	83.8	51.5	63.4	54.3
21/04/2015 11:48	0:05:00	66.8	87.7	50.6	71.5	53.3
21/04/2015 11:53	0:05:00	60.4	77.9	50.1	65.0	52.7
21/04/2015 11:58	0:05:00	62.0	83.8	47.5	63.3	51.4
21/04/2015 12:03	0:05:00	60.8	75.8	53.1	63.1	56.9
21/04/2015 12:08	0:05:00	61.6	84.1	51.8	63.3	54.2
21/04/2015 12:13	0:05:00	66.5	87.8	50.9	70.0	54.4
21/04/2015 14:45	0:05:00	59.8	75.8	51.7	62.6	54.9
21/04/2015 14:50	0:05:00	61.0	84.1	51.4	62.1	53.4
21/04/2015 14:55	0:05:00	66.8	87.6	52.0	71.5	55.4
21/04/2015 15:00	0:05:00	61.5	77.9	48.6	65.0	52.6
21/04/2015 15:05	0:05:00	62.0	84.8	47.8	63.4	51.8
21/04/2015 15:10	0:05:00	60.8	75.9	52.0	62.1	55.9
21/04/2015 15:15	0:05:00	61.0	83.6	50.7	62.1	53.8
21/04/2015 15:20	0:05:00	66.8	87.8	52.0	71.2	54.6
Evening Readings		**Sound pressure levels, dB**				
Time	**Duration**	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
21/04/2015 19:58	0:05:00	60.9	76.6	51.9	62.5	55.9
21/04/2015 20:03	0:05:00	61.0	84.4	50.5	62.2	53.6
21/04/2015 20:08	0:05:00	66.3	88.4	51.7	70.8	54.6
21/04/2015 20:13	0:05:00	61.3	78.4	50.1	64.1	52.8
21/04/2015 20:18	0:05:00	61.8	84.7	49.1	63.1	51.6
21/04/2015 20:23	0:05:00	61.2	75.1	51.9	61.8	55.9
21/04/2015 22:23	0:05:00	59.8	75.8	53.0	62.0	55.6
21/04/2015 22:28	0:05:00	61.0	83.2	51.0	62.3	53.3
21/04/2015 22:33	0:05:00	66.3	86.2	53.2	71.4	54.6
21/04/2015 22:38	0:05:00	61.2	78.6	50.1	64.8	52.8
21/04/2015 22:43	0:05:00	63.2	85.5	49.4	62.5	51.8
21/04/2015 22:48	0:05:00	62.0	77.0	52.6	62.0	55.9
Night-time Readings		**Sound pressure levels, dB**				
Time	**Duration**	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
21/04/2015 01:41	0:05:00	32.0	51.6	26.9	32.8	29.8
21/04/2015 01:46	0:05:00	33.9	55.3	26.6	33.3	30.2
21/04/2015 01:51	0:05:00	30.1	45.3	26.0	31.5	26.6
21/04/2015 01:56	0:05:00	28.1	47.0	26.0	28.8	26.5
21/04/2015 02:01	0:05:00	47.3	73.2	26.1	37.3	26.7
21/04/2015 02:06	0:05:00	34.7	59.5	26.2	32.7	26.9

Noise Measurement Results - Sraha 210415						
21/04/2015 02:11	0:05:00	29.7	50.1	26.4	29.6	27.0
21/04/2015 02:16	0:05:00	27.6	39.1	26.0	28.1	26.7
21/04/2015 04:22	0:05:00	47.7	69.0	32.8	48.3	34.7
21/04/2015 04:27	0:05:00	43.5	59.2	32.9	47.7	36.0
21/04/2015 04:32	0:05:00	46.1	68.8	32.8	48.8	35.4
21/04/2015 04:37	0:05:00	41.4	58.1	31.6	45.0	33.6
21/04/2015 04:42	0:05:00	46.4	65.7	31.5	50.4	33.9
21/04/2015 04:47	0:05:00	44.7	60.1	31.1	48.3	33.3
21/04/2015 04:52	0:05:00	46.1	57.9	31.9	50.0	36.9
21/04/2015 04:57	0:05:00	50.3	64.6	34.3	53.6	41.4
21/04/2015 23:05	0:05:00	48.9	74.0	27.0	44.5	29.1
21/04/2015 23:10	0:05:00	53.4	75.4	26.9	53.9	29.1
21/04/2015 23:15	0:05:00	38.8	64.5	26.6	33.5	27.9
21/04/2015 23:20	0:05:00	34.3	59.6	26.5	31.5	27.9
21/04/2015 23:25	0:05:00	38.1	66.1	26.8	34.7	27.7
21/04/2015 23:30	0:05:00	35.6	61.7	26.6	35.9	28.1
21/04/2015 23:35	0:05:00	34.2	62.8	26.7	32.3	27.6
21/04/2015 23:40	0:05:00	30.2	48.6	26.4	31.1	26.9

Noise Measurement Results - Sraha 220415						
Daytime Readings		**Sound pressure levels, dB**				
Time	**Duration**	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
22/04/2015 08:59	0:05:00	59.8	75.2	51.9	61.9	56.8
22/04/2015 09:04	0:05:00	61.0	83.3	51.2	62.3	53.4
22/04/2015 09:09	0:05:00	68.2	87.9	52.3	71.3	55.5
22/04/2015 09:14	0:05:00	61.1	77.9	50.3	64.3	53.6
22/04/2015 09:19	0:05:00	62.3	83.8	49.3	63.6	51.1
22/04/2015 09:24	0:05:00	61.2	77.8	50.2	64.5	52.7
22/04/2015 09:29	0:05:00	58.4	90.1	47.2	59.1	48.8
22/04/2015 09:34	0:05:00	54.9	79.4	44.9	56.9	46.6
22/04/2015 12:08	0:05:00	59.9	75.8	51.9	63.0	55.9
22/04/2015 12:13	0:05:00	61.1	84.1	51.3	61.8	54.4
22/04/2015 12:18	0:05:00	66.5	87.9	50.8	71.5	55.4
22/04/2015 12:23	0:05:00	61.2	77.8	50.2	63.2	53.2
22/04/2015 12:28	0:05:00	61.8	85.1	47.8	63.4	51.2
22/04/2015 12:33	0:05:00	61.0	77.2	50.4	63.9	53.6
22/04/2015 12:38	0:05:00	56.7	90.2	47.2	58.9	48.7
22/04/2015 12:43	0:05:00	54.9	78.5	44.9	57.1	48.2
22/04/2015 15:04	0:05:00	59.7	76.6	53.1	62.7	56.7
22/04/2015 15:09	0:05:00	61.6	83.4	50.8	61.9	53.4
22/04/2015 15:14	0:05:00	66.8	88.6	52.0	70.2	55.2
22/04/2015 15:19	0:05:00	61.3	78.5	50.7	63.9	53.2
22/04/2015 15:24	0:05:00	62.1	84.1	49.5	63.6	51.0
22/04/2015 15:29	0:05:00	61.3	77.4	50.6	64.4	52.6
22/04/2015 15:34	0:05:00	58.6	90.2	47.4	59.8	48.8
22/04/2015 15:39	0:05:00	56.3	79.2	44.9	58.0	48.6
Evening Readings		**Sound pressure levels, dB**				
Time	**Duration**	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
22/04/2015 19:07	0:05:00	60.3	75.9	51.9	61.8	55.9
22/04/2015 19:12	0:05:00	61.0	82.8	51.3	63.0	54.3
22/04/2015 19:17	0:05:00	67.4	88.7	51.2	70.5	54.6
22/04/2015 19:22	0:05:00	61.2	78.3	50.2	63.9	52.8
22/04/2015 19:27	0:05:00	61.7	84.2	49.6	63.1	51.9
22/04/2015 19:32	0:05:00	61.6	77.1	49.7	63.9	52.6
22/04/2015 21:28	0:05:00	60.2	75.9	52.8	61.9	56.1
22/04/2015 21:33	0:05:00	63.5	84.8	50.3	62.1	53.4
22/04/2015 21:38	0:05:00	66.8	87.9	51.3	70.4	55.5
22/04/2015 21:43	0:05:00	61.1	77.8	50.1	63.9	52.4
22/04/2015 21:48	0:05:00	61.6	84.4	49.1	62.9	51.1
22/04/2015 21:53	0:05:00	60.7	76.8	50.2	64.5	52.9
Night-time Readings		**Sound pressure levels, dB**				
Time	**Duration**	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
22/04/2015 00:59	0:05:00	28.3	35.2	26.1	29.9	26.6
22/04/2015 01:04	0:05:00	27.1	39.2	26.0	27.6	26.4
22/04/2015 01:09	0:05:00	27.2	35.0	25.9	27.7	26.4
22/04/2015 01:14	0:05:00	27.0	34.0	25.5	27.7	26.1
22/04/2015 01:19	0:05:00	26.9	35.4	26.0	27.2	26.4
22/04/2015 01:24	0:05:00	26.6	33.4	25.7	26.8	26.1

Noise Measurement Results - Sraha 220415						
22/04/2015 01:29	0:05:00	26.3	40.3	25.5	26.4	25.9
22/04/2015 01:34	0:05:00	26.9	32.1	25.6	27.4	26.0
22/04/2015 03:49	0:05:00	26.5	33.9	25.7	26.7	26.0
22/04/2015 03:54	0:05:00	26.6	39.4	25.5	26.7	25.9
22/04/2015 03:59	0:05:00	26.4	30.2	25.6	26.7	25.9
22/04/2015 04:04	0:05:00	40.8	54.5	26.1	46.6	26.5
22/04/2015 04:09	0:05:00	45.1	56.8	25.7	50.9	26.2
22/04/2015 04:14	0:05:00	26.7	31.7	25.6	27.0	26.1
22/04/2015 04:19	0:05:00	27.2	32.3	25.7	27.9	26.2
22/04/2015 04:24	0:05:00	27.0	38.4	25.9	27.6	26.2
22/04/2015 06:22	0:05:00	27.0	33.5	25.8	27.4	26.3
22/04/2015 06:27	0:05:00	26.9	32.3	25.8	27.4	26.3
22/04/2015 06:32	0:05:00	31.5	53.3	25.9	30.5	26.3
22/04/2015 06:37	0:05:00	27.6	44.7	25.9	28.3	26.4
22/04/2015 06:42	0:05:00	37.1	65.6	26.2	35.4	26.7
22/04/2015 06:47	0:05:00	34.1	47.5	26.3	37.4	27.6
22/04/2015 06:52	0:05:00	53.7	71.6	26.8	54.6	29.8
22/04/2015 06:57	0:05:00	59.9	70.7	33.5	65.2	40.0

Noise Measurement Results - JQ Accommodation Workers Buildings						
Daytime Readings		Sound pressure levels, dB				
Time	Duration	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
04/05/2017 15:11	0:30:00	57.7	74.9	49.7	60.4	53.3
04/05/2017 15:41	0:30:00	51.4	70.9	42.6	53.0	46.3
04/05/2017 16:11	0:30:00	51.3	68.7	41.9	53.7	45.8
04/05/2017 16:41	0:30:00	49.4	69.8	42.0	50.3	44.6
04/05/2017 17:11	0:30:00	54.3	84.2	38.7	53.1	42.1
04/05/2017 17:41	0:30:00	49.1	83.4	39.0	45.4	41.8
04/05/2017 18:11	0:30:00	45.4	67.1	41.0	45.6	42.8
04/05/2017 18:41	0:30:00	45.6	64.3	41.8	46.6	43.5
05/05/2017 07:11	0:30:00	53.2	90.6	40.6	47.8	42.6
05/05/2017 07:41	0:30:00	48.2	73.5	39.2	47.7	41.2
05/05/2017 08:11	0:30:00	43.5	62.0	39.1	44.8	41.1
05/05/2017 08:41	0:30:00	45.4	68.4	40.6	46.6	42.5
05/05/2017 09:11	0:30:00	57.7	87.0	39.3	57.7	43.9
05/05/2017 09:41	0:30:00	52.7	81.3	37.7	55.3	41.0
05/05/2017 10:11	0:30:00	53.7	78.8	37.7	52.3	41.3
05/05/2017 10:41	0:30:00	53.8	80.5	37.5	56.5	41.5
05/05/2017 11:11	0:30:00	62.2	92.6	36.7	54.8	40.1

Evening Readings (JQ)		Sound pressure levels, dB				
Time	**Duration**	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
04/05/2017 19:11	0:30:00	47.8	70.0	43.6	48.9	45.4
04/05/2017 19:41	0:30:00	49.2	74.6	44.6	49.7	46.2
04/05/2017 20:11	0:30:00	49.3	74.1	44.6	49.9	46.7
04/05/2017 20:41	0:30:00	49.3	67.9	45.3	49.8	47.2
04/05/2017 21:11	0:30:00	48.3	63.6	45.2	49.1	46.9
04/05/2017 21:41	0:30:00	49.7	78.4	45.4	50.1	47.5
04/05/2017 22:11	0:30:00	50.1	56.4	46.1	51.1	48.8
04/05/2017 22:41	0:30:00	51.9	71.7	46.7	52.8	50.2
Night-Time Readings (JQ)		**Sound pressure levels, dB**				
Time	**Duration**	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
04/05/2017 23:11	0:30:00	50.7	60.5	45.0	52.1	47.2
04/05/2017 23:41	0:30:00	49.2	60.9	44.5	50.8	46.2
05/05/2017 00:11	0:30:00	49.1	67.7	43.9	49.8	45.9
05/05/2017 00:41	0:30:00	48.3	51.7	44.2	49.6	46.3
05/05/2017 01:11	0:30:00	48.9	68.9	44.1	50.0	46.9
05/05/2017 01:41	0:30:00	48.4	59.4	43.5	50.1	45.7
05/05/2017 02:11	0:30:00	46.0	61.9	42.7	46.6	44.6
05/05/2017 02:41	0:30:00	47.9	57.0	42.4	49.5	44.7
05/05/2017 03:11	0:30:00	50.1	68.8	42.4	51.5	46.9
05/05/2017 03:41	0:30:00	51.5	58.6	43.0	52.3	50.5
05/05/2017 04:11	0:30:00	50.8	60.4	42.4	51.9	44.9
05/05/2017 04:41	0:30:00	50.6	56.8	43.2	51.8	47.8
05/05/2017 05:11	0:30:00	44.9	57.9	41.9	45.9	43.4
05/05/2017 05:41	0:30:00	43.8	58.0	40.4	45.2	42.2
05/05/2017 06:11	0:30:00	44.2	63.0	40.5	45.6	42.1
05/05/2017 06:41	0:30:00	43.6	60.2	38.3	45.3	40.6

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Appendix B - Air Quality Technical Appendix

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

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Ghana Bridge Power Project

Early Power Limited

Environmental and Social Impact Assessment: Air Quality Technical Appendix

Revision 2

August 2017

Document history and status

Revision	Date	Description	By	Review	Approved
Rev 0	Aug 2015	First issue	Sarah Kenyon	Andrew Smith	Andrew Smith
Rev 1	June 2016	Additional Power Plant Site (PPS) location (PPS2), with associated scenarios modelled	Gary Wilson	Andrew Smith	Martha McBarron
Rev 2	August 2017	Changed locations for PPS1 and PPS2. Consideration of diesel fuel oil (DFO) in modelling. Inclusion of numerical cumulative modelling Revised operational scenarios for fuel	Daisy Adewusi	Alice McLean / Andrew Smith	JP Wale

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Ghana Bridge Air

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Author:	Daisy Adewusi
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Contents

1. Introduction

1.1 This Report

This report provides the Technical Appendix for Chapter 11 (Air Quality) of the Environmental and Social Impact Assessment (ESIA) to accompany the application for the proposed Ghana Bridge Power Project by Early Power Limited (EPL), Ghana. This report should be read in conjunction with Chapter 11 of the ESIA. It provides details of the assessment methodology, study inputs and results of the air quality assessment in more detail.

In summary, Jacobs has undertaken an atmospheric dispersion modelling assessment to predict concentrations of pollutants at sensitive 'residential' receptors and offsite 'industrial' locations surrounding the proposed power plant. The modelling assessment has included a number of operating scenarios based on the staged approach to the plant development and various additional scenarios considering mix of fuel types and cumulative impacts.

The predicted concentrations have been compared to the relevant ambient air quality guidelines (AAQG) specified for the protection of human health.

1.2 Operation Development

For the purposes of the dispersion modelling assessment, the project has been assessed for the scenarios described below. It is understood that the use of Liquefied Petroleum Gas (LPG) will be utilised until Natural Gas (NG) is made fully available. In the event of a disruption to LPG supply, it may be necessary to utilise Diesel Fuel Oil (DFO) as a fuel. Therefore, this assessment considers the impacts when the plants will be fuelled on Liquefied Petroleum Gas (LPG) comprising 90% propane and 10% butane, or (DFO) comprising a sulphur content of 0.3%.

The scenarios considered in this assessment to cover these stages are outlined below:

- **Scenario 1 – Development Stage 1a:**

  5 x TM2500 LPG-fired turbine plant operating in open cycle mode; and

  5 x TM2500 DFO-fired turbine plant operating in open cycle mode
- **Scenario 2 – Development Stage 1b:**

  5 x TM2500 LPG-fired turbine plant fitted with Once Through Steam Generators (OTSGs) operating in combined cycle mode; and

  5 x TM2500 DFO-fired turbine plant fitted with Once Through Steam Generators (OTSGs) operating in combined cycle mode
- **Scenario 3 – Development Stages 1b and 2 (finalised plant development operational January 2020):**

  5 x TM2500 LPG-fired turbine plant fitted with Once Through Steam Generators (OTSGs) operating in combined cycle mode and 4 x LM6000PC Sprint LPG turbine plant fitted with Heat Recovery Steam Generators (HRSGs) operating in combined cycle mode, and

  5 x TM2500 DFO-fired turbine plant fitted with Once Through Steam Generators (OTSGs) operating in combined cycle mode and 4 x LM6000PC Sprint DFO turbine plant fitted with Heat Recovery Steam Generators (HRSGs) operating in combined cycle mode.
- **Sensitivity for Emergency DFO Operation – Development Stages 1b and 2:**

  Sensitivity assessment to establish the impacts of the following sensitivity scenarios on LPG / DFO:

  - 1 month operation on DFO and 11 months operation on LPG;
  - 3 month operation on DFO and 9 months operation on LPG;

  - 6 month operation on DFO / 6 months operation on LPG; and,
  - Year round operation on DFO.

- **Cumulative Impact Assessment**

  In addition, a cumulative assessment was undertaken of four key external power plants have been identified in the vicinity of the project, with emissions being estimated using US EPA AP42 emission factors and are based on the fuel and power rating of the plant.

Atmospheric emissions from the LPG fired turbines will predominately consist of oxides of nitrogen (NO_x) and carbon monoxide (CO). For DFO fired turbines, emissions will consist of NOx, CO, Sulphur dioxide (SO_2) and Particulates (particulate matter with aerodynamic diameter of 10 microns or less (PM_{10}) and with aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$).

1.3 Summary of Assessment

The assessment was carried out using an air dispersion modelling technique which consisted of the following components.

1) Determination of likely background concentrations of the relevant pollutants (NO_2, CO, SO_2, PM_{10} and $PM_{2.5}$), established from available measurement information, including monitoring surveys carried out to support the ESIA.

2) Computer dispersion modelling of the relevant release substances as described previously from the gas turbines, to identify likely concentrations of pollutants at identified sensitive human health receptor locations surrounding the proposed power plant.

3) Evaluation of significance by comparing modelled levels of emissions against the relevant guidelines for air quality.

4) Sensitivity analysis to consider worst case, emergency operation of the plant on DFO for 1, 3 and 6 months of the year, in addition to the full year results.

5) Evaluation of cumulative impacts of four identified power plants within the vicinity using US EPA AP42 emission factors.

The dispersion modelling methodology and study inputs are provided in Chapter 2 of this technical appendix and the dispersion modelling results are set out in Chapter 3. The interpretation and determination of significance of the modelled results is provided in the ESIA Chapter 11, along with the identification of mitigation measures.

2. Methodology and Study Inputs

2.1 Description of Dispersion Model

A current industry standard atmospheric dispersion model, ADMS version 5.2, was used to model releases of substances from the proposed Ghana Bridge project.

Air dispersion modelling using appropriate dispersion modelling software is an internationally accepted tool that can be used to determine if the design and location of emission sources result in acceptable air quality in the vicinity of a development site. This determination is made by comparing the maximum predicted dispersion modelling results at appropriate locations to the ambient air quality guideline stated in the applicable government regulations or other international standards. As such, if the predicted dispersion modelling results are within the air quality limits, the plant design is assumed to be acceptable for regulatory approval.

For this assessment, it was decided to apply the UK Atmospheric Dispersion Modelling System (ADMS) version 5.2 dispersion modelling software. In general, the results produced by AERMOD (an equivalent dispersion model developed in the US) and ADMS under identical input data and meteorological conditions are essentially very similar. Both ADMS and AERMOD are listed as appropriate for assessing “more complex and refined models” in the International Finance Corporation (IFC) “Environmental, Health and Safety Guidelines: Environmental, Air Emissions and Ambient Air Quality” guidance document.

The model takes, as a starting point, information on emissions from each source, including:

- release rate of the substances under consideration;
- release temperature;
- release velocity or volumetric flow;
- release point location;
- release point height;
- release point diameter; and,
- the location and dimensions of nearby buildings.

Information characterising a set of meteorological conditions is also required. This includes the wind speed, wind direction, and information relating to the atmospheric stability. This information is normally provided in the form of sequential hourly measurements, obtained from the nearest or most representative meteorological station. Given this information, the model provides an estimated concentration of the substance of interest at a specified location. This process is repeated for each hour in the year, and at each location under consideration, to build up an estimate of long-term mean and short-term peak concentrations over an area of interest or at a number of points of interest.

In any modelling study, there will be a degree of uncertainty in the model results. In the case of atmospheric dispersion modelling, models are generally more reliable for long period means than short period means. Models are usually more reliable over intermediate distances (100m to 1000m) than very close to the source or more distant from the source. This reflects the range of data that have been used to develop the models. To allow for these uncertainties, a conservative approach has been adopted in this study.

The model incorporates a number of complex modules, allowing for the effects of plume rise, complex terrain, buildings and coastlines to be incorporated within the modelling study, as necessary. The ADMS model has a number of distinct features that can be summarised as follows:

- Concentration distributions are Gaussian in stable and neutral conditions, but the vertical distribution is non-Gaussian in convective conditions to take account of the skewed structure of the vertical component of turbulence.

- Actual plume spread depends on the local wind speed and turbulence which therefore depends on plume height. This is accounted for within ADMS and contrasts with Pasquill-Gifford methods that are used within some alternative modelling systems where plume spread is independent of height.
- Where required, a meteorological pre-processor calculates the required boundary layer parameters from a variety of input data (e.g. wind speed, day, time, cloud cover or surface heat flux). Meteorological data may be of statistically analysed or raw, hourly averaged (or hourly sequential) format.
- A number of complex modules allow for the effects of plume rise, complex terrain, structures, coastlines and the calculation of concentration fluctuations and radioactive decay to be incorporated within the dispersion modelling study.
- The presence of buildings close to the release point can significantly affect the dispersion of material from a source. This influence can be taken into account by the use of an appropriate module in ADMS. The site buildings may influence the dispersion of emissions from the main stack. It is therefore important that building effects on dispersion are evaluated in detail. This was done using the ADMS buildings module.

2.2 Outline of Method

The dispersion modelling procedure is summarised as follows.

- Information on the design of the proposed power plant including site layout, stack location, proposed gas turbines and relevant emissions data was obtained from Early Power Limited. Details of the buildings and structures (obtained from web-based specifications and estimates agreed with Early Power Limited) using the buildings module in ADMS was used to account for the effect of site buildings on the dispersion of pollutants.
- Some of the emission parameters such as volumetric flow of exhaust gases were derived from first principles based on the fuel type, calorific value of the fuel and fuel consumption rate. Emission concentrations for NOx were based on the relevant emission limit values set out in the IFC guidelines for fuels other than natural gas. The emission limit for CO was set at the manufacturer's guaranteed limit. This is above the IFC Guideline limit of 100 mg/Nm^3.
- Five years of hourly sequential meteorological data was obtained from Accra airport, which is the nearest meteorological station and which records all the necessary parameters for dispersion modelling, and was used for the assessment (see Section 2.4.3). This is approximately 21.6km to the west south-west of the proposed site.
- Human health receptors surrounding the Tema Industrial area were identified at which the ambient concentrations of released substances were modelled. These represented individual properties located within the nearest residential areas or towns and are shown in Figure 11.2. In addition two informal residential properties (Receptors 5 and 13) were identified within the industrial area and it was confirmed that an adjacent commercial premises has overnight worker accommodation (included as Receptor 6).
- As well as at discrete receptors, concentrations were modelled on a regular receptor grid with 50m spacing, covering a 10km x 10 km grid square centred on the proposed site. This enabled generation of contour plots of the predicted ground level concentrations of the modelled pollutants and has enabled 'offsite' pollutant concentrations within the Tema Industrial area to be obtained.
- There are no sensitive ecological sites such as national parks within the vicinity of the proposed site and no further consideration of sensitive habitats was required.
- The above information was entered into the dispersion model.
- The dispersion model was run for each scenario to provide predicted ground-level concentrations of the assessed released substances. To ensure a conservative assessment, the results interpretation was based on the maximum modelled concentration at any of the sensitive human health receptor locations for any of the five years of meteorological data. It was also assumed that all plant would run at 100% load continuously for the year.
- Concentrations of NOx were converted to nitrogen dioxide (NO_2) as this is the pollutant associated with health effects – the conversion is discussed in more detail in Section 2.4.8.

- Modelled concentrations were assessed against the relevant ambient air quality guidelines taking the background concentrations into account.
- Cumulative modelling of other recent or proposed power plants in the airshed was also completed, as discussed in Section 11.5.4 below.

2.3 Air Quality Standards and Guidelines

Applicable Ghanaian Ambient Air Quality Guidelines (AAQG) are provided in Table 2.1 below, together with associated World Health Organisation (WHO) (2000) and World Bank Group Environmental, Health and Safety Guidelines (2007). It should be noted that the Ghanaian AAQG are applicable at defined locations, classified as 'Industrial' or 'Residential'. The WHO guidelines are understood to be applicable to the protection of public health. Air quality guideline concentration values are defined for each pollutant for specific averaging times, and are values which should not be exceeded in any given year.

The results of the dispersion modelling study were assessed against the relevant Ghanaian AAQG for a 'residential' and 'industrial' location, and where not available, the relevant WHO guideline. In this case, the EPA standards were supplemented with the WHO ambient air quality guidelines for annual mean NO_2 and the CO 1-hour and 8-hour rolling mean.

Table 2-1: Ambient Air Quality Guidelines

Pollutant	Standard & Guidelines (µg/m3)			
	Averaging Time	EPA		WHO Guidelines
		Location	Time weighted Average (TWA)	
Nitrogen dioxide (NO_2)	1 hour	Industrial	400	200
		Residential	200	
	24 hours	Industrial	150	-
		Residential	60	
	Annual	-	-	40
Carbon monoxide (CO)	1 hour	-	30,000	30,000
	8 hour	-	10,000	10,000
Sulphur dioxide (SO_2)	10 minute	-	-	500
	1hr	Industrial	900	-
		Residential	700	-
	24hrs	Industrial	150	20 Interim (1) 125 (2) 50
		Residential	100	
	Annual	Industrial	80	-
		Residential	50	
Particulate matter (PM_{10})	24hrs	-	70	50 Interim (1) 150 (2) 100 (3) 75
	Annual	-	-	20 Interim (1) 70 (2) 50 (3) 30
Particulate matter ($PM_{2.5}$)	24hrs	-	-	25 Interim (1) 75 (2) 50 (3) 37.5
	Annual	-	-	10 Interim (1) 35 (2) 25 (3) 15

2.4 Model Inputs

The input parameters to the model provided by Early Power Limited (or derived from that data) are presented in Table 2.2. It is noted that new release points are added when the TM2500 and LM6000 units are converted to combined cycle, as the original open cycle stacks are by passed.

The NOx emission concentrations used in the modelling assessment comply with the IFC emission limit for ‘fuels other than natural gas’ of 152 mg/Nm^3. The CO emission limits are set to the manufacturer’s guarantee of 100 mg/Nm^3.

The proposed site layout showing the location of exhaust stacks for all stages are presented in Figure 11.1 in the air quality chapter.

Note that additional model inputs were derived for the cumulative modelling exercise, as discussed in Section 2.4.10.

Table 2-2: Emissions Parameters All Stages

Source Description	Centre point		Stack Height	Stack Internal Diameter	Exhaust Gas Efflux Velocity	Exhaust Gas Volumetric Flow		Exhaust Gas Temp	Emission Concentration [1]				Emission Rate			
									NO_x	CO	PM_{10}	SO_2	NO_x	CO	PM_{10}	SO_2
	E (m)	N (m)	(m)		(m/s)	m^3/s (actual)	Nm^3/s [1] (reference)	°C	mg/Nm^3				g/s			
Stage 1a: 5 x TM2500 LPG turbine plant operating in open cycle mode																
TM2500 S1a-1	169800	628478														
TM2500 S1a-2	169812	628449														
TM2500 S1a-3	169824	628419	30	2.80	34.1	210	72.3	543.7	152	100	N/A		11	7.23	N/A	
TM2500 S1a-4	169836	628390														
TM2500 S1a-5	169848	628361														
Stage 1a: 5 x TM2500 DFO turbine plant operating in open cycle mode																
TM2500 S1a-1	169800	628478														
TM2500 S1a-2	169812	628449														
TM2500 S1a-3	169824	628419	30	2.80	34.0	209	74.2	547.3	152	100	50	58	11.3	7.42	3.71	12.08
TM2500 S1a-4	169836	628390														
TM2500 S1a-5	169848	628361														
Stage 1b: 5 x TM2500 LPG turbine plant operating in combined cycle mode																
TM2500 S1a-1	169789	628479														
TM2500 S1a-2	169801	628449														
TM2500 S1a-3	169814	628420	30	2.29	25.9	106	72.1	140.6	152	100	N/A		11	7.21	N/A	
TM2500 S1a-4	169826	628391														
TM2500 S1a-5	169838	628362														
Stage 1b: 5 x TM2500 DFO turbine plant operating in combined cycle mode																
TM2500 S1a-1	169789	628479														
TM2500 S1a-2	169801	628449														
TM2500 S1a-3	169814	628420	30	2.29	25.9	106	74.3	141.4	152	100	50	114	11.3	7.43	3.72	12.08
TM2500 S1a-4	169826	628391														
TM2500 S1a-5	169838	628362														

Source Description	Centre point		Stack Height	Stack Internal Diameter	Exhaust Gas Efflux Velocity	Exhaust Gas Volumetric Flow		Exhaust Gas Temp	Emission Concentration [1]				Emission Rate			
									NO_x	CO	PM_{10}	SO_2	NO_x	CO	PM_{10}	SO_2
	E (m)	N (m)	(m)		(m/s)	m^3/s (actual)	Nm^3/s [1] (reference)	°C	mg/Nm^3				g/s			
Stage 2: 4 x LM6000 PC SPRINT LPG turbine plant operating in combined cycle mode																
LM6000 PC-SPRINT P3-1	169709	628543	40	2.75	22.1	131.5	91.4	95	152	100	N/A		13.9	9.1	N/A	
LM6000 PC-SPRINT P3-2	169686	628534														
LM6000 PC-SPRINT P3-3	169663	628525														
LM6000 PC-SPRINT P3-4	169640	628515														
Stage 2: 4 x LM6000 PC SPRINT DFO turbine plant operating in combined cycle mode																
LM6000 PC-SPRINT P4-1	169709	628543	40	2.75	22.5	151.4	98.4	145	152	100	50	184	15.0	9.8	4.92	16.82
LM6000 PC-SPRINT P4-2	169686	628534														
LM6000 PC-SPRINT P4-3	169663	628525														
LM6000 PC-SPRINT P4-4	169640	628515														

2.4.1 Hours of Operation

For the purposes of the modelling study, it has been assumed that the turbines would operate simultaneously and continuously at maximum load (100% of maximum continuous rating) for the duration of a year (8760 hours). In practice, there will be some downtime for routine maintenance and inspection of equipment and so the modelling assessment represents an overestimate of actual operating hours.

2.4.2 Meteorological Data

Meteorological data from Accra Airport was used in the modelling assessment. This site is approximately 22km west south-west from the proposed site. Hourly sequential data from 2009, 2010, 2013, 2014 and 2015 were used in this study. It should be noted annual sequential meteorological data was not available. Wind roses for the respective years are shown in Diagrams 1 to 5. The highest predicted concentration from any of the five years of meteorological data was reported as 'worst case' and is a conservative approach.

Diagram 1: Wind Rose for the Accra 2009 Data

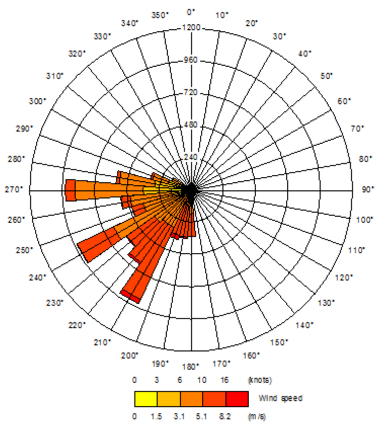


Diagram 2: Wind Rose for the Accra 2010 Data

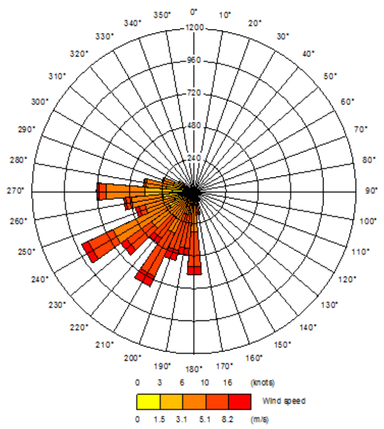


Diagram 3: Wind Rose for the Accra 2013 Data

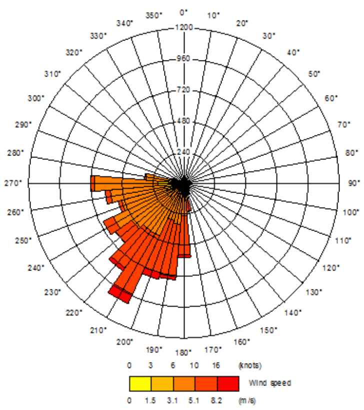


Diagram 4: Wind Rose for the Accra 2014 Data

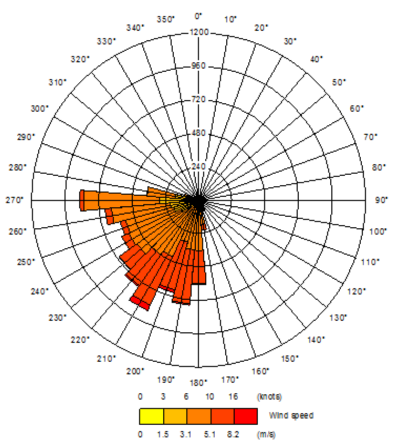
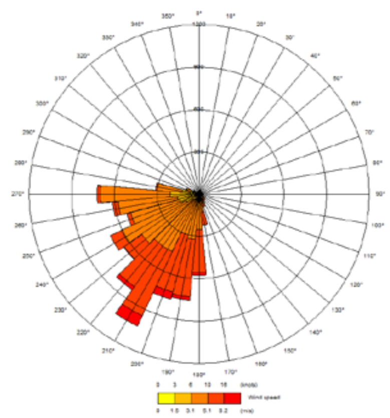


Diagram 5: Wind Rose for the Accra 2015 Data



2.4.3 Buildings and Structures

Buildings or other structures can have a significant influence on local air flow that, under certain circumstances, may draw an emission plume down towards ground level. This is referred to as “building downwash”.

The buildings included within the model to take account of this effect are set out in Table 2-3. Although some of the buildings are not associated with the operation in open cycle mode, which is the condition in the early stages of the project, they will be under construction and thus their presence could affect dispersion prior to the start of combined cycle operations. The buildings have therefore been included in the modelling of all project stages.

Table 2-3: Buildings and Structures

Description	Centre Point Grid Ref (m) (UTM Zone 31N coordinates)		Height	Length	Width	Angle with **North (°)**
	E	N	m	m	m	
TM2500 Structure Unit 1.1	169801	628478	6.1	24	2.8	70
TM2500 Structure Unit 1.2	169813	628449	6.1	24	2.8	70
TM2500 Structure Unit 1.3	169825	628420	6.1	24	2.8	70
TM2500 Structure Unit 1.4	169837	628391	6.1	24	2.8	70
TM2500 Structure Unit 1.5	169849	628362	6.1	24	2.8	70
Steam Turbine Building – Site 1	169754	628424	18.2	23	38	70
Air Cooled Condenser – Site 1	169771	628384	26.0	55	32	70
TM2500 Structure Unit 1.1	169794	628481	6.1	12.5	2.5	70
TM2500 Structure Unit 1.2	169806	628452	6.1	12.5	2.5	70
TM2500 Structure Unit 1.3	169818	628422	6.1	12.5	2.5	70
TM2500 Structure Unit 1.4	169830	628393	6.1	12.5	2.5	70
TM2500 Structure Unit 1.5	169843	628364	6.1	12.5	2.5	70
Steam Turbine Building – Site 2	169754	628424	18	23	38	70
Air Cooled Condenser – Site 2	169771	628384	26	55	32	70
LM6000PC Sprint Unit 3.1	169699	628566	10.1	4.3	48	70
LM6000PC Sprint Unit 3.2	169676	628557	10.1	4.3	48	70
LM6000PC Sprint Unit 3.3	169654	628548	10.1	4.3	48	70
LM6000PC Sprint Unit 3.4	169630	628538	10.1	4.3	48	70
Steam Turbine Building – Site 2	169723	628593	12	17.1	3.1	70

2.4.4 Terrain

The topography in the vicinity of the plant has the potential to affect the dispersion of pollutants. This is only likely to be significant if slopes exceed a gradient of 1:10 over significant distances compared with the distance over which dispersion is being modelled. For the proposed power plant, the topography of the local area was judged to have a gradient less than 1:10 in most places, so terrain effects were not modelled in this study.

2.4.5 Surface Roughness

The surface roughness is a length scale used to represent the turbulent effect of obstructions in the surrounding area. A surface roughness of 0.5m was used in this study which is considered appropriate for the area. A value of 0.3m was used to represent the surface roughness at the Accra meteorological station.

2.4.6 Minimum Monin-Obukhov Length, Surface Albedo and Priestley-Taylor Parameter

The ADMS model default values were used for Surface Albedo (0.23) and Priestley-Taylor Parameter (1) for the dispersion site and a minimum Monin-Obukhov length of 30m (representative of mixed urban / industrial areas).

2.4.7 Calculation of NO_x to NO_2

Emissions of NO_x from a combustion plant consist of the gases nitric oxide (NO) and nitrogen dioxide (NO_2). It is only NO_2 that is of concern in terms of direct health and environmental effects. However NO is a source of NO_2 in the atmosphere. The gases are in equilibrium in the air, with NO predominating at the stack exit. Typically, NO_x produced by combustion consists of 95% NO and 5% NO_2 at source.

In rural areas, where the atmosphere is relatively unpolluted, the oxidation process occurs rapidly downwind of the release point and NO_2 is the predominant species. However, in more polluted areas where the oxidizing capacity of the atmosphere may be limited, NO predominates. Urban areas are generally typical of this limited oxidation pattern.

When assessing the impacts on air quality of emissions to atmosphere from combustion sources, it is important that realistic estimates are made of how much NO has been oxidised to NO_2 at all receptors considered.

The rate of oxidation of NO to NO_2 depends on both the chemical reaction rates and the dispersion of the plume in the atmosphere. The oxidation rate is dependent on a number of factors that include the prevailing concentration of ozone, the wind speed and the atmospheric stability.

One method of estimating the proportion of the NO_x that will be in the form of nitrogen dioxide at ground level, in the study area, is the empirical estimates made by Janssen *et al*[1]. Between 1975 and 1985 about 60 sets of measurements were made of the concentrations of NO and NO_2 in various power station plumes. From the data collected Janssen *et al* suggests an empirical relationship for the percentage oxidation in the plume based on downwind distance, season of the year, wind speed and ambient ozone concentration. This can be described by the following equation:

$$\left(\frac{[NO_2]}{[NO_x]}\right) = A\left(1 - e^{-\alpha x}\right)$$

where x is the distance downwind (km) of the emission point, A is a coefficient dependent on ozone concentration and the intensity of sunlight and α is related to wind speed and ozone concentration.

The A coefficient can be determined from the expression: -

$$A = \left(\frac{k_2}{k_1[O_3]} + 1\right)^{-1}$$

Where k_1 is the second order rate constant for the reaction of NO with O_3 and k_2 is the rate constant for the photo-dissociation of NO_2. Janssen et al uses a value for k_1 of 29 ppm^{-1} min^{-1} determined by Becker and Schurath in 1975[2]. The value for k_2 is dependent on the intensity of sunlight at a particular location and Janssen *et al* quotes values determined by Parrish *et al* in 1983[3] of between 0 in the dark and 0.55 min^{-1} in full

1 L.H.J.M. Janssen, J.H.A. Van Wakeren, H. Van Duuren and A.J. Elshout, A Classification of NO Oxidation Rates in Power Plant Plumes Based on Atmospheric Conditions, Atmospheric Environment Vol. 22, No. 1, pp. 43 – 53, 1988.

2 Becker K. H. and Schurath U. Der Einfluss von Stickstoffoxiden auf atmospharische Oxidationsprozesse. Staub Vol. 35, pp. 156-161, 1975.

3 Parrish D. D., Murphy P. C., Albritton D. L. and Fehsenfeld F.C. The measurement of the photodissociation rate of NO2 in the atmosphere, Atmospheric Environment Vol. 17, pp. 1365-1379, 1983.

sunlight. Janssen obtains an average rate constant of 0.25 min^{-1} from measurements taken in the Netherlands. Typical midday meteorological conditions in The Netherlands are, namely 0.15 min^{-1}, 0.25 min^{-1} and 0.35 min^{-1} in winter, spring/autumn and summer respectively therefore a value of 0.35 min^{-1} is assumed for Tema.

The O_3 concentration used for this assessment was obtained at the start of an ongoing 6 month monitoring programme (April 2016 – October 2016) at 8 locations in proximity to the proposed site. The ozone concentration presented in Table 2-4 was obtained from the first batch of diffusion tubes deployed between 29 April 2016 and 13 May 2016.

Table 2-4: Monitored Mean Ozone Data

Site	Monitored Mean (ppb)	Year
Eight locations in proximity to the proposed site.	24	2016

Taking an average of the local monitored ozone concentration from the table (24 parts per billion, ppb) gives the following for A at the Proposed Development site: -

$$A = \left(\frac{0.35}{29 * 0.024} + 1 \right)^{-1} = 0.665$$

The value of α has been determined experimentally by Janssen *et al*. Because α is not believed to be a function of the intensity of solar radiation, it is assumed here that it is independent of latitude and can, therefore, be applied equally to plumes anywhere in the world. However, some seasonal variation of α was observed (higher values in summer, lower values in winter) and therefore it has been necessary to consider the maximum potential value here. Table 2-5 shows values of α determined by Janssen.

Table 2-5: Worst Case Values of α used for the Determination of NO_x Conversion Factors

Background ozone concentration (ppb)	Wind speed at plume height		
	0 – 5 m/s	5 – 15 m/s	> 15 m/s
120 – 200	0.40	0.65	0.8
60 – 120	0.2	0.35	0.45
40 – 60	0.15	0.25	0.35
30 – 40	0.1	0.15	0.25
20 – 30	0.1	**0.1**	0.15
10 – 20	0.1	0.1	0.1
0 – 10	0.05	0.05	0.05

As the wind speed will rarely exceed 15 m/s at plume height (i.e. above 23 m); for an ozone concentration of 24 ppb (i.e. the 20 – 30 ppb category), Table 2-6 yields a value for α of 0.10.

The overall empirical formula suggested by Janssen et al to describe NO_x conversion with distance at the proposed plant becomes: -

$$\left(\frac{[NO_2]}{[NO_x]} \right) = 0.665 * \left(1 - e^{-0.10x}\right)$$

This equation has therefore been used to calculate a specific maximum conversion rate at a range of distances from the source to give more realistic concentrations of NO_2 resulting from emissions of NO_x from the modelled combustion units.

Table 2-6: Calculated values of NO_2 in NO_x as a percentage with distance

Downwind Distance (km)	Conversion Factor (%) – Janssen Formula
0.25	2%
0.5	3%
0.75	5%
1	6%
1.5	9%
2	12%
2.5	15%
5	26%

Table 2-6 presents the calculated conversion factors for specific distances from the source using the above approach. The receptors assessed in this assessment are between 2.1km and 4.5km from the sources, for which a conversion factor of 12% to 24%, respectively, would be appropriate. The specific Janssen conversion for each receptor location and each grid point has been calculated using the formula described above.

2.4.8 Model / Study Domains

The ADMS model can calculate the predicted ground level concentrations based on a user-defined grid system of up to 101 x 101 points. Generally, the larger the study area, the greater the distance between the grid calculation points and the lower the resolution of the dispersion model predictions. This has to be offset against the requirement to encompass an appropriately wide area within the modelling study to capture the variation in dispersion of the stack emissions.

For this study, the modelled grid was specified as a 10 km x 10 km grid with calculation points every 50m (i.e. 101 points along each grid axis). This size of grid was selected to provide a good grid resolution and also encompass a sufficient area so that the maximum predicted concentrations would be determined for presenting in contour plots. The modelled grid parameters are provided in Table 2-7.

Table 2-7: Modelled Grid Parameters

Grid	Start	Finish	Number of points
X	164215	174215	101
Y	623463	633463	101
Z (height)	0	0	1

2.4.9 Sensitive Receptors

Residential receptors surrounding the proposed site were added to the model to identify the maximum predicted pollutant concentrations at potentially sensitive locations. Modelled concentrations at other receptors of similar sensitivity and located further from those modelled, are assumed to be lower. Twenty four sensitive receptor locations were identified as detailed in Table 2-8. A height of 1.5m was used at each receptor, which can be considered the “breathing zone” height.

It should be noted that Receptor 5, 6 and 13 are new receptors, identified since the previous ESIA iteration. Receptors 5 and 13 are likely to be relocated prior to the commencement of stage 2 construction and stage 1 operation.

Table 2-8 : Modelled Sensitive Receptor Locations

Receptor Description				Location (UTM Zone 31N Coordinates)	
Reference	Location	Direction from site	Distance from site (km)	E (m)	N (m)
1	Residential	NW	3.20	167656	630814
2	Residential	NNW	3.96	168512	632187
3	Residential	NNW	4.27	169257	632681
4	Residential	N	3.85	169748	632296
5*(new)	Informal dwelling	NNW	0.13	169731	628557
6**(new)	Commercial workers accommodation	SSE	0.25	169889	628216
7	Residential	NE	2.28	171196	630251
8	Residential	NNE	2.22	171296	630098
9	Residential	NNE	2.97	172059	630390
10	Residential	NNE	3.47	172561	630560
11	Residential	ESE	3.93	173369	630115
12	Residential	SE	3.43	173121	629327
13*** (new)	Informal dwelling	NW	0.73	170416	628859
14	Residential	SE	2.06	171558	627355
15	Residential	SE	1.73	170957	627159
16	Residential	S	2.03	169758	626419
17	Residential	SSW	3.14	169184	625374
18	Residential	SSW	4.03	168005	624842
19	Residential	SSW	3.55	167477	625773
20	Residential	SW	3.34	167081	626516
21	Residential	SW	3.25	166775	627275
22	Residential	W	3.39	166427	628178
23	Residential	WSW	3.69	166136	628842
24	Residential	WSW	3.94	166134	629881

** Receptor 5 is the Stage 2 site residential dwelling which is due to be relocated by the land owner before Stage 2 construction commences and therefore has been scoped out for stage 2 calculations. It is likely that the resettlement will take place prior to operation of Stage 1. However, the receptor has been included to confirm related impacts in the event that there are any delays to resettlement by the landowner.*

*** Receptor 6 is the workers' residences in the commercial premises adjacent to the south of PPS1.*

**** Receptor 13 is a newly established residential dwelling, which will be resettled as part of EPL's Stage 2 ARAP, prior to operation of Stage 1. This receptor is therefore not included in the assessment.*

2.4.10 Cumulative assessments

Four key external power plants have been identified in the vicinity of the project, for inclusion in the cumulative impacts assessment. These are identified in Table 2.9.

Table 2-9: External Power Plant Included in the Cumulative Analysis

Power plant	Fuel	Stack height	Rated Power	Emission rates			
				NOx	SO_2	CO	PM_{10}
		(m)	(MW)	(g/s)	(g/s)	(g/s)	(g/s)
Sunnon Asogli – Gas/LCO	LCO	45	360	99.3	620.7	20.7	8.3
Aksa HFO	HFO	70	187	88.7	296.4	9.4	23.4
Cenpower	LCO	45	340	74.0	462.8	15.4	6.2
Karpower Ship	HFO	45	470	223.0	745.0	23.7	59.0

In the absence of plant data other assumptions include an emission exit velocity of 0 m/s and a stack diameter of 1 m.

In addition, information from the Ghana EPA indicates that a new 450MW ship is under consideration for Tema, though it is currently not confirmed whether the Karpower ship expansion will proceed. The larger ship capacity assumed for purposes of conservative assessment.

2.5 Assumptions

2.5.1 Uncertainty

There are always uncertainties in dispersion models in common with any environmental modelling study because a dispersion model is an approximation to the complex processes which take place in the atmosphere. Some of the key factors which lead to uncertainty in atmospheric dispersion modelling are as follows.

- The quality of the model output depends on the accuracy of the input data used with the model. Where model input data are a less reliable representation of the true situation, the results are likely to be less accurate.
- The meteorological datasets used in the model are not likely to be completely representative of the meteorological conditions at the site. However, the most suitable available meteorological data were chosen for the assessment.
- Models are generally designed on the basis of data obtained for large scale point sources, and may be less well validated for modelling emissions from smaller scale sources.
- The dispersion of pollutants around buildings is a complex scenario to replicate. Dispersion models can take account of the effects of buildings on dispersion. However, there will be greater uncertainty in the model results when buildings are present in the scenario.
- Modelling does not specifically take into account individual small-scale features such as vegetation, local terrain variations and off-site buildings. The roughness length (z_o) selected is suitable to take account of the typical size of these local features.
- For the cumulative assessment, plant emissions parameters and dimensions have been determined based on visual observation and publicly available information including data on the fuel types used, operational capacity and dimensions of stack heights.

To take account of these uncertainties and to ensure the predictions are more likely to be over-estimates than under-estimates, the conservative assumptions described below have been used for this assessment.

2.5.2 Conservative Assumptions

The conservative assumptions adopted in this study are summarised below.

- It has been assumed that the LPG/DFO fired turbines would operate simultaneously and continuously at maximum load (100% of maximum continuous rating) for the entire year. In practice, there will be some downtime for routine maintenance and inspection, and so the modelling assessment represents an overestimate of actual operating hours and the operating load may not always be 100%.

- The study is based on emissions from the plant being continuously at the maximum emission concentrations for the proposed plant.
- The highest predicted concentrations obtained using any of the five years of meteorological data have been reported in this assessment. During a typical year the ground level concentrations are likely to be lower.
- The highest predicted concentration at any of the sensitive locations is included in the assessment of environmental effects. Concentrations at other locations are likely to be less than the maximum values presented.
- In the case of $PM_{2.5}$ it has been assumed that all particulates emitted are in the form of $PM_{2.5}$
- In modelling the cumulative assessments, it should be noted is that no mitigation on the emissions has been assumed which makes this assessment conservative.

2.6 Baseline Air Quality

2.6.1 Publically available information

In order to complete the assessment, it was necessary to combine modelled concentrations of substances emitted from the proposed plant with baseline concentrations present in the environment due to emissions from other sources. Air quality monitoring is not carried out by Ghana, and monitoring is generally project specific to support the ESIA process. Information on baseline air quality surrounding the proposed facility was obtained or sourced from publically available ESIAs and published material on the internet.

A review of publicly available ambient air quality information was carried out and it was concluded that the majority of the data was not relevant for the pollutants concerned in this assessment and is likely to have changed as several power plants have been commissioned in more recent years.

Ambient NO_2 concentrations for monitoring undertaken at four site locations in 2008 and reported within the Kpone ESIA 2013[4] averaged 21µg/m^3 for NO_2. This site is located to the southeast of the Tema Industrial area and is considered to be representative of its surroundings.

Table 2-10presents the facilities within Tema Industrial Area that contribute to the existing air quality and are assumed to be accounted for in the background measurements surrounding the proposed site.

Table 2-10 : Industrial Facilities Operating Within Proximity of The Proposed Power Plant

Facility type	Capacity	Fuel Type	In Operation (start date)	Approximate distance from PPS1	Direction (from PPS1/PPS2)
CENIT Thermal Power Plant	220 MW	LCO/ Gas	Yes (2012)	0.6km	SW (PPS2)
Trojan Power Ltd – Tema III	56 MW	Gas	When gas available (2016)	115m	WSW (PPS2)
VRA Station 3 upgrade	42 MW	Gas / Diesel	14 MW commissioned, others built	0.005	SW
Cenpower Kpone	350 MW	LCO / Diesel /	No (2016)	2.5	E

4 SKM Kpone Independent Power Plant, Vol 1 Environmental and Social Impact Assessment of the Kpone Thermal Power Project, February 2013.

Facility type	Capacity	Fuel Type	In Operation (start date)	Approximate distance from PPS1	Direction (from PPS1/PPS2)
Independent Power Plant		Natural Gas			
Sunon-Asogli Power Plant Expansion	360 MW	Natural Gas / LCO	Yes (Unknown)	3.4	E
AKSA Heavy Fuel Oil (HFO) Power Plant	200 MW	HFO	Yes (2017)	~0.8km	NNW
Karpower Ship	225 - 450 MW	HFO	225MW operating 2016 (new 450MW ship late 2017)	~5 km	SW (PPS1)

Notes:
LCO - Light crude oil.
The operation of gas-fired plants is intermittent as limited by availability of gas.

2.6.2 Project Specific Monitoring

In the absence of specific air quality information or monitoring data within the vicinity of the site, project-specific monitoring was undertaken during 2015 over a six month period for the pollutants NO_2 and SO_2 and over a 3 week period for PM_{10} and $PM_{2.5}$. An additional six-month monitoring survey was undertaken during a six-month period in 2016 for the pollutants NO_2 and ozone, to enable the derivation of site specific factors for the conversion of NO_x to NO_2. It is considered appropriate to use the results of the respective project specific monitoring surveys to inform this assessment.

The measured NO_2 levels provide an indication of NO_2 concentrations in the area for use as background measurements and to ascertain whether the proposed site is within a degraded or non-degraded air-shed. ‘Background’ is the average concentration of pollutants present in ambient air and is used to enable assessment of the impacts of particular emission sources to air without the need for all sources in the area to be considered explicitly. The air quality monitoring was managed by Associated Consultants, who has experience of air quality monitoring in Ghana, under the oversight of Jacobs Consultancy.

The average concentrations measured during each monitoring survey are presented in Table 2-11and the locations are shown in Figure 2.

Table 2-11 Diffusion Tube and Automatic Monitoring Data

Pollutant	Concentration µg/m^3	Description
NO_2	21.9	2015 (Apr - Oct) Diffusion tube monitoring at 6 locations in close proximity to the site. 2016 (Apr - Nov) Diffusion tube monitoring at 8 locations in close proximity to the site.
SO2	5.3	2015 (Apr - Oct) Diffusion tube monitoring at 6 locations in close proximity to the site.
PM10	187.5	2015 (9 Apr - 27 Apr) Automatic monitoring at monitoring location VRA Station 3 (169234, 628459), east of PPS2.
PM2.5	44.1	
O3	23.6	2016 (Apr - Nov) Diffusion tube monitoring at 8 locations in close proximity to the site.

Note 1: NO^2 concentration bias adjusted using a bias adjustment factor of 0.92 derived from Defra 5.

[5] Department for Environment Food and Rural Affairs, National Bias Adjustment Diffusion Tube Factor Spreadsheet. https://laqm.defra.gov.uk/bias-adjustment-factors/national-bias.html [accessed December 2016].

The long-term background concentrations were doubled to estimate the short-term background concentrations in line with the Environment Agency guidance[6].

In the absence of specific monitored background CO concentrations, the concentration of 140 µg/m^3 was adopted based on information within the WHO Air Quality Guidelines report (2000)[7].

[6] Environment Agency and Department for Environment, Food and Rural Affairs, Air emissions risk assessment for your environmental permit, https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit/, last updated August 2016.

[7] WHO Air Quality Guidelines for Europe – second Edition, Chapter 5.5 Carbon monoxide, 2000

3. Dispersion Modelling Results

3.1 Maximum Predicted Concentrations at Off-site Locations

The dispersion model results for each scenario described in Section 2.1 are set out in Table 3-1 to Table 3-24. The results are the maximum predicted concentrations at 'off-site' locations and the concentrations at selected sensitive receptors. The tables give the following information.

- Ambient Air Quality Guideline (AAQG) for each substance under consideration. The EPA AAQG for "Residential" locations has been applied. Where no EPA AAQG exists, the WHO AAQG has been applied and this is shown within the table.
- The background concentration of the pollutant.
- Process Contribution (PC), the maximum modelled concentration of the substance due to process emissions alone from the proposed site.
- Predicted Environmental Concentration (PEC), the maximum modelled concentration due to process emissions combined with estimated background concentrations.
- PC and PEC as a percentage of the AAQG.

Contour plots showing the maximum annual mean NO_2, maximum 1-hour mean NO_2 and maximum 24-hour mean NO_2 process contributions from the respective stages and scenarios are presented in the Figures section. Contour plots for CO are not produced as the contributions are not significant.

3.1.1 The LPG Scenarios

Table 3-1to Table 3-3present the maximum process contribution and the PEC for each operating mode on the modelled grid using LPG as fuel. While the PC does not exceed 25% of the AAQG, the high background concentrations mean that PEC when the plant is in operation is above 25% of the AAQG. The highest impact for the NO_2 occurs in Scenario 3 of the 24 hour mean where PEC is 90.0% of the AAQG.

Across the various scenarios, PEC levels of CO, for both averaging periods, are less than 5% and therefore is not considered significant.

3.1.1.1 Scenario 1 – Stage 1a: 5 x TM2500 Plant Operating in Open Cycle Mode (LPG)

Table 3-1: Predicted Maximum 'Off-Site' Modelled Concentrations for Scenario 1 (Stage 1)

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
Scenario 1 – Stage 1a (5 x TM2500 in OC mode on LPG)							
Nitrogen dioxide	Annual mean	40 (WHO)	21.9	0.77	22.7	1.93%	56.7%
	24 hour mean (maximum)	60	43.8	3.09	46.9	5.14%	78.1%
	1 hour mean (maximum)	200	43.8	6.52	50.3	3.26%	25.2%
Carbon monoxide	8 hour running mean (maximum)	10,000	280	223.6	503.6	2.24%	5.04%
	1 hour mean (maximum)	30,000	280	227.0	507.0	0.76%	1.69%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed)

3.1.1.2 Scenario 2 – Stage 1b: 5 x TM2500 Plants Operating in Combined Cycle Mode (LPG)

Table 3-2: Predicted Maximum 'Off-Site' Modelled Concentrations for Scenario 2 (Stage 1b)

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
Scenario 2 – Stage 1b (5 x TM2500 in CCGT mode on LPG)							
Nitrogen dioxide	Annual mean	40 (WHO)	21.9	1.51	23.4	3.78%	58.5%
	24 hour mean (maximum)	60	43.8	5.80	49.6	9.67%	82.7%
	1 hour mean (maximum)	200	43.8	12.2	56.0	6.11%	28.0%
Carbon monoxide	8 hour running mean (maximum)	10,000	280	358.3	638.3	3.58%	6.38%
	1 hour mean (maximum)	30,000	280	362.1	642.1	1.21%	2.14%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed).

3.1.1.3 Scenario 3 – Stages 1b and 2: 5 x TM2500 and 4 x LM6000PC Plant Operating in Combined Cycle Mode (LPG)

Table 3-3: Predicted Maximum 'Off-Site' Modelled Concentrations for Scenario 3 (Stage 1b+2 on LPG)

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
Scenario 3 – Stage 1a + 2 (5 x TM2500 4 x LM6000PC in CCGT mode on LPG)							
Nitrogen dioxide	Annual mean	40 (WHO)	21.9	2.35	24.2	5.87%	60.6%
	24 hour mean (maximum)	60	43.8	10.21	54.0	17.01%	90.0%
	1 hour mean (maximum)	200	43.8	25.2	69.0	12.59%	34.5%
Carbon monoxide	8 hour running mean (maximum)	10,000	280	358	638	3.58%	6.4%
	1 hour mean (maximum)	30,000	280	362	642	1.21%	2.14%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed)

3.1.2 The DFO Scenarios

Table 3-4 to Table 3-6 present the maximum process contribution and the Predicted Environmental Contribution for each operating mode on the modelled grid using DFO as fuel.

3.1.2.1 Scenario 1 – Stage 1a: 5 x TM2500 Plant Operating in Open Cycle Mode (DFO)

Table 3-4 : Predicted Maximum 'Off-Site' Modelled Concentrations for Scenario 1 (Stage 1)

Pollutant	Averaging Period	AAQG ($\mu g/m^3$)	Background conc ($\mu g/m^3$)	PC ($\mu g/m^3$)	PEC ($\mu g/m^3$)	PC / AAQG	PEC / AAQG
Scenario 3 – Stage 1a + 2 (5 x TM2500 4 x LM6000PC in CCGT mode on DFO)							
Nitrogen dioxide	Annual mean	40 (WHO)	21.9	0.82	22.72	2.05%	56.80%
	24 hour mean (maximum)	60	43.8	3.33	47.13	5.56%	78.56%
	1 hour mean (maximum)	200	43.8	6.69	50.49	3.35%	25.25%
Carbon monoxide	8 hour running mean (maximum)	10,000	280	229.63	509.63	2.30%	5.10%
	1 hour mean (maximum)	30,000	280	231.94	511.94	0.77%	1.71%
Sulphur dioxide	24 hour mean (maximum)	20	11	291.75	302.35	1458.73%	1511.73%
	10 minute	500	11	386.47	397.07	77.29%	79.41%
PM10	Annual mean	20	188	18.39	205.89	91.96%	1029.46%
	24 hour mean (maximum)	50	375	90.20	465.20	180.40%	930.40%
PM2.5	Annual mean	10	44	18.39	62.49	183.92%	624.92%
	24 hour mean (maximum)	25	88	90.20	178.40	360.79%	713.59%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed)

3.1.2.2 Scenario 2 – Stage 1b: 5 x TM2500 Plants Operating in Combined Cycle Mode (DFO)

Table 3-5: Predicted Maximum 'Off-Site' Modelled Concentrations for Scenario 2 (Stage 1b)

Pollutant	Averaging Period	AAQG ($\mu g/m^3$)	Background conc ($\mu g/m^3$)	PC ($\mu g/m^3$)	PEC ($\mu g/m^3$)	PC / AAQG	PEC / AAQG
Scenario 3 – Stage 1a + 2 (5 x TM2500 4 x LM6000PC in CCGT mode on DFO)							
Nitrogen dioxide	Annual mean	40 (WHO)	21.9	1.56	23.46	3.89%	58.64%
	24 hour mean (maximum)	60	43.8	5.96	49.76	9.93%	82.93%
	1 hour mean (maximum)	200	43.8	12.55	56.35	6.27%	28.17%
Carbon monoxide	8 hour running mean (maximum)	10,000	280	370.07	650.07	3.70%	6.50%
	1 hour mean (maximum)	30,000	280	373.88	653.88	1.25%	2.18%
Sulphur dioxide	24 hour mean (maximum)	20	11	422.95	433.55	2114.76%	2167.76%
	10 minute	500	11	619.80	630.40	123.96%	126.08%
PM10	Annual mean	20	188	40.28	227.78	201.38%	1138.88%

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
	24 hour mean (maximum)	50	375	187.19	562.19	374.38%	1124.38%
PM2.5	Annual mean	10	44	40.28	84.38	402.76%	843.76%
	24 hour mean (maximum)	25	88	187.19	275.39	748.76%	1101.56%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed).

3.1.2.3 Scenario 3 – Stages 1b and 2: 5 x TM2500 and 4 x LM6000PC Plant Operating in combined Cycle Mode (DFO)

Table 3-6: Predicted Maximum 'Off-Site' Modelled Concentrations for Scenario 3 (Stage 1b and 2 on DFO)

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
Scenario 3 – Stage 1a + 2 (5 x TM2500 4 x LM6000PC in CCGT mode on DFO)							
Nitrogen dioxide	Annual mean	40 (WHO)	21.9	2.21	24.1	5.5%	60.3%
	24 hour mean (maximum)	60	43.8	9.75	53.6	16.3%	89.3%
	1 hour mean (maximum)	200	43.8	22.7	66.5	11.3%	33.2%
Carbon monoxide	8 hour running mean (maximum)	10,000	280	370.07	650.07	3.70%	6.50%
	1 hour mean (maximum)	30,000	280	373.88	653.88	1.25%	2.18%
Sulphur dioxide	24 hour mean (maximum)	20	11	422.95	433.55	2114.76%	2167.76%
	10 minute	500	11	619.80	630.40	123.96%	126.08%
PM10	Annual mean	20	188	40.32	227.82	201.61%	1139.11%
	24 hour mean (maximum)	50	375	187.19	562.19	374.38%	1124.38%
PM2.5	Annual mean	10	44	40.32	84.42	403.23%	844.23%
	24 hour mean (maximum)	25	88	187.19	275.39	748.76%	1101.56%

OCGT = Open cycle gas turbine; CCGT = Combined cycle gas turbine (waste heat recovery unit installed)

3.2 Maximum Predicted Concentrations at Industrial Off-site Locations

Due to the location of the site in an Industrial zone; the following tables give the results are the maximum predicted concentrations at industrial off-site locations and therefore considers the maximum short term process contribution. The tables below give the following information.

- Ambient Air Quality Guideline (AAQG) for each substance under consideration. The EPA AAQG for "Industrial" locations has been applied. Where no EPA AAQG exists, the WHO AAQG has been applied and this is shown within the table.
- The background concentration of the pollutant.

3.2.1 The LPG Scenarios

3.2.1.1 Scenario 1 – Stage 1a: 5 x TM2500 Plant Operating in Open Cycle Mode (LPG)

Table 3-7: Predicted Maximum 'Off-Site' Modelled Concentrations for Scenario 1 (Stage 1)

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
Scenario 1 – Stage 1a (5 x TM2500 in OC mode on LPG)							
Nitrogen dioxide	24 hour mean (maximum)	150	43.8	3.09	46.9	2.06%	31.3%
	1 hour mean (maximum)	400	43.8	6.52	50.3	1.63%	12.6%
Carbon monoxide	8 hour running mean (maximum)	10,000	280	223.6	503.6	2.24%	5.04%
	1 hour mean (maximum)	30,000	280	227.0	507.0	0.76%	1.69%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed)

3.2.1.2 Scenario 2 – Stage 1b: 5 x TM2500 Plants Operating in Combined Cycle Mode (LPG)

Table 3-8: Predicted Maximum 'Off-Site' Modelled Concentrations for Scenario 2 (Stage 1b)

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
Scenario 2 – Stage 1b (5 x TM2500 in CCGT mode on LPG)							
Nitrogen dioxide	24 hour mean (maximum)	150	43.8	5.80	49.6	3.87%	33.1%
	1 hour mean (maximum)	400	43.8	12.2	56.0	3.05%	14.0%
Carbon monoxide	8 hour running mean (maximum)	10,000	280	358.3	638.3	3.58%	6.38%
	1 hour mean (maximum)	30,000	280	362.1	642.1	1.21%	2.14%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed).

3.2.1.3 Scenario 3 – Stages 1b and 2: 5 x TM2500 and 4 x LM6000PC Plant Operating in Combined Cycle Mode (LPG)

Table 3-9: Predicted Maximum 'Off-Site' Modelled Concentrations for Scenario 3 (Stage 1b+2 on LPG)

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
Scenario 3 – Stage 1a + 2 (5 x TM2500 4 x LM6000PC in CCGT mode on LPG)							
Nitrogen dioxide	24 hour mean (maximum)	150	43.8	10.21	54.0	6.81%	36.0%
	1 hour mean (maximum)	400	43.8	25.2	69.0	6.30%	17.2%
Carbon monoxide	8 hour running mean (maximum)	10,000	280	358	638	3.58%	6.4%

Pollutant	Averaging Period	AAQG ($\mu g/m^3$)	Background conc ($\mu g/m^3$)	PC ($\mu g/m^3$)	PEC ($\mu g/m^3$)	PC / AAQG	PEC / AAQG
	1 hour mean (maximum)	30,000	280	362	642	1.21%	2.14%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed)

3.2.2 The DFO Scenarios

3.2.2.1 Scenario 1 – Stage 1a: 5 x TM2500 Plant Operating in Open Cycle Mode (DFO)

Table 3-10: Predicted Maximum Industrial 'Off-Site' Modelled Concentrations for Scenario 1 (Stage 1)

Pollutant	Averaging Period	AAQG ($\mu g/m^3$)	Background conc ($\mu g/m^3$)	PC ($\mu g/m^3$)	PEC ($\mu g/m^3$)	PC / AAQG	PEC / AAQG
Scenario 3 – Stage 1a + 2 (5 x TM2500 4 x LM6000PC in CCGT mode on DFO)							
Nitrogen dioxide	24 hour mean (maximum)	150	43.8	3.33	47.13	2.22%	31.42%
	1 hour mean (maximum)	400	43.8	6.69	50.49	1.67%	12.62%
Carbon monoxide	8 hour running mean (maximum)	10,000	280	229.63	509.63	2.30%	5.10%
	1 hour mean (maximum)	30,000	280	231.94	511.94	0.77%	1.71%
Sulphur dioxide	24 hour mean (maximum)	150	11	291.75	302.35	194.50%	201.56%
	10 minute	500	11	386.47	397.07	77.29%	79.41%
PM10	Annual mean	20	188	18.39	205.89	91.96%	1029.46%
	24 hour mean (maximum)	50	375	90.20	465.20	180.40%	930.40%
PM2.5	Annual mean	10	44	18.39	62.49	183.92%	624.92%
	24 hour mean (maximum)	25	88	90.20	178.40	360.79%	713.59%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed)

3.2.2.2 Scenario 2 – Stage 1b: 5 x TM2500 Plants Operating in Combined Cycle Mode (DFO)

Table 3-11: Predicted Maximum Industrial 'Off-Site' Modelled Concentrations for Scenario 2 (Stage 1b)

Pollutant	Averaging Period	AAQG ($\mu g/m^3$)	Background conc ($\mu g/m^3$)	PC ($\mu g/m^3$)	PEC ($\mu g/m^3$)	PC / AAQG	PEC / AAQG
Scenario 3 – Stage 1a + 2 (5 x TM2500 4 x LM6000PC in CCGT mode on DFO)							
Nitrogen dioxide	24 hour mean (maximum)	150	43.8	5.96	49.76	3.97%	33.2%
	1 hour mean (maximum)	400	43.8	12.55	56.35	3.14%	14.1%
Carbon monoxide	8 hour running mean (maximum)	10,000	280	370.07	650.07	3.70%	6.50%
	1 hour mean (maximum)	30,000	280	373.88	653.88	1.25%	2.18%
Sulphur dioxide	24 hour mean (maximum)	150	11	422.95	433.55	281.97%	289.03%

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
	10 minute	500	11	619.80	630.40	123.96%	126.08%
PM10	Annual mean	20	188	40.28	227.78	201.38%	1138.88%
	24 hour mean (maximum)	50	375	187.19	562.19	374.38%	1124.38%
PM2.5	Annual mean	10	44	40.28	84.38	402.76%	843.76%
	24 hour mean (maximum)	25	88	187.19	275.39	748.76%	1101.56%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed).

3.2.2.3 Scenario 3 – Stages 1b and 2: 5 x TM2500 and 4 x LM6000PC Plant Operating in Combined Cycle Mode (DFO)

Table 3-12: Predicted Maximum Industrial 'Off-Site' Modelled Concentrations for Scenario 3 (Stage 1b and 2 on DFO)

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
Scenario 3 – Stage 1a + 2 (5 x TM2500 4 x LM6000PC in CCGT mode on DFO)							
Nitrogen dioxide	24 hour mean (maximum)	150	43.8	9.75	53.6	6.50%	35.70%
	1 hour mean (maximum)	400	43.8	22.7	66.5	5.67%	16.62%
Carbon monoxide	8 hour running mean (maximum)	10,000	280	370.07	650.07	3.70%	6.50%
	1 hour mean (maximum)	30,000	280	373.88	653.88	1.25%	2.18%
Sulphur dioxide	24 hour mean (maximum)	150	11	425.77	436.37	283.8%	290.9%
	10 minute	500	11	623.94	634.54	124.8%	126.9%
PM10	Annual mean	20	188	40.32	227.82	201.61%	1139.11%
	24 hour mean (maximum)	50	375	187.19	562.19	374.38%	1124.38%
PM2.5	Annual mean	10	44	40.32	84.42	403.23%	844.23%
	24 hour mean (maximum)	25	88	187.19	275.39	748.76%	1101.56%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed)

3.3 Predicted Concentrations at Sensitive Human Health Receptors

The dispersion model results for the proposed plant are set out in Table 3-13 to Table 3-18. The tables provide the following information:

- Receptor location; and,
- Process Contribution (PC), the maximum modelled concentration of each of the substances due to process emissions alone for each scenario considered. This is the maximum PC determined from the five years of meteorological data.

3.3.1 The LPG Scenarios

3.3.1.1 Scenario 1 – Stage 1a: 5 x TM2500 Plant Operating in Open Cycle Mode (LPG)

Table 3-13: Maximum Predicted Process Contributions at Sensitive Human Health Receptors – Stage 1a

Receptor	Modelled PC (µg/m^3)				
	Nitrogen dioxide			Carbon monoxide	
	Annual mean	Maximum 1-hr mean	Maximum 24-hr mean	Maximum 8-hr mean	Maximum 1- hr mean
1	0.04	3.3	0.9	6.8	11.9
2	0.07	3.8	0.8	9.0	11.5
3	0.18	3.8	1.1	8.1	10.8
4	0.28	3.5	1.1	8.4	10.9
5 (new)	0.01	0.5	0.1	20.5	37.8
6 (new)	0.00	1.3	0.1	7.3	51.2
7	0.47	3.2	1.9	14.4	15.7
8	0.45	3.2	1.9	14.9	15.7
9	0.38	5.1	1.6	10.8	19.5
10	0.38	6.3	1.6	11.3	21.4
11	0.33	6.2	2.2	10.1	19.0
12	0.24	6.1	1.0	11.4	20.9
13 (new)*	0.53	3.9	2.2	49.2	54.8
14	0.03	3.1	0.4	9.4	16.6
15	0.01	3.3	0.3	7.1	20.7
16	0.01	3.2	0.4	4.9	17.2
17	0.01	4.8	0.4	7.7	17.5
18	0.01	3.4	0.6	9.2	10.1
19	0.01	5.0	0.5	4.4	16.5
20	0.01	3.0	0.4	5.2	10.4
21	0.01	3.2	0.4	3.2	11.6
22	0.01	3.1	0.4	4.1	10.8
23	0.01	3.2	0.4	3.8	10.4
24	0.01	3.0	0.5	4.6	9.0

Table 3-14: Predicted Maximum at Selected Residential (Sensitive Human Health) Receptors - Modelled concentrations for Scenario 1 (Stage 1a)

Pollutant	Averaging Period	AAQG (µg/m³)	Background concentration (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG (%)	PEC / AAQG (%)
NO2	Annual mean	40	21.9	0.47	22.4	1.17%	55.9%
	24 hour mean (maximum)	60	43.8	2.20	46.0	3.67%	76.7%
	1 hour mean (maximum)	200	43.8	6.34	50.1	3.17%	25.1%
CO	8 hour running mean (maximum)	10000	280	20.5	301	0.21%	3.01%
	1 hour mean (maximum)	30000	280	51.2	331	0.17%	1.10%

3.3.1.2 Scenario 2 – Stage 1b: 5 x TM2500 Plants Operating in Combined Cycle Mode (LPG)

Table 3-15: Maximum Predicted Process Contributions at Human Health Receptors – Stage 1b on LPG

Receptor	Modelled PC (µg/m³)				
	Nitrogen dioxide			Carbon monoxide	
	Annual mean	**Maximum 1-hr mean**	**Maximum 24-hr mean**	**Maximum 8-hr mean**	**Maximum 1- hr mean**
1	0.07	8.3	1.8	15.1	30.1
2	0.10	10.2	1.6	15.5	30.8
3	0.28	9.8	1.9	20.6	27.8
4	0.44	10.2	2.3	24.7	31.7
5 (new)	0.08	1.0	0.3	70.0	72.9
6 (new)	0.00	2.6	0.3	49.4	105.5
7	0.82	7.0	3.3	27.7	34.1
8	0.80	6.9	3.8	28.2	34.4
9	0.74	8.9	2.8	22.2	34.2
10	0.67	8.6	3.0	18.8	28.9
11	0.56	8.8	3.2	23.1	26.7
12	0.58	8.8	2.8	20.7	30.0
13 (new)*	1.21	5.8	4.9	77.0	80.7
14	0.10	10.3	1.2	31.8	54.7
15	0.02	5.3	0.7	26.2	33.2
16	0.02	6.4	0.8	20.7	34.6
17	0.02	9.2	0.9	16.7	33.9
18	0.02	8.3	0.7	13.5	24.7
19	0.02	8.3	0.8	6.9	27.5
20	0.02	7.3	0.6	6.5	25.6
21	0.01	7.2	0.9	6.4	25.8
22	0.02	8.6	0.8	9.1	29.6

Receptor	Modelled PC (µg/m³)				
	Nitrogen dioxide			Carbon monoxide	
	Annual mean	**Maximum 1-hr mean**	**Maximum 24-hr mean**	**Maximum 8-hr mean**	**Maximum 1- hr mean**
23	0.02	7.6	0.7	7.3	24.5
24	0.02	6.9	1.1	14.1	20.9

Table 3-16: Predicted Maximum at Selected Residential Receptors (Sensitive Human Health) - Modelled Concentrations for Scenario 1 (Stage 1b) on LPG

Pollutant	Averaging Period	AAQG (µg/m3)	Background concentration (µg/m3)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG (%)	PEC / AAQG (%)
NO2	Annual mean	40	21.9	0.82	22.7	2.06%	56.8%
	24 hour mean (maximum)	60	43.8	3.81	47.6	6.35%	79.4%
	1 hour mean (maximum)	200	43.8	10.32	54.1	5.16%	27.1%
CO	8 hour running mean (maximum)	10000	280	69.98	350	0.70%	3.50%
	1 hour mean (maximum)	30000	280	105.51	386	0.352%	1.29%

3.3.1.3 Scenario 3 – Stages 1b and 2: 5 x TM2500 and 4 x LM6000PC Plant Operating in Combined Cycle Mode (LPG)

Table 3-17: Maximum Predicted Process Contributions at Human Health Receptors – Stage 2 on LPG

Receptor	Modelled PC (µg/m³)				
	Nitrogen dioxide			Carbon monoxide	
	Annual mean	Maximum 1-hr mean	Maximum 24-hr mean	Maximum 8-hr mean	Maximum 1- hr mean
1	0.14	16.9	3.6	30.5	61.0
2	0.21	19.5	3.5	33.5	59.0
3	0.61	19.3	3.7	44.2	54.8
4	0.93	20.3	4.7	51.1	62.9
5 (new)	0.08	1.0	0.3	70.0	72.9
6 (new)	0.01	4.5	0.7	94.6	184.1
7	1.56	13.4	6.7	52.3	66.5
8	1.58	13.0	6.8	44.2	58.7
9	1.42	17.3	5.2	40.8	59.9
10	1.27	17.4	6.5	39.6	65.1
11	1.05	19.7	5.4	51.8	111.5
12	1.12	19.1	5.6	36.5	64.8
13 (new)*	1.91	9.8	7.7	130.0	76.0
14	0.18	21.1	2.2	61.6	49.0
15	0.04	10.4	1.4	54.2	55.6
16	0.04	13.5	1.7	42.5	54.4
17	0.04	20.7	2.0	35.9	49.2
18	0.04	16.5	1.5	27.1	61.2
19	0.05	16.8	1.5	15.2	53.8
20	0.05	15.6	1.4	13.5	39.6
21	0.02	13.8	1.7	12.9	0.0
22	0.04	17.8	1.6	19.6	61.0
23	0.05	16.8	1.5	13.6	59.0
24	0.05	13.0	2.2	28.9	54.8

Table 3-18: PEC at Selected Residential Receptors (Sensitive Human Health) -- Modelled concentrations for Scenario 3 (Stage 2) on LPG

Pollutant	Averaging Period	AAQG(µg/m3)	Background concentration (µg/m³)	PC(µg/m³)	PEC(µg/m³)	PC /AAQG (%)	PEC / AAQG (%)
NO_2	Annual mean	40	21.9	1.58	23.5	3.95%	58.7%
	24 hour mean (maximum)	60	43.8	6.82	50.6	11.4%	84.4%
	1 hour mean (maximum)	200	43.8	21.1	64.9	10.53%	32.4%
CO	8 hour running mean (maximum)	10000	280	95	375	0.95%	3.75%
	1 hour mean (maximum)	30000	280	184	464	0.614%	1.55%

3.3.2 The DFO Scenarios

3.3.2.1 Scenario 1 – Stage 1a: 5 x TM2500 Plant Operating in Open Cycle Mode (DFO)

Table 3-19 : Maximum Predicted Process Contributions at Human Health Receptors – Stage 1a on DFO

Receptor	Modelled PC (µg/m³) Stage 1 (DFO)								
	Nitrogen dioxide			Carbon monoxide		SO_2		Particulates	
	Annual mean	Maximum 1-hr mean	Maximum 24-hr mean	Maximum 8-hr mean	Maximum 1-hr mean	Maximum 15 mins	Maximum 24 hr	Annual mean	Maximum 24-hr
1	0.03	3.27	0.62	6.95	11.85	24.61	3.61	0.05	1.12
2	0.07	3.89	0.80	7.87	11.80	25.23	3.91	0.10	1.21
3	0.16	3.69	1.17	9.45	10.52	22.28	5.38	0.22	1.66
4	0.24	3.53	1.20	9.46	10.95	28.55	6.02	0.37	1.86
5*	0.01	0.51	0.08	21.09	38.94	64.82	10.25	0.55	3.17
6	0.00	1.52	0.07	8.81	61.54	102.28	4.34	0.01	1.34
7	0.48	3.26	1.73	15.02	15.85	32.10	13.64	1.17	4.22
8	0.46	3.23	1.97	15.62	16.05	32.16	15.85	1.13	4.90
9	0.39	5.21	1.59	12.36	20.08	56.36	9.91	0.74	3.07
10	0.39	5.47	1.64	10.08	18.48	39.97	8.95	0.65	2.77
11	0.34	5.10	2.30	9.62	15.53	30.32	11.31	0.51	3.50
12	0.24	4.99	1.03	8.67	17.03	33.16	5.70	0.41	1.76
13	0.54	3.79	2.26	48.70	52.96	90.45	51.09	3.78	15.80
14	0.03	3.18	0.46	9.61	16.86	31.08	3.93	0.08	1.21
15	0.01	3.41	0.34	7.26	21.28	38.92	3.43	0.02	1.06
16	0.01	2.98	0.40	5.50	16.04	28.91	3.49	0.01	1.08
17	0.01	5.36	0.40	7.94	19.72	44.42	2.35	0.01	0.73
18	0.01	3.41	0.60	9.61	10.18	22.08	2.89	0.01	0.89
19	0.01	4.38	0.40	4.43	14.52	31.92	2.14	0.01	0.66
20	0.01	2.84	0.39	4.96	9.89	19.78	2.22	0.01	0.69
21	0.00	3.14	0.39	3.44	12.62	25.68	2.23	0.01	0.69
22	0.01	2.72	0.28	4.14	9.37	19.65	1.57	0.01	0.49
23	0.01	2.78	0.52	4.40	10.48	22.43	2.71	0.01	0.84
24	0.01	2.82	0.50	4.68	9.03	21.71	2.47	0.02	0.76

Table 3-20 : PEC at Predicted Maximum Selected Sensitive Human Health Receptors - Modelled Concentrations for Scenario 1 (Stage 1a)

Pollutant	Averaging Period	AAQG(µg /m3)	Background concentration (µg/m³)	PC(µg/m³)	PEC(µg/m³)	PC /AAQG (%)	PEC / AAQG (%)
NO_2	Annual mean	40	21.9	0.48	22.38	1.20%	55.95%
	24 hour mean (maximum)	60	43.8	2.30	46.10	3.83%	76.83%
	1 hour mean (maximum)	200	43.8	5.47	49.27	2.73%	24.63%
CO	8 hour running mean (maximum)	10000	280	21.09	301.09	0.21%	3.01%
	1 hour mean (maximum)	30000	280	61.54	341.54	0.21%	1.14%
SO_2	24 hour mean (maximum)	20	11	15.85	26.45	79.23%	132.23%
	10 minute	500	11	102.28	112.88	20.46%	22.58%
PM10	Annual mean	20	188	1.17	188.67	5.84%	943.34%
	24 hour mean (maximum)	50	375	4.90	379.90	9.80%	759.80%
PM2.5	Annual mean	10	44	1.17	45.27	11.69%	452.69%
	24 hour mean (maximum)	25	88	4.90	93.10	19.60%	372.40%

3.3.2.2 Scenario 2 – Stage 1b: 5 x TM2500 Plants Operating in Combined Cycle Mode (DFO)

Table 3-21 : Maximum Predicted Process Contributions at Human Health Receptors – Stage 1b

Receptor	Modelled PC (µg/m³) Stage 1 (DFO)								
	Nitrogen dioxide			Carbon monoxide		SO_2		Particulates	
	Annual mean	**Maximum 1-hr mean**	**Maximum 24-hr mean**	**Maximum 8-hr mean**	**Maximum 1- hr mean**	**Maximum 15 mins**	**Maximum 24 hr**	**Annual mean**	**Maximum 24-hr**
1	0.07	8.56	1.80	12.38	28.84	75.16	10.56	0.12	3.27
2	0.10	10.46	1.60	16.01	31.74	86.88	7.84	0.15	2.43
3	0.28	9.73	1.99	17.53	27.79	69.58	9.18	0.40	2.84
4	0.45	10.52	2.34	21.01	32.68	94.65	11.74	0.71	3.64
5	0.08	0.99	0.36	72.28	75.23	113.78	43.46	3.19	13.47
6	0.00	2.68	0.27	50.99	108.96	181.22	17.65	0.09	5.47
7	0.85	7.21	3.34	28.51	35.16	87.64	26.32	2.07	8.16
8	0.82	7.11	3.91	29.01	35.40	87.08	31.46	2.05	9.75
9	0.76	9.13	2.90	22.30	35.20	100.78	18.06	1.48	5.60
10	0.68	8.79	3.11	18.37	29.74	69.49	16.99	1.16	5.27
11	0.57	9.03	3.30	23.82	27.56	65.22	16.27	0.87	5.04
12	0.59	9.03	2.88	21.30	30.87	65.92	15.92	1.01	4.93
13	1.24	5.94	5.00	78.46	83.15	146.54	113.19	8.71	35.09
14	0.11	10.61	1.19	32.78	56.39	140.39	10.24	0.28	3.17

Receptor	Modelled PC (µg/m³) Stage 1 (DFO)								
	Nitrogen dioxide			Carbon monoxide		SO_2		Particulates	
	Annual mean	**Maximum 1-hr mean**	**Maximum 24-hr mean**	**Maximum 8-hr mean**	**Maximum 1- hr mean**	**Maximum 15 mins**	**Maximum 24 hr**	**Annual mean**	**Maximum 24-hr**
15	0.02	5.47	0.77	26.94	34.16	76.54	7.76	0.07	2.41
16	0.02	6.60	0.86	20.52	35.62	74.54	7.51	0.06	2.33
17	0.02	9.49	0.92	11.92	34.96	84.54	5.50	0.04	1.70
18	0.02	8.53	0.75	9.67	25.48	72.99	3.62	0.03	1.12
19	0.03	8.55	0.80	7.13	28.37	67.74	4.31	0.04	1.34
20	0.02	7.54	0.66	6.65	26.33	59.45	3.71	0.04	1.15
21	0.01	7.44	0.92	6.54	26.60	68.52	5.28	0.02	1.64
22	0.01	6.53	0.64	8.68	30.52	71.03	4.70	0.04	1.46
23	0.02	5.50	0.69	7.52	25.23	55.00	3.73	0.04	1.16
24	0.02	7.05	1.10	11.11	21.51	53.73	5.42	0.04	1.68

Table 3-22 : PEC at Predicted Maximum Selected Sensitive Human Health Receptors - Modelled Concentrations for Scenario 2 (Stage 1b)

Pollutant	Averaging Period	AAQG (µg/m3)	Background concentration (µg/m³)	PC(µg/m3)	PEC(µg/m3)	PC /AAQG (%)	PEC / AAQG (%)
NO_2	Annual mean	40	21.9	0.85	22.75	2.12%	56.87%
	24 hour mean (maximum)	60	43.8	3.91	47.71	6.52%	79.52%
	1 hour mean (maximum)	200	43.8	10.61	54.41	5.30%	27.20%
CO	8 hour running mean (maximum)	10000	280	72.28	352.28	0.72%	3.52%
	1 hour mean (maximum)	30000	280	108.96	388.96	0.36%	1.30%
SO_2	24 hour mean (maximum)	20	11	43.46	54.06	217.28%	270.28%
	10 minute	500	11	181.22	191.82	36.24%	38.36%
PM_{10}	Annual mean	20	188	3.19	190.69	15.95%	953.45%
	24 hour mean (maximum)	50	375	13.47	388.47	26.94%	776.94%
$PM_{2.5}$	Annual mean	10	44	3.19	47.29	31.91%	472.91%
	24 hour mean (maximum)	25	88	13.47	101.67	53.89%	406.69%

3.3.2.3 Scenario 3 – Stages 1b and 2: 5 x TM2500 and 4 x LM6000PC Plant Operating in Combined Cycle Mode (DFO)

Table 3-23: Maximum Predicted Process Contributions at Human Health Receptors – Stage 2

Receptor	Modelled PC (µg/m³) Stage 1 (DFO)								
	Nitrogen dioxide			Carbon monoxide		SO_2		Particulates	
	Annual mean	Maximum 1-hr mean	Maximum 24-hr mean	Maximum 8-hr mean	Maximum 1- hr mean	Maximum 15 mins	Maximum 24 hr	Annual mean	Maximum 24-hr
1	0.13	14.9	3.5	26.7	53.9	133.4	20.9	0.24	6.3
2	0.21	15.5	3.4	30.9	47.0	128.9	17.2	0.32	5.1
3	0.60	16.9	3.7	38.3	48.2	104.3	17.7	0.85	5.3
4	0.91	18.7	4.4	42.8	58.0	162.8	22.5	1.42	6.8
5	0.08	1.0	0.4	72.3	75.2	114.5	43.7	3.19	13.5
6	0.01	4.4	0.5	82.6	177.9	303.6	32.1	0.18	9.6
7	1.50	10.8	6.0	47.8	52.7	124.4	48.6	3.64	14.6
8	1.50	11.8	6.3	41.3	58.8	120.4	51.6	3.74	15.6
9	1.36	17.5	4.9	39.0	67.2	176.2	31.3	2.63	9.4
10	1.24	15.0	6.4	36.1	50.4	111.0	36.3	2.10	10.8
11	1.03	19.0	5.5	51.1	57.8	146.5	27.6	1.57	8.3
12	1.05	18.8	4.8	36.3	64.1	161.8	26.9	1.79	8.1
13	1.80	9.3	7.1	126.8	129.9	227.9	162.8	12.63	49.4
14	0.16	19.0	2.1	45.5	100.9	252.4	18.6	0.43	5.6
15	0.04	9.9	1.3	31.4	61.9	123.9	13.2	0.11	4.0
16	0.04	10.5	1.5	34.1	56.5	126.2	13.5	0.10	4.1
17	0.04	20.0	1.7	36.8	73.5	206.2	10.6	0.07	3.2
18	0.04	14.7	1.6	28.3	43.7	120.8	7.8	0.05	2.3
19	0.05	14.9	1.5	14.8	49.4	133.7	8.4	0.08	2.5
20	0.04	13.3	1.4	13.0	46.3	107.7	7.9	0.08	2.4
21	0.02	13.9	1.6	13.1	49.6	113.9	9.4	0.03	2.8
22	0.04	13.9	1.6	17.0	47.9	111.8	9.0	0.07	2.7
23	0.05	13.4	1.4	12.9	43.0	88.0	7.5	0.08	2.3
24	0.05	12.3	2.1	25.8	37.2	96.2	10.6	0.07	3.2

Table 3.24 : PEC at Predicted Maximum Selected Sensitive Human Health Receptors - Modelled concentrations for Scenario 3 (Stage 2)

Pollutant	Averaging Period	AAQG(µg/m3)	Background concentration (µg/m³)	PC(µg/m3)	PEC(µg/m3)	PC /AAQG (%)	PEC / AAQG (%)
NO_2	Annual mean	40	21.9	1.50	23.4	3.76%	58.5%
	24 hour mean (maximum)	60	43.8	6.42	50.2	10.7%	83.7%
	1 hour mean (maximum)	200	43.8	20.0	63.8	10.02%	31.9%

Pollutant	Averaging Period	AAQG(µg/m3)	Background concentration (µg/m^3)	PC(µg/m3)	PEC(µg/m3)	PC /AAQG (%)	PEC / AAQG (%)
CO	8 hour running mean (maximum)	10000	280	82.6	363	0.83%	3.63%
	1 hour mean (maximum)	30000	280	177.9	458	0.59%	1.53%
SO_2	24 hour mean (maximum)	20	11	51.6	62.2	257.81%	310.8%
	10 minute	500	11	303.6	314.2	60.72%	62.8%
PM_{10}	Annual mean	20	188	3.74	191.24	18.71%	956.21%
	24 hour mean (maximum)	50	375	15.57	390.57	31.14%	781.14%
$PM_{2.5}$	Annual mean	10	44	3.74	47.84	0.37	4.78
	24 hour mean (maximum)	25	88	15.57	103.77	0.62	4.15

4. Sensitivity Assessment of Fuel mix operating modes

Due to the exceedances recorded on base case of running DFO all year round, and the potential uncertainty of the LPG supply Jacobs has performed a sensitivity analysis considering 3 additional operating scenarios for the fully operational plant (stage 2).

It should be noted that because the peak concentrations for the 10-minute, 1-hour, 8-hour and 24-hour averaging periods are driven by the meteorological conditions during the relevant periods, the predicted peak concentrations of these short duration averaging are identical for the plant running on diesel, no matter how long the plant is using diesel.

The main impact will therefore be seen on the annual average concentrations, and the combined total contribution is calculated by using the appropriate fraction of the LPG and diesel annual mean concentrations, scaled by the fraction of time the plant uses each fuel. This results are presented in Table 4-1 below and considered a fuel mix of DFO and LPG at the following proportions:

- 1 month running on diesel, 11 months on LPG;
- 3 month running on diesel, 9 months on LPG;
- 6 month running on diesel, 6 month's on LPG; and,
- Year round operation on DFO.

Table 4-1 : Predicted Maximum Pollutant Concentration at Residential Receptors for Different Fuel Mix Modes - Scenario 3

Pollutant	Averaging Period	AAQG(µg /m3)	Background concentration (µg/m^3)	PC(µg/m^3)	PEC(µg/m^3)	PC /AAQG (%)	PEC / AAQG (%)
NO_2	Annual mean - 1 month diesel	40	21.9	1.90	23.8	4.75%	59.50%
	Annual mean - 3 month diesel	40	21.9	1.88	23.8	4.71%	59.46%
	Annual mean - 6 month diesel	40	21.9	1.86	23.8	4.64%	59.39%
	Annual mean – all year	40	21.9	1.5	23.4	3.76%	58.5%
PM_{10}	Annual mean - 1 month diesel	20	187.5	0.91	188.41	4.54%	942.04%
	Annual mean - 3 month diesel	20	187.5	2.72	190.22	13.61%	951.11%
	Annual mean - 6 month diesel	20	187.5	5.44	192.94	27.22%	964.72%
	Annual mean – all year	20	187.5	5.44	192.94	27.22%	964.72%
$PM_{2.5}$	Annual mean - 1 month diesel	10	44.1	0.91	45.0	9.07%	450.07%
	Annual mean - 3 month diesel	10	44.1	2.72	46.8	27.22%	468.22%
	Annual mean - 6 month diesel	10	44.1	5.44	49.5	54.44%	495.44%
	Annual mean – all year	10	44.1	3.2	47.3	31.9%	473%
SO_2	Annual mean - 1 month diesel	50	5.3	1	6	2%	12%
	Annual mean - 3 month diesel	50	5.3	3	8	6%	16%
	Annual mean - 6 month diesel	50	5.3	6	11	12%	22%
	Annual mean – all year	50	5.3	12	17	24%	34%

5. Cumulative impact Assessment

The dispersion model results for cumulative impact assessment as described in Section 2.1 are set out in Table 5-1 to Table 5-6. The results are the maximum predicted concentrations at 'off-site' locations and the concentrations at selected sensitive human health receptors. The tables give the following information:

- Ambient Air Quality Guideline (AAQG) for each substance under consideration. The EPA AAQG for "Industrial" locations has been applied. Where no EPA AAQG exists, the WHO AAQG has been applied and this is shown within the table.
- The background concentration of the pollutant; which is the sum of the measured and the PC.
- Process Contribution (PC), the maximum modelled concentration of the substance due to process emissions alone from the proposed site.
- Predicted Environmental Concentration (PEC), the maximum modelled concentration due to process emissions combined with estimated background concentrations.
- PC and PEC as a percentage of the AAQG.

5.1 Cumulative LPG Scenarios

5.1.1.1 Scenario 1 – Stage 1a: 5 x TM2500 Plant Operating in Open Cycle Mode (LPG)

Table 5-1 : Predicted Maximum 'Off-Site' Modelled Concentrations for Scenario 1 (Stage 1a)

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
Scenario 1 – Stage 1a (5 x TM2500 in OC mode on LPG)							
Nitrogen dioxide	Annual mean	40 (WHO)	30.0	0.77	30.8	1.93%	76.9%
	24 hour mean (maximum)	150	60.0	3.09	63.1	2.06%	42.1%
	1 hour mean (maximum)	400	60.0	6.52	66.5	1.63%	16.6%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed)

5.1.1.2 Scenario 2 – Stage 1b: 5 x TM2500 Plants Operating in Combined Cycle Mode (LPG)

Table 5-2: Predicted Maximum 'Off-Site' Modelled Concentrations for Scenario 2 (Stage 1b)

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
Scenario 2 – Stage 1b (5 x TM2500 in CCGT mode on LPG)							
Nitrogen dioxide	Annual mean	40 (WHO)	30.0	1.51	31.5	3.78%	78.8%
	24 hour mean (maximum)	150	60.0	5.80	65.8	3.87%	43.9%
	1 hour mean (maximum)	400	60.0	12.2	72.2	3.05%	18.1%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed).

5.1.1.3 Scenario 3 – Stages 1b and 2: 5 x TM2500 and 4 x LM6000PC Plant Operating in Combined Cycle Mode (LPG)

Table 5-3 : Predicted Maximum 'Off-Site' Modelled Concentrations for Scenario 3 (Stage 1b and 2 on LPG)

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
Scenario 3 – Stage 1a + 2 (5 x TM2500 4 x LM6000PC in CCGT mode on LPG)							
Nitrogen dioxide	Annual mean	40 (WHO)	30.0	2.35	32.3	5.87%	80.9%
	24 hour mean (maximum)	150	60.0	10.21	70.2	6.81%	46.8%
	1 hour mean (maximum)	400	60.0	25.2	85.2	6.30%	21.3%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed)

5.2 Cumulative DFO Scenarios

5.2.1.1 Scenario 1 – Stage 1a: 5 x TM2500 Plant Operating in Open Cycle Mode (DFO)

Table 5-4 : Predicted Maximum Industrial 'Off-Site' Modelled Concentrations for Scenario 1 (Stage 1a)

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
Scenario 3 – Stage 1a and 2 (5 x TM2500 4 x LM6000PC in CCGT mode on DFO)							
Nitrogen dioxide	Annual mean	40 (WHO)	30.0	0.82	30.8	2.0%	77.0%
	24 hour mean (maximum)	150	60.0	3.33	63.3	2.22%	42.22%
	1 hour mean (maximum)	400	60.0	6.69	66.7	1.67%	16.67%
Sulphur dioxide	24 hour mean (maximum)	20	40	291.75	331.75	1458.73%	1658.73%
	10 minute	500	40	386.47	426.47	77.29%	85.29%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed)

5.2.1.2 Scenario 2 – Stage 1b: 5 x TM2500 Plants Operating in Combined Cycle Mode (DFO)

Table 5-5: Predicted Maximum Industrial 'Off-site' Modelled Concentrations for Scenario 2 (Stage 1b)

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
Scenario 3 – Stage 1a and 2 (5 x TM2500 4 x LM6000PC in CCGT mode on DFO)							
Nitrogen dioxide	Annual mean	40 (WHO)	30.0	1.56	31.56	3.89%	78.9%
	24 hour mean (maximum)	150	60.0	5.96	65.96	3.97%	44.0%
	1 hour mean (maximum)	400	60.0	12.55	72.55	3.14%	18.1%
Sulphur dioxide	24 hour mean (maximum)	20	40	422.95	462.95	2114.76%	2314.76%

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
	10 minute	500	40	619.80	659.80	123.96%	131.96%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed).

5.2.1.3 Scenario 3 – Stages 1b and 2: 5 x TM2500 and 4 x LM6000PC Plant Operating in Combined Cycle Mode (DFO)

Table 5-6 : Predicted Maximum Industrial 'Off-site' Modelled Concentrations for Scenario 3 (Stage 1b and 2 on DFO)

Pollutant	Averaging Period	AAQG (µg/m³)	Background conc (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AAQG	PEC / AAQG
Scenario 3 – Stage 1a and 2 (5 x TM2500 4 x LM6000PC in CCGT mode on DFO)							
Nitrogen dioxide	Annual mean	40 (WHO)	30.0	2.21	32.2	5.5%	80.5%
	24 hour mean (maximum)	150	60.0	9.75	69.75	6.50%	46.50%
	1 hour mean (maximum)	400	60.0	22.66	82.66	5.67%	20.67%
Sulphur dioxide	24 hour mean (maximum)	20	40	425.77	465.77	2128.9%	2328.9%
	10 minute	500	40	623.94	663.94	124.8%	132.8%

OC = Open cycle; CCGT = Combined cycle gas turbine (waste heat recovery unit installed)

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Appendix C – Flood Risk Technical Appendix

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Appendix C – Flood Risk

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JACOBS CONSULTANCY PROJECT NO: 60K36301

Revision History

Date	Description of Alteration	Rev No
August 2017	First issue of FRA Appendix	0

Contents

Figures and Tables

1 Flood Risk Technical Appendix

1.1 Overview

This appendix supports the fluvial flood risk section within chapter 13 of the ESIA. It includes all technical details (hydrology and hydraulic modelling) used in the updated fluvial flood risk assessment.

1.2 Fluvial Flood Risk Technical Considerations

1.2.1 Input Data

The data used to construct the hydraulic model is summarised in Table 1-1.

Table 1-1: Data used to build the hydraulic model

Data	Description	Source
Mapping	Background sites	Google Maps
Channel Survey	In-channel cross-sections and hydraulic structures	Jacobs site survey 2017
Watercourse photographs	Photographs of watercourse and hydraulic structures	Jacobs site survey 2017
Hydrological analysis	Hydrological analysis carried out as discussed in chapter 7.	Jacobs 2017

1.2.2 Hydrology

Design Rainfall Depth and Storm Profile

The following rainfall intensity-duration-frequency (IDF) data sources for the Accra coastal area were obtained:

- JB Dankwa, 1974. Maximum Rainfall Intensity-Duration-Frequencies in Ghana. Ghana Meteorological Services (GMS) Department – Departmental Note No.23.
- Logah FY, Kankam-Yeboah K & Bekoe EO, 2013. Developing Short Duration Rainfall Intensity Frequency Curves for Accra in Ghana. International Journal of Latest Research in Engineering and Computing (IJLREC), Vol1, Issue 1: Page 67-73.Sept – Oct 2013.
- Glay DG, 2016. Development of Intensity Duration Frequency Curves for Accra. Master's Thesis, Kwane Nkrumah University of Science and Technology, Kumasi, Ghana.

The three sources provide estimates of the 100-year rainfall for Accra that differ significantly, as shown in Figure 1-1.

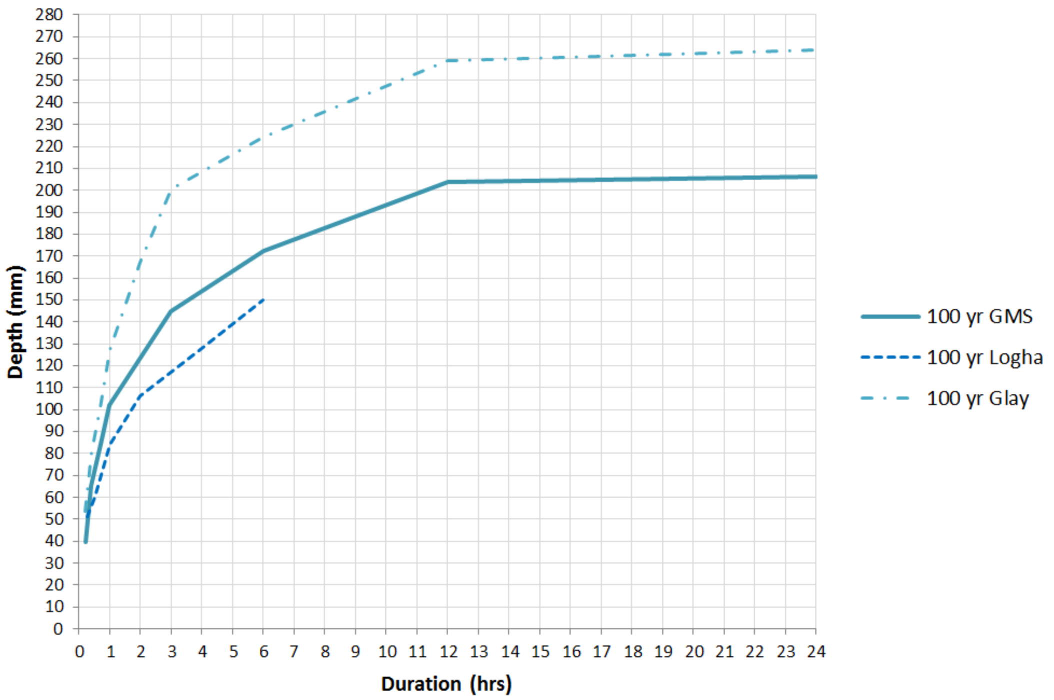


Figure 1-1: 100-year rainfall depth as a function of duration for Accra

The estimates provided in the GMS reference are believed by Jacobs to be the generally accepted reference data set for the Accra region. However they are derived from data that is more than 40 years old and may therefore be considered out of date, especially in the context of climate change.

The estimates from Logha and Glay are both based on more recent data (Logha: 1990 to 2012; Glay: 1971 to 1979 and 1991 to 2009). They give quite differing estimates for the same statistic, with Logha suggesting a possible reduction whilst Glay suggests an increase, in rainfall depth in comparison to the GMS dataset. Without recourse to the raw data and a full review of the techniques used it has not been possible to confirm the validity of their estimates. To undertake such an analysis is considered to be outside the resources of the current project. Consequently within this study the GMS estimates have been accepted and uncertainty in the design rainfall introduced into the sensitivity analysis of the flood model (discussed later in the section).

The SCS method also requires the specification of a design storm profile. This was assessed by constructing a theoretical profile from the GMS depth-duration curve via a nesting procedure. This involved fitting a logarithmic curve to the depth – duration data. Using a time step of 0.2 hours, the central 0.2 hour component of the design profile was taken from the fitted curve. The two 0.2 time steps either side of the central one (already established) were obtained by extracting the 0.6 hour rainfall depth and subtracting the 0.2 rainfall depth and splitting this residual evenly on either side of the central component. This was then repeated until a 24 hour profile had been derived. Figure 1-2 compares the derived Accra profile (as a cumulative plot) to the standard rainfall profiles provided within the SCS method. The Type II profile was accordingly selected.

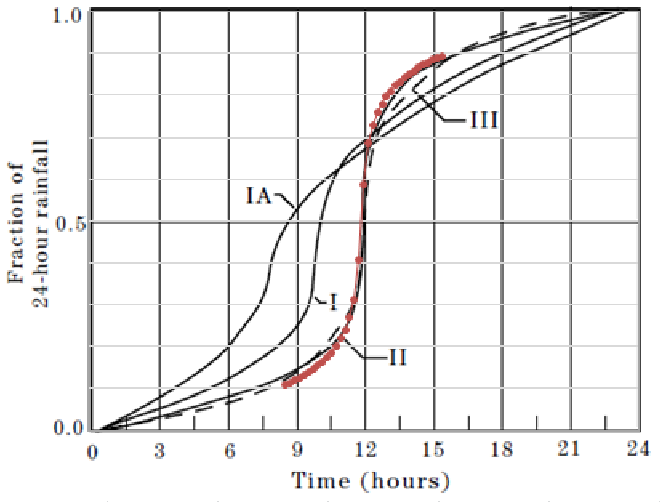


Figure 1-2: The derived cumulative rainfall profile for Accra (red dots) compared to standard SCS profile types

SCS Curve Number

The SCS method requires selection of a Curve Number which determines the losses (the proportion of storm rainfall that does not form flood runoff in the watercourse) within the rainfall-runoff model. The curve number is dependent upon: the type of soil, the land cover and its condition.

Soil:
Characterisation of the soil at the proposed development sites was obtained from the Preliminary Ground Investigation Report[1]. This suggested that the top soil (0.5m deep) comprises loose fine sand, silt and clay. The sub-soil is described as being split into a top and a lower layer: where the top layer is 2-3m deep and is a mixture of sandy silty clay and sandy clayey silts. The lower layer comprises approximately 3m of gravelly, clayey, silty to very silty fine to medium grained thinly laminated sands.

The soil is underlain by Quartz Schist, and this is mapped as extending beneath the entire catchment (RIMOG, 2016). Weathered schist is experienced at the site until unweathered bed rock is met at 11m to 15m below ground level. The water table at the site was recorded amongst an array of sample sites to be between 2m to 5m deep (recorded late October and early November 2016). This measurement period is a little after the rainy season so may not reflect the typical levels during and shortly after the wettest periods and the site investigation reported the potential for some groundwater units to be under an element of confining pressure.

Given the small area and relatively flat nature of the catchment along with the likely uniform underlying geology, it is considered that the site soils (or similar) are likely to be representative of most of the catchment.

The SCS method requires that soils types are distinguished from the following four groups:

[1] RIMOG, 2016. Preliminary Ground Investigation - Bridge Power Phase 2 Project, Tema, Ghana.

- **Group A**: deep sand, deep loss, aggregated silts
- **Group B**: shallow loess, sandy loam
- **Group C**: clay loams, shallow sandy loam, soils low in organic content and soils usually high in clay
- **Group D**: soils that swell significantly when wet, heavy plastic clays, and certain saline soils.

With only the detailed soils information at the site and inferred characteristics elsewhere, it is difficult to be precise about the catchment soils. However, using the site data, soil groups A and D were discounted. Sensitivity analysis upon Groups B and C was taken forward in the SCS method sensitivity analysis.

Satellite imagery (Google Earth) and project site visit photographs were used to determine the typical vegetation and ground condition of the land across the catchment. The chronological history of the Google Earth images allowed a seasonal perspective to be considered. The non-developed areas within the catchment appear to be largely fallow ground, comprising mainly low stature vegetation that does not attain full land cover. Some areas are farmed, including on the proposed project plant sites. Based upon this information, two land cover categories were selected as candidate cover classifications for the rural components of the catchment.

The catchment is being progressively developed, as evidenced from Google Earth images spanning the period 2003 to 2015. In the most recent images it is clear that further plots are in the process of being prepared for industrial purposes. Based on this information it is estimated that up to 20% of the catchment can currently be considered to be impervious with the residual evenly split between fallow\farmed and disturbed land. To account for the urbanisation, the procedure for incorporating impervious areas into the determination of SCS curve numbers has been followed[2]. This requires an estimate of the proportion of impervious surface runoff that is directly connected to the main channel. In this assessment both 50% and 100% direct connection has been considered in the sensitivity analysis.

Table 1-2 summarises the range of possible SCS curve numbers that may plausibly apply. There is appreciable uncertainty in the identification of what is a good curve number for a particular catchment. The range given below allows a degree of uncertainty to be incorporated into the subsequent flow prediction.

[2] United States Department of Agriculture, 1986. Urban Hydrology for Small Watersheds, TR-55.

Table 1-2: Range of Possible SCS Curve Numbers for the Tema Catchment

Cover Type	Hydrologic condition	% Impervious	Proportion directly connected	1% AEP Peak Flow (m^3/s)	
				Soil Group B	Soil Group C
A Brush - brush-weed-grass mix (Agricultural land)	Poor (<50% ground cover)	20	1	74	82
B Herbaceous - brush-weed-grass mix (Semi-arid))	Fair (30-70% ground cover)	20	1	76	84
A Brush - brush-weed-grass mix (Agricultural land)	Poor (<50% ground cover)	20	0.5	72	80
B Herbaceous - brush-weed-grass mix (Semi-arid))	Fair (30-70% ground cover)	20	0.5	75	83

Time of Concentration

Based on guidance given in Maidment (1993)[3] the Kirpich formula was used to estimate the time of concentration (tc) for the catchment:

tc = K. L0.770. S-0.385

Where

tc = time-of-concentration (minutes)

K = 0.0915 for SI units

L = Channel flow length (m)

S = dimensionless main-channel slope

The Tema catchment has L = 3750m and S = 0.0084, giving tc = 67 minutes. This estimate is for the catchment in a rural state. Given the catchment is partially developed the tc was slightly reduced to 60 minutes to reflect the expected faster response of the partially developed catchment.

Peak rate factor

The peak rate factor defines the shape of the dimensionless unit hydrograph (DUH). A default value of 484 is usually adopted (the minimum permissible value is 100; the maximum permissible value is 600). Within the SCS model the Peak rate factor is normally kept as the default value. However the NOAA National Weather Service Office of Hydrology Hydrologic Research Laboratory & National Operational Hydrologic Remote Sensing Centre provides the following guide values given in Table 1-3.

[3] Maidment DR, 1993. Handbook of Hydrology. McGraw-Hill, Inc.

Table 1-3: Dimensionless Unit Hydrograph Peak Rate Factors

General description	DUH peak rate factor
Urban areas: steep slopes	575
Typical SCS	484
Mixed urban rural	400
Rural, rolling hills	300
Rural, slight slopes	200
Rural, very flat	100

Base flow

It is understood that the storm water channel does not pass a significant base flow outside of storm events. Therefore a nominal base flow of 1 m3/s is included in the design simulations.

Design flow simulation

The SCS unit hydrograph model was run using the 24-hour design rainfall depth and storm profile, determined as described above.

Estimation of the SCS model parameters is subject to uncertainty. To examine the sensitivity of the predicted flows the following suite of runs was undertaken where the underlined parameter values were taken as the default values from which each parameter was individually changed across the below ranges. The resultant flows are taken to provide an indicative measure of the range of uncertainty in the predicted 100-year flow.

- 100-year rainfall depth (24-hour duration): 186mm, 206mm, 227mm (+/- 10% around the central value).
- Curve numbers: 72, 78, 84
- Time of concentration: 0.8 hrs, 1.0 hrs, 1.2 hrs
- Peak rate factor: 484, 400, 300

Table **1-4** presents the predicted peak flows for the above combinations of parameter values. An arithmetic mean of the peak flows given in the table gives a flow of 132 +/- 18 m3/s (+/- 1 standard deviation)4.

[4] It is accepted that the result of the default parameters appears in the sensitivity analysis of each parameter, and that therefore the mean value is weighted towards this value. This is judged acceptable since the default parameters represent the favoured set up of the model, and the range is only an indicative measure of the uncertainty.

Table 1-4: Predicted peak flows

Parameter	Parameter value	Peak Flow (m^3/s)
100-year (24-hour duration) rainfall depth (mm)	186	119
	206	137
	227	155
SCS Curve Number	72	120
	78	137
	84	152
Time of concentration (hours)	0.8	157
	1.0	137
	1.2	121
Peak rate factor	484	137
	400	119
	300	95

Figure 1-3 presents the predicted design hydrograph with a peak flow of 132 m3/s, together with an upper and lower estimate of +/- 18 m3/s. The upper and lower estimates are not a true measure of the uncertainty: rather they provide an indicative sense of the uncertainty due to plausible estimated ranges of the model parameters. How well suited the model is to the Ghanaian catchment and meteorological conditions is not revealed and the actual uncertainty (had it been possible to examine in a more rigorous way) is likely to be more than that depicted in Figure 1-2. However, the upper and lower bounds are given to alert the project to the real presence of appreciable uncertainty that is associated with this small, ungauged, partially urbanised catchment flood study.

The 0.1% AEP flood event was also estimated using a scaling factor of 1.18 to scale a 1% AEP flow to 0.1% AEP[5]. The resulting 0.1% AEP peak flow is 156m^3/s.

[5] Wilson, E.M (1990) Engineering Hydrology.

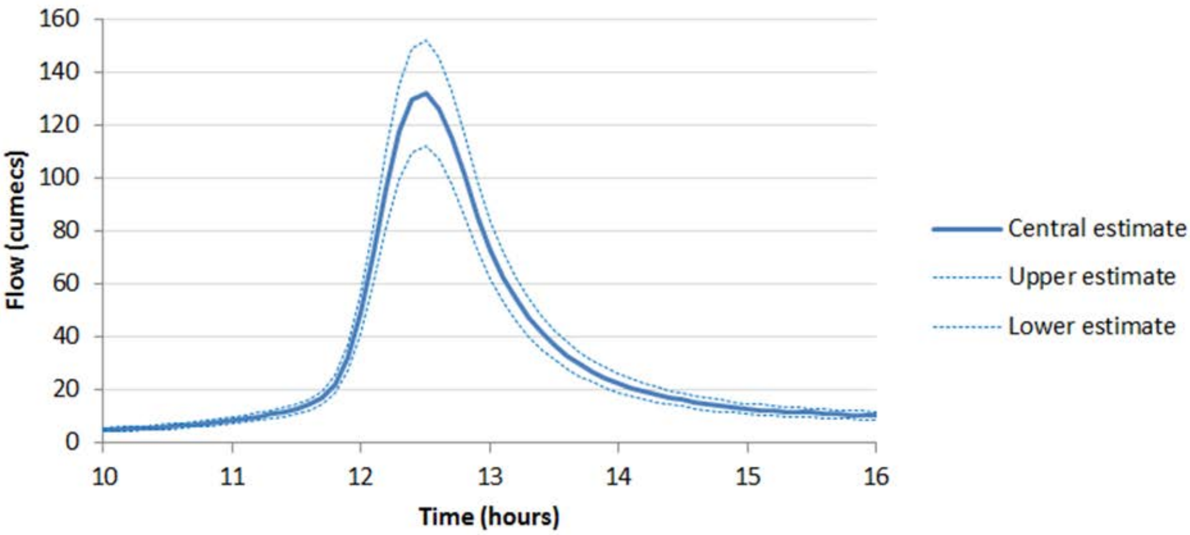


Figure 1-3: The predicted 1% AEP flood flow hydrograph

Anecdotal understanding of the frequency and level of flows in the storm water channel may provide useful corroboration of this desk study and it is recommended that this be sought if a more refined understanding is required. This recommendation is common to most ungauged catchment flood studies but it should be noted that this may prove a particularly challenging task to undertake in this case since the catchment appears to be undergoing significant change which may render historic observations of only limited relevance.

A more refined and robust understanding would be reached if the flows in the channel could be gauged. Statistical analysis will not be possible as this needs decades of data. However the monitoring of both rainfall and flow for at least one rainy season may yield valuable information that might be useful for refining the understanding of the rainfall-runoff response. However such a monitoring programme will need to capture large flood events since the catchment's response to smaller storm events may not be representative of rare events.

1.2.3 Model construction

<u>In-channel geometry</u>

Surveyed river cross-section data has been used to inform the in-channel geometry of the modelled watercourses. In total, cross-section survey was undertaken at 34 points along the modelled river reach. To aid model performance interpolated cross-sections were added between the surveyed cross-sections where needed.

<u>In-channel friction</u>

Hydraulic roughness (Manning's 'n' coefficient) values were determined primarily using the photographs obtained during the site survey. The in-channel coefficients used are shown in Table 1-5. Roughness values adopted were taken from standard guidance[6].

[6] Chow, Ven Te (1959). Open-Channel Hydraulics. McGraw-Hill.

Table 1-5: In-channel Manning's 'n' coefficients

Watercourse	Manning's 'n'	Bed Material
Watercourse 2	0.017	Unfinished concrete (assume that channel is dredged)
Tributary 1	0.017	Unfinished concrete
Tributary 2	0.017	Unfinished concrete
Tributary 3	0.017	Unfinished concrete
Residual catchment	0.017	Unfinished concrete

In-channel Hydraulic Structures

The in-channel hydraulic structures included in the model are specified in Table 1-6 and their locations are shown in Figure 1-4.

Table 1-6: In-channel hydraulic structures

Structure	Flood Modeller Node	Specification
Bridge at ch3158	Chan_3128bu	Type: ARCH Spans: 3 Total Width: 7.1m Upstream Bed Level: 33.66mAD Downstream Bed Level: 33.59mAD Maximum Height: 1.7m
Bridge at ch1280	Chan_1280bu	Type: ARCH Spans: 3 Total Width: 9.8m Upstream Bed Level: 25.783mAD Downstream Bed Level: 25.783mAD Maximum Height: 2.3m
Bridge at ch1214	Chan_1214bu	Type: ARCH Spans: 3 Total Width: 9.8m Upstream Bed Level: 25.445mAD Downstream Bed Level: 22.445mAD Maximum Height: 2.3m
3no. circular culverts along tributary 3.	Trib3_0135c1 Trib3_0135c2 Trib3_0135c3	Type: Circular conduit Number of culverts: 3 Diameter = 0.9m Inlet invert = 26.144mAD Outlet invert = 25.872mAD Length = 34m
6no. circular culverts along tributary 3.	Trib3_0055c1 Trib3_0055c2 Trib3_0055c3 Trib3_0055c4 Trib3_0055c5	Type: Circular conduit Number of culverts: 6 Diameter = 0.6m Inlet invert = 25.556 mAD Outlet invert = 25.473 mAD

Structure	Flood Modeller Node	Specification
	Trib3_0055c6	Length = 16.2m
2no. box culverts at ch939	Chan_0939c1 Chan_0939c2	Type: Rectangular conduit Number of culverts: 2 Width = 2.2m Height = 1.6m Inlet invert = 24.479 mAD Outlet invert = 24.110 mAD Length = 260m
Bridge at ch322	Chan_0322bu	Type: ARCH Spans: 8 Total Width: 13.4m Upstream Bed Level: 22.965mAD Downstream Bed Level: 22.964mAD Maximum Height: 2.3m

Unfortunately, due to access issues two structures (located along tributary 1 and tributary 2 at their confluences with watercourse 2) were unable to be surveyed and as such are not represented in the hydraulic model. These tributaries are small in comparison to watercourse 2 and therefore the exclusion of these structures should not affect results since they would be likely to overtop during high flows.

Boundary Conditions

The upstream and downstream boundary conditions applied to the model are described in Table 1-7 below. Locations are shown in Figure 1-4.

Table 1-7: Model boundary conditions

Type of Boundary	Flood Modeller Node	Description
Flow-Time Boundary	Channel_3563	Hydrological inflow applied at the upstream end of watercourse 2.
Flow-Time Boundary	Lat_Inflow	Hydrological inflow distributed laterally between nodes Chan_2145 and Chan_0117.
Flow-Time Boundary	Trib3_0174	Hydrological inflow applied at the upstream end of the tributary 3.
Flow-Time Boundary	Trib2_0106	Hydrological inflow applied at the upstream end of the tributary 2.
Flow-Time Boundary	Trib1_0088	Hydrological inflow applied at the upstream end of the tributary 1.
Normal Depth Boundary	Channel_0000	Normal depth boundary condition applied at the downstream end of the model on watercourse 2.

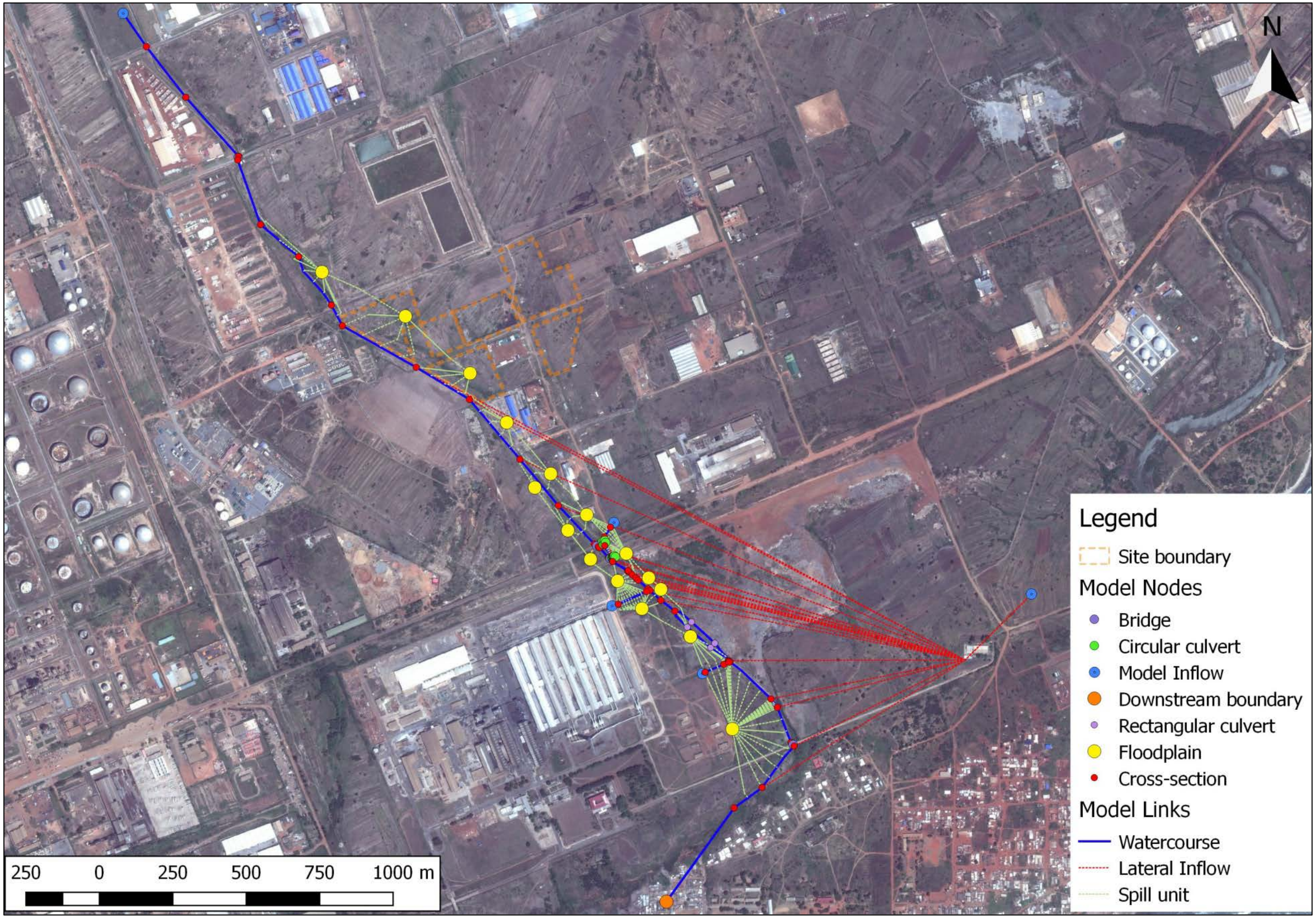


Figure 1-4: Model schematisation.

Floodplain Schematisation

Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model data shows that the catchment of watercourse 2 is relatively flat and the survey data indicates a channel slope of 1 in 266 supporting this finding.

The initial model build used truncated cross-sections (truncated at the watercourses left and right banks) to represent watercourse 2 and the 3 tributaries. Hydraulic structures (bridges, culverts etc.) were also incorporated, though the floodplain was not explicitly represented. During the early model runs, the high flows associated with the 1% AEP flood event resulted in 'glass-walling' (a model state when the predicted water level is higher than the highest ground level in the cross-section) throughout the model.

To address the glass-walling effect, the survey data (topographical spot levels and cross-section data) was merged together to create a triangulated irregular network (TIN) model using GIS software. The TIN model is illustrated in Figure 1-5 below.

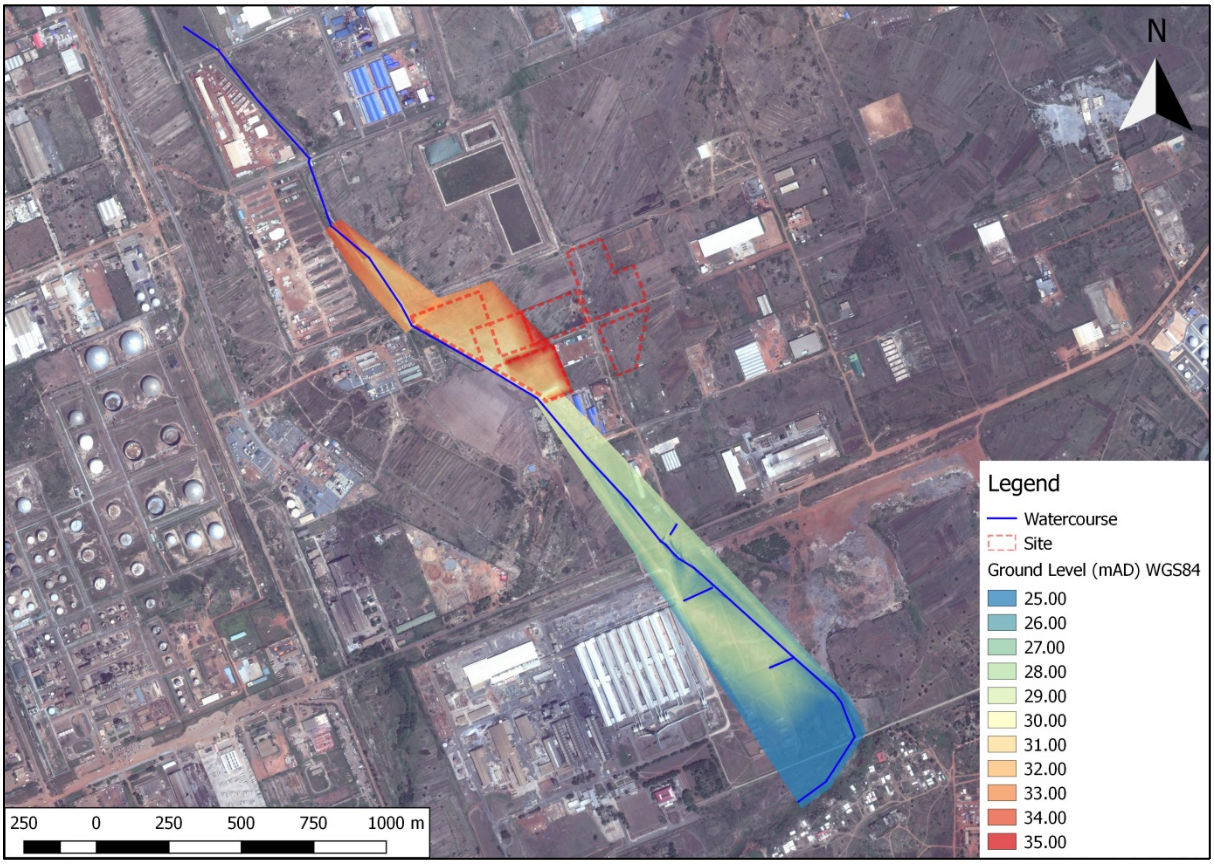
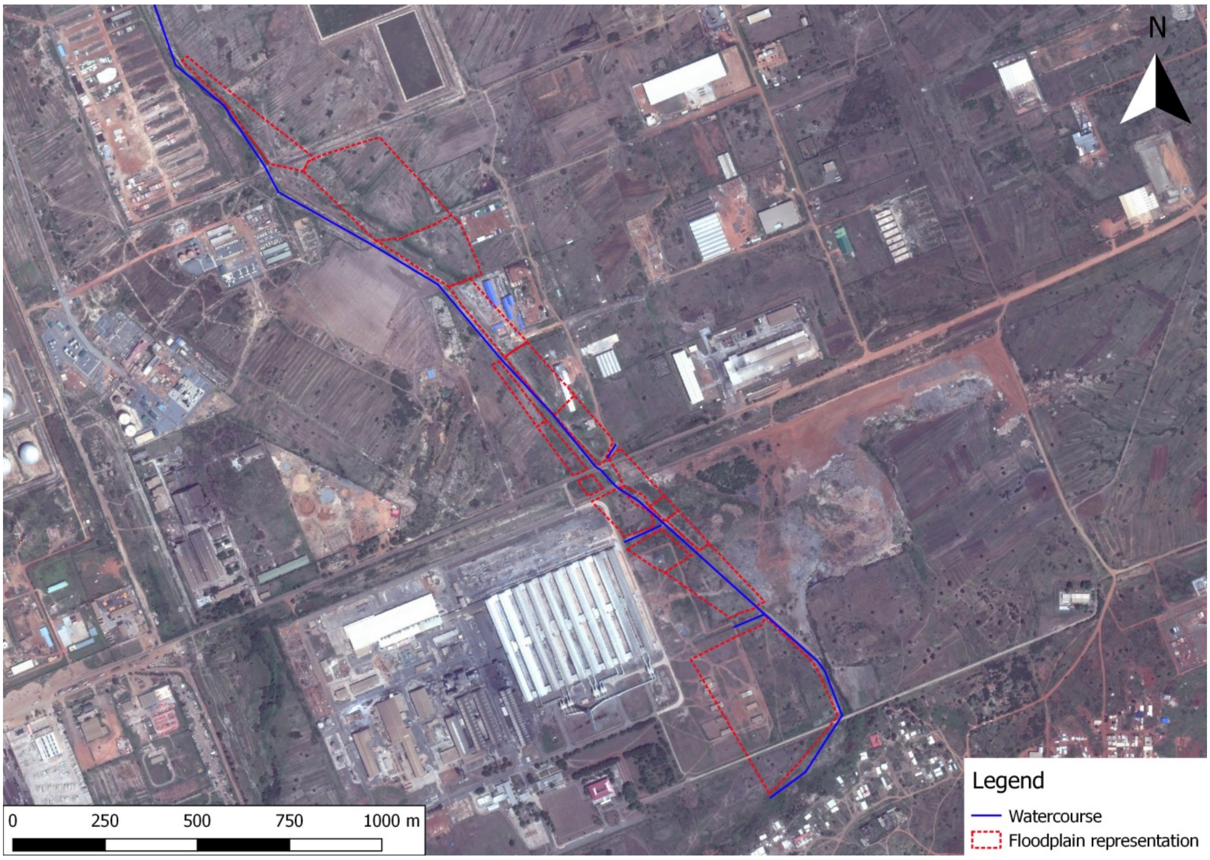


Figure 1-5: TIN Model

Using the TIN model, 16 reservoir units were developed using the Flood Modeller reservoir unit tool. A polygon was created using GIS software for each individual reservoir unit representing a section of the floodplain. The floodplain coverage (including each individual floodplain cell) is illustrated in Figure **1-6**.



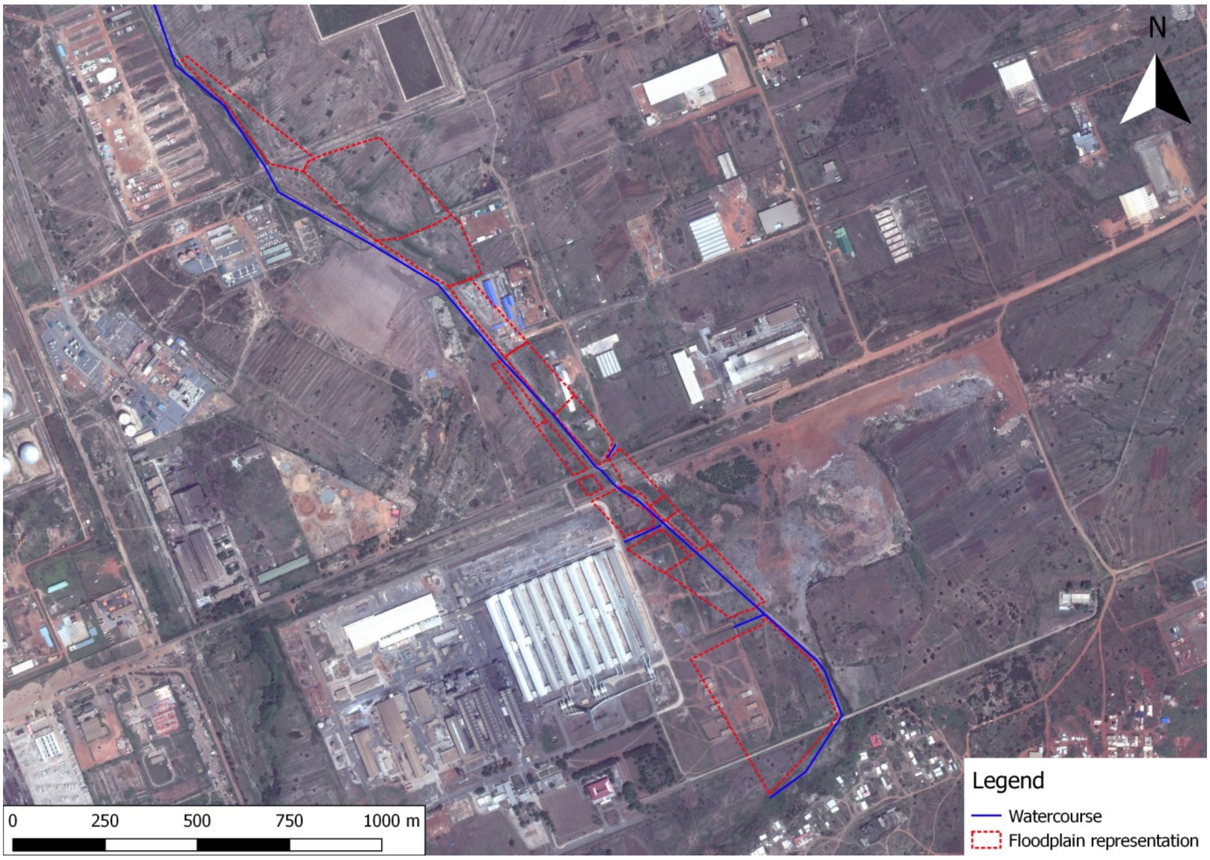


Figure 1-6: Floodplain representation

Using the Flood Modeller reservoir unit tool an area/elevation relationship for each individual reservoir unit was created. This requires both a polygon shapefile (to inform the model what the maximum extent of each individual reservoir is) and a Digital Elevation model (in this case the TIN created from surveyed data). These area/elevation relationships were then added to their corresponding reservoir units.

Each reservoir unit representing the floodplain was linked to the appropriate river cross-section using spill units. The ground levels used within the spill units were extracted from the channel survey. Spill units allow the transfer of water from a channel (represented by cross-sections) into the reservoir units (representing the floodplain). Spill units were also used to link two adjacent reservoir units together allowing transfer of water across the floodplain.

Spill units were also used to allow water to overtop any hydraulic structures within the model and flow to the downstream side of the structure when the water level exceeds the deck level of said structure.

The model was used to simulate the 1% and 0.1% AEP flood event, results of which are discussed in Section 13 of the ESIA.

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Appendix D - Terrestrial Ecology

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Appendix D1
2015 Terrestrial Ecology Survey – including Tank Farm

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

TERRESTRIAL ECOLOGY SURVEY OF THE PROJECT AREAS OF
GHANA BRIDGE POWER PROJECT, TEMA

Prepared By:
Andrews Agyekumhene

2015

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EXECUTIVE SUMMARY

Populations of wildlife in Ghana have over the years dwindled due to illegal killing, habitat destruction and habitat conversion. The once bio-diversed ecosystems in Ghana are now serving as havens for a smaller portion of the species that previously inhabited these areas. This study is therefore a component of an Environmental and Social Impact Assessment (ESIA) by Jacobs for the Ghana Bridge Power project.

The surveys were conducted to determine the ecological significance of flora and fauna that currently exist around the plant and tank farm sites including pipeline routes of the concession for the power project where physical structures are to be situated. Existing wildlife and flora in the project area were assessed to determine any impact that the power project is likely to have on wildlife and their habitat as well as the flora in the area. This is to enable the project develop strategies to avoid, minimize or mitigate them. The main methods used in data collection for this study were desktop literature reviews, interviews and direct field observations.

The project area supports just a small fraction of the wildlife species reported in the Region. This is due to the continuous decline in the ecological integrity of the habitats in the area from decreasing vegetation cover through infrastructural development and industrial activities which are the main threat to wildlife and their habitat in the area. None of the fauna species encountered within the project site surveyed is of conservation interest internationally but one (*Bubulcus ibis*) is of conservation importance nationally. The highly migratory nature of this species could also mean that the species visits the area to forage and may not inhabit that particular area. The species of national conservation interest will therefore likely not receive any significant impact from the proposed project.

The proposed project is anticipated to have very little negative impact on both the wildlife in the area and their habitats. The impact on the wildlife will however be minimal considering the small population of fauna that currently inhabit the area. Notwithstanding, it is recommended for the project to commence during the dry season when some of the fauna is expected to migrate out of the area.

SECTION ONE

1.0 GENERAL INTRODUCTION

1.1 Background

Ghana is endowed with viable populations of wildlife that has over the years supported the growing eco-tourism industry and complements the nation's strong cultural and historical attractions. Most of the wildlife is however found in the protected areas which provide the only refuge for them against illegal hunting, habitat degradation and habitat conversion. Terrestrial wildlife in Ghana ranges from relatively small animals to larger ones living in primary or secondary vegetation.

To protect the low diversity and population of wildlife remaining outside these protected areas, Ghana's environmental and social impact assessment (ESIA) requires that ecology field studies are conducted as part of the scope of ESIA to get a better understanding of the ecological significance of the project area and its sensitivity to project impacts. This document presents the findings of the terrestrial surveys by Associated Consultants Limited. The relevance of the study to the Ghana Bridge Power project emanates from the fact that all phases of the project activity right from the construction to decommissioning activities could adversely impact on the fauna and flora within the area. This could occur along the pipeline route and at the sites of other associated structures that will be erected such as the booster station, TOR sphere and the Tank Farm. If adequate migratory steps are not put into place, biological diversity in the areas of the project could be threatened and some possibly lost. This study therefore is to identify the biological diversity of the area and to determine the level of impact on them.

1.2 Wildlife in Ghana

Ghana is centrally located on the coast of West Africa and is endowed with both small and large wildlife occurring in different habitat ranges in Ghana. These include toads, frogs, snakes and mice as well as smaller antelope species such as duiker. The large wildlife in Ghana includes the forest and savannah elephant (*Loxodonta Africana*), Yellow-backed duiker (*Cephalophus silvicultor*), Roan antelope (*Hippotragus equinus*), Buffalo (*Syncerus caffer*), Hartebeest (*Alcelaphus buselaphus*), Warthog (*Phacochoerus africanus*), Red river hog (*Potamochoerus porcus*), Bongo (*Tragelaphus eurycerus*), Hippopotamus (*Hippopotamus amphibius*), Giant pangolin (*Manis gigantea*), Giant forest hog (*Hylochoerus meinertzhageni*), Water chevrotain (*Hyemoschus aquaticus*), and Leopards (Panthera pardus). Primate species such as Common chimpanzees (*Pan troglodytes*), Whitenapped sooty mangabey (*Cercocebus atys*), Diana monkey (*Cercopithecus diana*), and the Black and white colobus (*Colobus polykomos*) are also found in Ghana (Wildlife Division of Forestry Commission, 2010). There are also fairly high diversity of birds, butterflies and reptiles identified in Ghana.

1.3 Site Description

The study was conducted along the pipelines and tanks farms of the proposed Ghana Bridge Power Project. The project is located within a coastal scrub vegetation habitat type dominated by grassland and occasional shrubs and thickets. Forest species of both fauna and flora are almost non-existent in the project area. Being an industrial enclave, there are no settlements close to the project site. The main economics activities of the area are therefore industrial productions.

Figure 1.1 below shows the catchment of the project site and the locations of some infrastructure. Surveys were concentrated along the 12'' pipeline but areas within the immediate surroundings of the pipelines were also surveyed.

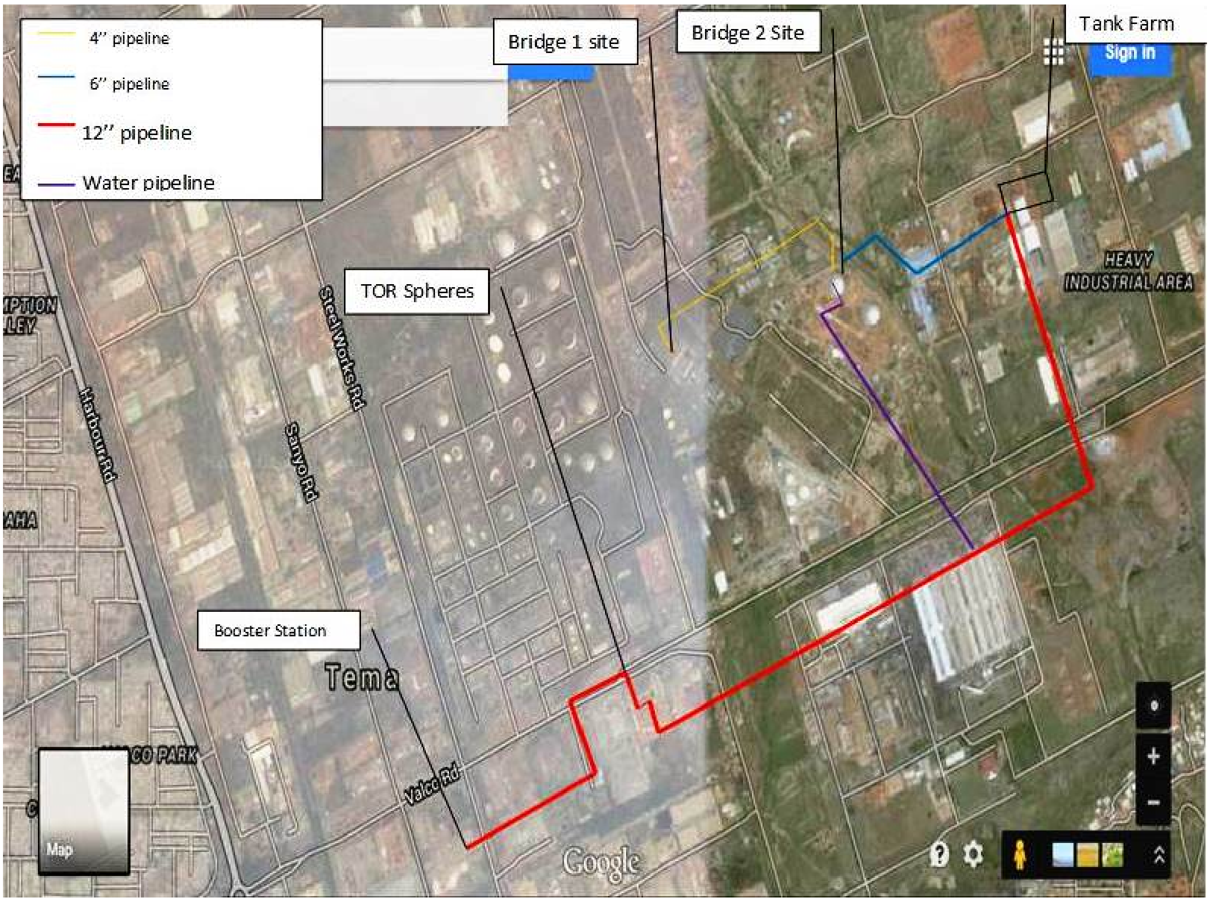

***Figure 1.1**: Map showing the general location of the project site and survey areas. Red lines indicate the pipeline route along which surveys were conducted (Source: Ghana Bridge Power Project)*

1.4 Objectives of the study

The objective of this survey is to obtain representative information on the terrestrial ecosystems and associated biodiversity and habitat of the area along the pipeline (indicated in red in figure 1.1). The relative ecological health of the site and its ability to absorb project impacts was determined. The survey also reports the relative biodiversity assets of the wetlands to enable the proposed project ascertain potential impacts on the wetland to allow for full consideration and mitigation of those impacts. The assessment will form part of ecological impact assessment for the Ghana Bridge Power energy project and help avoid or minimize adverse impacts on and to protect environmentally sensitive areas.

Specifically, the objectives of the surveys were to;

- Assess the fauna and flora composition along the pipeline route
- Determine the ecological significance of the flora and fauna along the pipeline route and its immediate environment
- Assess threats to fauna and flora in the area
- Determine the sensitivity of the fauna and flora of the project area to absorb impacts of any project

SECTION TWO

2.0 METHODOLOGY

The study included both office desktop information gathering and also field surveys. There were no communities and settlements within or close to the proposed project area so no interviews were conducted. The study was carried out on the early morning of 17th August 2015 by a three-member team.

2.1 Desk Study

Desktop work was carried out to review existing and available literature on terrestrial fauna and flora in the project area and its immediate surroundings. Existing literature and reports from work done in the Region relating to wildlife and habitats were also reviewed and summarized as part of the study. Relevant literature were consulted and where used, referenced appropriately.

2.2 Field Surveys

Field surveys were concentrated along the pipeline (indicated with re in Figure 1.1) of the proposed project site for the Ghana Bridge Power project. However, surveying was extended to the immediate environment around the pipeline. Distances of areas surveyed from the pipeline route were dependent on field conditions; up to about 15 meters along the pipeline route were surveyed for both their fauna and flora composition. Surveys were conducted in the early morning when most wildlife are still active.

2.2.1 Vegetation

The flora survey aimed at determining (i) the previous and existing vegetation type along the pipeline route and its immediate environment, (ii) the most commonly occurring plant species and their relative abundance (subjectively scored as dominant, abundant, frequent, occasional or rare) and (iii) whether any species are endangered according to the IUCN list of threatened species. A species list was compiled for the project site and its immediate surroundings.

Areas along the pipeline route of the concession were surveyed by walking along the pipeline. Walks were conducted along route and vegetation studied through direct observation. All species observed were identified and recorded. Identification was carried using examination of floristic features, leaves of the plant (shape, arrangements etc), the life form of the plant and in some cases the scent of the plant. Samples of species that were difficult to identify on the field were taken to the Botany Department of University of Ghana for further identification.

2.2.2 Fauna

The terrestrial fauna assessment consisted of mammal, avifauna, reptile, amphibian and invertebrates survey. Both secondary and primary data were collected on the terrestrial fauna of the project areas and analysed for this report.

The general survey procedure involved slow attentive walks along the pipeline route during which any fauna seen or heard was identified and recorded. All features of ecological interest observed were also noted and recorded. Areas of dense vegetation or thickets were thoroughly surveyed to identify any wildlife that may be in hiding. Areas identified as possible habitats for certain species were also thoroughly searched. Surveys were targeted at finding any signs of activity that the animals might have left behind. Activities carried out during the survey included (i) direct opportunistic observation (used to identify any living animal encountered in the area), (ii) spoors (recording any sign left by a living animal such as a constructed burrow or holes, faecal pellets, footprints etc since most mammals almost always leave signs of their activities behind them) and (iii) interviews some inhabitants of the various local communities in the area. Refuge examinations were also conducted using sticks to search, since some animals like hinged back tortoises (*Kinixyx* spp) often conceal themselves under and in fallen logs, rotten tree stumps, under rocks, in leaf litter, rodent burrows, ponds, old termite mounds, etc.

Identity of unfamiliar bird species was confirmed with the help of a field bird guide book (Borrow and Demey, 2004). Observation of birds at distant point was done with the help of pair of Binoculars.

2.3 Data Analysis

Quantitative assessment using charts in excel was used to depict the species abundance in the area. Higher abundance are represented by longer bars on the chart. Conservation and protection status of each species of fauna recorded was determined using the IUCN Red List of Threatened Mammals (http://www.iucnredlist.org/), and the Wildlife Conservation Regulation (LI 685, 1971) of Ghana. All the wildlife species in Ghana, with the exception of grasscutter, fall under the category of Closed Season Protected (CSP) during the closed season period, August 1st to December 1st each year.

The ecological significance and conservation status of the flora species encountered were defined using the IUCN Red List of Threatened Species.

SECTION THREE

3.0 RESULTS

3.1 Overview

The Greater Accra Region of Ghana is endowed with rich flora and fauna diversity. The project area however support just a small fraction of the wildlife species reported in the general area due to the significant decline in the ecological integrity of the habitats as a result of decreasing vegetation cover through infrastructural and industrial development and habitat conversion (Bass et al., 2003). Threats mainly emanate from industrial developments and operations which have contributed to the decline in the species of fauna and flora. None of the fauna species encountered within the project site and its immediate surroundings areas is of conservation interest internationally but only one (*Bubulcus ibis*) is of conservation importance nationally. The vegetation of the project area is high in diversity. Only 1 out of the 95 flora species recorded during surveys is of conservation interest, and rarely occurs within the project site where it will receive significant impact from the project.

3.2 Desk Study

3.2.1 Vegetation and Habitats

The survey area is located within a coastal scrub vegetation habitat type dominated by grassland and occasional shrubs. Flora belonging to the families Papilionaceae, Euphorbiaceae, and Graminae are dominant and well represented in the area. Introduced shrubs including the bougainvillea are also very prominent. Other flora present in the general area include the neem tree (*Azadirachta indica*) thickets interspersed with food crop farms of cassava (*Manihot esculenta*), maize (*Zea mays*), okra, pepper (*Capsicum annuum*), mangoes, cassias, avocados, and palms (*Cocos nucifera* and *Elaeis guineensis*).

Habitats identified at Tema area include coastal lagoon and associated mangrove vegetation, coastal strand vegetation, coastal scrub vegetation and grassland vegetation.

The coastal scrub vegetation of the Tema area has also been greatly modified by farming, developments and industrial activities over the years. The typical vegetation has been replaced with a farm-regrowth and grasses. The families Papilionaceae, Euphorbiaceae, and Graminae and herbs were the dominant life form. The proposed project site falls within this habitat type, which is generally characterized by coastal grassland and neem tree (*Azadirachta indica*) thickets.

The Gao Lagoon is fringed with a narrow strip (about 4m wide) of mangrove composed of mainly white mangrove (*Avicennia germinans*) and red mangrove (*Rhizophora mangle*). The white mangrove constitutes about 80% of the mangrove flora. Notable flora associated with the mangroves in Tema area are *Sesuvium portulacastrum* and *Paspalum vaginatum*.

The coastal strand of the Tema area has been greatly disturbed by human activities so that the coastal strand community is now comprised of farm re-growth with okra (*Abelmoschus esculentus*), grasses such as southern sandspur (*Cenchrus echinatus*), and crowfoot grass (*Dactyloctenium aegyptium*), and forbs such as flattop mille grain (*Oldenlandia corymbosa*), red hogweed (*Boerhavia diffusa*), and nettleleaf vervain (*Stachytarpheta indica*). The Papilionaceae, Euphorbiaceae and Graminae are the largest families, with a dominance of herb and shrub life forms.

3.2.2 Fauna

The literature reviewed showed that the wildlife of the Greater Accra Region and the project area was very rich and diverse a decade ago. Four amphibian species, 20 reptile species, 47 bird species and 16 mammal species have been documented to occur in the project area. Of the 87 wildlife species reported in the area, only one bird (*Neophron monachus*) and one mammal (*Eidolon helvum*) are of conservation importance internationally; the bird listed as Endangered, and the mammal Near Threatened on the IUCN list of Threatened Species. The table in Appendix A-1.1 below show some identified fauna species documented for the general Tema area covering the project area. None of these documented fauna of international conservation importance were recorded to occur in the project area during the current survey.

3.3 Field Survey

3.3.1 Flora

The floral species encountered at the proposed project site are common in Ghana and majority do not occur on any national or international list of endangered plant species. The Chaff flower (*Achyranthes sp*) is the only flora species found in the project area that is listed as Near Threatened by the IUCN Red List of Threatened species of flora and fauna (see **Appendix B1**). The *Achyranthes sp* is however rare in the entire area and only one plant was encountered at the locations they occur. Generally the floristic composition of the project site was found to be very diverse. The survey encountered 95 species of flora in the project site and its immediate surroundings.

The main vegetation type identified in the project area was grassland vegetation with *Leucaena glauca* and *Azadirachta indica* dominated thickets (**Figure C-1**). The dominant grasses encountered within the area include *Sporobolus pyramidalis* (**Figure C-2**).

3.3.2 Fauna

Generally, surveys along the pipeline routes and the tank farm revealed that entire project area supports a very low species diversity (**Table 3.1**) and population (**Figure 3.1**) of wildlife. This is most likely due to the continuous disturbances in the area from industrial activities. The highly degraded vegetation and habitats in the area also makes it inhabitable by any wildlife. Animals are known to generally exhibit close and specific associations with specific habitat types, and so an area with very few habitat types such at the project area is more likely to support a very low diversity of wildlife species compared to an area with highly diverse habitat types. None of the fauna encountered was of international importance. Only one bird species, Cattle egret (*Bubulcus ibis*) was listed as Completely Protected by the Wildlife Conservation Regulation which offered the species a national importance.

The rainbow lizard (*Agama agama*) was the only reptile encountered in the project area during the survey with the grass yellow butterflies (*Eurema sp*) also being the only insect seen in the area. No dragon fly was encountered during the surveys. Dropping of rabbit was encountered at two locations in the project along the pipeline routes which is indicative of their presence in the area. the presence of vegetation like the coat buttons (*Tridax procumbense*) which is a major food item for rabbits may suggest that the animals uses the place as foraging habitat. This food item however rarely occurs in the entire project area and could therefore not support a high population of rabbit.

***Table 3.1**: Wildlife Species encountered in the project area during field surveys*

SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS					
		EN	VU	NT	LC	CP	PP
Reptilia							
Agama agama	Rainbow (Agama) lizard				+		
Aves							
*Bubulcus ibis***	Cattle egret				+	+	
Crinifer piscator	Western Grey plantain-eater				+		
Nigrita canicapillus	Grey-headed negrofinch				+		
Passer griseus	Southern grey-headed sparrow				+		
Streptopelia senegalensis	Laughing dove				+		
Veles binotatus	Brown nightjar				+		
Mammalia							
Unidentified	Rabbit				+		
Insecta							
Eurema sp.	Grass yellow butterfly				+		

*(LC- Least Concern; NT- Near Threatened; VU- Vulnerable; EN- Endangered; WCR- Wildlife Conservation Regulation; PP- Partly Protected; CP- Completely Protected; Empty cell- Status not assessed; **- Species sighted in flight over project area)*

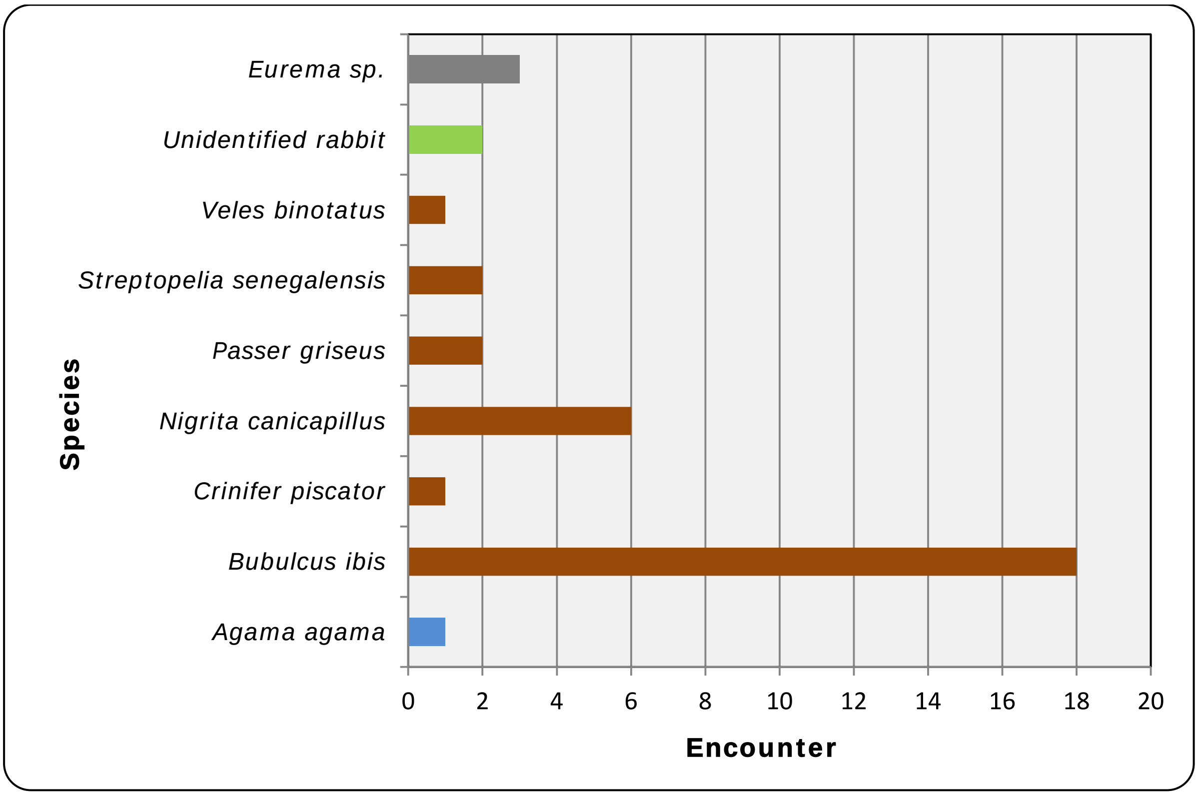

***Figure 3.2**: Activity count for the various species of reptiles (blue), aves (brown), mammal (lemon green) and insect (ash) encountered indicating the low abundance of fauna in the project area.*

The class aves recorded the highest number of species and encounters (F**igure 3.2**). None of the The cattle egret (*Bubulcus ibis*) which was the most encountered bird species during the survey were sighted in flight over the project area. Cow dungs seen in the area indicates that the cattle egret may be using the area as foraging habitat as well since they are known to follow cow and peck on the insects that fly as the cows disturb the grasses during feeding. The absence of nests may suggest that none of the birds seen during the survey utilise the area for breeding habitats. Birds encountered may therefore be non-breeding visitors to the area.

3.4 Evaluation of Results

Major finding coming out of the surveys is the poor diversity of fauna of the proposed project area. There is also very low abundance of the individual species encountered in the area (**Figure 3.1**). The field survey did not record any fauna of international conservation interest within the project site and its immediate environment. The hooded vulture (*Necrosyrtes monachus*) and the Straw-coloured fruit bat (*Eidolon helvum*) are species of conservation importance reported in the area (**Appendix A-1.1**). None of these species were encountered during the survey within the project site and its immediate surroundings. These species of conservation interest will therefore not receive any significant impact from the project.

The major threat facing wildlife in the area is industrial development and this has resulted in drastic population decline over the years and could account for the low numbers and species of fauna encountered during the survey. The low quality of the habitat is also a possible cause of few species and abundance of fauna recorded. These observations make it very unlikely for the proposed project to result in any huge and significant negative impact on the wildlife in the area since the wildlife is already heavily impacted on.

A total of 95 flora species were recorded for the project site and its immediate surroundings. The Chaff flower (*Achyranthes sp*) is the only species out of the 95 species of flora that is of conservation interest, and occurs rarely within the project site. The proposed project is anticipated to remove this Near Threatened species (*Achyranthes sp*) and hence its ecological functions from the project site.

SECTION FOUR

4.0 DISCUSSION

4.1 Anticipated Impacts of the project on wildlife in the area

Coastal development have been reported to have negative impact on wildlife through direct displacement, mortality, reduced reproductive rates, and increased susceptibility for predator capture. The highly degraded nature of the habitats in the area, caused by industrial development and activities, coupled with the low habitat types available reduces the sensitivity of the project site to impacts from activities of the proposed project. The low abundance and diversity of fauna in the area also reduces the sensitivity of the site. The proposed project is therefore anticipated to have negligible impact on wildlife in the area and their habitat since the area is already heavily impacted. All the fauna species of international and national conservation interest reported in the area were not encountered during surveys even though the cattle egret (*Bubulcu* ibis) may occasionally visit the area to feed. This further renders the proposed project as unlikely to significantly impact negatively on any fauna species of conservation interest. The Chaff flower (*Achyranthes sp*), which is the only flora species of international conservation interest, will be impacted by the project. Its ecological functions in the general area is however minimal since they are rare (mostly single plant) in areas where occurs.

Anticipated negative impacts associated with projects such as the Ghana Bridge Power Project are degradation/loss of habitat, loss of breeding space and fauna mortality. From the field surveys, these impacts are not expected since the area is already impacted by the constant disturbance and numerous threats to the fauna from already existing industries. Wildlife species have been known to respond to disturbance and changes in their environment (habitat destruction or conversion, pollution, noise, etc) by either migrating or adapting. Destruction of vegetation and disturbance from already existing industrial activities and movement of heavy machinery in the project area might have caused most wildlife species to already migrate from the area which could account for the low numbers and diversity.

Wildlife species encountered during the survey were bird that utilised the area for feeding and grooming but never breeding. Some birds also come to the area to ‘sand bath’ as observed for one brown nightjar (*Veles binotatus*) (**Figure C-4**). These birds are highly migratory and may only visit the area from other parts of the Tema where conditions are more favourable for breeding and inhabiting. For example the proposed tank farm shares boundary with the construction site for a 100,000MT petroleum product facility by Quantum Terminal Limited. The constant noise coming from activities at the site makes the tank farm area unfavourable to most wildlife hence the few species in the area. Also the use of the tank farm area for an activity like scrap metal gathering (**Figure C-5**), disturb the sites and drives wildlife away.

The absence of breeding signs in the area is indicative that the area is not suitable for breeding and hence the project is unlikely to impact any breeding areas. The highly migratory nature of the few birds encountered in the project area depicts their ability to migrate quickly and thus avoid any impact from the proposed project. Motilities resulting from the project is therefore reduced greatly.

SECTION FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Desktop studies were carried out to identify the terrestrial ecology environment of the project region through review of existing works carried out in the area. Field surveys were also undertaken to assess the ecological status of the project site and its immediate environment. Surveys included those for vegetation type and animal diversity and abundance in the area.

The literature shows a marked decline in fauna of the area. Only a few species and population of wildlife currently exist in the area due to numerous threats emanating mainly from industrial sources. Observations made during the field survey of the proposed project area and its immediate surroundings suggested a significant change in the ecological condition of the habitat and the associated species over the years. Threats to wildlife in the area include habitat degradation and conversion for industrialisation. Disturbance from heavy machinery operation was also identified as a threat in the area.

The low numbers of fauna in the area is another significant findings made during the survey. Most of the mammals and reptiles that were documented to previously occur in the survey area were not encountered during the recent survey because they are no more using the area or the population has declined greatly. The construction of the various industrial facilities directly and indirectly degraded pristine habitats around the project areas and could have resulted in the decline of wildlife.

Only one species of butterfly was observed in low numbers at the proposed project site. The poor vegetation diversity (mainly grassland) of the project area accounted for very low butterfly population since butterflies have been found to have high diversity and numbers in areas of high floral diversity.

The proposed project site for the Ghana Bridge Power project is very poor in fauna diversity and abundance. No species of international conservation interest was encountered in the project area. All the species recorded were classified as Least Concern (LC) by the IUCN Red List of Threatened Species and as Partly Protected (PP) by the Wildlife Conservation Regulation of Ghana except the Cattle egret (*Bubulcus ibis*) which was listed as Completely Protected (CP) by the Wildlife Conservation Regulation of Ghana. The species however is a visitor to the project area and does not inhabit or breed in the area.

The proposed project is unlikely to have any significant adverse impact on the fauna of the area since a very low faunal population and poor species diversity currently occur in the project area.

The species composition of fauna and flora in the area is not expected to change considerably between the wet season and the dry season. No new flora is expected to emerge during the dry season but rather existing flora are expected to dry up. This will likely cause some of the fauna species recorded to move out of the area during the dry season in search of suitable habitats. For example rabbits that require green grass to feed on will migrate away from area in search of food.

5.2 Recommendations

Based on the result of the baseline study and the conclusions, the following recommendation is proposed as a measure to further reduce and mitigate the already low impact anticipated from this proposed project;

1. Construction activities for the project should commence during the dry season. Since some of the species encountered are likely to move out of the area during this period, any activity is likely to have less impact, if any, on the wildlife of the area.

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7.0 APPENDIX

APPENDIX A- TERRESTRIAL FAUNA APPENDIX

Appendix A-1.1*: List of fauna documented in the Greater Accra Region and Tema Area with their conservation status (Source: WAGP-IA, 2004)*

SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS					
		IUCN				WCR	
		EN	VU	NT	LC	CP	PP
AMPHIBIA							
Bufo regularis	Common toad				+		
Dicroglossus occipitalis	Common frog				+		
Hylarana galamensis	Common frog						
Phrynobatrachus accraensis	Ahl's River Frog				+		
REPTILIA							
Chelonia (Tortoises/Terrapins)							
Pelomedusa subrufa	Marsh terrapin						+
Squamata: Lacertilia							
Agama agama	Rainbow lizard				+		
Chamaeleo gracilis	Chameleon				+		
Mabuya affinis	Skink						
Mabuya perroteti	Orange-flanked skink						
Panaspis togoensis	Togo Skink				+		
Varanus exanthematicus	Savanna monitor				+		
Varanus niloticus	Nile monitor					+	
Squamata: Serpentes							
Bitis arietans	Puff adder						
Causus maculates	Night adder						
Dasypeltis scabra	Common egg-eating snake				+		
Dendroaspis viridis	Green mamba				+		
Lamprophis fuliginosus	House snake						
N. nigricollis	Spitting cobra						
Philothamnus semivariegatus	Green tree snake						
Psammophis sibilans	Hissing sand snake				+		
Python regius	Royal python				+		
Python sebae	African python						
Rhamphiophis oxyrhynchus	Beaked snake						
Thelothornis kirtlandii	Twig snake						
AVES							
Ardeidae							
Bubulcus ibis	Cattle egret				+	+	
Accipitricidae							
Buteo augularis	Red-tailed buzzard					+	
Milvus migrans	Black kite				+	+	
Neophron monachus	Hooded vulture	+					
Falconidae							
Falco naumanni	Lesser kestrel				+	+	
Phasianidae							
Ptilopachus petrosus	Stone partridge				+		
Charadriidae							
Charadrius hiaticula	Common ringed plover				+		
Haematopus ostralegus	Eurasian oystercatcher				+		
Himantopus himantopus	Black-winged stilt				+		
Jacanidae							

Actophilornis africana	African jacana						
Burhinidae							
Burhinus senegalensis	Senegal thick-knee				+		
Columbidae							
Columba livia	Pigeon				+		
Streptopelia semitorquata	Red-eyed dove				+		
Streptopelia senegalensis	Laughing dove				+		
Turtur afer	Red-billed wood-dove				+		
Musophagidae							
Crinifer piscator	Grey plantain-eater				+		
Tauraco persa	Green-crested touraco				+		
Cuculidae							
Centropus senegalensis	Senegal coucal				+		
Chrysococcyx klaas	Klaas cuckoo				+		
Apodidae							
Apus affinis	Little swift				+		
Cypsilurus parvus	Palm swift						
Alcedinidae							
Ceryle rudis	Pied kingfisher				+		
Bucerotidae							
Tockus nasutus	Grey hornbill				+		
Capitonidae							
Lybius vieilloti	Vieillot's barbet				+		
Pogoniulus subsulphureus	Yellow-fronted tinker bird				+		
Corvidae							
Corvus albus	Pied crow				+		
Estrildidae							
Lonchura cucullata	Bronze mannikin				+		
Hirundinidae							
Hirundo rustica	European swallow				+		
Laniidae							
Laniarius barbarus	Barbary shrike				+		
Muscicapidae							
Cossypha niveicapilla	Snowy-crowned robin-chat				+		
Platysteira cyanea	Scarlet-spectacled wattle-eye				+		
Nectariniidae							
Nectarinia coccinigaster	Splendid sunbird				+		
Ploceidae							
Euplectes orix	Red bishop				+		
Lonchura cucullata	Bronze mannkin				+		
Ploceus cucullatus	Village weaver				+		
Ploceus nigricollis	Spectacled weaver				+		
Tchagra senegala	Black-crowned tchagra				+		
Pycnonotidae							
Chlorocichla simplex	Simple leaf-love				+		
Pycnonotus barbatus	Common garden bulbul				+		
Sturnidae							
Lamprotornis purpureus	Purple glossy starling				+		
Sylviidae							
Camaroptera brachyura	Grey-backed camaroptera				+		
Cisticola natalensis	Striped cisticola				+		
Prinia subflava	West African prinia				+		
Timaliidae							
Turdioides plebejus	Brown babbler						
Turdioides reinwardii	White-capped babbler						

Turdidae							
Luscinia megarhynchos	Nightingale				+		
Turdus pelios	West African thrush				+		
MAMMALIA							
Chiroptera							
Eidolon helvum	Straw-coloured fruit bat			+			
Primates							
Cercopithecus aethiops	Green monkey				+		+
Galagoides demidoff	Demidoff's galago				+		
Rodentia							
Arvicanthis niloticus Rufous	Nile rat						
Cricetomys gambianus	Gambian giant pouched rat				+		
Euxerus erythropus	Unstriped ground squirrel						+
Mastomys erythroleucus	Multimammate mouse				+		
Praomys tullbergi	Soft-furred rat				+		
Rattus rattus	Common rat				+		
Thryonomys swinderianus	Grasscutter				+		+
Lagomorpha							
Lepus zechi	Togo hare						
Carnivora							
Mungos gambianus	Gambian mongoose				+		+
Hyracoidea							
Procavia ruiceps	Rock hyrax						+
Artiodactyla							
Cephalophus maxwelli	Maxwell's duiker				+		+
Neotragus pygmaeus	Royal antelope				+		+
Tragelaphus scriptus	Bushbuck				+		+

(LC- Least Concern; NT- Near Threatened; VU- Vulnerable; EN- Endangered; WCR- Wildlife Conservation Regulation; PP- Partly Protected; CP- Completely Protected; Empty cell- Status not assessed)

Appendix A-1.2: Mode of identification of the animal species encountered during field surveys

SCIENTIFIC NAME	COMMON NAME	MODE OF IDENTIFICATION						
Reptilia		**S**	**FS**	**FP**	**H**	**B**	**D**	**C**
Agama agama	Rainbow lizard	+						
Aves								
Bubulcus ibis	Cattle egret	+						
Crinifer piscator	Western Grey plantain-eater	+						
Nigrita canicapillus	Grey-headed negrofinch	+						
Passer griseus	Southern grey-headed sparrow	+						
Streptopelia senegalensis	Laughing dove	+						
Veles binotatus	Brown nightjar	+						
Mammalia								
Unidentified	Rabbit						+	
Insecta								
Eurema sp.	Grass yellow butterfly	+						

(S-Sighted/ Seen; FS- Feeding Sign; FP- Foot Print; H- Hole made by animal for refuge; B- Burrow made by animal for refuge; D- Dropping/Dung; C- Calls heard from bird)

A-2: LEGEND FOR CONSERVATION STATUS

A-2.1: IUCN (International Union for the Conservation of Nature)

The IUCN publishes a Threatened Species List *(Red List of Threatened Animals)* which categorizes globally-threatened animals as follows:

- *Vulnerable (VU):* Species believed likely to move to the *EN (Endangered)* category, if the causal factors continue operating, because of rapidly decreasing populations and extensive habitat destruction.
- *Lower Risk (LR):* Taxa which have been evaluated but do not satisfy the criteria for any of the above categories. There are three sub-categories
- *Near Threatened (NT):* Taxa which do not qualify for *Conservation Dependent*, but which are close to qualifying for *Vulnerable*
- *Data Deficient (DD):* A taxon on which there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well-studied, and its biology well-known, but appropriate data on abundance and/or distribution is lacking,

A-2.2: National Criteria (Ghana Wildlife Conservation Regulations)

Ghana's Wildlife Laws (Ghana Wildlife Conservation Regulations, 1971 LI 685, and Ghana Wildlife

Conservation (Amendment) Regulations, 1988 LI 1357) also categorizes animal species into three main Schedules based on the level of protection required for a particular species:

- *Schedule I- Animals Wholly Protected;* species are completely protected (CP); the hunting, capture or destruction of species under this schedule is prohibited at all times.
- *Schedule II- Animals Partly Protected;* species are partially protected (PP); the hunting, capture and destruction of any young animal, or adult accompanied by young, is absolutely prohibited at all times.
- *Schedule III- Animals Protected in Close Season;* species are close season Protected (CSP); the hunting capturing or destruction of species under this schedule is absolutely prohibited between 1st August and 1st December of any season.

APPENDIX B – TERRESTRIAL FLORA APPENDICES

Appendix B-1: Species list of flora recorded within the project area and its immediate surroundings

Table B-1.1*: Flora species recorded at pipeline areas opposite the PUMA Oil* (Location: N 05.67956^0; W 000.01604^0)

Scientific Name	English Name	IUCN Status
Abutilon depauperatum	Indian mallow	
Achyranthes sp	Chaff flower	NT
Amaranthus spinosus		
Azadirachta indica	Neem tree	
Calotropis procera	Casol bean/ Crown flower	
Aspilia africana	Haemorrhage plant	
Chloris sp	Rhodes grass	
Cleome viscosa	Yellow spider flower	
Crotalaria retusa	Rattleweed	
Eclipta alba	False daisy	
Flacourtia flavascens	Niger plum	
Heteropogon contortus	Speargrass	LC
Hyptis suaveolens	Mint weed	
Indigofera erecta		
Indigofera hirsuta	Hairy indigo	
Jasminum grandifolia	Royal jasmin	
Paspalum vaginathum	Biscuit grass	
Passiflora foetida	Passion flower	
Phyllanthus ananus		
Physalis angulata	Baloon cherry	
Securinega virosa		
Spigelia anthelmia	Wormbush	
Sporobolus pyramidalis	Catstail dropseed	
Stachytapheta grandiflora		
Tridax procumbense	Coat buttons	
Vetiveria sp		

(LC- Least Concer; Empty cell- Status not assessed)

Table B-1.2: *Flora species recorded at Tank Farm site*
(Location: N 05.679780°; W 000.020960°)

Scientific Name	English Name	IUCN Status
Abutilon depauperatum	Indian mallow	LC
Achyranthes sp	Chaff flower	NT
Azadirachta indica	Neem tree	
Calotropis procera		
Casia tora		
Cassia occidentalis		
Cassia occidentalis	Stinking weed	
Cleome viscosa		
Cloris sp		
Croton lobata	Rushfoil / Croton	
Datura stramousa		
Heteropogor wrtortus	Speargrass	
Indigofera erecta		
Ipomea mouritiana	Morning glory	
Leucaena glauca	White leadtree	
Momordica charantia		
Panicum maxima	Guinea grass	
Paspalum vaginathum	Biscuit grass	
Passiflora feotida		
Physalis angulata	Baloon cherry	
Securinega virosa		
Sorghum sp	Goatweed	
Sporobolus		
Stachypherta grandifolia	Snakeweed	
Tridax procumbense	Coat buttons	
Vernonia cineria	Bitterleaf	
Vernonia cororata		

*(LC- Least Concern; NT- Near Threatened; Empty cell- Status not assessed; **- Species rarely occurring area)*

***Table B-1.2**: Flora species recorded at pipeline areas from Tank Farm site to TOR tankers loading point*

(Location: From- N 05.67884^0; W 000.02072^0 - Through 05.67253^0; W 000.02314^0 - To N05.67037^0; W 000.01806^0)

Scientific Name	English Name	IUCN Status
Abutilon depauperatum	Indian mallow	LC
Achyranthes sp	Chaff flower	NT
Azadirachta indica	Neem tree	
Bluemea sp		
Calotropis procera	Casol bean/ Crown flower	
Cassia occidentalis	Stinking weed	
Chloris sp	Rhodes grass	
Chromolaena odorata	Christmas bush	
Cleome viscosa	Yellow spider flower	
Commelina erecta	Mouth day flower	LC
Croton lobata	Rushfoil / Croton	
Cuba pentandra	Black myrtle	
Dichrostarchys glomerata	Acacia Saint	
Eclipta alba	False daisy	DD
Euphoribu heterophylla	Mexican fireplant	
Grewia carpinifolia	Donkey berry	
Heteropogor wrtortus	Speargrass	
Hyptis suaveolens	Mint weed	
Indigofera erecta		
Ipomea sp	Morning glory	
Jasminum grandifolia	Royal jasmin	
Jatropha gossipifolia	Cotton leaf	
Kigelia africana	Sausage tree	
Kylinga sp	Mullumbimby couch	
Lantana camara	Large leaf lantana	
Letivaria sp		
Leucaena glauca	White leadtree	
Luffa sp	Egyptian cucumber	
Marantus spinosus	Pigweed	
Paciflora foetida	Beechwood bunny	
Panicum maxima	Guinea grass	
Paspalum vaginathum	Biscuit grass	
Physalis angulata	Baloon cherry	
Ricinus sp	Casol bean	
Scoparia duicis		
Securinega virosa		
Sorghum sp	Goatweed	
Stachypherta grandifolia	Snakeweed	
Tridax procumbense	Coat buttons	

Typha domingensis	Southern cattail	LC
Vernonia cineria	Bitterleaf	
Xanthozylum zanthozyloides	Toothache tree	

*(LC- Least Concern; NT- Near Threatened; DD- Data Deficient; Empty cell- Status not assessed; **- Species rarely occurring area)*

APPENDIX C - PHOTO GALLERY

Figure C-1: *Sporobolus pyramidalis (foreground) grassland with Leucaena glauca dominated thicket (Background)*

Figure C-2: *Section of project area showing dominant grass, Sporobolus pyramidalis*

Figure C-3: *Droppings of rabbit indicating their presence in the project area*

Figure C-4*: Picture showing area of sand bathing by Veles binotatus*

Figure C-5*: Scrap metal site within the tank farm area*

Figure C-6*: Identification of flora species in the field*

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Appendix D2
2016 Terrestrial Ecology Survey – PPS1 (Formerly PPS2)

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

TERRESTRIAL ECOLOGY SURVEY OF THE POWER PLANT 2 SITE FOR THE GHANA BRIDGE POWER PROJECT, TEMA

17TH June 2016

Prepared By:
Andrews Agyekumhene

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EXECUTIVE SUMMARY

Populations of wildlife in Ghana have over the years dwindled due to illegal killing, habitat destruction and habitat conversion. The once bio-diversed ecosystems in Ghana are now serving as havens for a smaller portion of the species that previously inhabited these areas. This study is therefore a component of an Environmental and Social Impact Assessment (ESIA) by Jacobs for the Ghana Bridge Power project and assesses the new proposed power plant 2 site (PPS2).

The surveys were conducted to determine the ecological significance of flora and fauna that currently exist within the new site acquired for the Bridge power project where physical structures are to be situated for PPS2. Existing wildlife and flora in the project area were assessed to determine their ecological importance and also any impact that the power project is likely to have on wildlife as well as their habitat in the area including the flora. This is to enable the project develop strategies to avoid, minimize or mitigate them. The main methods used in data collection for this study were desktop literature reviews, interviews and direct field observations.

The project area supports just a small fraction of the wildlife species reported in the Region. This is due to the continuous decline in the ecological integrity of the habitats in the area resulting from decreasing vegetation cover through industrial infrastructural development and farming activities which are the main threat to wildlife and their habitat in the area. No mammal species was encountered during the survey. Only 9 birds species, 1 reptile and 7 butterflies were recorded in the survey. None of the fauna species encountered within the project site surveyed is of conservation interest internationally but one (*Bubulcus ibis*) is of conservation importance nationally. The absence of breeding sign for the Cattle egret indicates that the species may only visit to forage hence is not likely to receive any significant impact from the proposed project. The proposed project in general is anticipated to have no significant negative impact on both the wildlife in the area and their habitats.

SECTION ONE

1.0 GENERAL INTRODUCTION

1.1 Background

Ghana is endowed with viable populations of wildlife that has over the years supported the growing eco-tourism industry and complements the nation's strong cultural and historical attractions. Most of the wildlife is however found in the protected areas which provide the only refuge for them against illegal hunting, habitat degradation and habitat conversion. Terrestrial wildlife in Ghana ranges from relatively small animals to larger ones living in primary or secondary vegetation.

To protect the low diversity and population of wildlife remaining outside these protected areas, Ghana's environmental and social impact assessment (ESIA) requires that ecology field studies are conducted as part of the scope of ESIA to get a better understanding of the ecological significance of the project area and its sensitivity to project impacts. This document presents the findings of the terrestrial surveys by Associated Consultants Limited. The relevance of the study to the Ghana Bridge Power project emanates from the fact that all phases of the project activity right from the construction to decommissioning activities could adversely impact on the fauna and flora within the area. This could occur along the pipeline route and at the sites of other associated structures that will be erected such as the booster station, TOR sphere and the Tank Farm. If adequate migratory steps are not put into place, biological diversity in the areas of the project could be threatened and some possibly lost. This study therefore is to identify the biological diversity of the area and to determine the level of impact on them.

1.2 Wildlife in Ghana

Ghana is centrally located on the coast of West Africa and is endowed with both small and large wildlife occurring in different habitat ranges in Ghana. These include toads, frogs, snakes and mice as well as smaller antelope species such as duiker. The large wildlife in Ghana includes the forest and savannah elephant (*Loxodonta Africana*), Yellow-backed duiker (*Cephalophus silvicultor*), Roan antelope (*Hippotragus equinus*), Buffalo (*Syncerus caffer*), Hartebeest (*Alcelaphus buselaphus*), Warthog (*Phacochoerus africanus*), Red river hog (*Potamochoerus porcus*), Bongo (*Tragelaphus eurycerus*), Hippopotamus

(*Hippopotamus amphibius*), Giant pangolin (*Manis gigantea*), Giant forest hog (*Hylochoerus meinertzhageni*), Water chevrotain (*Hyemoschus aquaticus*), and Leopards (Panthera pardus). Primate species such as Common chimpanzees (*Pan troglodytes*), Whitenapped sooty mangabey (*Cercocebus atys*), Diana monkey (*Cercopithecus diana*), and the Black and white colobus (*Colobus polykomos*) are also found in Ghana (Wildlife Division of Forestry Commission, 2010). There are also fairly high diversity of birds, butterflies and reptiles identified in Ghana.

1.3 Site Description

The study was conducted within the new site of the proposed Ghana Bridge Power Project (Figure 1). The project is located within a coastal scrub vegetation habitat type dominated by grassland and occasional shrubs and thickets. Typical forest species of both fauna and flora are almost non-existent in the project area. Being an industrial enclave, there are no permanent settlements close to the project site. There is a big drainage along the western boundary of the site. The main economics activities of the area are therefore industrial productions. Few small scale farming activities are carried out in the area with farmers cultivating mainly vegetables. The project area is used for farming vegetables and this has resulted in the clearing of most of the vegetation by the farmers leaving a few areas with grass and Neem- dominated thickets. At the time of this survey, green pepper and okro had been farmed on the site and were being harvested. The other sections of the site had been cleared and ploughed to be cultivated. This has left most areas of the site bare of vegetation.

Figure 1.1 below shows the catchment of the project site and the locations of some infrastructure. Surveys were concentrated within the immediate boundaries of the site indicated in yellow.

***Figure 1**: Map showing the general location of the project site. Yellow line indicates the boundary of the site within which the survey was conducted (Source: Ghana Bridge Power Project)*

1.4 Objectives of the study

The objective of this survey is to obtain representative information on the terrestrial ecosystems and associated biodiversity and habitat of the proposed project area (indicated in yellow in figure 1). The relative ecological health of the site and its ability to absorb project impacts was determined. The survey also reports the relative biodiversity assets of the wetlands to enable the proposed project ascertain potential impacts on the wetland to allow for full consideration and mitigation of those impacts. The assessment will form part of ecological impact assessment for the Ghana Bridge Power energy project and help avoid or minimize adverse impacts on and to protect environmentally sensitive areas.

Specifically, the objectives of the surveys were to;

- Assess the fauna and flora composition within the site
- Determine the ecological significance of the flora and fauna identified within the site and its immediate environment
- Assess threats to fauna and flora in the area
- Determine the sensitivity of the fauna and flora of the project area to absorb impacts of any project

SECTION TWO

2.0 METHODOLOGY

The study included both office desktop information gathering and also field surveys. Interviews were conducted with farmers working on their farm within the survey area. The study was carried out on the early morning of 10th June 2016 by a three-member team.

2.1 Desk Study

Desktop work was carried out to review existing and available literature on terrestrial fauna and flora in the project area and its immediate surroundings. Existing literature and reports from work done in the Region relating to wildlife and habitats were also reviewed and summarized as part of the study. Relevant literature were consulted and where used, referenced appropriately.

2.2 Interviews

There were no communities and settlements within or close to the proposed project area so no interviews were conducted in communities. However two farmers who farm the site area for vegetables were available and so were interviewed during this current survey. The interview sought to find out what species of animal species they have seen in the area and what species they still see in the area.

2.3 Field Surveys

Field surveys were concentrated within the site (indicated with yellow in Figure 1) of the proposed project site for the Ghana Bridge Power project. Intensity of the survey dependent on field conditions; areas with denser and thicker vegetation were thoroughly examined to see if any species may be hiding in them. Surveys were conducted in the early morning when most wildlife are still active.

2.3.1 Vegetation

The flora survey aimed at determining (i) the existing vegetation type within the site and its immediate environment, (ii) the most commonly occurring plant species and their relative abundance (subjectively scored as dominant, abundant, frequent, occasional or rare) and

(iii) whether any species are endangered according to the IUCN list of threatened species. A species list was compiled for the project site and its immediate surroundings.

Areas along the within the survey site were surveyed by walking through the vegetation. Walks were also conducted along route and vegetation studied through direct observation. All species observed were identified and recorded. Identification was carried using examination of floristic features, leaves of the plant (shape, arrangements etc), the life form of the plant and in some cases the scent of the plant. Samples of species that were difficult to identify on the field were taken to the Botany Department of University of Ghana for further identification.

2.3.2 Fauna

The terrestrial fauna assessment consisted of mammal, avifauna, reptile, amphibian and invertebrates survey. Both secondary and primary data were collected on the terrestrial fauna of the project areas and analysed for this report.

The general survey procedure involved slow attentive walks within the site during which any fauna seen or heard was identified and recorded. All features of ecological interest observed were also noted and recorded. Areas of dense vegetation or thickets were thoroughly surveyed to identify any wildlife that may be in hiding. Areas identified as possible habitats for certain species were also thoroughly searched. Surveys were targeted at finding any signs of activity that the animals might have left behind. Activities carried out during the survey included (i) direct opportunistic observation (used to identify any living animal encountered in the area), (ii) spoors (recording any sign left by a living animal such as a constructed burrow or holes, faecal pellets, footprints etc since most mammals almost always leave signs of their activities behind them). Refuge examinations were also conducted using sticks to search, since some animals like hinged back tortoises (*Kinixyx* spp) often conceal themselves under and in fallen logs, rotten tree stumps, under rocks, in leaf litter, rodent burrows, ponds, old termite mounds, etc.

Identity of unfamiliar bird species was confirmed with the help of a field bird guide book (Borrow and Demey, 2004). Observation of birds at distant point was done with the help of pair of Binoculars.

2.3 Data Analysis

Quantitative assessment using charts in excel was used to depict the species abundance in the area. Higher abundance are represented by longer bars on the chart. Conservation and protection status of each species of fauna recorded was determined using the IUCN Red List of Threatened Mammals (http://www.iucnredlist.org/), and the Wildlife Conservation Regulation (LI 685, 1971) of Ghana. All the wildlife species in Ghana, with the exception of grasscutter, fall under the category of Closed Season Protected (CSP) during the closed season period, August 1st to December 1st each year.

The ecological significance and conservation status of the flora species encountered were defined using the IUCN Red List of Threatened Species.

SECTION THREE

3.0 RESULTS

3.1 Overview

The Greater Accra Region of Ghana was endowed with rich flora and fauna diversity. A few pockets of these rich flora and fauna however currently exist. The project area support just a small fraction of the wildlife species reported in the general area due to the significant decline in the ecological integrity of the habitats as a result of decreasing vegetation cover through infrastructural and industrial development and habitat conversion (Bass et al., 2003). Threats to wildlife in the area mainly emanate from industrial developments and operations which have contributed to the huge decline in the species of fauna and flora. None of the fauna species encountered within the project site and its immediate surroundings areas is of conservation interest internationally. Only the Cattle Egret (*Bubulcus ibis*) is of conservation importance nationally. The vegetation of the project area is low in diversity. None of the 20 flora species recorded during surveys is of conservation interest.

3.2 Desk Study

3.2.1 Vegetation and Habitats

The survey area is located within a coastal scrub vegetation habitat type dominated by grassland and occasional shrubs. Flora belonging to the families Papilionaceae, Euphorbiaceae, and Graminae are dominant and well represented in the area. Introduced shrubs including the bougainvillea are also very prominent in most areas. Other flora present in the general area include the neem tree (*Azadirachta indica*) thickets interspersed with food crop farms of cassava (*Manihot esculenta*), maize (*Zea mays*), okra, pepper (*Capsicum annuum*), mangoes, cassias, avocados, and palms (*Cocos nucifera* and *Elaeis guineensis*).

Habitats identified at Tema area include coastal lagoon and associated mangrove vegetation, coastal strand vegetation, coastal scrub vegetation and grassland vegetation.

The coastal scrub vegetation of the Tema area has also been greatly modified by farming, developments and industrial activities over the years. The typical vegetation has been replaced with a farm-regrowth and grasses. The families Papilionaceae, Euphorbiaceae, and

Graminae and herbs were the dominant life form. The proposed project site falls within this habitat type, which is generally characterized by coastal grassland and neem tree (*Azadirachta indica*) thickets.

The Gao Lagoon is fringed with a narrow strip (about 4m wide) of mangrove composed of mainly white mangrove (*Avicennia germinans*) and red mangrove (*Rhizophora mangle*). The white mangrove constitutes about 80% of the mangrove flora. Notable flora associated with the mangroves in Tema area are *Sesuvium portulacastrum* and *Paspalum vaginatum*.

The coastal strand of the Tema area has been greatly disturbed by human activities so that the coastal strand community is now comprised of farm re-growth with okra (*Abelmoschus esculentus*), grasses such as southern sandspur (*Cenchrus echinatus*), and crowfoot grass (*Dactyloctenium aegyptium*), and forbs such as flattop mille grain (*Oldenlandia corymbosa*), red hogweed (*Boerhavia diffusa*), and nettleleaf vervain (*Stachytarpheta indica*). The Papilionaceae, Euphorbiaceae and Graminae are the largest families, with a dominance of herb and shrub life forms.

3.2.2 Fauna

The literature reviewed showed that the wildlife of the Greater Accra Region and the project area was very rich and diverse a decade ago. Four amphibian species, 20 reptile species, 47 bird species and 16 mammal species have been documented to occur in the project area. Of the 87 wildlife species reported in the area, only one bird (*Neophron monachus*) and one mammal (*Eidolon helvum*) are of conservation importance internationally; the bird listed as Endangered, and the mammal Near Threatened on the IUCN list of Threatened Species. The table in Appendix A-1 below show some identified fauna species documented for the general Tema area covering the project area. None of these documented fauna of international conservation importance were recorded to occur in the project area during the current survey.

3.3 Interviews

Interactions were held with the two farming cultivating vegetables within the project area. According to the farmers, no medium or large mammal species have been encountered in the project area since they started cultivating the site. The only mammal species encountered are the rats which are occasionally seen moving through the farms probably in search of food. None of the rats reported were however encountered on this current survey and this could be due to the flooded nature of the site as a result of the rains.

3.4 Field Survey

3.4.1 Flora

The floral species encountered at the proposed project site are common in Ghana and none occur on any national or international list of endangered plant species. Generally the floristic composition of the project site was found to be low in diversity. The survey encountered only 20 species of flora within the project site.

The main vegetation type identified in the project area was grassland vegetation with *Leucaena glauca* and *Azadirachta indica* dominated thickets. The dominant grasses encountered within the area include *Sporobolus pyramidalis*.

3.4.2 Fauna

Generally, surveys within the site revealed that entire project area supports a very low species diversity (**Table 3.1**) and population (**Figure 3.1**) of fauna. This is most likely due to the continuous disturbances in the area from industrial and farming activities. The general project area is an industrial zone with lot of infrastructure development occurring on large and regular basis. This has resulted in the clearing of original vegetation for citing infrastructure and has rid the area of virgin vegetation and habitats. The highly degraded vegetation and habitats in the area makes it inhabitable by any wildlife. Several heavy duty machines working on daily basis at the numerous industries are major sources of noise to the wildlife in the area. Farming within general area and project the site is also another source of disturbance to wildlife in the area which has possibly resulted in the low abundance and species of fauna at the survey site.

Animals are known to generally exhibit close and specific associations with specific habitat types, and so an area with very few habitat types such at the project site is more likely to support a very low diversity of wildlife species compared to an area with highly diverse habitat types. The few habitat types in the project site could therefore account for the low abundance and diversity of fauna encountered during this survey.

No mammal species was encountered in the area during the current survey and could be due to several factors as the disturbance from farming activities, degraded habitats, and also the flood in the area. The project site had experience rains and massive flooding the previous day before the survey and most areas were still flood during the survey (See Appendix C, Figure C-5). Only 9 species of birds were encountered none of which was of international importance. Only one out of the 9 bird species, Cattle egret (*Bubulcus ibis*) was listed as Completely Protected by the Wildlife Conservation Regulation which offered the species a national importance. The Cattle egrets (*Bubulcus ibis*) were however not resident in the area but were following a herd of cattle that were moving through the area. Cattle egrets are known to follow cow and peck on the insects that fly as the cows disturb the grasses during feeding. No breeding sign (indicated by absence of nests) was also recorded for any of the bird species encountered. The absence of nests may suggest that none of the birds seen during the survey utilise the area for breeding habitats. Birds encountered may therefore be non-breeding visitors to the area. The project will thus not have any impact on the bird species recorded on the survey.

The female rainbow lizard (*Agama agama*) was the only reptile encountered in the project area during the survey with 7 individual butterflies belonging to the *Papilio* sp. also being the only insect seen in the area.

Table 3.1*: Wildlife Species encountered in the project area during field surveys*

COMMON NAME	SCIENTIFIC NAME	CONSERVATION STATUS					
		IUCN				WCR	
		EN	VU	NT	LC	CP	PP
Reptilia							
Rainbow lizard	*Agama agama*				+		
Aves							
Bronz Mannikin	*Lonchura cucullata*				+		
Cattle Egret*	*Bubulcus ibis*				+	+	
Common Bulbul	*Pycnonotus barbatus*				+		
Laughing Dove	*Spilopelia senegalensis*				+		
Northern Grey Headed Sparrow	*Passer griseus*				+		
Northern Red Bishop	*Euplectes franciscanus*				+		
Royal Tern	*Thalasseus maximus*				+		
Spur-winged Lapwing	*Vanellus spinosus*				+		
Western Grey plantain-eater	*Crinifer piscator*				+		
Insecta							
Grass yellow butterfly	*Papilio sp*				+		

*(LC- Least Concern; NT- Near Threatened; VU- Vulnerable; EN- Endangered; WCR- Wildlife Conservation Regulation; PP- Partly Protected; CP- Completely Protected; Empty cell- Status not assessed; *- Species sighted in flight over project area)*

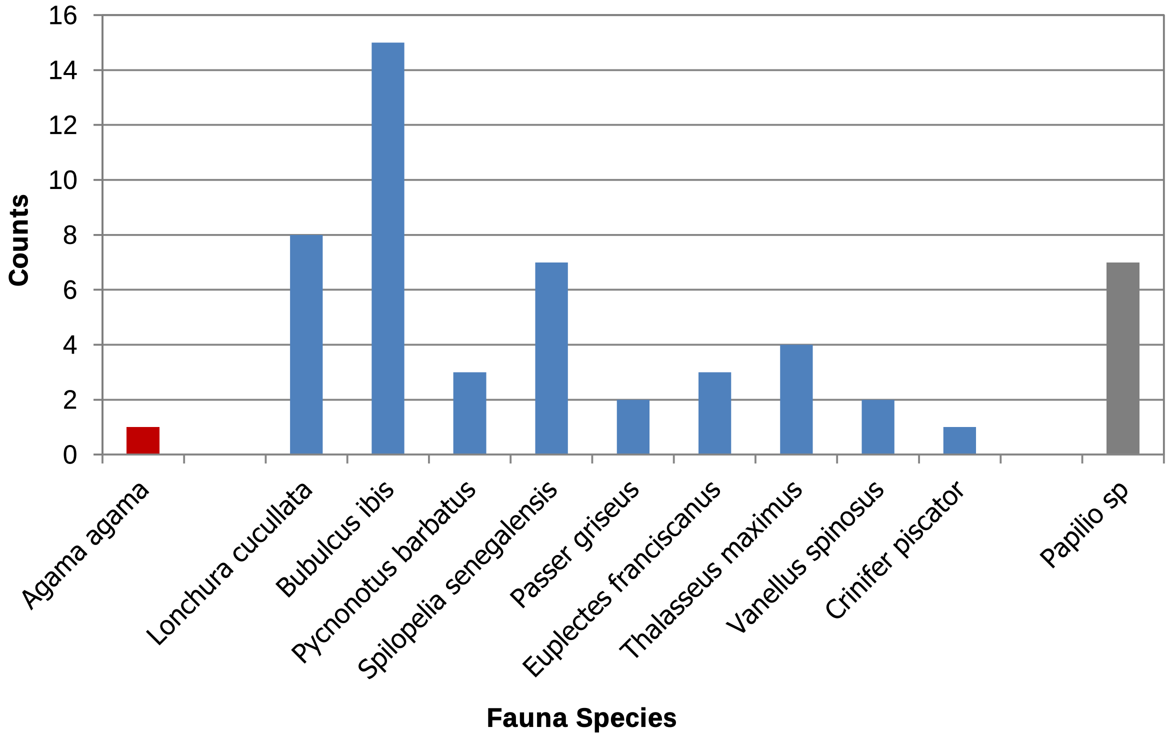

***Figure 3.2**: Activity count for the various species of reptiles (brown), aves (blue), and insect (ash) encountered indicating the low abundance of fauna in the project site.*

3.5 Evaluation of Results

Major finding coming out of the surveys is the poor diversity of fauna within the proposed project site. There is also very low abundance of the individual species encountered in the area (**Figure 3.1**). The field survey did not record any fauna of international conservation interest within the project site and its immediate environment.

The major threat facing wildlife in the general area is industrial development and this has resulted in drastic population decline over the years and could account for the low numbers and species of fauna encountered during the survey. The site-specific threat to wildlife is the farming activity carried out on the site which has resulted in the clearing of vegetation and destruction of habitats. The low quality of the habitat and the inundations of the site from the rains are the main possible cause of few species and abundance of fauna recorded. These observations make it very unlikely for the proposed project to result in any significant negative impact on the wildlife in the area since the wildlife is already absent from the area or have the tendency to easily migrate (especially the birds) to other areas.

A total of 20 flora species were recorded for the project site and its immediate surroundings. None of these species of flora at the site is of conservation interest. The proposed project is therefore not going to destroy or remove the ecological function of any flora of conservation interest.

SECTION FOUR

4.0 DISCUSSION

4.1 Anticipated Impacts of the project on wildlife in the area

Coastal development have been reported to have negative impact on wildlife through direct displacement, mortality, reduced reproductive rates, and increased susceptibility for predator capture. The highly degraded nature of the habitats in the area, caused by industrial development and activities, coupled with the low habitat types available from vegetation clearing for farming reduces the sensitivity of the project site to impacts from any activities of the proposed project. The absence of mammals and the low abundance and diversity of birds in the area further reduces the sensitivity of the project site. The proposed project is therefore anticipated to have negligible impact on wildlife in the area and their habitat since the area is already heavily impacted form anthropogenic activities. All the fauna species of international and national conservation interest reported in similar areas along the coast of Ghana were not encountered during this survey. Even though the cattle egret (*Bubulcu* ibis) was encountered, it was undertaking a foraging migration through the site and was not a breeding resident at the site. This further renders the proposed project as unlikely to significantly impact negatively on any fauna species of conservation interest.

Anticipated negative impacts associated with projects such as the Ghana Bridge Power Project are degradation/loss of habitat, loss of feeding and breeding space and fauna mortality. From the field surveys, these impacts are not expected since the area is already impacted by the constant disturbance and numerous threats to the fauna from already existing industries. Wildlife species have been known to respond to disturbance and changes in their environment (habitat destruction or conversion, pollution, noise, etc) by either migrating or adapting. Destruction of vegetation and disturbance from already existing industrial and farming activities in the project area might have caused most wildlife species to already migrate from the area which could account for the low numbers and diversity.

Wildlife species encountered during the survey were bird that utilised the area for feeding and grooming but never breeding. These birds are highly migratory and may only visit the area from other parts of the Tema where conditions are more favourable for breeding and inhabiting. The absence of breeding signs in the area is indicative that the area is not suitable for breeding and hence the project is unlikely to impact any breeding species and areas. The highly migratory nature of the few birds encountered in the project area depicts their ability to migrate quickly and thus avoid any impact from the proposed project. Motilities resulting from the project is therefore reduced greatly.

SECTION FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Desktop studies were carried out to identify the terrestrial ecology environment of the project region through review of existing works carried out in the area. Field surveys (interviews and direct observations) were also undertaken to assess the ecological status of the project site and its immediate environment. Surveys included those for vegetation type and animal diversity and abundance in the area.

The literature shows a marked decline in fauna of the area. Only a few species and population of wildlife that once occurred in the area currently exist due to numerous threats emanating mainly from industrial sources. Observations made during the field survey of the proposed project area and its immediate surroundings suggested a significant change in the ecological condition of the habitat and the associated species over the years. Threats to wildlife in the area include habitat degradation and conversion for industrialisation. Disturbance from heavy machinery operation was also identified as a threat in the area. On the project site, the main threat is clearing of vegetation for farming which disturbs wildlife in the area.

The low numbers of fauna in the area is the significant findings made during the survey. Most of the mammals and reptiles that were documented to previously occur in the survey area were not encountered during the recent survey because they are no more using the area or the population has declined greatly that they have extirpated from the area. The construction of the various industrial facilities directly and indirectly degraded pristine vegetation and habitats around the project site and could have resulted in the decline of wildlife in the general area.

Only seven individuals of butterfly was observed at the proposed project site. The poor vegetation diversity (mainly grassland) of the project area accounted for very low butterfly population since butterflies have been found to have high diversity and numbers in areas of high floral diversity.

The proposed project site for the Ghana Bridge Power project is very poor in fauna diversity and abundance. No species of international conservation interest was encountered in the project area. All the species recorded were classified as Least Concern (LC) by the IUCN Red List of Threatened Species and as Partly Protected (PP) by the Wildlife Conservation Regulation of Ghana except the Cattle egret (*Bubulcus ibis*) which was listed as Completely Protected (CP) by the Wildlife Conservation Regulation of Ghana. The species however is a visitor to the project area and does not inhabit or breed in the area.

The proposed project is unlikely to have any significant adverse impact on the fauna of the area since a very low faunal population and poor species diversity currently occur in the project area.

The species composition of fauna and flora in the area is not expected to change considerably between the wet season and the dry season. No new flora is expected to emerge during the dry season but rather existing flora are expected to dry up and die. The drying up of vegetation even cause some of the fauna species recorded to move out of the area during the dry season in search of suitable habitats. For example species like rabbits and grasscutter that require green grass to feed on will migrate away from area in search of food.

5.2 Recommendations

Based on the result of the baseline study and the conclusions, the following recommendation is proposed as a measure to further reduce and mitigate the already low impact anticipated from this proposed project;

1. Construction activities for the project should commence during the dry season. Since those species that may visit the area are likely to move out of the area during this period, any activity is likely to have less impact, if any, on the wildlife of the area.

2. The project should consider carrying out clearing activities during the periods outside the closed season when most wildlife species are breeding or attending to their young. This will prevent impacts on any species that may select the few thickets in the area for breeding site. However, if clearing is done right after the farming activities and the area is not left to grow back before clearing, no impact is expected since the farming already disturbs the wildlife.

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7.0 APPENDIX

APPENDIX A- TERRESTRIAL FAUNA APPENDIX

***Appendix A-1**: List of fauna documented in the Greater Accra Region and Tema Area with their conservation status (Source: WAGP-IA, 2004)*

SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS					
		IUCN				WCR	
		EN	VU	NT	LC	CP	PP
AMPHIBIA							
Bufo regularis	Common toad				+		
Dicroglossus occipitalis	Common frog				+		
Hylarana galamensis	Common frog						
Phrynobatrachus accraensis	Ahl's River Frog				+		
REPTILIA							
Chelonia (Tortoises/Terrapins)							
Pelomedusa subrufa	Marsh terrapin						+
Squamata: Lacertilia							
Agama agama	Rainbow lizard				+		
Chamaeleo gracilis	Chameleon				+		
Mabuya affinis	Skink						
Mabuya perroteti	Orange-flanked skink						
Panaspis togoensis	Togo Skink				+		
Varanus exanthematicus	Savanna monitor				+		
Varanus niloticus	Nile monitor					+	
Squamata: Serpentes							
Bitis arietans	Puff adder						
Causus maculates	Night adder						
Dasypeltis scabra	Common egg-eating snake				+		
Dendroaspis viridis	Green mamba				+		
Lamprophis fuliginosus	House snake						
N. nigricollis	Spitting cobra						
Philothamnus semivariegatus	Green tree snake						
Psammophis sibilans	Hissing sand snake				+		
Python regius	Royal python				+		
Python sebae	African python						
Rhamphiophis oxyrhynchus	Beaked snake						
Thelothornis kirtlandii	Twig snake						
AVES							
Ardeidae							
Bubulcus ibis	Cattle egret				+	+	
Accipitricidae							
Buteo augularis	Red-tailed buzzard					+	
Milvus migrans	Black kite				+	+	
Neophron monachus	Hooded vulture	+					
Falconidae							
Falco naumanni	Lesser kestrel				+	+	
Phasianidae							

Ptilopachus petrosus	Stone partridge				+		
Charadriidae							
Charadrius hiaticula	Common ringed plover				+		
Haematopus ostralegus	Eurasian oystercatcher				+		
Himantopus himantopus	Black-winged stilt				+		
Jacanidae							
Actophilornis africana	African jacana						
Burhinidae							
Burhinus senegalensis	Senegal thick-knee				+		
Columbidae							
Columba livia	Pigeon				+		
Streptopelia semitorquata	Red-eyed dove				+		
Streptopelia senegalensis	Laughing dove				+		
Turtur afer	Red-billed wood-dove				+		
Musophagidae							
Crinifer piscator	Grey plantain-eater				+		
Tauraco persa	Green-crested touraco				+		
Cuculidae							
Centropus senegalensis	Senegal coucal				+		
Chrysococcyx klaas	Klaas cuckoo				+		
Apodidae							
Apus affinis	Little swift				+		
Cypsilurus parvus	Palm swift						
Alcedinidae							
Ceryle rudis	Pied kingfisher				+		
Bucerotidae							
Tockus nasutus	Grey hornbill				+		
Capitonidae							
Lybius vieilloti	Vieillot's barbet				+		
Pogoniulus subsulphureus	Yellow-fronted tinker bird				+		
Corvidae							
Corvus albus	Pied crow				+		
Estrildidae							
Lonchura cucullata	Bronze mannikin				+		
Hirundinidae							
Hirundo rustica	European swallow				+		
Laniidae							
Laniarius barbarus	Barbary shrike				+		
Muscicapidae							
Cossypha niveicapilla	Snowy-crowned robin-chat				+		
Platysteira cyanea	Scarlet-spectacled wattle-eye				+		
Nectariniidae							
Nectarinia coccinigaster	Splendid sunbird				+		
Ploceidae							
Euplectes orix	Red bishop				+		
Lonchura cucullata	Bronze mannkin				+		
Ploceus cucullatus	Village weaver				+		
Ploceus nigricollis	Spectacled weaver				+		
Tchagra senegala	Black-crowned tchagra				+		
Pycnonotidae							

Chlorocichla simplex	Simple leaf-love				+		
Pycnonotus barbatus	Common garden bulbul				+		
Sturnidae							
Lamprotornis purpureus	Purple glossy starling				+		
Sylviidae							
Camaroptera brachyura	Grey-backed camaroptera				+		
Cisticola natalensis	Striped cisticola				+		
Prinia subflava	West African prinia				+		
Timaliidae							
Turdioides plebejus	Brown babbler						
Turdioides reinwardii	White-capped babbler						
Turdidae							
Luscinia megarhynchos	Nightingale				+		
Turdus pelios	West African thrush				+		
MAMMALIA							
Chiroptera							
Eidolon helvum	Straw-coloured fruit bat			+			
Primates							
Cercopithecus aethiops	Green monkey				+		+
Galagoides demidoff	Demidoff's galago				+		
Rodentia							
Arvicanthis niloticus Rufous	Nile rat						
Cricetomys gambianus	Gambian giant pouched rat				+		
Euxerus erythropus	Unstriped ground squirrel						+
Mastomys erythroleucus	Multimammate mouse				+		
Praomys tullbergi	Soft-furred rat				+		
Rattus rattus	Common rat				+		
Thryonomys swinderianus	Grasscutter				+		+
Lagomorpha							
Lepus zechi	Togo hare						
Carnivora							
Mungos gambianus	Gambian mongoose				+		+
Hyracoidea							
Procavia ruiceps	Rock hyrax						+
Artiodactyla							
Cephalophus maxwelli	Maxwell's duiker				+		+
Neotragus pygmaeus	Royal antelope				+		+
Tragelaphus scriptus	Bushbuck				+		+

(LC- Least Concern; NT- Near Threatened; VU- Vulnerable; EN- Endangered; WCR- Wildlife Conservation Regulation; PP- Partly Protected; CP- Completely Protected; Empty cell- Status not assessed)

Appendix A-1.2: Mode of identification of the animal species encountered during field surveys

COMMON NAME	SCIENTIFIC NAME	MODE OF IDENTIFICATION						
		S	FS	FP	H	B	D	C
Reptilia								
Rainbow lizard	*Agama agama*	+						
Aves								
Bronz Mannikin	*Lonchura cucullata*	+						
Cattle Egret	*Bubulcus ibis*	+						
Common Bulbul	*Pycnonotus barbatus*	+						
Laughing Dove	*Spilopelia senegalensis*	+						
Northern Grey Headed Sparrow	*Passer griseus*	+						
Northern Red Bishop	*Euplectes franciscanus*	+						
Royal Tern	*Thalasseus maximus*	+						
Spur-winged Lapwing	*Vanellus spinosus*	+						
Western Grey plantain-eater	*Crinifer piscator*	+						
Insecta								
Butterfly	*Papilio sp*	+						

(S-Sighted/ Seen; FS- Feeding Sign; FP- Foot Print; H- Hole made by animal for refuge; B- Burrow made by animal for refuge; D- Dropping/Dung; C- Calls heard from bird)

A-2: LEGEND FOR CONSERVATION STATUS

A-2.1: IUCN (International Union for the Conservation of Nature)

The IUCN publishes a Threatened Species List *(Red List of Threatened Animals)* which categorizes globally-threatened animals as follows:

- *Vulnerable (VU):* Species believed likely to move to the *EN (Endangered)* category, if the causal factors continue operating, because of rapidly decreasing populations and extensive habitat destruction.
- *Lower Risk (LR):* Taxa which have been evaluated but do not satisfy the criteria for any of the above categories. There are three sub-categories
- *Near Threatened (NT):* Taxa which do not qualify for *Conservation Dependent*, but which are close to qualifying for *Vulnerable*
- *Data Deficient (DD):* A taxon on which there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well-studied, and its biology well-known, but appropriate data on abundance and/or distribution is lacking,

A-2.2: National Criteria (Ghana Wildlife Conservation Regulations)

Ghana's Wildlife Laws (Ghana Wildlife Conservation Regulations, 1971 LI 685, and Ghana Wildlife

Conservation (Amendment) Regulations, 1988 LI 1357) also categorizes animal species into three main Schedules based on the level of protection required for a particular species:

- *Schedule I- Animals Wholly Protected;* species are completely protected (CP); the hunting, capture or destruction of species under this schedule is prohibited at all times.
- *Schedule II- Animals Partly Protected;* species are partially protected (PP); the hunting, capture and destruction of any young animal, or adult accompanied by young, is absolutely prohibited at all times.
- *Schedule III- Animals Protected in Close Season;* species are close season Protected (CSP); the hunting capturing or destruction of species under this schedule is absolutely prohibited between 1st August and 1st December of any season.

APPENDIX B – TERRESTRIAL FLORA APPENDICES

Appendix B-1: Species list of flora recorded within the project site

SCIENTIFIC NAME	ENGLISH NAME	IUCN STATUS			
		EN	VU	NT	LC
Abutilon depauperatum	Indian mallow				
Azadirachta indica	Neem tree				
Calotropis procera	Casol bean/ Crown flower				
Chloris sp	Rhodes grass				
Cleome viscosa	Yellow spider flower				
Crotalaria retusa	Rattleweed				
Flacourtia flavascens	Niger plum				
Heteropogon contortus	Speargrass				+
Hyptis suaveolens	Mint weed				
Indigofera erecta					
Indigofera hirsuta	Hairy indigo				
Jasminum grandifolia	Royal jasmin				
Leucaena glauca	Miracle Tree				
Paspalum vaginathum	Biscuit grass				
Phyllanthus ananus					
Physalis angulata	Baloon cherry				
Securinega virosa					
Spigelia anthelmia	Wormbush				
Sporobolus pyramidalis	Catstail dropseed				
Stachytapheta grandiflora					
Vetiveria sp					

(LC- Least Concer; Empty cell- Status not assessed)

APPENDIX C - PHOTO GALLERY

Figure C-1: Sections of the project site ploughed and prepared by farmers to be used for cultivating vegetables (Foreground). Only a small area of the site is left with grasses and thicket (background).

Figure C-2: Green pepper cultivated on the project site. Pepper was being harvested at the time of the survey indicating the planting has taken place some months back.

Figure C-3: Section of the project site used to cultivate okro. Harveting of okro had already taken place during the survey indicating the threat of disturbance in the area.

Figure C-4: *Farmer working on his farm during survey. This is a source of disturbance to the fauna of the area and could account for the low number encountered.*

Figure C-5: *Picture of the project site showing some flooded sections. Spur-winged lapwing bird was spotted in this area.*

APPENDIX D: RECORD FORMS FROM FIELD SURVEYS

FAUNA FIELD RECORD FORM DATE: 10-06-16 SPECIALIST: Andrews Agyekumhene

ID (WP)	Species	Counts	Evidence	Habitat Type	Coordinates (Optional)	Comments Habitat Status
1.	Bronze mannikin	3	S	Thicket		among neem trees.
2.	Spur winged lapwing	1	S	grassland		Innundated
3.	Laughing dove	2	S	thickets		among neem trees
4.	Spurwinged lapwing	1	S	grassland		waterlogged area
5.	Laughing dove	2	S	Grassland		
6.	laughing dove	3	S	grassland		
7.	Bronze mannikin	2	S	grassland		
8.	Bronze mannikin	1	S	grassland		
9.	Cattle egret	2	S	grassland		
10.	Cattle egret	5 (flying)	S			In flight
11.	Northern Red Bishop	1	S	thicket		among neem trees.
12.	Cattle egret	2	S			In flight
13.	Cattle egret (flight)	6	S			In flight
14.	Grey headed Sparrow	2	S	thickets		degraded.

Evidence Type: S- Sighted / FP- Foot Print / FS- Feeding Sign / H- Hole / T- Trail / D- Dung / O- Others

FAUNA FIELD RECORD FORM DATE: 10-06-16 SPECIALIST: Andrews Agyekumhene

ID (WP)	Species	Counts	Evidence	Habitat Type	Coordinates (Optional)	Comments Habitat Status
15.	N. Red Bishop	2	S	farmland		on okro farm
16.	Common bulbul	1	S	grassland		perching on a grass.
17.	Common bulbul	2	S	farmland		degraded habitat
18.	Royal terns	4	S	flying		
19.	Bronze manikin	2	S	thicket		among neem trees
20.	Agama Lizard	1	S	on wall around site		female
21.	Papilio butterfly	7	S	grassland		Swallowtail butterfly (1)
22	Grey Plantain eater	1	S	thickets		

Evidence Type: S- Sighted / FP- Foot Print / FS- Feeding Sign / H- Hole / T- Trail / D- Dung / O- Others

END OF REPORT

Jacobs Consultancy
Petroleum, Chemicals & Energy Practice
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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Appendix D3
2017 Terrestrial Ecology Survey – New Power Plant Site 2 (PPS2)

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

TERRESTRIAL FLORA AND FAUNA SURVEY
GHANA BRIDGE POWER ENERGY PROJECT, TEMA

Prepared By:
Andrews Agyekumhene

Submitted To:
Associate Consultants Limited

May 2017

Table of Contents

EXECUTIVE SUMMARY

Populations of wildlife in Ghana have over the years dwindled due to illegal killing, habitat destruction and habitat conversion. The once bio-diverse ecosystems in Ghana are now serving as havens for a smaller portion of the species that previously inhabited these areas. This study is therefore a component of an Environmental and Social Impact Assessment (ESIA) by Jacobs for the Ghana Bridge Power project. The project includes the development of power plant facilities across two sites, as well as a fuel storage tank farm, and fuel and water delivery pipelines.

A number of changes to the project proposals have been required during late 2016 and early 2017, and as such this report supplements the previous survey report, covering additional areas not surveyed previously. Specifically, the study area for the initial surveys was Power Plant Site 1, whilst the surveys which are the subject of this report covered the LPG pipeline route and Power Plant Site 2, and only those results are reported here.

The surveys were conducted to determine the ecological significance of flora and fauna that currently exist around the proposed project site 2, including the LPG pipeline route of the concession for the power project where physical structures are to be situated ("project area", "survey area"). Existing flora and fauna in the survey area were assessed to determine their conservation status and also any impact that the power project is likely to have on wildlife and the habitat in the area. The main methods used in data collection for this study were desktop literature reviews and direct field assessment/observations.

The project area supports small population and species of wildlife. This is due to the continuous decline in the ecological integrity of the habitats in the area from decreasing vegetation cover through infrastructural development and industrial activities which are the main threat to wildlife and their habitat in the area. The fauna encountered during the survey include 1 reptile, 7 birds and 1 insect species. None of the fauna species encountered within the project site surveyed is of conservation interest. The survey reported 55 species of flora notable of which were the *Azadirachta indica* and *Sporobolus pyramidalis.* None of the species of flora was of conservation importance.

The proposed project is anticipated to have very little negative impact on both the wildlife in the area and their habitats. The impact on the wildlife will however be minimal considering the small population of fauna that currently inhabit the area. Notwithstanding, it is recommended for the project to commence during the dry season and period outside the closed season to further reduce the minimal potential impacts.

SECTION ONE: GENERAL INTRODUCTION

1.1 Background

Ghana is endowed with viable populations of wildlife that has over the years supported the growing eco-tourism industry and complements the nation's strong cultural and historical attractions. Most of the wildlife is however found in the protected areas which provide the only refuge for them against illegal hunting, habitat degradation and habitat conversion. Terrestrial wildlife in Ghana ranges from relatively small animals to larger ones living in primary or secondary vegetation.

To protect the low diversity and population of wildlife remaining outside these protected areas, Ghana's environmental and social impact assessment (ESIA) requires that ecology field studies are conducted as part of the scope of ESIA to get a better understanding of the ecological significance of the project area and its sensitivity to project impacts. This document presents the findings of the terrestrial surveys by Associated Consultants Limited. The relevance of the study to the Ghana Bridge Power project emanates from the fact that all phases of the project activity right from the construction to decommissioning activities could impact the fauna and flora within the project's area of influence. If adequate migratory steps are to be put into place, biological diversity in the areas of the project needed to be carried out to understand any potential impacts. This study therefore is to identify the biological diversity of the area and to determine the level of potential impact on them.

1.2 Wildlife in Ghana

Ghana is centrally located on the coast of West Africa and is endowed with both small and large wildlife occurring in different habitat ranges in Ghana. These include toads, frogs, snakes and mice as well as smaller antelope species such as duiker. The large wildlife in Ghana includes the forest and savannah elephant (*Loxodonta Africana*), Yellow-backed duiker (*Cephalophus silvicultor*), Roan antelope (*Hippotragus equinus*), Buffalo (*Syncerus caffer*), Hartebeest (*Alcelaphus buselaphus*), Warthog (*Phacochoerus africanus*), Red river hog (*Potamochoerus porcus*), Bongo (*Tragelaphus eurycerus*), Hippopotamus (*Hippopotamus amphibius*), Giant pangolin (*Manis gigantea*), Giant forest hog (*Hylochoerus meinertzhageni*), Water chevrotain (*Hyemoschus aquaticus*), and Leopards (Panthera pardus). Primate species such as Common chimpanzees (*Pan troglodytes*), Whitenapped sooty mangabey (*Cercocebus atys*), Diana monkey (*Cercopithecus diana*), and the Black and white colobus (*Colobus polykomos*) are also found in Ghana (Wildlife Division of Forestry Commission, 2010). There are also fairly high diversity of birds, butterflies and reptiles identified in Ghana.

1.3 Site Description

The study was conducted within the proposed site for the extension of the Bridge power project, known as Power Plant Site 2 (PPS2) (Figure 1.1) and also along the proposed LPG pipeline route (Figure 1.2). The project is located within a coastal scrub vegetation habitat type dominated by grassland and occasional shrubs and thickets. Forest species of both fauna and flora are almost non-existent in the proposed project area.

Being an industrial enclave, there are no major settlements within or close to the project site except temporal structures occupied by manual worker for some of the construction companies in the area. The main economics activities of the area are industrial productions with a few individuals undertaking temporal vegetable farming mostly on lands earmarked for industrial development. With new companies coming up, constructional activities are common in the area. Heavy machinery involved in the construction activity is a major source of noise in the area.

Figure 1.1 below shows the catchment of the proposed project site and the locations of some survey points. Surveys were concentrated within the red boundaries and also along the pipeline but areas within the immediate surroundings of the pipelines were also surveyed (Figure 1.2).

Figure 1.1: *Map showing the survey areas. Red lines indicate the boundaries within which surveys were conducted. Pipeline route surveyed is not shown on map. Green points indicate locations of major thickets within the survey area*

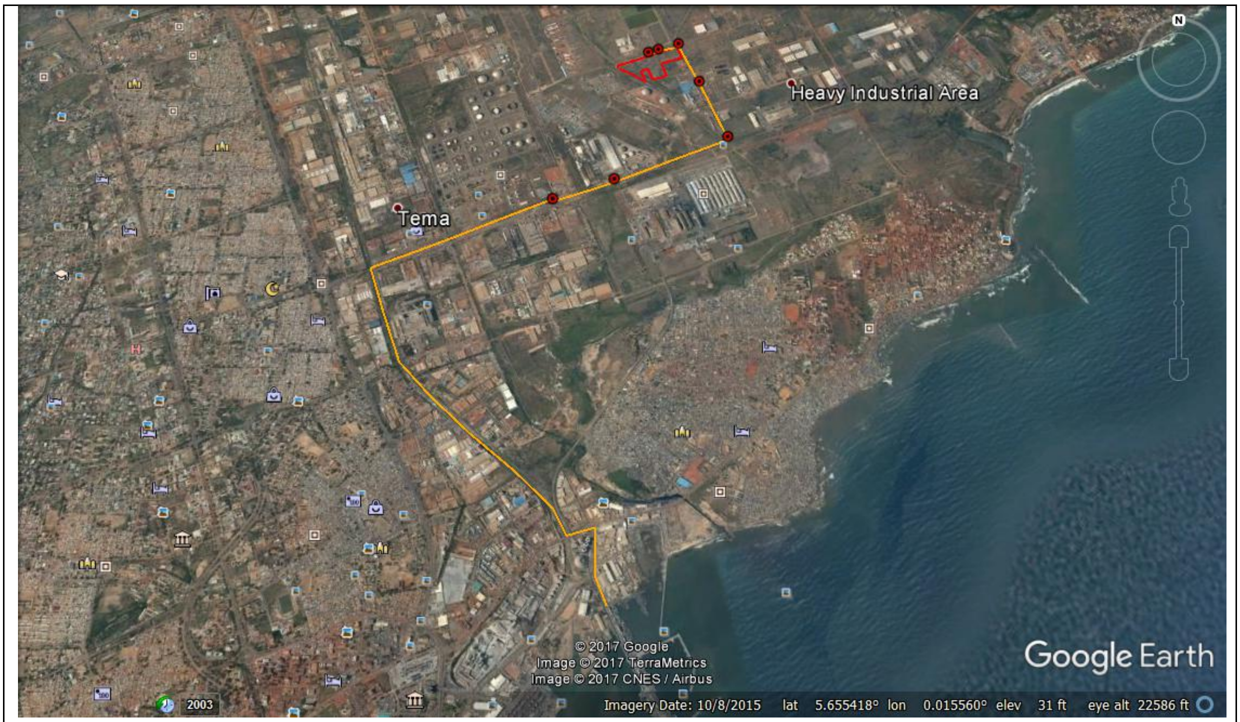

Figure 1.1*: Map showing the survey areas alng the pipeline route. Orange lines indicate the route along which surveys were conducted. Red dots indicate survey points.*

1.4 Objectives of the study

The objective of this survey is to obtain representative information on the terrestrial ecosystems and associated biodiversity and habitat of the area along the pipeline route. The relative ecological health of the site and its ability to absorb project impacts was determined. The survey also reports the relative biodiversity assets of the project site to enable the proposed project ascertain potential impacts on the wetland to allow for full consideration and mitigation of those impacts. The assessment will form part of ecological impact assessment for the Ghana Bridge Power energy project and help avoid or minimize adverse impacts on and to protect environmentally sensitive areas.

Specifically, the objectives of the surveys were to;

- Assess the fauna and flora composition within the proposed Power Plant Site 2 of the Ghana Bridge Power energy Project and its immediate surroundings
- Assess the fauna and flora composition along the pipeline route for the Ghana Bridge Power energy Project
- Determine the ecological significance of the flora and fauna within the site and along the pipeline route and its immediate environment
- Assess threats to fauna and flora in the area
- Determine potential impact to flora and fauna in the area from projects activities
- Assess the sensitivity of the fauna and flora of the project area to absorb impacts of any project

SECTION TWO: METHODOLOGY

The study included both office desktop information gathering and also field surveys. There were no communities and settlements within or close to the proposed project area so no interviews were conducted. The study was carried out on the early morning of 2^{nd} May 2017 by a two-member team.

2.1 Desk Study

Desktop work was carried out to review existing and available literature on terrestrial fauna and flora in the project area and its immediate surroundings. Existing literature and reports from work done in the Region relating to wildlife and habitats were also reviewed and summarized as part of the study. Relevant literature were consulted and where used, referenced appropriately.

2.2 Field Surveys

Field surveys were concentrated within the proposed PPS2and its immediate environment (See Figure 1.1) and also the pipeline for the Ghana Bridge Power project. The survey was extended to the immediate environment around the pipeline. Distances of areas surveyed from the pipeline route were dependent on field conditions; up to about 15 meters along the pipeline route were surveyed for both their fauna and flora composition. Surveys were conducted in the early morning when most wildlife are still active.

2.2.1 Vegetation

The flora survey aimed at determining (i) the existing vegetation type within the site and along the pipeline route and their immediate environment, and (ii) whether any species are endangered according to the IUCN list of threatened species. A species list was compiled for the project site and its immediate surroundings and also for the pipeline route and its immediate areas which are all Area of influence for the project.

For the flora surveys, a slow attentive walk was conducted through the project area and all flora encountered along the path of walk was observed and recorded. Areas along the pipeline route were also surveyed by walking and vegetation studied through direct observation. All species observed were identified and recorded. Identification was carried using examination of floristic features, leaves of the plant (shape, arrangements etc), the life form of the plant and in some cases the scent of the plant.

2.2.2 Fauna

The terrestrial fauna assessment consisted of mammal, avifauna, reptiles and amphibian survey. Both secondary and primary data were collected on the terrestrial fauna of the project areas and analysed for this report.

The general survey procedure involved slow attentive walks within the project site and along the pipeline route during which any fauna seen or heard (in the case of birds) was identified and recorded. All features of ecological interest for fauna observed were also noted and recorded. Areas of dense vegetation or thickets were thoroughly surveyed to identify any wildlife that may be in hiding. Areas identified as possible habitats for certain species were also thoroughly searched. Surveys were targeted at finding any signs of activity that the animals might have left behind. Activities carried out during the survey included (i) direct opportunistic observation (used to identify any living animal encountered in the area), and (ii) spoors (recording any sign left by a living animal such as a constructed burrow or holes, faecal pellets, footprints etc since most mammals almost always leave signs of their activities behind them).

Identity of unfamiliar bird species was confirmed with the help of a field bird guide book (Borrow and Demey, 2004). Observation of birds at distant point was done with the help of pair of Binoculars.

2.3 Data Analysis

The list of wildlife species encountered were compiled and presented in tables for this report. Conservation and protection status of each species of fauna recorded was determined using the IUCN Red List of Threatened Mammals (http://www.iucnredlist.org/), and the Wildlife Conservation Regulation (LI 685, 1971) of Ghana. All the wildlife species in Ghana, with the exception of grasscutter, fall under the category of Closed Season Protected (CSP) during the closed season period, August 1st to December 1st each year.

The ecological significance and conservation status of the flora species encountered were defined using the IUCN Red List of Threatened Species.

SECTION THREE: RESULTS

3.1 Overview

The Greater Accra Region of Ghana is endowed with rich flora and fauna diversity. The project area however support just a small fraction of the wildlife species reported in the general area due to the significant decline in the ecological integrity of the habitats as a result of decreasing vegetation cover which is usually associated with infrastructural and industrial development and habitat conversion (Bass et al., 2003). Threats mainly emanate from industrial developments and operations which have contributed to the decline in the species of fauna and flora in the area. None of the fauna species encountered within the project site and its immediate surroundings areas is of conservation interest internationally and nationally. The vegetation of the project area is high in diversity. The main habitat type of the area is grassland with thicket clumps. The rapid survey did not encounter any flora species of international conservation interest within the project area or along the pipeline.

3.2 Desk Study

3.2.1 Vegetation and Habitats

Habitats identified at general Tema area close to the project site include coastal lagoon and associated mangrove vegetation, coastal strand vegetation, coastal scrub vegetation and grassland vegetation. The Gao Lagoon located close to the area is fringed with a narrow strip (about 4m wide) of mangrove composed of mainly white mangrove (*Avicennia germinans*). Notable flora associated with the mangroves in Tema area are *Conocarpus erectus*, *Sesuvium portulacastrum* and *Paspalum vaginatum*.

The coastal scrub vegetation of the Tema area has also been greatly modified by farming, developments and industrial activities over the years. The typical vegetation has been replaced with a farm-regrowth and grasses. The families Papilionaceae, Euphorbiaceae, and Graminae and herbs were the dominant life form. The proposed project site falls within this habitat type, which is generally characterized by coastal grassland and neem tree (*Azadirachta indica*) thickets.

The coastal strand of the Tema area has also been greatly disturbed by human activities so that the coastal strand community is now comprised of farm re-growth with okra (*Abelmoschus esculentus*), grasses such as southern sandspur (*Cenchrus echinatus*), and crowfoot grass (*Dactyloctenium aegyptium*), and forbs such as flattop mille grain (*Oldenlandia corymbosa*), red hogweed (*Boerhavia diffusa*), and nettleleaf vervain (*Stachytarpheta indica*). The Papilionaceae, Euphorbiaceae and Graminae are the largest families, with a dominance of herb and shrub life forms.

The survey area is located within a coastal scrub vegetation habitat type of the area and is dominated by grassland and occasional shrubs and thickets. Like most areas in the Tema industrial enclave, flora belonging to the families Papilionaceae, Euphorbiaceae, and Graminae are the most dominant and well represented vegetation type in the project area.

Other flora well represent in the general area include the neem tree (*Azadirachta indica*) which are usually found in the thickets. The only farm within the project site (Figure 1.1) has sweet pepper (*Capsicum annuum*) which occupies just a small portion of the project site. The majority of the site appeared to have been farmed in the past.

3.2.2 Fauna

The literature reviewed showed that the wildlife of the Greater Accra Region and the project area was very rich and diverse a decade ago. Four amphibian species, 20 reptile species, 47 bird species and 16 mammal species have been documented to occur in the project area. Of the 87 wildlife species reported in the area in the past, only one bird (*Neophron monachus*) and one mammal (*Eidolon helvum*) are of conservation importance internationally; the bird listed as Endangered, and the mammal Near Threatened on the IUCN list of Threatened Species. The table in Appendix A-1.1 below show some identified fauna species documented for the general Tema area including the project area. None of these documented fauna of international conservation importance were recorded to occur in the project area during the current survey.

3.3 Field Survey

3.3.1 Flora

The floral species encountered at the proposed project site are common in Ghana and the Tema area. The flora recorded do not occur on any national or international list of endangered plant species.

Generally the floristic composition of the project site was found to be very diverse. The survey encountered 55 species of flora in the project site and its immediate surroundings including areas along the pipeline. Of the total species recorded in the project areas, 26 species were recorded within the site while 42 species were recorded along the pipeline route.

The main vegetation type identified in the project area was grassland vegetation with *Azadirachta indica* dominated thickets. The dominant grasses encountered within the area include *Sporobolus pyramidalis*.

3.3.2 Fauna

Surveys within the site and along the pipeline routes revealed that the population and species diversity of the project area was very low and population (**Table 3.1**). This is most likely due to the continuous disturbances in the area from industrial activities. The highly degraded vegetation and habitats in the area also makes it less suitable to support any significant wildlife. Animals are known to generally exhibit close and specific associations with specific habitat types, and so an area with very few habitat types such at the project area is more likely to support a very low diversity of wildlife species compared to an area with highly diverse habitat types. None of the fauna encountered was of international importance.

The class aves recorded the highest number of species and encounters in this current survey but numbers and diversity were still lower that those recorded in past surveys indicating a continuous decline in the wildlife of the area over the years. The presence of construction activities close to the project site during the survey could have also accounted for the low wildlife encountered. At the time of survey, there was a road construction going on just infront of the site. A plant belonging to the Tema Oil Refinery was also in operation and presented a lot of noise which could be heard from the survey area. Birds are known to respond to disturbance such as noise by flying away and this could account for the fewer birds recorded during the survey.

Contrary to expectations, no cattle egret were observed during the surveys. However, cow dungs seen in the area indicates that the cattle egret may be using the area as foraging habitat as well since they are known to exhibit a commensal relationship with the cattle; follow the cattle and peck on the insects that fly as the cows disturb the grasses during feeding. The absence of bird nests suggest that none of the birds utilise the area for breeding habitats. Birds encountered may therefore be non-breeding visitors to the area.

The only reptile encountered in the area were female and males rainbow lizards (*Agama agama*). Also, only one unidentified dragon fly was encountered during walks along the pipeline.

***Table 3.1**: Wildlife Species encountered in the project area during field surveys*

SCIENTIFIC NAME	COMMON NAME	NUMBER OF ENCOUNTER	CONSERVATION STATUS					
			EN	VU	NT	LC	CP	PP
Reptilia								
Agama agama	Rainbow (Agama) lizard	3				+		+
Aves								
Passer griseus	Southern grey-headed sparrow	6				+		+
Streptopelia senegalensis	Laughing dove	9				+		+
Lonchura cucullata	Bronz mannikin	40				+		+
Passer griseus	Grey-headed Sparrow					+		+
Pycnonotus barbatus	Common bulbul	3				+		+
Vanellus spinosus	Spur-winged lapwing					+		+
Euplectes franciscanus	Northern Red Bishop	1				+		+
Insecta								
Unidentified	Dragon fly	1				+		+

*(LC- Least Concern; NT- Near Threatened; VU- Vulnerable; EN- Endangered; WCR- Wildlife Conservation Regulation; PP- Partly Protected; CP- Completely Protected; Empty cell- Status not assessed; **- Species sighted in flight over project area)*

3.4 Evaluation of Results

Major finding coming out of the surveys is the poor diversity of fauna of the proposed project areas (within the site and along the pipeline route). There is also very low abundance of the individual species encountered in the area. The field survey did not record any fauna of international conservation interest within the project site and its immediate environment. The hooded vulture (*Necrosyrtes monachus*) and the Straw-coloured fruit bat (*Eidolon helvum*) are species of conservation importance reported in the area in past surveys (see **Appendix A-1.1**). None of these species were encountered during the survey within the project site and its immediate surroundings. These and other species of conservation interest will therefore not receive any significant impact from the project.

The major threat facing wildlife in the area is industrial development and this has resulted in drastic population decline over the years and could account for the low numbers and species of fauna encountered during the survey. The low quality of the habitat is also a possible cause of few species and abundance of fauna recorded. These observations make it very unlikely for the proposed project to result in any huge and significant negative impact on the wildlife in the area since the wildlife is already heavily impacted on.

A total of 55 flora species were recorded for the project area of impacts (within the site and along the pipeline) and its immediate surroundings. None of the 55 species of flora is of conservation interest, and occurs rarely within the project site. The proposed project will result in the clearance of vegetation on the project site and remove their ecological benefits from the project area, however these species persist in the wider area.

SECTION FOUR: DISCUSSION

4.1 Anticipated Impacts of the project on wildlife in the area

Coastal development have been reported to have negative impact on wildlife through direct displacement, mortality, reduced reproductive rates, and increased susceptibility for predator capture. The highly degraded nature of the habitats in the area, caused by industrial development and activities, coupled with the low habitat types available reduces the sensitivity of the project site to impacts from activities of the proposed project. The low abundance and diversity of fauna in the area (Table 3.1) also reduces the sensitivity of the site to project impacts. The proposed project is therefore anticipated to have less significant impact on wildlife in the area.

All the fauna species of international and national conservation interest reported in the area from past surveys were not encountered during the current surveys even though the cattle egret (*Bubulcus ibis*) may occasionally visit the area to feed. This renders the proposed project as unlikely to directly impact negatively on any fauna species of conservation interest.

Anticipated negative impacts associated with projects such as the Ghana Bridge Power Project are degradation/loss of habitat, loss of breeding space and fauna mortality. From the field surveys, these impacts are not expected since the area is already impacted by the constant disturbance and numerous threats from already existing industries. Wildlife species have been known to respond to disturbance and changes in their environment (habitat destruction or conversion, pollution, noise, etc) by either migrating or adapting. Species that are not able to adapt or migrate early enough face mortality. Destruction of vegetation and disturbance from already existing industrial activities and movement of heavy machinery in the project area might have caused most wildlife species to already migrate from the area which could account for the low numbers and diversity.

Wildlife species encountered during the survey were bird that utilised the area for feeding and grooming but not breeding. These birds are highly migratory and may only visit the area from other parts of the Tema where conditions are more favourable for breeding and inhabiting. The constant noise coming from activities close to the site makes the area unfavourable to most wildlife hence the few species in the area.

The absence of breeding signs in the area is indicative that the area is not suitable for breeding and hence the project is unlikely to impact any breeding areas or young ones of any species. The highly migratory nature of birds also makes it possible for the few species encountered in the project area to migrate quickly and thus avoid any impact from the proposed project. Motilities resulting from the project is therefore greatly reduced.

SECTION FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Desktop studies were carried out to identify the terrestrial ecology environment of the project region through review of existing works carried out in the area. Field surveys were also undertaken to assess the ecological status of the project site and its immediate environment. Surveys included those for vegetation type and animal diversity and abundance in the area.

The literature shows a marked decline in fauna of the area. Only a fraction of the previously occurring species and population of wildlife currently exist in the area due to numerous threats emanating mainly from the many industrial activities in the Tema area. Observations made during the field survey of the proposed project area and its immediate surroundings suggested a significant change in the ecological condition of the habitat and the associated species over the years. Threats to wildlife in the area include habitat degradation and conversion for industrialisation. Disturbance from heavy machinery operation was also identified as a threat in the area.

The low numbers of fauna in the area is another significant findings made during the survey. Most of the mammals and reptiles that were documented to previously occur in the survey area were not encountered during the recent survey because they are probably no more using the area. The construction of the various industrial facilities directly and indirectly degraded pristine habitats around the project areas and could drive wildlife away.

The proposed project site for the Ghana Bridge Power project is very poor in fauna diversity and abundance. No species of international conservation interest was encountered in the project area. All the species recorded were classified as Least Concern (LC) by the IUCN Red List of Threatened Species and as Partly Protected (PP) by the Wildlife Conservation Regulation of Ghana.

The floristic composition of the area was high in species diversity with none of the 55 species recorded being of conservation value on the IUCN red list. These flora species will all be cleared during the construction phase of the project.

The proposed project will not have any adverse impact on the fauna and flora of conservation interest.

5.2 Recommendations

Based on the result of the baseline study and the conclusions, the following recommendation is proposed as a measure to further reduce and mitigate the already low impact anticipated from this proposed project;

1. Notwithstanding the low faunal found in the area, construction activities for the project should commence during the dry season since some of the wildlife species encountered are likely to move out of the area during this period in search of food or water. Any activity is therefore likely to have less impact, if any, on the wildlife of the area.
2. Vegetation clearing associated with the construction phase of the project should be conducted during periods outside the close season when some of the animals are expected to be carrying or tending to their young. This reduce any impact on burrowing organisms that may be staying in their burrows hence were not encountered by the recent survey.

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APPENDICES

Appendix A- Terrestrial Fauna Appendix

Appendix A-1.1*: List of fauna documented in the Greater Accra Region and Tema Area with their conservation status (Source: WAGP-IA, 2004)*

SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS					
		IUCN				WCR	
		EN	VU	NT	LC	CP	PP
AMPHIBIA							
Bufo regularis	Common toad				+		
Dicroglossus occipitalis	Common frog				+		
Hylarana galamensis	Common frog						
Phrynobatrachus accraensis	Ahl's River Frog				+		
REPTILIA							
Chelonia (Tortoises/Terrapins)							
Pelomedusa subrufa	Marsh terrapin						+
Squamata: Lacertilia							
Agama agama	Rainbow lizard				+		
Chamaeleo gracilis	Chameleon				+		
Mabuya affinis	Skink						
Mabuya perroteti	Orange-flanked skink						
Panaspis togoensis	Togo Skink				+		
Varanus exanthematicus	Savanna monitor				+		
Varanus niloticus	Nile monitor					+	
Squamata: Serpentes							
Bitis arietans	Puff adder						
Causus maculates	Night adder						
Dasypeltis scabra	Common egg-eating snake				+		
Dendroaspis viridis	Green mamba				+		
Lamprophis fuliginosus	House snake						
N. nigricollis	Spitting cobra						
Philothamnus semivariegatus	Green tree snake						
Psammophis sibilans	Hissing sand snake				+		
Python regius	Royal python				+		
Python sebae	African python						
Rhamphiophis oxyrhynchus	Beaked snake						
Thelothornis kirtlandii	Twig snake						
AVES							
Ardeidae							
Bubulcus ibis	Cattle egret				+	+	
Accipitricidae							
Buteo augularis	Red-tailed buzzard					+	
Milvus migrans	Black kite				+	+	
Neophron monachus	Hooded vulture	+					
Falconidae							
Falco naumanni	Lesser kestrel				+	+	
Phasianidae							
Ptilopachus petrosus	Stone partridge				+		

Charadriidae							
Charadrius hiaticula	Common ringed plover				+		
Haematopus ostralegus	Eurasian oystercatcher				+		
Himantopus himantopus	Black-winged stilt				+		
Jacanidae							
Actophilornis africana	African jacana						
Burhinidae							
Burhinus senegalensis	Senegal thick-knee				+		
Columbidae							
Columba livia	Pigeon				+		
Streptopelia semitorquata	Red-eyed dove				+		
Streptopelia senegalensis	Laughing dove				+		
Turtur afer	Red-billed wood-dove				+		
Musophagidae							
Crinifer piscator	Grey plantain-eater				+		
Tauraco persa	Green-crested touraco				+		
Cuculidae							
Centropus senegalensis	Senegal coucal				+		
Chrysococcyx klaas	Klaas cuckoo				+		
Apodidae							
Apus affinis	Little swift				+		
Cypsilurus parvus	Palm swift						
Alcedinidae							
Ceryle rudis	Pied kingfisher				+		
Bucerotidae							
Tockus nasutus	Grey hornbill				+		
Capitonidae							
Lybius vieilloti	Vieillot's barbet				+		
Pogoniulus subsulphureus	Yellow-fronted tinker bird				+		
Corvidae							
Corvus albus	Pied crow				+		
Estrildidae							
Lonchura cucullata	Bronze mannikin				+		
Hirundinidae							
Hirundo rustica	European swallow				+		
Laniidae							
Laniarius barbarus	Barbary shrike				+		
Muscicapidae							
Cossypha niveicapilla	Snowy-crowned robin-chat				+		
Platysteira cyanea	Scarlet-spectacled wattle-eye				+		
Nectariniidae							
Nectarinia coccinigaster	Splendid sunbird				+		
Ploceidae							
Euplectes orix	Red bishop				+		
Lonchura cucullata	Bronze mannkin				+		
Ploceus cucullatus	Village weaver				+		
Ploceus nigricollis	Spectacled weaver				+		
Tchagra senegala	Black-crowned tchagra				+		
Pycnonotidae							

Chlorocichla simplex	Simple leaf-love				+		
Pycnonotus barbatus	Common garden bulbul				+		
Sturnidae							
Lamprotornis purpureus	Purple glossy starling				+		
Sylviidae							
Camaroptera brachyura	Grey-backed camaroptera				+		
Cisticola natalensis	Striped cisticola				+		
Prinia subflava	West African prinia				+		
Timaliidae							
Turdioides plebejus	Brown babbler						
Turdioides reinwardii	White-capped babbler						
Turdidae							
Luscinia megarhynchos	Nightingale				+		
Turdus pelios	West African thrush				+		
MAMMALIA							
Chiroptera							
Eidolon helvum	Straw-coloured fruit bat			+			
Primates							
Cercopithecus aethiops	Green monkey				+		+
Galagoides demidoff	Demidoff's galago				+		
Rodentia							
Arvicanthis niloticus Rufous	Nile rat						
Cricetomys gambianus	Gambian giant pouched rat				+		
Euxerus erythropus	Unstriped ground squirrel						+
Mastomys erythroleucus	Multimammate mouse				+		
Praomys tullbergi	Soft-furred rat				+		
Rattus rattus	Common rat				+		
Thryonomys swinderianus	Grasscutter				+		+
Lagomorpha							
Lepus zechi	Togo hare						
Carnivora							
Mungos gambianus	Gambian mongoose				+		+
Hyracoidea							
Procavia ruiceps	Rock hyrax						+
Artiodactyla							
Cephalophus maxwelli	Maxwell's duiker				+		+
Neotragus pygmaeus	Royal antelope				+		+
Tragelaphus scriptus	Bushbuck				+		+

(LC- Least Concern; NT- Near Threatened; VU- Vulnerable; EN- Endangered; WCR- Wildlife Conservation Regulation; PP- Partly Protected; CP- Completely Protected; Empty cell- Status not assessed)

A-2: Legend for Conservation Status

A-2.1: IUCN (International Union for the Conservation of Nature)

The IUCN publishes a Threatened Species List *(Red List of Threatened Animals)* which categorizes globally-threatened animals as follows:

- *Vulnerable (VU):* Species believed likely to move to the *EN (Endangered)* category, if the causal factors continue operating, because of rapidly decreasing populations and extensive habitat destruction.
- *Lower Risk (LR):* Taxa which have been evaluated but do not satisfy the criteria for any of the above categories. There are three sub-categories
- *Near Threatened (NT):* Taxa which do not qualify for *Conservation Dependent*, but which are close to qualifying for *Vulnerable*
- *Data Deficient (DD):* A taxon on which there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well-studied, and its biology well-known, but appropriate data on abundance and/or distribution is lacking,

A-2.2: National Criteria (Ghana Wildlife Conservation Regulations)

Ghana's Wildlife Laws (Ghana Wildlife Conservation Regulations, 1971 LI 685, and Ghana Wildlife

Conservation (Amendment) Regulations, 1988 LI 1357) also categorizes animal species into three main Schedules based on the level of protection required for a particular species:

- *Schedule I- Animals Wholly Protected;* species are completely protected (CP); the hunting, capture or destruction of species under this schedule is prohibited at all times.
- *Schedule II- Animals Partly Protected;* species are partially protected (PP); the hunting, capture and destruction of any young animal, or adult accompanied by young, is absolutely prohibited at all times.
- *Schedule III- Animals Protected in Close Season;* species are close season Protected (CSP); the hunting capturing or destruction of species under this schedule is absolutely prohibited between 1st August and 1st December of any season.

Appendix B – Terrestrial Flora Appendices

Table B-1.1: *Flora species recorded within PPS2 and its immediate environment (LC- Least Concern; Empty cell- Status not assessed)*

English Name	Scientific Name	IUCN Status
Indian mallow	*Abutilon depauperatum*	
	Amaranthus spinosus	
Haemorrhage plant	*Aspilia africana*	
Neem tree	*Azadirachta indica*	
Casol bean/ Crown flower	*Calotropis procera*	
Rhodes grass	*Chloris sp*	
Yellow spider flower	*Cleome viscosa*	
Rattleweed	*Crotalaria retusa*	
False daisy	*Eclipta alba*	
Niger plum	*Flacourtia flavascens*	
Speargrass	*Heteropogon contortus*	LC
Mint weed	*Hyptis suaveolens*	
	Indigofera erecta	
Hairy indigo	*Indigofera hirsuta*	
Royal jasmin	*Jasminum grandifolia*	
Biscuit grass	*Paspalum vaginathum*	
Passion flower	*Passiflora foetida*	
	Phyllanthus ananus	
Baloon cherry	*Physalis angulata*	
	Securinega virosa	
Wormbush	*Spigelia anthelmia*	
Catstail dropseed	*Sporobolus pyramidalis*	
	Stachytapheta grandiflora	
Coat buttons	*Tridax procumbense*	
	Vetiveria sp	

Table B-1.2: *Flora species recorded along the pipeline routes and its immediate environments (LC- Least Concern; NT- Near Threatened; Empty cell- Status not assessed)*

English Name	Scientific Name	IUCN Status
Indian mallow	*Abutilon depauperatum*	LC
Neem tree	*Azadirachta indica*	
	Bluemea sp	
Casol bean/ Crown flower	*Calotropis procera*	
Stinking weed	*Cassia occidentalis*	
Rhodes grass	*Chloris sp*	
Christmas bush	*Chromolaena odorata*	

Yellow spider flower	*Cleome viscosa*	
Mouth day flower	*Commelina erecta*	LC
Rushfoil / Croton	*Croton lobata*	
Black myrtle	*Cuba pentandra*	
Acacia Saint	*Dichrostarchys glomerata*	
False daisy	*Eclipta alba*	DD
Mexican fireplant	*Euphoribu heterophylla*	
Donkey berry	*Grewia carpinifolia*	
Speargrass	*Heteropogon contortus*	
Mint weed	*Hyptis suaveolens*	
	Indigofera erecta	
Morning glory	*Ipomea sp*	
Royal jasmin	*Jasminum grandifolia*	
Cotton leaf	*Jatropha gossipifolia*	
Sausage tree	*Kigelia africana*	
Mullumbimby couch	*Kylinga sp*	
Large leaf lantana	*Lantana camara*	
	Letivaria sp	
White leadtree	*Leucaena glauca*	
Egyptian cucumber	*Luffa sp*	
Pigweed	*Marantus spinosus*	
Beechwood bunny	*Passiflora foetida*	
Guinea grass	*Panicum maxima*	
Biscuit grass	*Paspalum vaginathum*	
Baloon cherry	*Physalis angulata*	
Casol bean	*Ricinus sp*	
	Scoparia duicis	
	Securinega virosa	
Goatweed	*Sorghum sp*	
Snakeweed	*Stachytapherta grandifolia*	
Coat buttons	*Tridax procumbense*	
Southern cattail	*Typha domingensis*	LC
Bitterleaf	*Vernonia cineria*	
Toothache tree	*Xanthozylum zanthozyloides*	

END OF REPORT

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Appendix E - Traffic and Transport

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Appendix E1

Traffic Assessment Report

TRAFFIC ASSESSMENT FOR THE GHANA BRIDGE POWER PROJECT

Draft Final Report

June, 2015

ASSOCIATED CONSULTANTS LTD.
CONSULTING ENGINEERS, ARCHITECTS, PLANNERS AND SURVEYORS
P.O. BOX M.259
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Associated Consultants Ltd.

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1. INTRODUCTION

1.1. BACKGROUND

Development of the Emergency (Bridge) Power Project has been requested by the Ministry of Power for Ghana to increase the capacity available to the country and it is to be located on one site within the Volta River Authority (VRA) Tema Thermal Power Complex (TTPC), in Tema, Ghana. The project will utilise Liquefied Petroleum Gas (LPG) sourced via a new pipeline from the Tema Oil Refinery (TOR) Jetty via the TOR and a newly developed tank LPG farm and pipeline into the TTPC site.

As part of the implementation preparation, Messrs Associated Consultants Ltd. have been contracted to conduct a Traffic Assessment along the route from the Tema Port to the Project Site.

1.2. OBJECTIVES OF THE ASSIGNMENT

The main objective of the assignment is to assess the existing traffic condition along the corridor between the Tema Port and the Project Site.

1.3. SCOPE OF WORK

The scope of work comprises:

- Traffic Data Collection
- Analysis of Traffic Data, and
- Assessment of the Existing Traffic Situation

1.3.1. Components of the Data Collection

The main component of the assessment was to collect Road Link volumes, for Motorised traffic and Bicycles.

1.4. STRUCTURE OF REPORT

This report is organized as follows:

- Chapter 1 covers the Introduction, which addresses the Background, Objectives of the Assignment, Scope of work and Structure of report.
- Chapter 2 addresses the Methodology for performing the assignment for both field data collection and the analysis of data.
- Chapter 3 presents the Summary results, analyses and discussions of the results
- Conclusions and Recommendations drawn from the analysis results are presented in Chapter 4.

2. METHODOLOGY

This addresses the Methodology for performing the assignment for both field data collection and the analysis of data. The summaries of results of the analysis are presented under *Chapter 3* of this report.

2.1. SITE RECONNAISSANCE SURVEY

The Consultant undertook site reconnaissance survey of the route from the Tema Port to the Project Site before the start of the data collection. The site visit was to assist the Consultant to obtain first-hand information and appreciation of the route under consideration and also identify the traffic study locations.

2.2. FIELD DATA COLLECTION

The road corridor was divided into four (4) sections or links based on traffic pattern and road configuration. Manual, directional and classified traffic volume counts were conducted for a period of three (3) consecutive days at 15-minute intervals for 12 - 24 hours each day on each section of the road corridor. Details of the study locations are provided in Table 2.1 and also presented in Figure 2.1. The counts started at 6:30am each day.

The categories of traffic counted conformed to the Department of Urban Roads type which comprises the following for Motorised traffic:

(i) Motor Bikes
(ii) Cars
(iii) Taxis
(iv) Pick Ups / 4-WD
(v) Small Buses / Vans
(vi) Medium Buses
(vii) Large Buses
(viii) Mammy Wagons
(ix) Light Trucks
(x) Medium Trucks
(xi) Heavy Trucks
(xii) 3-Axle Semi-Trailers (Light)
(xiii) 4-Axle Semi-Trailers (Heavy)
(xiv) 5- Axle (Truck Trailers)
(xv) > 5-Axles (Extra Large Trucks), and
(xvi) Others

Bicycles constitute the Non-Motorised traffic (NMT) counted.

Table 2.1: Details of Traffic Study Locations

Name of Road	Section	Length (km)	Count Location	Count Duration	Count Date
Harbour Road	Between the Tema Port and Harbour Roundabout (LV 1)	1.0	Near Cocax Impex Ltd	12 hours	Monday, 4th May, 2015
				24 hours	Tuesday, 5th May, 2015
				24 hours	Wednesday, 6th May, 2015
	Between the Harbour Roundabout and Community Four Roundabout (LV 2)	2.0	Near Mankoadze Roundabout	12 hours	Monday, 4th May, 2015
				24 hours	Tuesday, 5th May, 2015
				24 hours	Wednesday, 6th May, 2015
	Between the Community Four Roundabout and Tema Motorway Roundabout (LV 3)	3.9	Near Total Filling Station	12 hours	Thursday, 7th May, 2015
				24 hours	Friday, 8th May, 2015
				24 hours	Saturday, 9th May, 2015
Aflao Road	Between the Tema Motorway Roundabout and Thermal Village Junction (LV 4)	2.3	Near Shell Filling Station	12 hours	Thursday, 7th May, 2015
				24 hours	Friday, 8th May, 2015
				24 hours	Saturday, 9th May, 2015
Total Length (km)		**9.2**			

Figure 2.1: Traffic Study Locations

2.3 ANALYSIS OF DATA

The Consultant employed in-house spreadsheets for data analysis. For the purpose of the study, the following have been computed:

- Average Daily Traffic (ADT)
- Hourly Traffic Distribution
- Peak Hour Volumes and the times they occurred.

2.3.1 Average Daily Traffic (ADT)

The 12-hour volumes were expanded to 24 hours, using average Daily Adjustment Factors (DAF) computed for each type of vehicle from the 24-hour volume count data. Percentage compositions of each vehicle type as well as the vehicle group/class were also computed. These were computed by direction as well the total 2-way.

The following relations were used:

$$V24 = V12 \; x \; DAF, \qquad where: V24 = 24 \; - hour \; volume \; (vpd), \; V12 = 12 - hour \; volume,$$
$$DAF = Daily \; Adjustment \; Factor$$
$$DAF = \; V24/V12 \, , \; ADT \; = Average \; of \; the \; 24 \; - hour \; volumes \; (vpd)$$

2.3.2 Hourly Traffic Distribution

The hourly traffic volumes were determined for the various sections studied by direction and the total 2-way. These were computed by summing up four (4) consecutive 15-minute volumes for both Motorised traffic and Bicycles.

2.3.3 Peak Hour Volumes

The highest hourly flows were determined from the hourly volumes. Peak hour volumes were obtained from the maximum of the total of four (4) consecutive 15-minute volumes for a period of 24 hours for both Motorised traffic and Bicycles. These were also computed by direction and total 2-way.

3. RESULTS AND ANALYSIS

This Chapter presents the summary results of the various studies in the form of tables and charts. It also covers the analyses/discussions of the results.

3.1 AVERAGE DAILY TRAFFIC (ADT)

This section contains the results of the ADT volumes by direction as well as the total two-way traffic for the four road sections. The directional spilt and composition of traffic by vehicle group was also computed by direction and two-way traffic. Figure 3.5 depicts the comparison of ADT by vehicle group.

3.1.1 Link Section 1 (LV1): Between the Tema Port and Harbour Roundabout ≈ 1km

The summaries of the ADT by vehicle type and vehicle groups are presented in Table 3.1.

The results reveal the following traffic characteristics of the road section:

- The total Motorised ADT recorded was 25,211 vpd.
- Directional split is 47%-53% for Motorised traffic and 52%-48% for Bicycles, with the south-bound traffic (towards Tema Port), recording higher percentage for the Motorised traffic.
- Bicycles which totalled 206 vpd, constitute about 0.81% of the total traffic volume
- Heavy goods vehicles constitute 13.9% of the total all traffic volume recording ADT of 3,392 vpd.
- Light vehicles were the most predominant, recording ADT of 20,927 vpd which represents 83% of the total traffic volume.

The percentage composition of the vehicle types by direction is depicted in Figure 3.1.

Table 3.1: Summary of Average Daily Traffic by Vehicle Type and Group

Road Section: LV 1 (Between the Tema Port and the Harbour Roundabout)

VEHICLE TYPE	DIRECTION					
	NORTH BOUND		SOUTH BOUND		TWO - WAY	
	ADT	% of Total	ADT	% of Total	ADT	% of Total
Motor Bikes	519	4.2	485	3.8	1,004	4.0
Cars	2,887	23.4	3,154	24.5	6,040	24.0
Taxis	4,476	36.3	4,219	32.7	8,695	34.5
Pick Ups / 4-WD	1,951	15.8	2,108	16.3	4,058	16.1
Small Buses / Vans	505	4.1	625	4.9	1,130	4.5
Medium Buses	127	1	176	1.4	303	1.2
Large Buses	22	0.2	83	0.6	106	0.4
Mammy Wagons	8	0.1	7	0.1	15	0.1
Light Trucks	226	1.8	243	1.9	469	1.9
Medium Trucks	114	0.9	65	0.5	179	0.7
Heavy Trucks	97	0.8	65	0.5	162	0.6
3-Axle Semi-Trailers (Light)	88	0.7	159	1.2	248	1.0
4-Axle Semi-Trailers (Heavy)	150	1.2	204	1.6	354	1.4
5- Axle (Truck Trailers)	435	3.5	580	4.5	1,015	4.0
> 5-Axles (Extra Large Trucks)	697	5.7	694	5.4	1,392	5.5
Others	20	0.2	23	0.2	43	0.2
TOTAL	**12,320**	**100**	**12,890**	**100**	**25,211**	**100**
VEHICLE GROUP						
Light	10337	83.9	10,590	82.2	20,927	83.0
Medium	382	3.1	509	4	892	3.5
Heavy	1601	13	1,791	13.9	3,392	13.5
TOTAL	12,320	100	12,890	100	25,211	100
Directional split	47.2%		52.8%		100.0%	
BICYCLES						
Bicycles	107	100	99	100	206	100
TOTAL	107	100	99	100	206	100
Directional split	51.9%		48.1%		100.0%	
ALL TRAFFIC						
TOTAL (All Traffic)	12,427		12,989		25,417	
Directional split	48.9%		51.1%		100.0%	

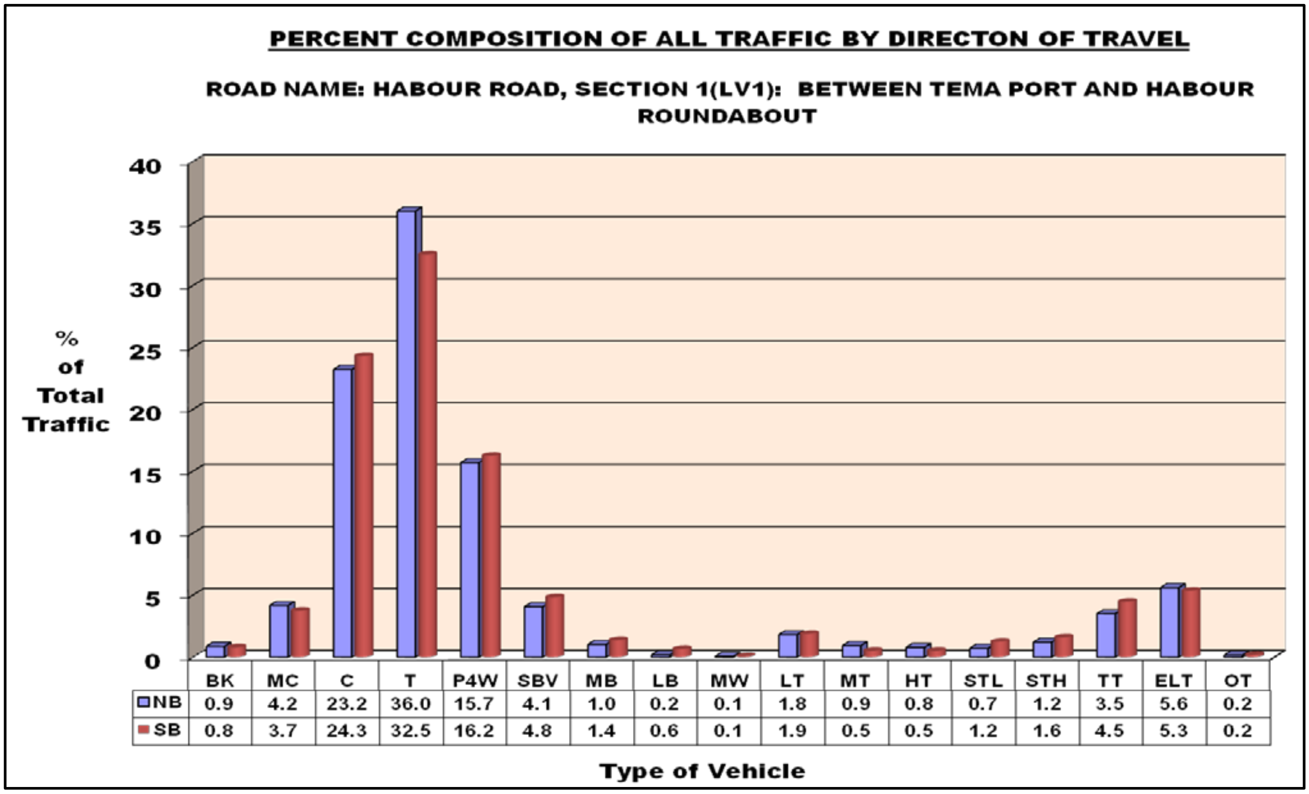

Figure 3.1: Percent composition of all traffic by direction

3.1.2 Link Section 2 (LV2): Between the Harbour Roundabout and Community Four Roundabout ≈ 2km

The summaries of the ADT by vehicle type and vehicle groups are presented in Table 3.2.

The results reveal the following traffic characteristics of the road section:

- The total Motorised ADT recorded was 27,816 vpd.
- Directional split is 44%-56% for Motorised traffic and 56%-44% for Bicycles, with the south-bound, (towards Habour Roundabout), traffic recording a higher percentage for the Motorised traffic.
- Bicycles which totalled 93 constitute about 0.3% of the total traffic volume
- Heavy goods vehicles constitute 10.3% of the total all traffic volume recording ADT of 2,873 vpd. Light vehicles were the most predominant, recording ADT of 23,198 vpd which represents 83.4% of the total traffic volume.

The percentage composition of the vehicle types by direction is depicted in Figure 3. 2.

Table 3.2: Summary of Average Daily Traffic by Vehicle Type and Group

Road Section: LV 2 (Between the Harbour Roundabout - Community four Roundabout)

VEHICLE TYPE	DIRECTION					
	NORTH BOUND		SOUTH BOUND		TWO - WAY	
	ADT	*% of Total*	ADT	*% of Total*	ADT	*% of Total*
Motor Bikes	745	*6.1*	677	*4.4*	1,422	*5.1*
Cars	3,282	*26.7*	3,497	*22.6*	6,779	*24.4*
Taxis	1,749	*14.2*	3,181	*20.5*	4,931	*17.7*
Pick Ups / 4-WD	2,073	*16.8*	2,227	*14.4*	4,299	*15.5*
Small Buses / Vans	2,049	*16.6*	3,718	*24.0*	5,767	*20.7*
Medium Buses	481	*3.9*	262	*1.7*	743	*2.7*
Large Buses	70	*0.6*	107	*0.7*	177	*0.6*
Mammy Wagons	3	*0*	4	*0.0*	7	*0.0*
Light Trucks	432	*3.5*	387	*2.5*	819	*2.9*
Medium Trucks	112	*0.9*	220	*1.4*	332	*1.2*
Heavy Trucks	144	*1.2*	227	*1.5*	371	*1.3*
3-Axle Semi-Trailers (Light)	128	*1*	102	*0.7*	229	*0.8*
4-Axle Semi-Trailers (Heavy)	117	*1*	113	*0.7*	230	*0.8*
5- Axle (Truck Trailers)	358	*2.9*	361	*2.3*	719	*2.6*
> 5-Axles (Extra Large Trucks)	546	*4.4*	405	*2.6*	951	*3.4*
Others	23	*0.2*	18	*0.1*	41	*0.1*
TOTAL	**12,311**	***100***	**15,506**	***100***	**27,816**	***100***
VEHICLE GROUP						
Light	9,898	*80.4*	13,300	*85.8*	23,198	*83.4*
Medium	986	*8*	760	*4.9*	1,746	*6.3*
Heavy	1,427	*11.6*	1,446	*9.3*	2,873	*10.3*
TOTAL	12,311	*100*	15,505	*100*	27,816	*100*
Directional split	44.3%		55.7%		100.0%	
BICYCLES						
Bicycles	52	*100.0*	41	*100.0*	93	*100.0*
TOTAL	52	*100*	41	*100*	93	*100*
Directional split	55.91%		44.09%		100.0%	
ALL TRAFFIC						
TOTAL (All Traffic)	12,363		15,547		27,909	
Directional split	44.30%		55.71%		100%	

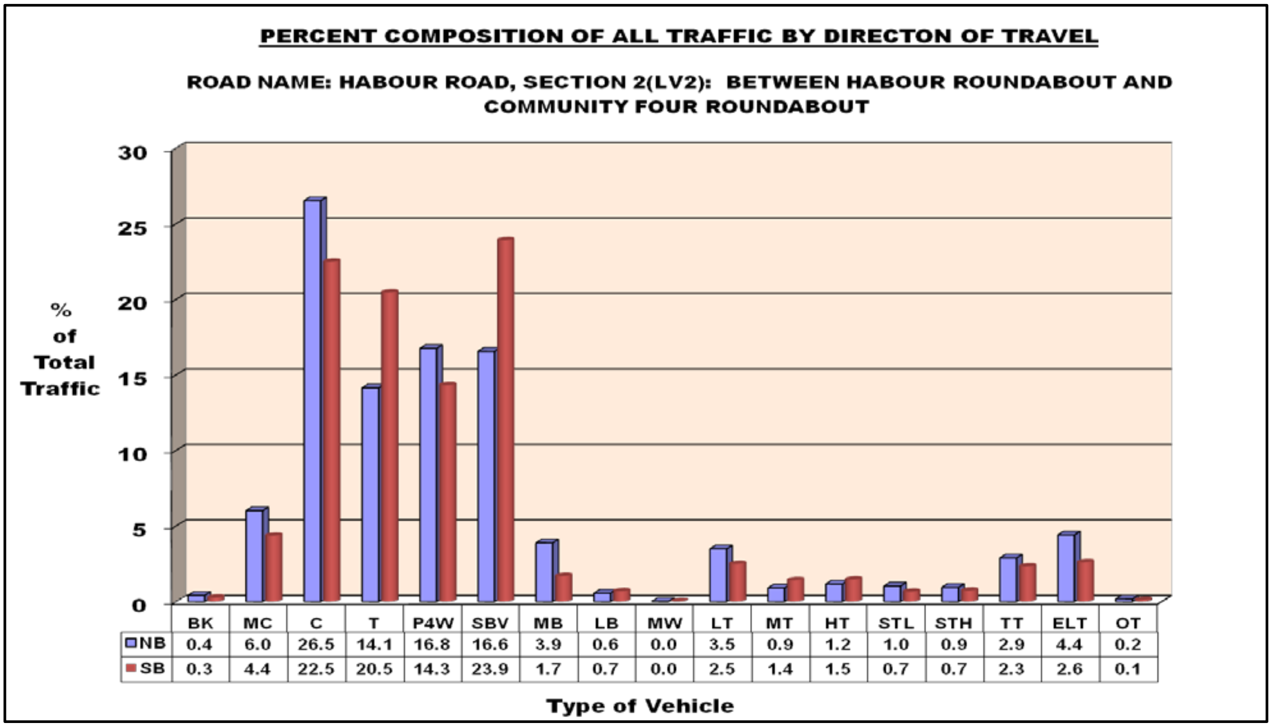

Figure 3.2: Percent composition of all traffic by direction

3.1.3 Link Section 3 (LV3): Between the Community Four Roundabout and Tema Motorway Roundabout ≈ 3.9km

The summaries of the ADT by vehicle type and group are presented in Table 3.3.

The results reveal the following traffic characteristics of the road section:

- The total Motorised ADT recorded was 28,899 vpd.
- Directional split is 43%-57% for Motorised traffic and 73%-27% for Bicycles, with the south-bound, (towards Tema Motorway Roundabout), traffic recording a higher percentage for the Motorised traffic.
- Bicycles which totalled 297 constitute about 1.0% of the total traffic volume
- Heavy goods vehicle constitute 8% of the total all traffic volume recording ADT of 2,303 vpd. Light vehicles were the most predominant, recording ADT of 25,127 vpd which represents 87% of the total all traffic volume.

Table 3.3: Summary of Average Daily Traffic by Vehicle Type and Group

Road Section: LV 3 (Between the Community Four Roundabout - Tema Motorway Roundabout)

VEHICLE TYPE	DIRECTION					
	NORTH BOUND		SOUTH BOUND		TWO - WAY	
	ADT	*% of Total*	ADT	*% of Total*	ADT	*% of Total*
Motor Bikes	846	*6.8*	753.6	*4.6*	1,599	*5.5*
Cars	3,136	*25.4*	4,751	*28.7*	7,888	*27.3*
Taxis	2,085	*16.9*	3,418	*20.7*	5,503	*19.0*
Pick Ups / 4-WD	2,374	*19.2*	2,996	*18.1*	5,370	*18.6*
Small Buses / Vans	2,192	*17.7*	2,575.50	*15.6*	4,768	*16.5*
Medium Buses	215	*1.7*	349.7	*2.1*	565	*2.0*
Large Buses	48	*0.4*	101.2	*0.6*	149	*0.5*
Mammy Wagons	7	*0.1*	14	*0.1*	21	*0.1*
Light Trucks	313	*2.5*	420.4	*2.5*	734	*2.5*
Medium Trucks	147	*1.2*	146.2	*0.9*	293	*1.0*
Heavy Trucks	99	*0.8*	159.8	*1*	259	*0.9*
3-Axle Semi-Trailers (Light)	80	*0.6*	78.7	*0.5*	159	*0.5*
4-Axle Semi-Trailers (Heavy)	98	*0.8*	115.3	*0.7*	214	*0.7*
5- Axle (Truck Trailers)	261	*2.1*	239.8	*1.4*	501	*1.7*
> 5-Axles (Extra Large Trucks)	456	*3.7*	409.3	*2.5*	866	*3.0*
Others	3	*0*	10	*0.1*	13	*0.0*
TOTAL	**12,360**	***100***	**16,539**	***100***	**28,899**	***100***
VEHICLE GROUP						
Light	10,633	*86*	14,495	*87.6*	25,127	*87.0*
Medium	583	*4.7*	885	*5.4*	1,468	*5.1*
Heavy	1,144	*9.3*	1,159	*7*	2,303	*8.0*
TOTAL	12,360	*100*	16,539	*100*	28899	*100*
Directional split	42.8%		57.2%		100%	
BICYCLES						
Bicycles	216	*100*	81	*100*	297	*100.0*
TOTAL	216	*100*	81	*100*	297	*100*
Directional split	72.73%		27.27%		100%	
ALL TRAFFIC						
TOTAL (All Traffic)	12,576		16,620		29,196	
Directional split	43.07%		56.93%		100%	

The percentage composition of the vehicle types by direction is depicted in Figure 3. 3.

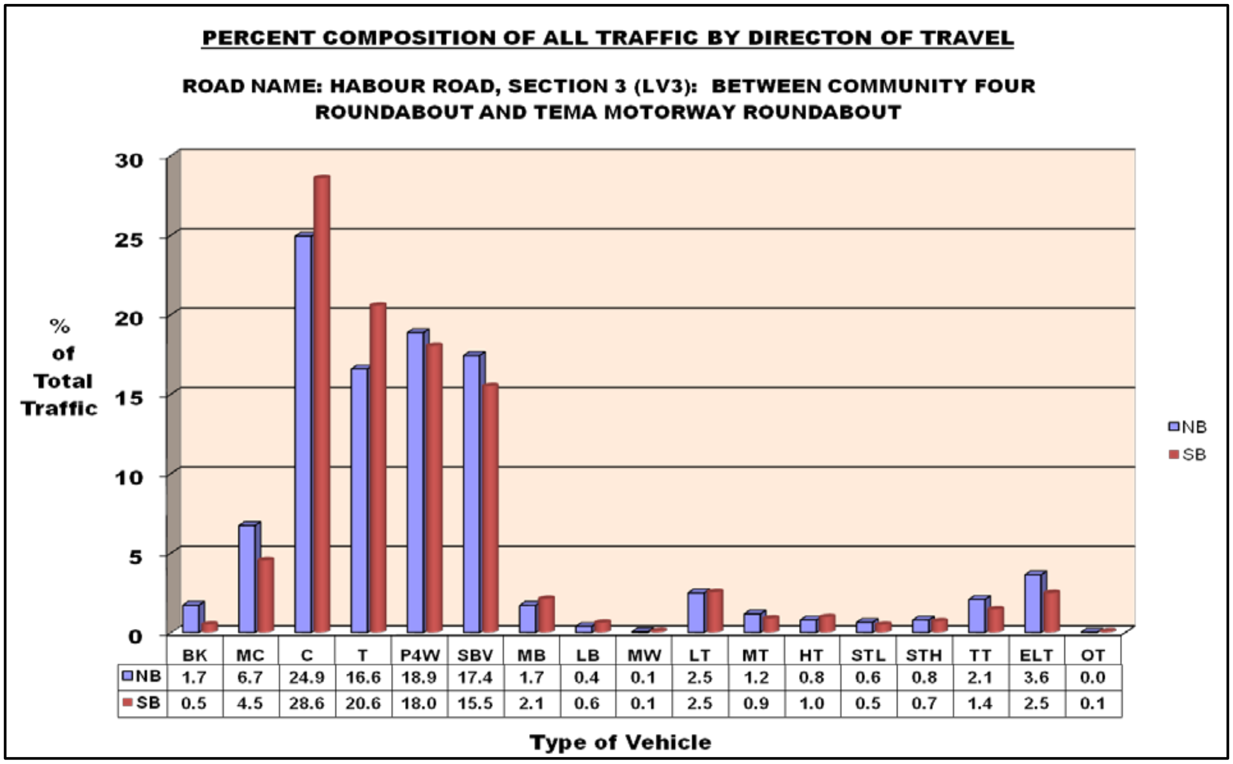

Figure 3.3: Percent composition of all traffic by direction

3.1.4 Link Section 4 (LV4): Between Tema Motorway Roundabout and the Thermal Village Junction ≈ 2.3km

The summaries of the ADT by vehicle type and group are presented in Table 3.4.

The results reveal the following traffic characteristics of the road section:

- The total traffic Motorised ADT recorded was 31,173vpd.
- Directional split is 49%-51% for Motorised traffic and 54%-46% for Bicycles, with the West-bound, (towards Thermal Village Junction), traffic recording a higher percentage for the Motorised traffic.
- Bicycles totalled 168vpd and constitute about 0.58% of the total traffic volume
- Heavy goods vehicle constitute 6.8% of the total all traffic volume recording ADT of 2,135vpd. Light vehicles were the most predominant, recording ADT of 27,279vpd which represents 87.5% of the total all traffic volume.

The percentage composition of the vehicle types by direction is depicted in Figure 3. 4.

Table 3.4: Summary of Average Daily Traffic by Vehicle Type and Group

Road Section: LV 4 (Between the Tema Motorway Roundabout - Thermal Village Junction)

VEHICLE TYPE	DIRECTION					
	EAST BOUND		WEST BOUND		TWO - WAY	
	ADT	*% of Total*	ADT	*% of Total*	ADT	*% of Total*
Motor Bikes	703	*4.6*	639.5	*4.1*	1,342	*4.3*
Cars	4,497	*29.2*	4,278	*27.2*	8,776	*28.2*
Taxis	2,245	*14.6*	1,974	*12.5*	4,220	*13.5*
Pick Ups / 4-WD	3,470	*22.5*	3,729	*23.7*	7,199	*23.1*
Small Buses / Vans	2,565	*16.6*	3,176.70	*20.2*	5,742	*18.4*
Medium Buses	380	*2.5*	201	*1.3*	581	*1.9*
Large Buses	123	*0.8*	86.4	*0.5*	210	*0.7*
Mammy Wagons	7	*0*	3.3	*0*	11	*0.0*
Light Trucks	442	*2.9*	516.8	*3.3*	959	*3.1*
Medium Trucks	162	*1.1*	236.2	*1.5*	399	*1.3*
Heavy Trucks	222	*1.4*	224.9	*1.4*	447	*1.4*
3-Axle Semi-Trailers (Light)	65	*0.4*	60.2	*0.4*	126	*0.4*
4-Axle Semi-Trailers (Heavy)	84	*0.5*	75.9	*0.5*	160	*0.5*
5- Axle (Truck Trailers)	136	*0.9*	148.8	*0.9*	285	*0.9*
> 5-Axles (Extra Large Trucks)	303	*2*	361.5	*2.3*	664	*2.1*
Others	18	*0.1*	37	*0.2*	55	*0.2*
TOTAL	**15,423**	***100***	**15,750**	***100***	**31,173**	***100***
VEHICLE GROUP						
Light	13,480	*87.4*	13,798.10	*87.6*	27,279	*87.5*
Medium	952	*6.2*	807.5	*5.1*	1,760	*5.6*
Heavy	990	*6.4*	1,144	*7.3*	2,135	*6.8*
TOTAL	15,423	*100*	15,750	*100*	31,173	*100*
Directional split	49.5%		50.5%		100%	
BICYCLES						
Bicycles	90	*100*	79	*100*	169	*100.0*
TOTAL	90	*100*	79	*100*	169	*100*
Directional split	53.3%		46.7%		100%	
ALL TRAFFIC						
TOTAL (All Traffic)	15,513		15,829		31,342	
Directional split	49.5%		50.5%		100%	

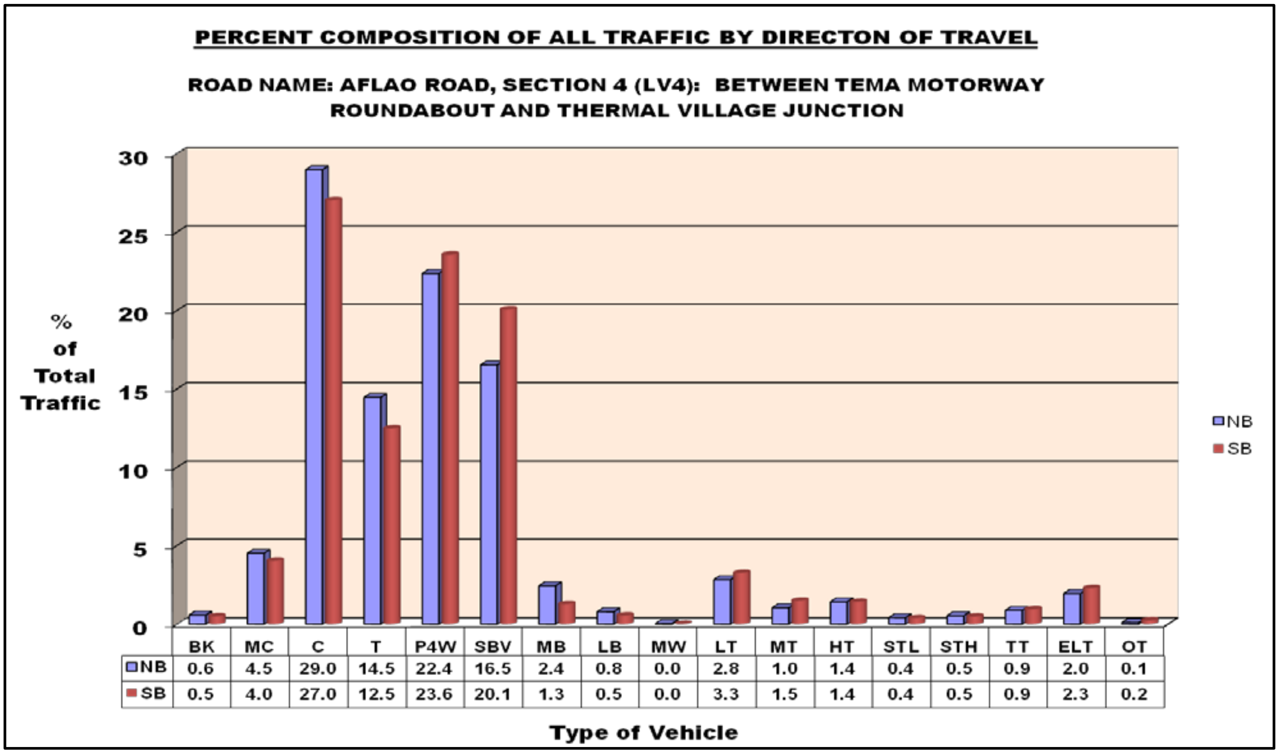

Figure 3.4: Percent composition of all traffic by direction

A comparison of the total ADT along the four sections of the route by vehicle category is presented in Table 3.5 and illustrated in Figure 3.5. The results reveal that:

- Vehicles in the light category made up the highest proportion of vehicles on each road section with the maximum being recorded on Section 4.
- Section 1 recorded the highest proportion of heavy goods vehicles of 3,392 vpd while Section 4 recorded the least proportion of 2,135 vpd
- The highest proportion of Bicycles was recorded on Section 3 totalling 297 vpd while the least was recorded on Section 2 totalling 93 vpd.

The percentage composition of the vehicle categories by road section is depicted in Figure 3. 6.

Table 3.5: Comparison of Average Daily Traffic Volume by Vehicle category

Road Section	Motorised	Bicycles	Total (All Traffic)		
	ADT (vpd)	ADT (vpd)	ADT(vpd)	% Motorised	% Bicycles
Section 1 (LV1)	25,211	206.0	25,417	99.2	0.8
Section 2 (LV2)	27,816	93.0	27,909	99.7	0.3
Section 3 (LV3)	28,899	297	29,196	99.0	1.0
Section 4 (LV4)	31,173	169	31,342	99.5	0.5

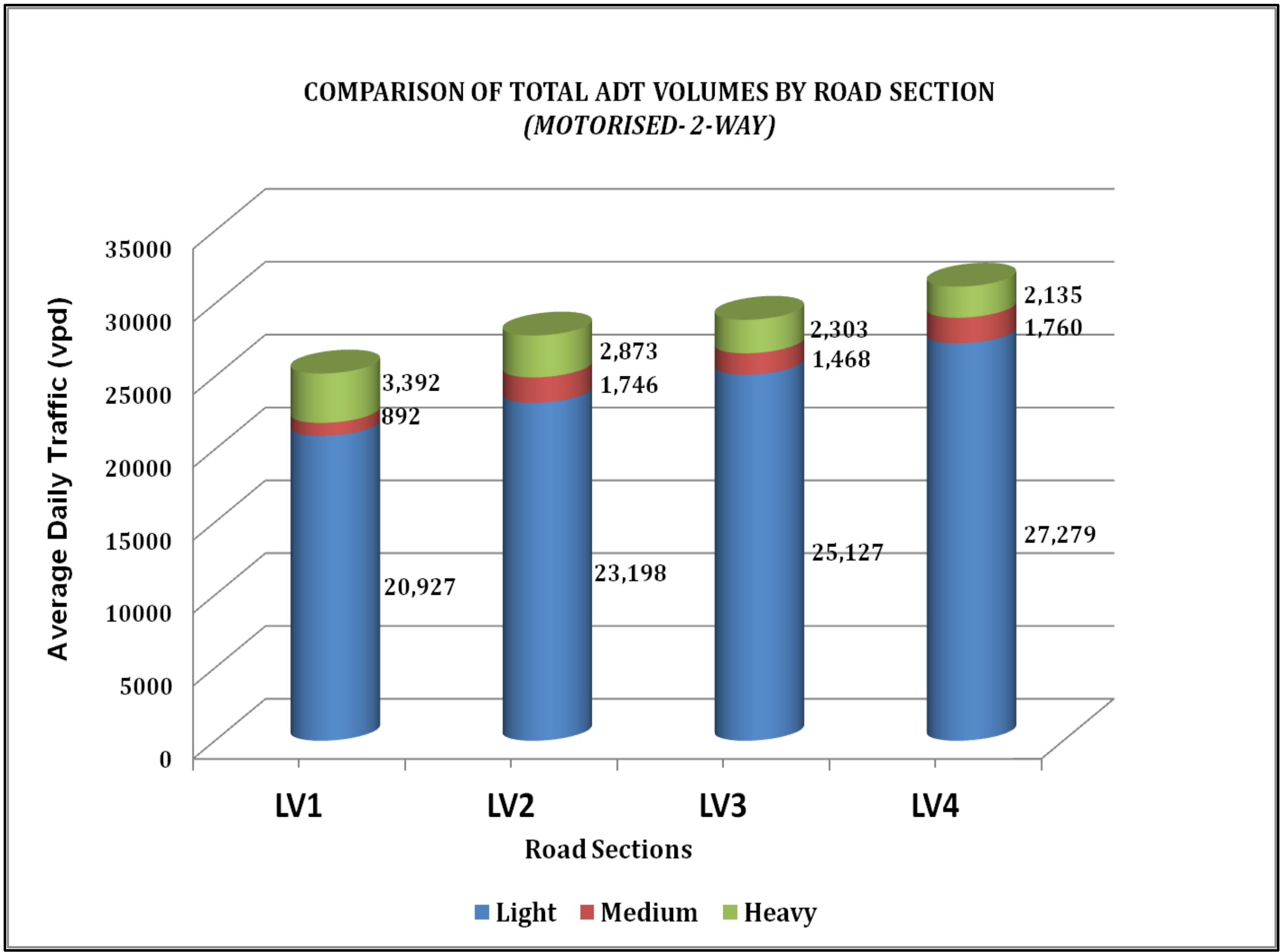

Figure 3.5: Comparison of Average Daily Traffic (ADT) Volumes by Road Section (Motorised)

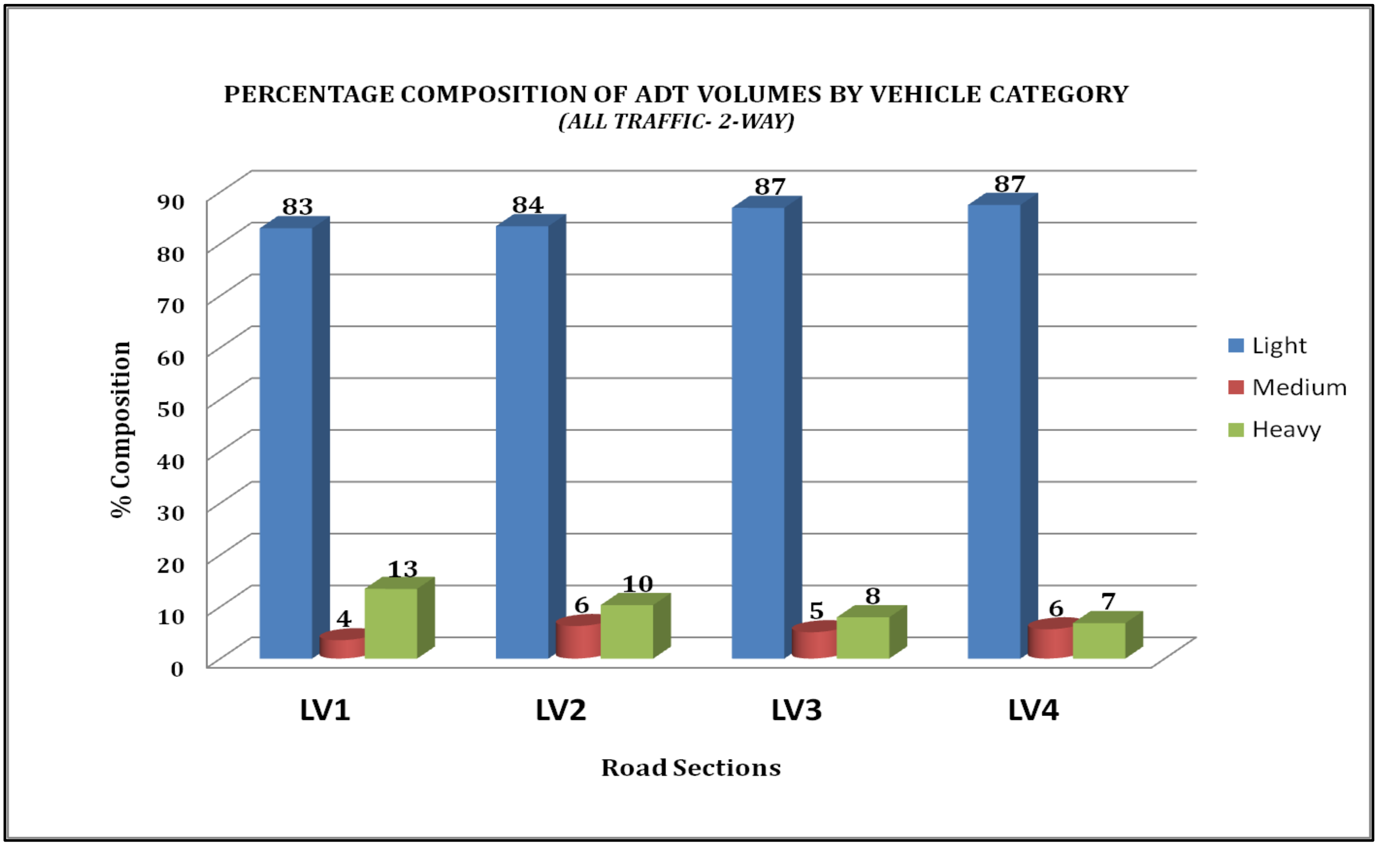

Figure 3.6: Comparison of Percentage composition of ADT Volumes by Vehicle Category

3. 2. HOURLY TRAFFIC DISTRIBUTION

The hourly traffic distribution covers the average day variation by road section as well as by direction of travel. Figure 3.14 depicts the hourly variation by road section.

3.2.1 Link Section 1 (LV1): Between Tema Port and the Harbour Roundabout ≈ 1km

Table 3.6 gives the summary of hourly variation of traffic for motorised traffic and bicycles. Figure 3.6 and 3.7 shows the hourly variation by direction and total variation in a day.

Table 3.6: Summary of Average Hourly Distribution by direction

Road Section: LV 1 (Between the Tema Port and the Harbour Roundabout)

TIME		DIRECTION											
		NORTH BOUND				SOUTH BOUND				TWO - WAY			
		MOTORISED		BICYCLES		MOTORISED		BICYCLES		MOTORISED		BICYCLES	
FROM	TO	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*
6:30 AM	7:30 AM	675	*1.5*	12	*3.1*	835	*1.8*	16	*4.7*	1510	*1.6*	28	*3.8*
6:45 AM	7:45 AM	706	*1.6*	12	*3.1*	892	*1.9*	14	*4.2*	1598	*1.7*	26	*3.6*
7:00 AM	8:00 AM	716	*1.6*	10	*2.6*	927	*2.0*	13	*3.8*	1643	*1.8*	23	*3.1*
7:15 AM	8:15 AM	729	*1.6*	9	*2.3*	967	*2.1*	9	*2.6*	1695	*1.8*	18	*2.4*
7:30 AM	8:30 AM	774	*1.7*	7	*1.7*	1026	*2.2*	7	*2.1*	1800	*2.0*	14	*1.9*
7:45 AM	8:45 AM	787	*1.7*	6	*1.6*	985	*2.1*	5	*1.6*	1772	*1.9*	11	*1.6*
8:00 AM	9:00 AM	841	*1.8*	6	*1.6*	978	*2.1*	3	*1.0*	1819	*2.0*	9	*1.3*
8:15 AM	9:15 AM	864	*1.9*	9	*2.4*	925	*2.0*	3	*0.9*	1789	*1.9*	12	*1.7*
8:30 AM	9:30 AM	887	*1.9*	9	*2.4*	865	*1.9*	3	*0.9*	1753	*1.9*	12	*1.7*
8:45 AM	9:45 AM	896	*2.0*	11	*2.8*	910	*1.9*	3	*0.8*	1806	*2.0*	13	*1.8*
9:00 AM	10:00 AM	878	*1.9*	10	*2.7*	898	*1.9*	4	*1.3*	1776	*1.9*	15	*2.0*
9:15 AM	10:15 AM	861	*1.9*	7	*1.9*	892	*1.9*	5	*1.4*	1753	*1.9*	12	*1.7*
9:30 AM	10:30 AM	846	*1.9*	8	*2.0*	882	*1.9*	4	*1.3*	1728	*1.9*	12	*1.7*
9:45 AM	10:45 AM	833	*1.8*	6	*1.6*	857	*1.8*	6	*1.7*	1689	*1.8*	12	*1.7*
10:00 AM	11:00 AM	817	*1.8*	8	*2.2*	864	*1.8*	4	*1.2*	1681	*1.8*	12	*1.7*
10:15 AM	11:15 AM	816	*1.8*	8	*2.1*	869	*1.9*	5	*1.4*	1685	*1.8*	13	*1.8*
10:30 AM	11:30 AM	796	*1.7*	8	*2.1*	882	*1.9*	5	*1.4*	1677	*1.8*	13	*1.8*
10:45 AM	11:45 AM	807	*1.8*	6	*1.6*	870	*1.9*	3	*1.0*	1677	*1.8*	10	*1.3*
11:00 AM	12:00 PM	818	*1.8*	5	*1.2*	842	*1.8*	3	*1.0*	1660	*1.8*	8	*1.1*
11:15 AM	12:15 PM	847	*1.9*	7	*1.9*	835	*1.8*	3	*0.8*	1682	*1.8*	10	*1.4*
11:30 AM	12:30 PM	861	*1.9*	7	*1.7*	803	*1.7*	2	*0.7*	1663	*1.8*	9	*1.2*
11:45 AM	12:45 PM	871	*1.9*	8	*2.1*	821	*1.8*	3	*0.9*	1692	*1.8*	11	*1.5*
12:00 PM	1:00 PM	861	*1.9*	10	*2.6*	837	*1.8*	5	*1.6*	1698	*1.8*	15	*2.1*
12:15 PM	1:15 PM	844	*1.9*	10	*2.5*	840	*1.8*	6	*1.7*	1684	*1.8*	15	*2.1*
12:30 PM	1:30 PM	835	*1.8*	8	*2.2*	891	*1.9*	7	*2.1*	1726	*1.9*	15	*2.1*
12:45 PM	1:45 PM	824	*1.8*	9	*2.3*	882	*1.9*	6	*1.8*	1706	*1.8*	15	*2.1*
1:00 PM	2:00 PM	807	*1.8*	6	*1.6*	874	*1.9*	4	*1.2*	1681	*1.8*	10	*1.4*
1:15 PM	2:15 PM	811	*1.8*	7	*1.7*	884	*1.9*	4	*1.2*	1695	*1.8*	11	*1.5*
1:30 PM	2:30 PM	835	*1.8*	8	*2.0*	859	*1.8*	3	*0.8*	1694	*1.8*	10	*1.4*
1:45 PM	2:45 PM	841	*1.8*	6	*1.6*	878	*1.9*	4	*1.1*	1719	*1.9*	10	*1.3*
2:00 PM	3:00 PM	888	*1.9*	8	*2.2*	884	*1.9*	4	*1.1*	1772	*1.9*	12	*1.7*
2:15 PM	3:15 PM	875	*1.9*	6	*1.5*	867	*1.9*	3	*1.0*	1742	*1.9*	9	*1.2*
2:30 PM	3:30 PM	886	*1.9*	4	*1.1*	889	*1.9*	6	*1.8*	1775	*1.9*	10	*1.4*
2:45 PM	3:45 PM	834	*1.8*	4	*1.0*	893	*1.9*	6	*1.8*	1728	*1.9*	10	*1.3*
3:00 PM	4:00 PM	809	*1.8*	2	*0.6*	897	*1.9*	7	*2.1*	1706	*1.8*	9	*1.3*
3:15 PM	4:15 PM	805	*1.8*	3	*0.9*	1038	*2.2*	8	*2.4*	1843	*2.0*	11	*1.6*
3:30 PM	4:30 PM	799	*1.8*	4	*1.1*	1010	*2.2*	6	*1.7*	1810	*2.0*	10	*1.4*
3:45 PM	4:45 PM	873	1.9	5	*1.4*	962	*2.1*	7	*2.0*	1834	*2.0*	12	*1.7*
4:00 PM	5:00 PM	880	1.9	5	*1.3*	973	*2.1*	8	*2.3*	1852	*2.0*	13	*1.8*
4:15 PM	5:15 PM	968	2.1	4	*1.0*	812	*1.7*	10	*2.9*	1780	*1.9*	14	*1.9*
4:30 PM	5:30 PM	1,001	2.2	4	*1.1*	793	*1.7*	10	*3.1*	1794	*1.9*	15	*2.0*
4:45 PM	5:45 PM	1,016	2.2	6	*1.6*	792	*1.7*	11	*3.4*	1808	*2.0*	18	*2.4*
5:00 PM	6:00 PM	982	2.2	9	*2.3*	749	*1.6*	13	*3.9*	1731	*1.9*	22	*3.0*
5:15 PM	6:15 PM	894	2.0	10	*2.7*	725	*1.6*	12	*3.5*	1619	*1.8*	22	*3.0*
5:30 PM	6:30 PM	827	1.8	10	*2.7*	703	*1.5*	13	*3.9*	1529	*1.7*	23	*3.2*
5:45 PM	6:45 PM	698	1.5	9	*2.4*	616	*1.3*	10	*3.0*	1315	*1.4*	19	*2.7*

TIME		DIRECTION											
		NORTH BOUND				SOUT BOUND				TWO - WAY			
		MOTORISED		BICYCLES		MOTORISED		BICYCLES		MOTORISED		BICYCLES	
FROM	TO	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*
6:00 PM	7:00 PM	629	*1.4*	7	*1.9*	521	*1.1*	7	*2.0*	1150	*1.2*	14	*1.9*
6:15 PM	7:15 PM	538	*1.2*	5	*1.3*	446	*1.0*	5	*1.4*	984	*1.1*	10	*1.3*
6:30 PM	7:30 PM	573	*1.3*	4	*0.9*	361	*0.8*	3	*0.8*	934	*1.0*	6	*0.9*
6:45 PM	7:45 PM	563	*1.2*	2	*0.6*	341	*0.7*	3	*0.8*	904	*1.0*	5	*0.7*
7:00 PM	8:00 PM	536	*1.2*	1	*0.3*	319	*0.7*	2	*0.6*	854	*0.9*	3	*0.5*
7:15 PM	8:15 PM	491	*1.1*	2	*0.4*	272	*0.6*	1	*0.4*	764	*0.8*	3	*0.4*
7:30 PM	8:30 PM	336	*0.7*	2	*0.6*	252	*0.5*	1	*0.2*	587	*0.6*	3	*0.4*
7:45 PM	8:45 PM	292	*0.6*	2	*0.4*	217	*0.5*	0	*0.0*	508	*0.6*	2	*0.2*
8:00 PM	9:00 PM	250	*0.5*	1	*0.3*	180	*0.4*	0	*0.0*	430	*0.5*	1	*0.1*
8:15 PM	9:15 PM	226	*0.5*	1	*0.2*	162	*0.3*	0	*0.0*	389	*0.4*	1	*0.1*
8:30 PM	9:30 PM	201	*0.4*	0	*0.1*	140	*0.3*	0	*0.0*	341	*0.4*	0	*0.0*
8:45 PM	9:45 PM	171	*0.4*	1	*0.2*	155	*0.3*	1	*0.2*	327	*0.4*	1	*0.2*
9:00 PM	10:00 PM	162	*0.4*	1	*0.3*	156	*0.3*	1	*0.2*	319	*0.3*	2	*0.2*
9:15 PM	10:15 PM	149	*0.3*	1	*0.3*	164	*0.4*	1	*0.2*	314	*0.3*	2	*0.2*
9:30 PM	10:30 PM	131	*0.3*	1	*0.3*	165	*0.4*	1	*0.2*	297	*0.3*	2	*0.2*
9:45 PM	10:45 PM	119	*0.3*	1	*0.3*	144	*0.3*	0	*0.0*	263	*0.3*	1	*0.2*
10:00 PM	11:00 PM	95	*0.2*	1	*0.3*	135	*0.3*	0	*0.0*	230	*0.2*	1	*0.1*
10:15 PM	11:15 PM	83	*0.2*	1	*0.3*	128	*0.3*	0	*0.0*	211	*0.2*	1	*0.2*
10:30 PM	11:30 PM	70	*0.2*	1	*0.3*	102	*0.2*	0	*0.0*	172	*0.2*	1	*0.1*
10:45 PM	11:45 PM	58	*0.1*	0	*0.1*	82	*0.2*	0	*0.0*	140	*0.2*	0	*0.0*
11:00 PM	12:00 AM	47	*0.1*	0	*0.1*	67	*0.1*	0	*0.0*	114	*0.1*	0	*0.0*
11:15 PM	12:15 AM	32	*0.1*	0	*0.0*	46	*0.1*	0	*0.0*	78	*0.1*	0	*0.0*
11:30 PM	12:30 AM	26	*0.1*	0	*0.0*	44	*0.1*	0	*0.0*	70	*0.1*	0	*0.0*
11:45 PM	12:45 AM	26	*0.1*	0	*0.0*	37	*0.1*	0	*0.0*	63	*0.1*	0	*0.0*
12:00 AM	1:00 AM	30	*0.1*	0	*0.0*	32	*0.1*	0	*0.0*	62	*0.1*	0	*0.0*
12:15 AM	1:15 AM	36	*0.1*	0	*0.0*	35	*0.1*	0	*0.0*	71	*0.1*	0	*0.0*
12:30 AM	1:30 AM	35	*0.1*	0	*0.0*	41	*0.1*	0	*0.0*	75	*0.1*	0	*0.0*
12:45 AM	1:45 AM	32	*0.1*	0	*0.0*	43	*0.1*	0	*0.0*	75	*0.1*	0	*0.0*
1:00 AM	2:00 AM	30	*0.1*	0	*0.0*	48	*0.1*	0	*0.0*	77	*0.1*	0	*0.0*
1:15 AM	2:15 AM	23	*0.0*	0	*0.0*	42	*0.1*	0	*0.0*	65	*0.1*	0	*0.0*
1:30 AM	2:30 AM	22	*0.0*	0	*0.0*	37	*0.1*	0	*0.0*	59	*0.1*	0	*0.0*
1:45 AM	2:45 AM	19	*0.0*	0	*0.0*	33	*0.1*	0	*0.0*	52	*0.1*	0	*0.0*
2:00 AM	3:00 AM	17	*0.0*	0	*0.0*	29	*0.1*	0	*0.0*	46	*0.1*	0	*0.0*
2:15 AM	3:15 AM	18	*0.0*	0	*0.0*	31	*0.1*	0	*0.0*	49	*0.1*	0	*0.0*
2:30 AM	3:30 AM	18	*0.0*	0	*0.0*	35	*0.1*	0	*0.0*	53	*0.1*	0	*0.0*
2:45 AM	3:45 AM	22	*0.0*	0	*0.0*	38	*0.1*	0	*0.0*	60	*0.1*	0	*0.0*
3:00 AM	4:00 AM	28	*0.1*	0	*0.0*	44	*0.1*	0	*0.0*	72	*0.1*	0	*0.0*
3:15 AM	4:15 AM	32	*0.1*	1	*0.2*	47	*0.1*	0	*0.0*	79	*0.1*	1	*0.1*
3:30 AM	4:30 AM	45	*0.1*	1	*0.3*	51	*0.1*	0	*0.0*	96	*0.1*	1	*0.1*
3:45 AM	4:45 AM	55	*0.1*	1	*0.3*	62	*0.1*	0	*0.0*	117	*0.1*	1	*0.1*
4:00 AM	5:00 AM	61	*0.1*	1	*0.3*	73	*0.2*	0	*0.1*	134	*0.1*	1	*0.2*
4:15 AM	5:15 AM	82	*0.2*	0	*0.1*	91	*0.2*	1	*0.3*	173	*0.2*	1	*0.2*
4:30 AM	5:30 AM	110	*0.2*	1	*0.3*	133	*0.3*	2	*0.5*	242	*0.3*	3	*0.4*
4:45 AM	5:45 AM	104	*0.2*	2	*0.4*	164	*0.4*	2	*0.7*	268	*0.3*	4	*0.6*
5:00 AM	6:00 AM	108	*0.2*	2	*0.4*	223	*0.5*	3	*0.9*	331	*0.4*	5	*0.6*
5:15 AM	6:15 AM	100	*0.2*	2	*0.4*	273	*0.6*	5	*1.5*	373	*0.4*	7	*0.9*
5:30 AM	6:30 AM	82	*0.2*	0	*0.1*	308	*0.7*	5	*1.6*	391	*0.4*	6	*0.8*
Maximum Values		*1,016*	*2*	*12*	*3*	*1,038*	*2.1*	*16*	*4.7*	*1,852*	*2*	*28*	*3.8*
Minimum Values		*17*	*0*	*0*	*0*	*29*	*0*	*0*	*0*	*46*	*0*	*0*	*0*

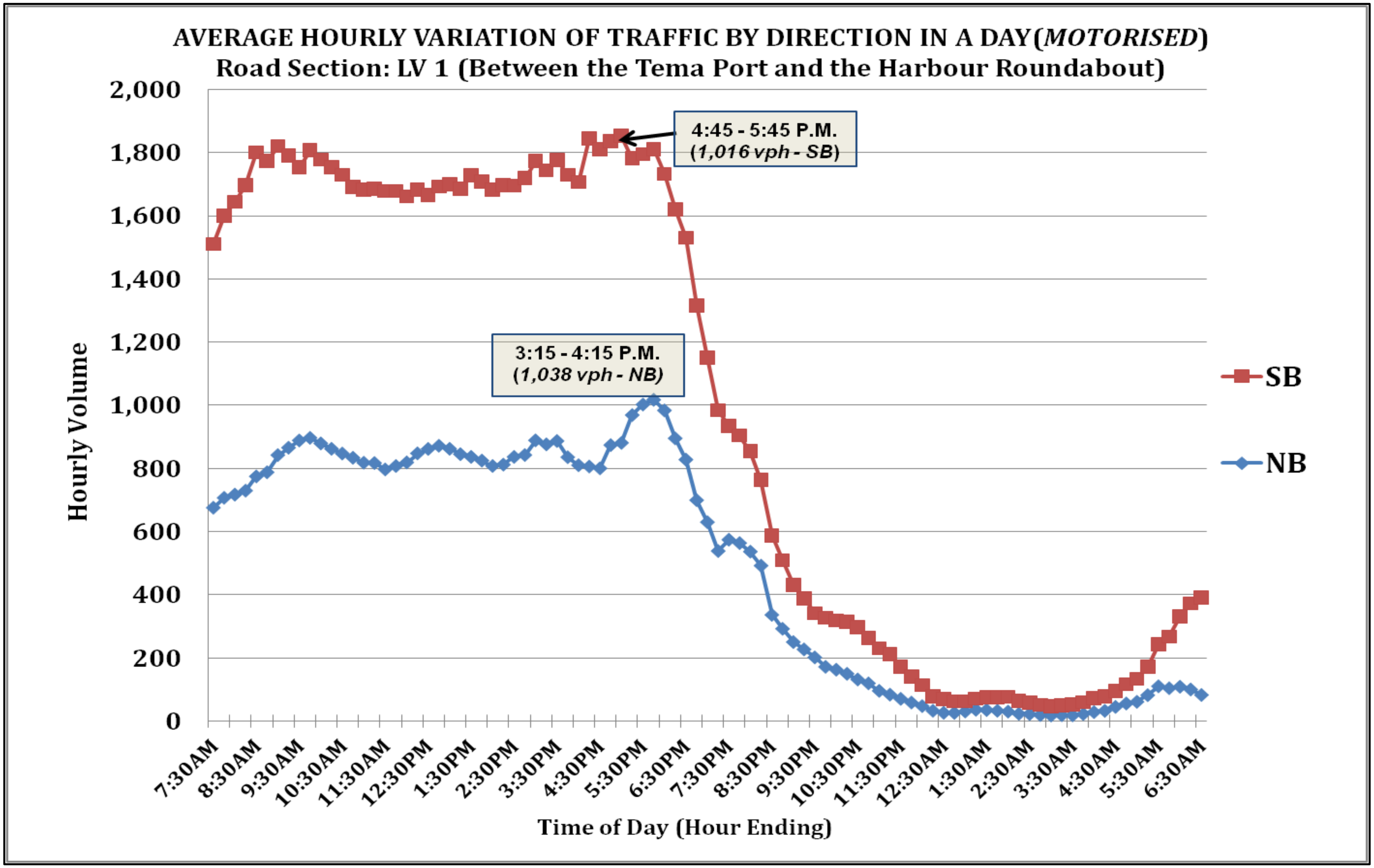

Figure 3.6: Average Hourly Traffic Variation by Direction for Motorised Traffic

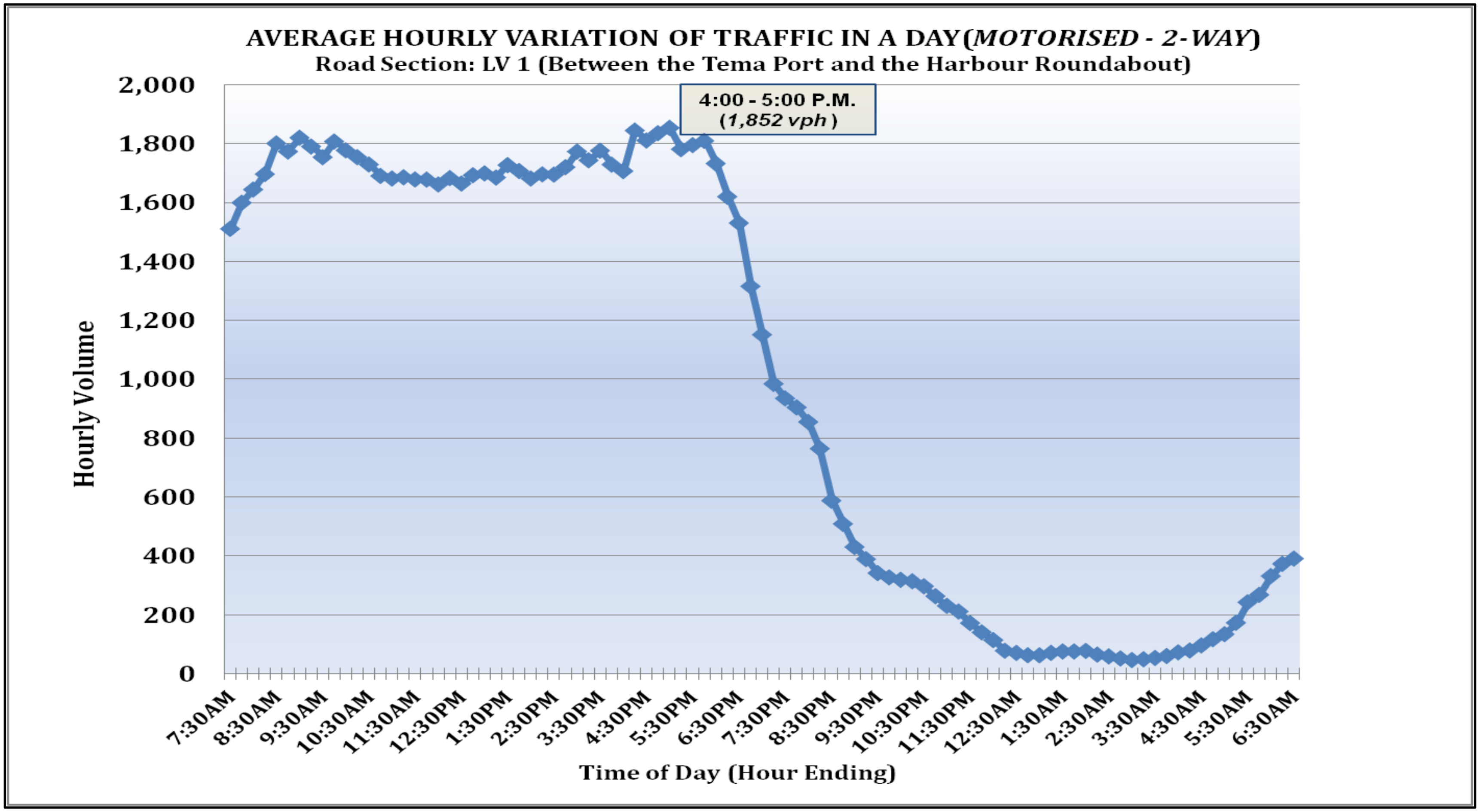

Figure 3.7: Average Hourly Traffic Variation in a Day (Motorised)

3.2.2 Link Section 2 (LV2): Road section between the Harbour Roundabout - Community Four Roundabout ≈ 2km

Table 3.7 gives the summary of hourly variation of traffic for motorised and bicycles. Figure 3.8 and 3.9 shows the hourly variation by direction and total variation in a day.

Table 3.7: Summary of Average Hourly Distribution by direction for Motorised Traffic

Road Section: LV 2 (Between the Harbour Roundabout - Community Four Roundabout)

TIME		DIRECTION											
		NORTH BOUND				SOUTH BOUND				TWO - WAY			
		MOTORISED		BICYCLES		MOTORISED		BICYCLES		MOTORISED		BICYCLES	
FROM	TO	Total Volume	% of Total	Total Volume	% of Total	Total Volume	% of Total	Total Volume	% of Total	Total Volume	% of Total	Total Volume	% of Total
6:30 AM	7:30 AM	612	1.4	4	2.0	1,189	2.2	3	2.3	1801	1.8	7	2.1
6:45 AM	7:45 AM	660	1.5	3	1.6	1,318	2.4	6	4.1	1978	2.0	9	2.7
7:00 AM	8:00 AM	703	1.6	3	1.6	1,474	2.7	5	3.4	2177	2.2	8	2.4
7:15 AM	8:15 AM	729	1.7	2	1.2	1,577	2.9	4	2.5	2306	2.3	6	1.8
7:30 AM	8:30 AM	758	1.7	2	1.1	1,591	2.9	3	2.3	2349	2.4	5	1.6
7:45 AM	8:45 AM	772	1.8	2	1.1	1,503	2.7	1	0.7	2275	2.3	3	0.9
8:00 AM	9:00 AM	782	1.8	1	0.7	1,407	2.6	1	0.5	2189	2.2	2	0.6
8:15 AM	9:15 AM	788	1.8	1	0.7	1,290	2.3	2	1.1	2079	2.1	3	0.9
8:30 AM	9:30 AM	776	1.8	2	0.9	1,211	2.2	2	1.1	1987	2.0	3	1.0
8:45 AM	9:45 AM	1,071	2.4	3	1.6	1,170	2.1	2	1.1	2240	2.3	5	1.4
9:00 AM	10:00 AM	1,052	2.4	3	1.8	1,134	2.1	3	1.8	2187	2.2	6	1.8
9:15 AM	10:15 AM	1,046	2.4	3	1.6	1,097	2.0	2	1.4	2143	2.2	5	1.5
9:30 AM	10:30 AM	1,055	2.4	2	1.2	1,063	1.9	3	1.8	2118	2.1	5	1.5
9:45 AM	10:45 AM	756	1.7	2	1.2	1,076	2.0	3	2.3	1832	1.9	6	1.7
10:00 AM	11:00 AM	786	1.8	4	2.1	1,075	2.0	2	1.6	1861	1.9	6	1.9
10:15 AM	11:15 AM	811	1.9	4	2.1	1,050	1.9	3	2.0	1860	1.9	7	2.1
10:30 AM	11:30 AM	815	1.9	4	2.3	1,057	1.9	3	2.3	1872	1.9	8	2.3
10:45 AM	11:45 AM	820	1.9	4	2.0	1,011	1.8	3	1.8	1831	1.9	6	1.9
11:00 AM	12:00 PM	822	1.9	2	1.2	991	1.8	2	1.6	1813	1.8	5	1.4
11:15 AM	12:15 PM	802	1.8	3	1.4	1,014	1.8	2	1.1	1816	1.8	4	1.3
11:30 AM	12:30 PM	787	1.8	3	1.8	964	1.8	1	0.9	1751	1.8	5	1.4
11:45 AM	12:45 PM	771	1.8	4	2.0	944	1.7	1	0.9	1715	1.7	5	1.5
12:00 PM	1:00 PM	753	1.7	4	2.3	935	1.7	2	1.4	1688	1.7	6	1.9
12:15 PM	1:15 PM	772	1.8	4	2.3	901	1.6	2	1.6	1673	1.7	7	2.0
12:30 PM	1:30 PM	758	1.7	4	2.0	950	1.7	2	1.6	1708	1.7	6	1.8
12:45 PM	1:45 PM	779	1.8	3	1.8	1,010	1.8	3	1.8	1789	1.8	6	1.8
1:00 PM	2:00 PM	790	1.8	3	1.6	980	1.8	3	1.8	1770	1.8	6	1.7
1:15 PM	2:15 PM	802	1.8	3	1.4	1,012	1.8	3	1.8	1813	1.8	5	1.6
1:30 PM	2:30 PM	835	1.9	3	1.4	951	1.7	2	1.6	1786	1.8	5	1.5
1:45 PM	2:45 PM	831	1.9	2	1.2	890	1.6	2	1.1	1720	1.7	4	1.2
2:00 PM	3:00 PM	825	1.9	2	1.1	908	1.7	2	1.1	1733	1.8	4	1.1
2:15 PM	3:15 PM	807	1.8	2	1.1	820	1.5	2	1.1	1627	1.6	4	1.1
2:30 PM	3:30 PM	793	1.8	2	0.9	840	1.5	2	1.4	1633	1.7	4	1.1
2:45 PM	3:45 PM	758	1.7	2	0.9	847	1.5	3	1.8	1605	1.6	4	1.3
3:00 PM	4:00 PM	753	1.7	1	0.7	850	1.5	2	1.4	1602	1.6	3	1.0
3:15 PM	4:15 PM	722	1.6	2	0.9	863	1.6	2	1.4	1585	1.6	4	1.1
3:30 PM	4:30 PM	724	1.7	2	0.9	853	1.6	2	1.6	1577	1.6	4	1.2
3:45 PM	4:45 PM	733	1.7	2	1.2	856	1.6	4	2.5	1589	1.6	6	1.8
4:00 PM	5:00 PM	727	1.7	3	1.6	837	1.5	6	3.8	1564	1.6	9	2.6
4:15 PM	5:15 PM	767	1.8	5	2.8	847	1.5	6	4.3	1614	1.6	12	3.5
4:30 PM	5:30 PM	769	1.8	9	4.6	838	1.5	6	4.1	1607	1.6	15	4.4
4:45 PM	5:45 PM	787	1.8	10	5.3	785	1.4	5	3.4	1572	1.6	15	4.5
5:00 PM	6:00 PM	767	1.8	9	5.0	744	1.4	4	2.7	1511	1.5	13	4.0
5:15 PM	6:15 PM	707	1.6	8	4.3	699	1.3	3	2.3	1405	1.4	11	3.4
5:30 PM	6:30 PM	665	1.5	5	2.7	641	1.2	3	2.0	1305	1.3	8	2.4
5:45 PM	6:45 PM	578	1.3	3	1.4	570	1.0	2	1.4	1148	1.2	5	1.4

TIME		DIRECTION											
		NORTH BOUND				SOUT BOUND				TWO - WAY			
		MOTORISED		BICYCLES		MOTORISED		BICYCLES		MOTORISED		BICYCLES	
FROM	TO	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*
6:00 PM	7:00 PM	509	*1.2*	3	*1.6*	511	*0.9*	1	*0.7*	1020	*1.0*	4	*1.2*
6:15 PM	7:15 PM	453	*1.0*	2	*1.1*	467	*0.9*	0	*0.2*	920	*0.9*	2	*0.7*
6:30 PM	7:30 PM	388	*0.9*	2	*0.9*	409	*0.7*	0	*0.2*	797	*0.8*	2	*0.6*
6:45 PM	7:45 PM	394	*0.9*	2	*0.9*	399	*0.7*	0	*0.2*	793	*0.8*	2	*0.6*
7:00 PM	8:00 PM	352	*0.8*	1	*0.7*	348	*0.6*	0	*0.2*	700	*0.7*	2	*0.5*
7:15 PM	8:15 PM	336	*0.8*	1	*0.4*	311	*0.6*	0	*0.2*	647	*0.7*	1	*0.3*
7:30 PM	8:30 PM	305	*0.7*	1	*0.5*	287	*0.5*	0	*0.0*	592	*0.6*	1	*0.3*
7:45 PM	8:45 PM	260	*0.6*	2	*0.9*	259	*0.5*	0	*0.0*	519	*0.5*	2	*0.5*
8:00 PM	9:00 PM	274	*0.6*	1	*0.7*	251	*0.5*	2	*1.4*	525	*0.5*	3	*1.0*
8:15 PM	9:15 PM	247	*0.6*	2	*0.9*	247	*0.4*	2	*1.4*	493	*0.5*	4	*1.1*
8:30 PM	9:30 PM	239	*0.5*	1	*0.7*	236	*0.4*	2	*1.4*	475	*0.5*	3	*1.0*
8:45 PM	9:45 PM	222	*0.5*	1	*0.4*	226	*0.4*	2	*1.4*	447	*0.5*	3	*0.8*
9:00 PM	10:00 PM	192	*0.4*	1	*0.4*	241	*0.4*	0	*0.0*	433	*0.4*	1	*0.2*
9:15 PM	10:15 PM	172	*0.4*	1	*0.4*	218	*0.4*	0	*0.0*	390	*0.4*	1	*0.2*
9:30 PM	10:30 PM	250	*0.6*	0	*0.2*	208	*0.4*	0	*0.0*	458	*0.5*	0	*0.1*
9:45 PM	10:45 PM	232	*0.5*	0	*0.2*	203	*0.4*	0	*0.0*	435	*0.4*	0	*0.1*
10:00 PM	11:00 PM	214	*0.5*	0	*0.2*	175	*0.3*	0	*0.0*	389	*0.4*	0	*0.1*
10:15 PM	11:15 PM	197	*0.5*	0	*0.0*	155	*0.3*	0	*0.0*	352	*0.4*	0	*0.0*
10:30 PM	11:30 PM	88	*0.2*	0	*0.0*	141	*0.3*	0	*0.0*	229	*0.2*	0	*0.0*
10:45 PM	11:45 PM	71	*0.2*	0	*0.0*	111	*0.2*	0	*0.0*	181	*0.2*	0	*0.0*
11:00 PM	12:00 AM	54	*0.1*	0	*0.0*	89	*0.2*	0	*0.0*	143	*0.1*	0	*0.0*
11:15 PM	12:15 AM	45	*0.1*	0	*0.0*	78	*0.1*	0	*0.0*	124	*0.1*	0	*0.0*
11:30 PM	12:30 AM	29	*0.1*	0	*0.0*	59	*0.1*	0	*0.0*	88	*0.1*	0	*0.0*
11:45 PM	12:45 AM	30	*0.1*	0	*0.0*	51	*0.1*	0	*0.0*	80	*0.1*	0	*0.0*
12:00 AM	1:00 AM	31	*0.1*	0	*0.0*	47	*0.1*	0	*0.0*	78	*0.1*	0	*0.0*
12:15 AM	1:15 AM	29	*0.1*	0	*0.0*	40	*0.1*	0	*0.0*	70	*0.1*	0	*0.0*
12:30 AM	1:30 AM	30	*0.1*	0	*0.0*	39	*0.1*	0	*0.0*	69	*0.1*	0	*0.0*
12:45 AM	1:45 AM	28	*0.1*	0	*0.0*	36	*0.1*	0	*0.0*	63	*0.1*	0	*0.0*
1:00 AM	2:00 AM	25	*0.1*	0	*0.0*	31	*0.1*	0	*0.0*	56	*0.1*	0	*0.0*
1:15 AM	2:15 AM	23	*0.1*	0	*0.0*	31	*0.1*	0	*0.0*	55	*0.1*	0	*0.0*
1:30 AM	2:30 AM	22	*0.1*	0	*0.0*	30	*0.1*	0	*0.0*	52	*0.1*	0	*0.0*
1:45 AM	2:45 AM	21	*0.0*	0	*0.0*	30	*0.1*	0	*0.0*	51	*0.1*	0	*0.0*
2:00 AM	3:00 AM	22	*0.0*	0	*0.0*	29	*0.1*	0	*0.0*	50	*0.1*	0	*0.0*
2:15 AM	3:15 AM	24	*0.1*	0	*0.0*	26	*0.0*	0	*0.0*	51	*0.1*	0	*0.0*
2:30 AM	3:30 AM	27	*0.1*	0	*0.0*	25	*0.0*	0	*0.0*	52	*0.1*	0	*0.0*
2:45 AM	3:45 AM	31	*0.1*	0	*0.0*	32	*0.1*	0	*0.2*	63	*0.1*	0	*0.1*
3:00 AM	4:00 AM	35	*0.1*	0	*0.0*	34	*0.1*	1	*0.5*	69	*0.1*	1	*0.2*
3:15 AM	4:15 AM	35	*0.1*	0	*0.0*	38	*0.1*	1	*0.5*	73	*0.1*	1	*0.2*
3:30 AM	4:30 AM	46	*0.1*	0	*0.0*	55	*0.1*	1	*0.5*	101	*0.1*	1	*0.2*
3:45 AM	4:45 AM	57	*0.1*	0	*0.0*	82	*0.1*	1	*0.5*	138	*0.1*	1	*0.2*
4:00 AM	5:00 AM	78	*0.2*	0	*0.0*	103	*0.2*	0	*0.2*	181	*0.2*	0	*0.1*
4:15 AM	5:15 AM	116	*0.3*	0	*0.2*	142	*0.3*	1	*0.5*	258	*0.3*	1	*0.3*
4:30 AM	5:30 AM	159	*0.4*	0	*0.2*	201	*0.4*	1	*0.5*	360	*0.4*	1	*0.3*
4:45 AM	5:45 AM	225	*0.5*	1	*0.7*	270	*0.5*	1	*0.7*	495	*0.5*	2	*0.7*
5:00 AM	6:00 AM	281	*0.6*	2	*1.2*	356	*0.6*	1	*0.7*	637	*0.6*	3	*1.0*
5:15 AM	6:15 AM	337	*0.8*	3	*1.8*	440	*0.8*	1	*0.7*	778	*0.8*	4	*1.3*
5:30 AM	6:30 AM	380	*0.9*	4	*2.3*	506	*0.9*	1	*0.7*	886	*0.9*	5	*1.6*
Maximum Values		*1,071*	*2.4*	*10*	*5.3*	*1,591*	*2.9*	*6*	*4.1*	*2,349*	*2.4*	*15*	*4.4*
Minimum Values		*21*	*0*	*0*	*0*	*25*	*0*	*0*	*0*	*50*	*0*	*0*	*0*

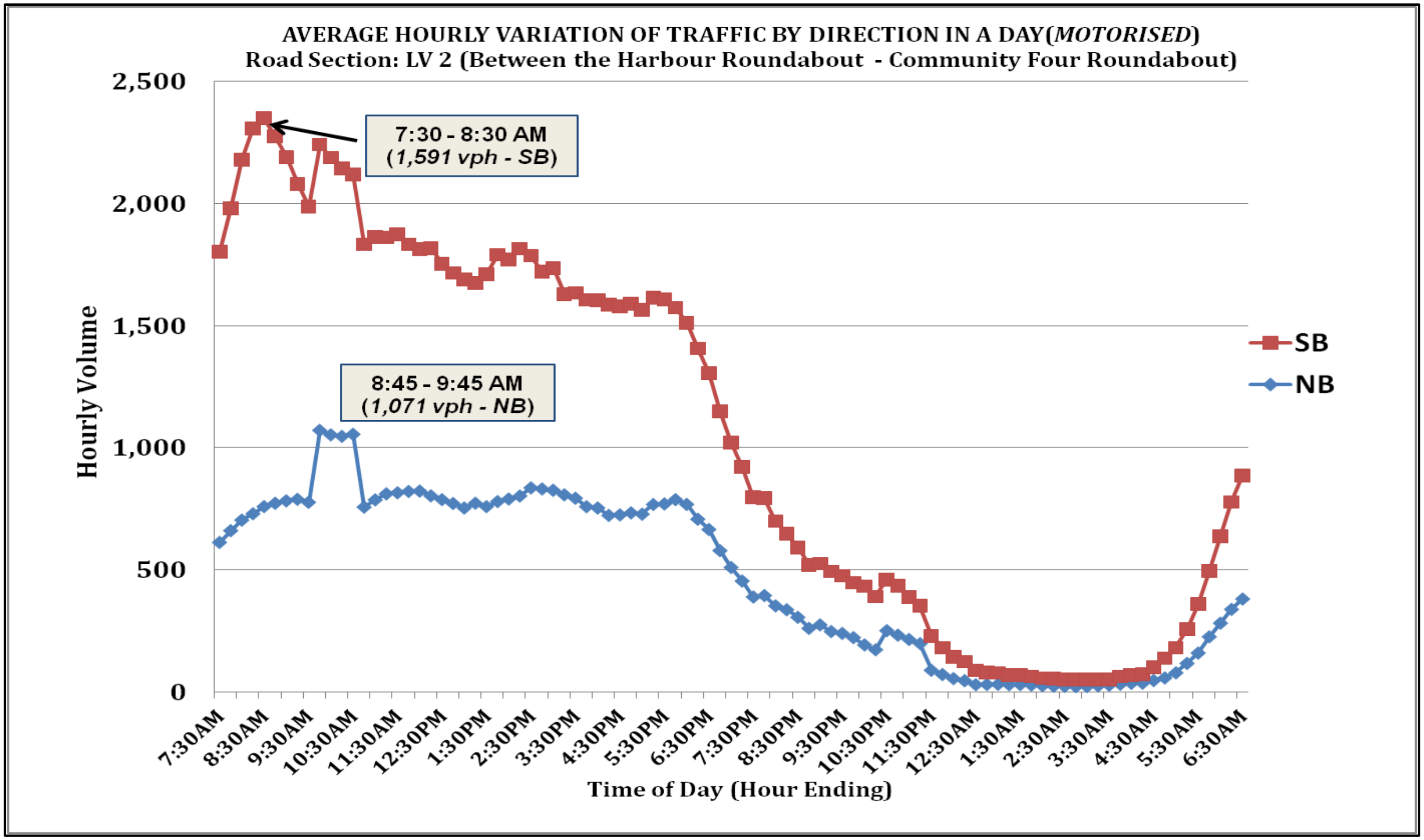

Figure 3.8: Average hourly traffic variation by direction for Motorised vehicles

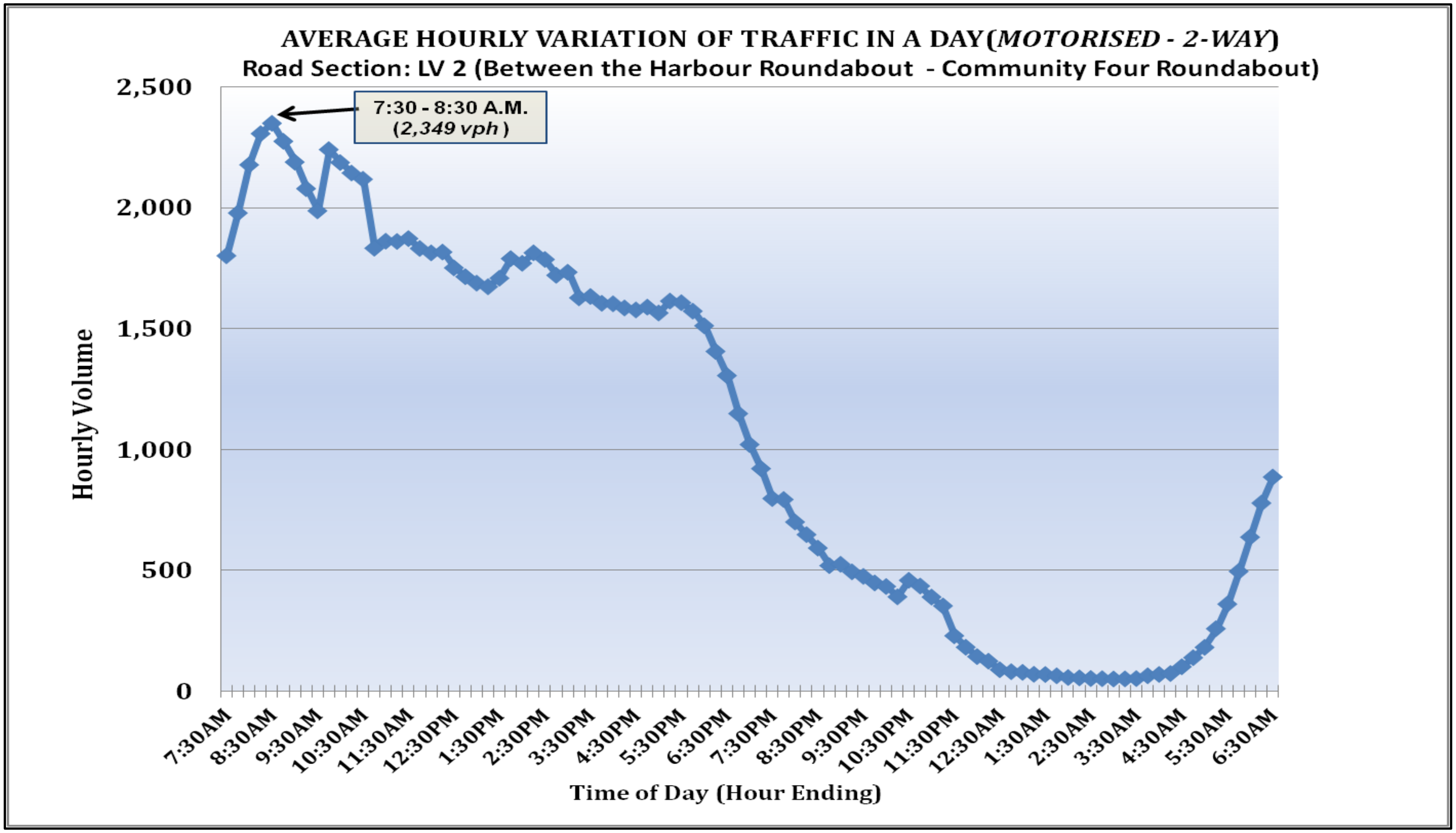

Figure 3.9: Average Hourly Traffic Variation in a Day (Motorised)

3.2.3 Link Section 3 (LV3): Road section Between the Community four Roundabout - Tema Motorway Roundabout ≈ 3.9km

Table 3.8 gives the summary of hourly variation of traffic for motorised and bicycles. Figure 3.10 and 3.11 shows the hourly variation by direction and total variation in a day.

Table 3.8: Summary of Average Hourly Distribution by direction for Motorised Traffic

Road Section: LV 3 (Between the Community Four Roundabout - Tema Motorway Roundabout)

TIME		DIRECTION											
		NORTH BOUND				SOUTH BOUND				TWO - WAY			
		MOTORISED		BICYCLES		MOTORISED		BICYCLES		MOTORISED		BICYCLES	
FROM	TO	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	% of Total	Total Volume	% of Total
6:30 AM	7:30 AM	880	*2.1*	15	*2.0*	1,584	*2.8*	17	*6.9*	2464	2.5	32	3.2
6:45 AM	7:45 AM	854	*2.0*	11	*1.4*	1,646	*2.9*	17	*7.2*	2500	2.5	28	2.8
7:00 AM	8:00 AM	846	*2.0*	9	*1.2*	1,680	*3.0*	19	*8.0*	2526	2.5	29	2.9
7:15 AM	8:15 AM	870	*2.0*	10	*1.3*	1,582	*2.8*	16	*6.5*	2452	2.5	26	2.6
7:30 AM	8:30 AM	842	*2.0*	10	*1.3*	1,519	*2.7*	15	*6.1*	2361	2.4	25	2.5
7:45 AM	8:45 AM	818	*1.9*	9	*1.2*	1,330	*2.3*	8	*3.5*	2148	2.2	17	1.7
8:00 AM	9:00 AM	830	*1.9*	8	*1.0*	1,178	*2.1*	5	*1.9*	2008	2.0	13	1.3
8:15 AM	9:15 AM	781	*1.8*	6	*0.7*	1,118	*2.0*	4	*1.8*	1899	1.9	10	1.0
8:30 AM	9:30 AM	755	*1.8*	4	*0.6*	1,010	*1.8*	3	*1.1*	1765	1.8	7	0.7
8:45 AM	9:45 AM	728	*1.7*	4	*0.5*	1,050	*1.8*	2	*1.0*	1777	1.8	6	0.6
9:00 AM	10:00 AM	679	*1.6*	4	*0.6*	1,071	*1.9*	2	*0.7*	1750	1.8	6	0.6
9:15 AM	10:15 AM	697	*1.6*	3	*0.4*	1,062	*1.9*	2	*0.8*	1759	1.8	5	0.5
9:30 AM	10:30 AM	671	*1.6*	3	*0.4*	1,057	*1.9*	2	*0.7*	1728	1.7	5	0.5
9:45 AM	10:45 AM	693	*1.6*	3	*0.4*	1,040	*1.8*	2	*1.0*	1733	1.7	5	0.5
10:00 AM	11:00 AM	722	*1.7*	2	*0.3*	1,022	*1.8*	2	*1.0*	1745	1.7	4	0.4
10:15 AM	11:15 AM	648	*1.5*	2	*0.3*	1,024	*1.8*	2	*0.7*	1672	1.7	4	0.4
10:30 AM	11:30 AM	632	*1.5*	2	*0.2*	1,016	*1.8*	2	*1.0*	1649	1.7	4	0.4
10:45 AM	11:45 AM	616	*1.4*	3	*0.4*	1,004	*1.8*	2	*1.0*	1620	1.6	5	0.5
11:00 AM	12:00 PM	620	*1.4*	6	*0.8*	962	*1.7*	2	*1.0*	1582	1.6	8	0.8
11:15 AM	12:15 PM	645	*1.5*	6	*0.7*	904	*1.6*	3	*1.1*	1550	1.6	8	0.8
11:30 AM	12:30 PM	666	*1.6*	8	*1.1*	865	*1.5*	2	*0.7*	1530	1.5	10	1.0
11:45 AM	12:45 PM	679	*1.6*	13	*1.7*	797	*1.4*	2	*0.7*	1476	1.5	15	1.5
12:00 PM	1:00 PM	679	*1.6*	11	*1.4*	786	*1.4*	1	*0.6*	1465	1.5	12	1.2
12:15 PM	1:15 PM	679	*1.6*	13	*1.7*	839	*1.5*	2	*0.7*	1518	1.5	15	1.5
12:30 PM	1:30 PM	663	*1.5*	12	*1.6*	850	*1.5*	1	*0.6*	1513	1.5	14	1.4
12:45 PM	1:45 PM	648	*1.5*	8	*1.0*	873	*1.5*	1	*0.4*	1521	1.5	9	0.9
1:00 PM	2:00 PM	625	*1.5*	9	*1.2*	867	*1.5*	1	*0.4*	1492	1.5	10	1.0
1:15 PM	2:15 PM	635	*1.5*	8	*1.0*	850	*1.5*	1	*0.3*	1485	1.5	8	0.8
1:30 PM	2:30 PM	666	*1.6*	11	*1.4*	938	*1.6*	1	*0.6*	1605	1.6	12	1.2
1:45 PM	2:45 PM	675	*1.6*	10	*1.3*	948	*1.7*	1	*0.4*	1623	1.6	11	1.1
2:00 PM	3:00 PM	680	*1.6*	9	*1.2*	1,001	*1.8*	1	*0.4*	1682	1.7	10	1.0
2:15 PM	3:15 PM	663	*1.5*	11	*1.4*	959	*1.7*	2	*1.0*	1622	1.6	13	1.3
2:30 PM	3:30 PM	616	*1.4*	9	*1.1*	866	*1.5*	2	*1.0*	1482	1.5	11	1.1
2:45 PM	3:45 PM	597	*1.4*	10	*1.3*	867	*1.5*	3	*1.1*	1464	1.5	12	1.2
3:00 PM	4:00 PM	594	*1.4*	11	*1.4*	790	*1.4*	3	*1.1*	1384	1.4	14	1.4
3:15 PM	4:15 PM	590	*1.4*	12	*1.5*	821	*1.4*	2	*0.7*	1411	1.4	13	1.3
3:30 PM	4:30 PM	619	*1.4*	12	*1.5*	872	*1.5*	1	*0.6*	1491	1.5	13	1.3
3:45 PM	4:45 PM	629	*1.5*	14	*1.8*	817	*1.4*	1	*0.6*	1446	1.4	15	1.5
4:00 PM	5:00 PM	646	*1.5*	17	*2.2*	809	*1.4*	3	*1.4*	1455	1.5	20	2.0
4:15 PM	5:15 PM	718	*1.7*	21	*2.7*	791	*1.4*	3	*1.4*	1509	1.5	24	2.4
4:30 PM	5:30 PM	762	*1.8*	31	*4.1*	753	*1.3*	6	*2.6*	1515	1.5	38	3.7
4:45 PM	5:45 PM	820	*1.9*	39	*5.1*	751	*1.3*	7	*3.0*	1571	1.6	46	4.6
5:00 PM	6:00 PM	847	*2.0*	43	*5.6*	757	*1.3*	7	*2.9*	1605	1.6	50	4.9
5:15 PM	6:15 PM	854	*2.0*	46	*6.1*	706	*1.2*	6	*2.6*	1560	1.6	53	5.2
5:30 PM	6:30 PM	818	*1.9*	42	*5.5*	651	*1.1*	5	*1.9*	1469	1.5	46	4.6
5:45 PM	6:45 PM	695	*1.6*	34	*4.4*	613	*1.1*	5	*2.1*	1308	1.3	39	3.8

TIME		DIRECTION											
		NORTH BOUND				SOUT BOUND				TWO - WAY			
		MOTORISED		BICYCLES		MOTORISED		BICYCLES		MOTORISED		BICYCLES	
FROM	TO	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	% of Total	Total Volume	*% of Total*	Total Volume	*% of Total*
6:00 PM	7:00 PM	611	*1.4*	28	*3.7*	552	*1.0*	4	1.7	1163	*1.2*	32	*3.2*
6:15 PM	7:15 PM	512	*1.2*	21	*2.8*	539	*0.9*	4	1.7	1052	*1.1*	25	*2.5*
6:30 PM	7:30 PM	450	*1.1*	16	*2.0*	491	*0.9*	2	1.0	941	*0.9*	18	*1.8*
6:45 PM	7:45 PM	465	*1.1*	13	*1.7*	482	*0.8*	1	0.3	947	*0.9*	13	*1.3*
7:00 PM	8:00 PM	447	*1.0*	10	*1.4*	476	*0.8*	0	0.0	923	*0.9*	10	*1.0*
7:15 PM	8:15 PM	445	*1.0*	8	*1.1*	459	*0.8*	0	0.1	903	*0.9*	9	*0.9*
7:30 PM	8:30 PM	432	*1.0*	7	*0.9*	482	*0.8*	0	0.1	914	*0.9*	7	*0.7*
7:45 PM	8:45 PM	420	*1.0*	7	*1.0*	480	*0.8*	0	0.1	900	*0.9*	8	*0.8*
8:00 PM	9:00 PM	393	*0.9*	5	*0.7*	473	*0.8*	0	0.1	865	*0.9*	6	*0.6*
8:15 PM	9:15 PM	350	*0.8*	4	*0.5*	453	*0.8*	0	0.1	802	*0.8*	4	*0.4*
8:30 PM	9:30 PM	331	*0.8*	2	*0.3*	415	*0.7*	0	0.1	746	*0.7*	2	*0.2*
8:45 PM	9:45 PM	328	*0.8*	1	*0.2*	427	*0.7*	1	0.3	755	*0.8*	2	*0.2*
9:00 PM	10:00 PM	334	*0.8*	2	*0.3*	403	*0.7*	1	0.4	737	*0.7*	3	*0.3*
9:15 PM	10:15 PM	331	*0.8*	2	*0.3*	377	*0.7*	1	0.4	709	*0.7*	3	*0.3*
9:30 PM	10:30 PM	335	*0.8*	3	*0.3*	360	*0.6*	1	0.6	695	*0.7*	4	*0.4*
9:45 PM	10:45 PM	298	*0.7*	2	*0.2*	288	*0.5*	1	0.4	586	*0.6*	3	*0.3*
10:00 PM	11:00 PM	269	*0.6*	1	*0.1*	248	*0.4*	1	0.3	516	*0.5*	1	*0.1*
10:15 PM	11:15 PM	243	*0.6*	1	*0.1*	223	*0.4*	0	0.1	466	*0.5*	1	*0.1*
10:30 PM	11:30 PM	193	*0.4*	0	*0.0*	200	*0.4*	0	0.0	393	*0.4*	0	*0.0*
10:45 PM	11:45 PM	157	*0.4*	0	*0.0*	181	*0.3*	0	0.0	339	*0.3*	0	*0.0*
11:00 PM	12:00 AM	125	*0.3*	0	*0.0*	160	*0.3*	0	0.0	285	*0.3*	0	*0.0*
11:15 PM	12:15 AM	90	*0.2*	0	*0.0*	146	*0.3*	0	0.0	236	*0.2*	0	*0.0*
11:30 PM	12:30 AM	74	*0.2*	0	*0.0*	126	*0.2*	0	0.0	199	*0.2*	0	*0.0*
11:45 PM	12:45 AM	74	*0.2*	0	*0.0*	113	*0.2*	0	0.0	187	*0.2*	0	*0.0*
12:00 AM	1:00 AM	71	*0.2*	0	*0.0*	114	*0.2*	0	0.0	184	*0.2*	0	*0.0*
12:15 AM	1:15 AM	71	*0.2*	0	*0.0*	92	*0.2*	0	0.0	163	*0.2*	0	*0.0*
12:30 AM	1:30 AM	66	*0.2*	0	*0.0*	88	*0.2*	0	0.0	154	*0.2*	0	*0.0*
12:45 AM	1:45 AM	63	*0.1*	0	*0.0*	82	*0.1*	0	0.0	145	*0.1*	0	*0.0*
1:00 AM	2:00 AM	57	*0.1*	0	*0.0*	65	*0.1*	0	0.0	122	*0.1*	0	*0.0*
1:15 AM	2:15 AM	50	*0.1*	0	*0.0*	60	*0.1*	0	0.0	111	*0.1*	0	*0.0*
1:30 AM	2:30 AM	46	*0.1*	0	*0.0*	49	*0.1*	0	0.0	95	*0.1*	0	*0.0*
1:45 AM	2:45 AM	44	*0.1*	0	*0.0*	45	*0.1*	0	0.0	89	*0.1*	0	*0.0*
2:00 AM	3:00 AM	38	*0.1*	0	*0.0*	43	*0.1*	0	0.0	81	*0.1*	0	*0.0*
2:15 AM	3:15 AM	35	*0.1*	0	*0.0*	44	*0.1*	0	0.0	79	*0.1*	0	*0.0*
2:30 AM	3:30 AM	36	*0.1*	0	*0.0*	44	*0.1*	0	0.0	80	*0.1*	0	*0.0*
2:45 AM	3:45 AM	38	*0.1*	0	*0.0*	45	*0.1*	0	0.0	83	*0.1*	0	*0.0*
3:00 AM	4:00 AM	40	*0.1*	0	*0.0*	49	*0.1*	0	0.0	89	*0.1*	0	*0.0*
3:15 AM	4:15 AM	50	*0.1*	0	*0.0*	58	*0.1*	0	0.0	108	*0.1*	0	*0.0*
3:30 AM	4:30 AM	63	*0.1*	0	*0.0*	74	*0.1*	0	0.0	138	*0.1*	0	*0.0*
3:45 AM	4:45 AM	85	*0.2*	0	*0.0*	99	*0.2*	0	0.0	184	*0.2*	0	*0.0*
4:00 AM	5:00 AM	110	*0.3*	1	*0.1*	121	*0.2*	0	0.1	231	*0.2*	1	*0.1*
4:15 AM	5:15 AM	139	*0.3*	2	*0.3*	152	*0.3*	1	0.6	291	*0.3*	4	*0.4*
4:30 AM	5:30 AM	192	*0.4*	3	*0.4*	217	*0.4*	2	0.7	410	*0.4*	5	*0.5*
4:45 AM	5:45 AM	234	*0.5*	4	*0.5*	287	*0.5*	3	1.4	522	*0.5*	7	*0.7*
5:00 AM	6:00 AM	289	*0.7*	10	*1.4*	365	*0.6*	4	1.8	653	*0.7*	15	*1.5*
5:15 AM	6:15 AM	337	*0.8*	11	*1.5*	423	*0.7*	6	2.5	761	*0.8*	17	*1.7*
5:30 AM	6:30 AM	366	*0.9*	16	*2.0*	450	*0.8*	6	2.5	816	*0.8*	22	*2.2*
Maximum Values		*880*	*2.1*	*46*	*6.1*	*1,680*	*3*	*19*	*8*	*2,526*	*2.5*	*53*	*5.2*
Minimum Values		*35*	*0*	*0*	*0*	*43*	*0*	*0*	*0*	*79*	*0*	*0*	*0*

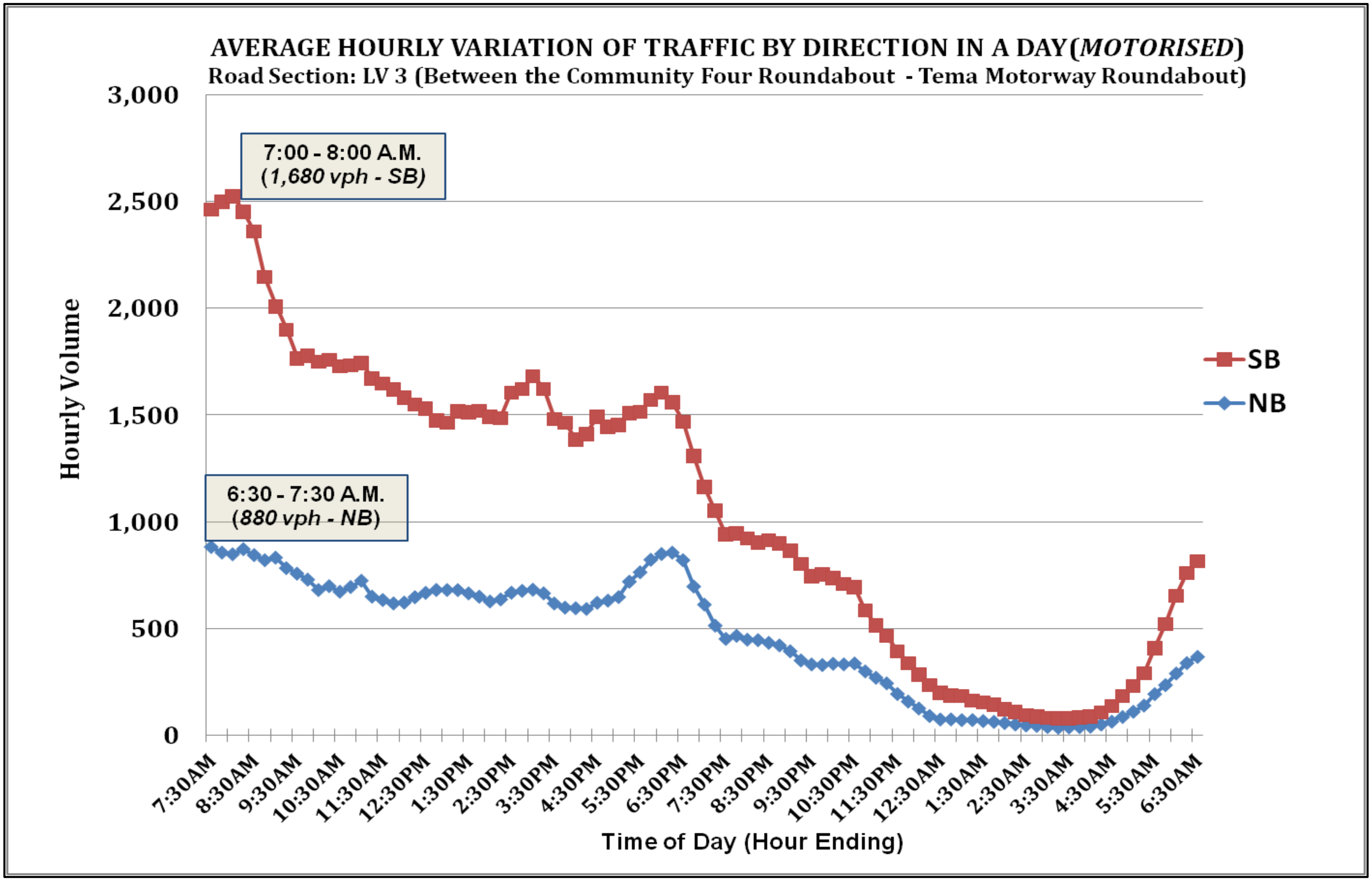

Figure 3.10: Average hourly traffic variation by direction for Motorised vehicles

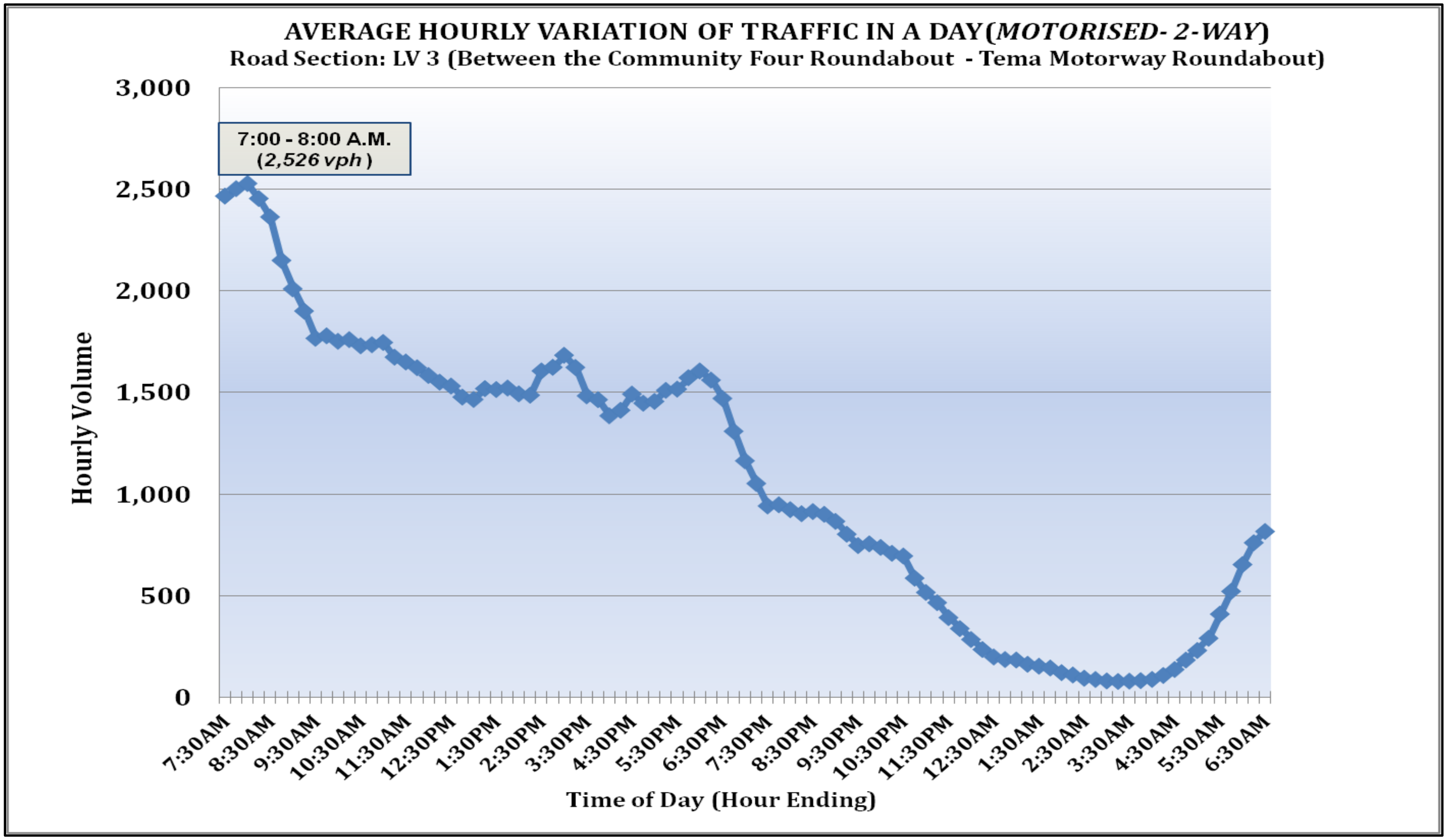

Figure 3.11: Average Hourly Traffic Variation in a Day (Motorised)

3.2.3 Link Section 4 (LV4): Road section between Tema Motorway Roundabout - Thermal Village Junction ≈ 2.3km

Table 3.9 gives the summary of hourly variation of traffic for motorised and bicycles. Figure 3.12 and 3.13 shows the hourly variation by direction and total variation in a day.

Table 3.9: Summary of Average Hourly Distribution by direction for Motorised Traffic

Road Section: LV 4 (Between the Tema Motorway Roundabout - Thermal Village Junction)

TIME		DIRECTION											
		EAST BOUND				WEST BOUND				TWO - WAY			
		MOTORISED		BICYCLES		MOTORISED		BICYCLES		MOTORISED		BICYCLES	
FROM	TO	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*
6:30 AM	7:30 AM	1,024	*1.9*	12	*3.8*	1,131	*2.0*	5	*1.7*	2155	*2.0*	17	*2.8*
6:45 AM	7:45 AM	1,035	*1.9*	13	*4.3*	1,152	*2.1*	5	*1.6*	2187	*2.0*	18	*3.0*
7:00 AM	8:00 AM	1,039	*1.9*	17	*5.4*	1,142	*2.1*	5	*1.7*	2181	*2.0*	22	*3.6*
7:15 AM	8:15 AM	1,057	*1.9*	14	*4.6*	1,161	*2.1*	7	*2.3*	2218	*2.0*	21	*3.5*
7:30 AM	8:30 AM	1,060	*2.0*	14	*4.4*	1,171	*2.1*	7	*2.4*	2231	*2.0*	21	*3.4*
7:45 AM	8:45 AM	1,075	*2.0*	11	*3.6*	1,086	*2.0*	6	*2.0*	2160	*2.0*	17	*2.8*
8:00 AM	9:00 AM	1,058	*1.9*	8	*2.6*	1,088	*2.0*	5	*1.6*	2146	*2.0*	13	*2.1*
8:15 AM	9:15 AM	985	*1.8*	9	*2.8*	1,033	*1.9*	2	*0.8*	2018	*1.8*	11	*1.8*
8:30 AM	9:30 AM	911	*1.7*	8	*2.7*	1,020	*1.8*	1	*0.3*	1931	*1.8*	9	*1.5*
8:45 AM	9:45 AM	847	*1.6*	7	*2.2*	983	*1.8*	2	*0.7*	1829	*1.7*	9	*1.4*
9:00 AM	10:00 AM	839	*1.5*	7	*2.2*	962	*1.7*	3	*0.9*	1801	*1.6*	9	*1.5*
9:15 AM	10:15 AM	869	*1.6*	6	*1.9*	967	*1.7*	3	*1.0*	1836	*1.7*	9	*1.5*
9:30 AM	10:30 AM	896	*1.7*	6	*1.9*	962	*1.7*	5	*1.6*	1858	*1.7*	11	*1.8*
9:45 AM	10:45 AM	947	*1.7*	5	*1.7*	1,050	*1.9*	3	*1.1*	1996	*1.8*	9	*1.4*
10:00 AM	11:00 AM	950	*1.7*	4	*1.4*	1,057	*1.9*	4	*1.2*	2007	*1.8*	8	*1.3*
10:15 AM	11:15 AM	945	*1.7*	3	*1.1*	1,082	*1.9*	4	*1.4*	2028	*1.8*	7	*1.2*
10:30 AM	11:30 AM	990	*1.8*	4	*1.4*	1,098	*2.0*	2	*0.8*	2088	*1.9*	7	*1.1*
10:45 AM	11:45 AM	980	*1.8*	4	*1.4*	1,031	*1.9*	4	*1.5*	2010	*1.8*	9	*1.4*
11:00 AM	12:00 PM	1,004	*1.8*	4	*1.3*	983	*1.8*	3	*1.1*	1987	*1.8*	7	*1.2*
11:15 AM	12:15 PM	1,024	*1.9*	5	*1.5*	900	*1.6*	3	*1.0*	1924	*1.8*	8	*1.3*
11:30 AM	12:30 PM	1,021	*1.9*	3	*1.1*	844	*1.5*	4	*1.4*	1865	*1.7*	7	*1.2*
11:45 AM	12:45 PM	990	*1.8*	4	*1.3*	781	*1.4*	3	*0.9*	1771	*1.6*	7	*1.1*
12:00 PM	1:00 PM	948	*1.7*	4	*1.2*	747	*1.3*	2	*0.8*	1695	*1.5*	6	*1.0*
12:15 PM	1:15 PM	922	*1.7*	2	*0.8*	769	*1.4*	3	*1.1*	1691	*1.5*	6	*0.9*
12:30 PM	1:30 PM	887	*1.6*	3	*0.9*	825	*1.5*	3	*0.9*	1712	*1.6*	5	*0.9*
12:45 PM	1:45 PM	896	*1.6*	4	*1.2*	884	*1.6*	2	*0.8*	1780	*1.6*	6	*1.0*
1:00 PM	2:00 PM	912	*1.7*	4	*1.3*	926	*1.7*	2	*0.7*	1838	*1.7*	6	*1.0*
1:15 PM	2:15 PM	900	*1.7*	5	*1.7*	975	*1.8*	2	*0.7*	1875	*1.7*	7	*1.2*
1:30 PM	2:30 PM	928	*1.7*	5	*1.5*	1,004	*1.8*	3	*0.9*	1932	*1.8*	7	*1.2*
1:45 PM	2:45 PM	945	*1.7*	4	*1.4*	1,035	*1.9*	4	*1.2*	1980	*1.8*	8	*1.3*
2:00 PM	3:00 PM	952	*1.8*	4	*1.2*	1,029	*1.8*	4	*1.2*	1981	*1.8*	7	*1.2*
2:15 PM	3:15 PM	950	*1.7*	3	*0.9*	981	*1.8*	3	*1.0*	1931	*1.8*	6	*0.9*
2:30 PM	3:30 PM	900	*1.7*	2	*0.8*	909	*1.6*	4	*1.2*	1810	*1.6*	6	*1.0*
2:45 PM	3:45 PM	866	*1.6*	2	*0.6*	908	*1.6*	4	*1.5*	1774	*1.6*	6	*1.0*
3:00 PM	4:00 PM	816	*1.5*	3	*1.0*	943	*1.7*	6	*2.0*	1759	*1.6*	9	*1.5*
3:15 PM	4:15 PM	800	*1.5*	3	*0.9*	987	*1.8*	7	*2.3*	1787	*1.6*	9	*1.5*
3:30 PM	4:30 PM	832	*1.5*	4	*1.3*	1,036	*1.9*	8	*2.8*	1868	*1.7*	12	*2.0*
3:45 PM	4:45 PM	824	*1.5*	4	*1.4*	1,043	*1.9*	8	*2.6*	1867	*1.7*	12	*2.0*
4:00 PM	5:00 PM	868	*1.6*	4	*1.2*	1,042	*1.9*	6	*2.2*	1910	*1.7*	10	*1.7*
4:15 PM	5:15 PM	952	*1.8*	6	*1.9*	1,034	*1.9*	10	*3.3*	1986	*1.8*	16	*2.6*
4:30 PM	5:30 PM	937	*1.7*	6	*1.9*	1,059	*1.9*	10	*3.3*	1996	*1.8*	16	*2.6*
4:45 PM	5:45 PM	942	*1.7*	8	*2.6*	1,071	*1.9*	12	*4.0*	2013	*1.8*	20	*3.3*
5:00 PM	6:00 PM	971	*1.8*	9	*2.9*	1,084	*1.9*	17	*5.9*	2055	*1.9*	26	*4.4*
5:15 PM	6:15 PM	964	*1.8*	8	*2.6*	1,092	*2.0*	19	*6.3*	2055	*1.9*	27	*4.4*
5:30 PM	6:30 PM	963	*1.8*	8	*2.7*	1,028	*1.8*	19	*6.6*	1991	*1.8*	28	*4.6*
5:45 PM	6:45 PM	905	*1.7*	5	*1.6*	891	*1.6*	17	*5.7*	1796	*1.6*	22	*3.6*

TIME		DIRECTION											
		EAST BOUND				WEST BOUND				TWO - WAY			
		MOTORISED		BICYCLES		MOTORISED		BICYCLES		MOTORISED		BICYCLES	
FROM	TO	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*	Total Volume	*% of Total*
6:00 PM	7:00 PM	788	*1.5*	4	*1.2*	757	*1.4*	11	*3.6*	1545	*1.4*	14	*2.4*
6:15 PM	7:15 PM	663	*1.2*	3	*0.9*	646	*1.2*	5	*1.6*	1309	*1.2*	7	*1.2*
6:30 PM	7:30 PM	577	*1.1*	1	*0.2*	540	*1.0*	2	*0.6*	1117	*1.0*	2	*0.4*
6:45 PM	7:45 PM	554	*1.0*	1	*0.2*	535	*1.0*	1	*0.3*	1089	*1.0*	2	*0.3*
7:00 PM	8:00 PM	530	*1.0*	0	*0.1*	517	*0.9*	1	*0.3*	1047	*1.0*	1	*0.2*
7:15 PM	8:15 PM	501	*0.9*	0	*0.0*	473	*0.9*	1	*0.3*	974	*0.9*	1	*0.2*
7:30 PM	8:30 PM	458	*0.8*	0	*0.1*	457	*0.8*	0	*0.1*	914	*0.8*	1	*0.1*
7:45 PM	8:45 PM	423	*0.8*	0	*0.1*	424	*0.8*	1	*0.3*	848	*0.8*	1	*0.2*
8:00 PM	9:00 PM	399	*0.7*	1	*0.2*	389	*0.7*	1	*0.3*	788	*0.7*	2	*0.3*
8:15 PM	9:15 PM	387	*0.7*	1	*0.2*	358	*0.6*	2	*0.6*	745	*0.7*	2	*0.4*
8:30 PM	9:30 PM	382	*0.7*	1	*0.2*	326	*0.6*	1	*0.5*	708	*0.6*	2	*0.3*
8:45 PM	9:45 PM	379	*0.7*	1	*0.2*	290	*0.5*	1	*0.2*	669	*0.6*	1	*0.2*
9:00 PM	10:00 PM	355	*0.7*	0	*0.1*	260	*0.5*	1	*0.2*	615	*0.6*	1	*0.2*
9:15 PM	10:15 PM	317	*0.6*	0	*0.1*	233	*0.4*	0	*0.0*	551	*0.5*	0	*0.1*
9:30 PM	10:30 PM	274	*0.5*	0	*0.1*	213	*0.4*	0	*0.0*	487	*0.4*	0	*0.1*
9:45 PM	10:45 PM	224	*0.4*	0	*0.1*	189	*0.3*	0	*0.0*	413	*0.4*	0	*0.1*
10:00 PM	11:00 PM	198	*0.4*	0	*0.1*	181	*0.3*	0	*0.1*	379	*0.3*	1	*0.1*
10:15 PM	11:15 PM	178	*0.3*	0	*0.1*	171	*0.3*	0	*0.1*	349	*0.3*	1	*0.1*
10:30 PM	11:30 PM	170	*0.3*	0	*0.0*	157	*0.3*	0	*0.1*	327	*0.3*	0	*0.1*
10:45 PM	11:45 PM	152	*0.3*	0	*0.0*	153	*0.3*	0	*0.1*	305	*0.3*	0	*0.1*
11:00 PM	12:00 AM	136	*0.3*	0	*0.0*	136	*0.2*	0	*0.0*	272	*0.2*	0	*0.0*
11:15 PM	12:15 AM	122	*0.2*	0	*0.0*	120	*0.2*	0	*0.0*	243	*0.2*	0	*0.0*
11:30 PM	12:30 AM	105	*0.2*	0	*0.1*	99	*0.2*	0	*0.0*	205	*0.2*	0	*0.1*
11:45 PM	12:45 AM	98	*0.2*	0	*0.1*	76	*0.1*	0	*0.0*	175	*0.2*	0	*0.1*
12:00 AM	1:00 AM	80	*0.1*	0	*0.1*	55	*0.1*	0	*0.0*	136	*0.1*	0	*0.1*
12:15 AM	1:15 AM	67	*0.1*	0	*0.1*	44	*0.1*	0	*0.0*	111	*0.1*	0	*0.1*
12:30 AM	1:30 AM	57	*0.1*	0	*0.0*	40	*0.1*	0	*0.0*	98	*0.1*	0	*0.0*
12:45 AM	1:45 AM	49	*0.1*	0	*0.0*	38	*0.1*	0	*0.0*	87	*0.1*	0	*0.0*
1:00 AM	2:00 AM	52	*0.1*	0	*0.0*	32	*0.1*	0	*0.0*	83	*0.1*	0	*0.0*
1:15 AM	2:15 AM	48	*0.1*	0	*0.0*	38	*0.1*	0	*0.0*	86	*0.1*	0	*0.0*
1:30 AM	2:30 AM	50	*0.1*	0	*0.0*	39	*0.1*	0	*0.0*	89	*0.1*	0	*0.0*
1:45 AM	2:45 AM	53	*0.1*	0	*0.0*	37	*0.1*	0	*0.0*	90	*0.1*	0	*0.0*
2:00 AM	3:00 AM	45	*0.1*	0	*0.0*	36	*0.1*	0	*0.0*	81	*0.1*	0	*0.0*
2:15 AM	3:15 AM	49	*0.1*	0	*0.0*	25	*0.0*	0	*0.0*	75	*0.1*	0	*0.0*
2:30 AM	3:30 AM	52	*0.1*	0	*0.1*	25	*0.0*	0	*0.0*	77	*0.1*	0	*0.1*
2:45 AM	3:45 AM	48	*0.1*	0	*0.1*	26	*0.0*	0	*0.0*	74	*0.1*	0	*0.1*
3:00 AM	4:00 AM	52	*0.1*	0	*0.1*	27	*0.0*	0	*0.0*	79	*0.1*	0	*0.1*
3:15 AM	4:15 AM	58	*0.1*	0	*0.1*	44	*0.1*	0	*0.1*	103	*0.1*	1	*0.1*
3:30 AM	4:30 AM	61	*0.1*	0	*0.0*	58	*0.1*	0	*0.1*	119	*0.1*	0	*0.1*
3:45 AM	4:45 AM	84	*0.2*	0	*0.0*	70	*0.1*	0	*0.1*	154	*0.1*	0	*0.1*
4:00 AM	5:00 AM	102	*0.2*	0	*0.0*	95	*0.2*	0	*0.1*	197	*0.2*	0	*0.1*
4:15 AM	5:15 AM	128	*0.2*	0	*0.0*	114	*0.2*	0	*0.0*	242	*0.2*	0	*0.0*
4:30 AM	5:30 AM	181	*0.3*	0	*0.0*	142	*0.3*	0	*0.0*	324	*0.3*	0	*0.0*
4:45 AM	5:45 AM	229	*0.4*	1	*0.2*	180	*0.3*	1	*0.3*	409	*0.4*	2	*0.3*
5:00 AM	6:00 AM	294	*0.5*	2	*0.8*	220	*0.4*	2	*0.6*	514	*0.5*	4	*0.7*
5:15 AM	6:15 AM	353	*0.7*	5	*1.6*	258	*0.5*	2	*0.6*	611	*0.6*	7	*1.1*
5:30 AM	6:30 AM	400	*0.7*	7	*2.3*	303	*0.5*	2	*0.6*	702	*0.6*	9	*1.4*
Maximum Values		*1,075*	*2.0*	*17*	*5.4*	*1,171*	*2.1*	*19*	*6.6*	*2,231*	*2.0*	*28*	*4.6*
Minimum Values		*45*	*0.1*	*0*	*0.0*	*25.00*	*0.0*	*0.00*	*0.0*	*73.67*	*0.1*	*0.00*	*0.0*

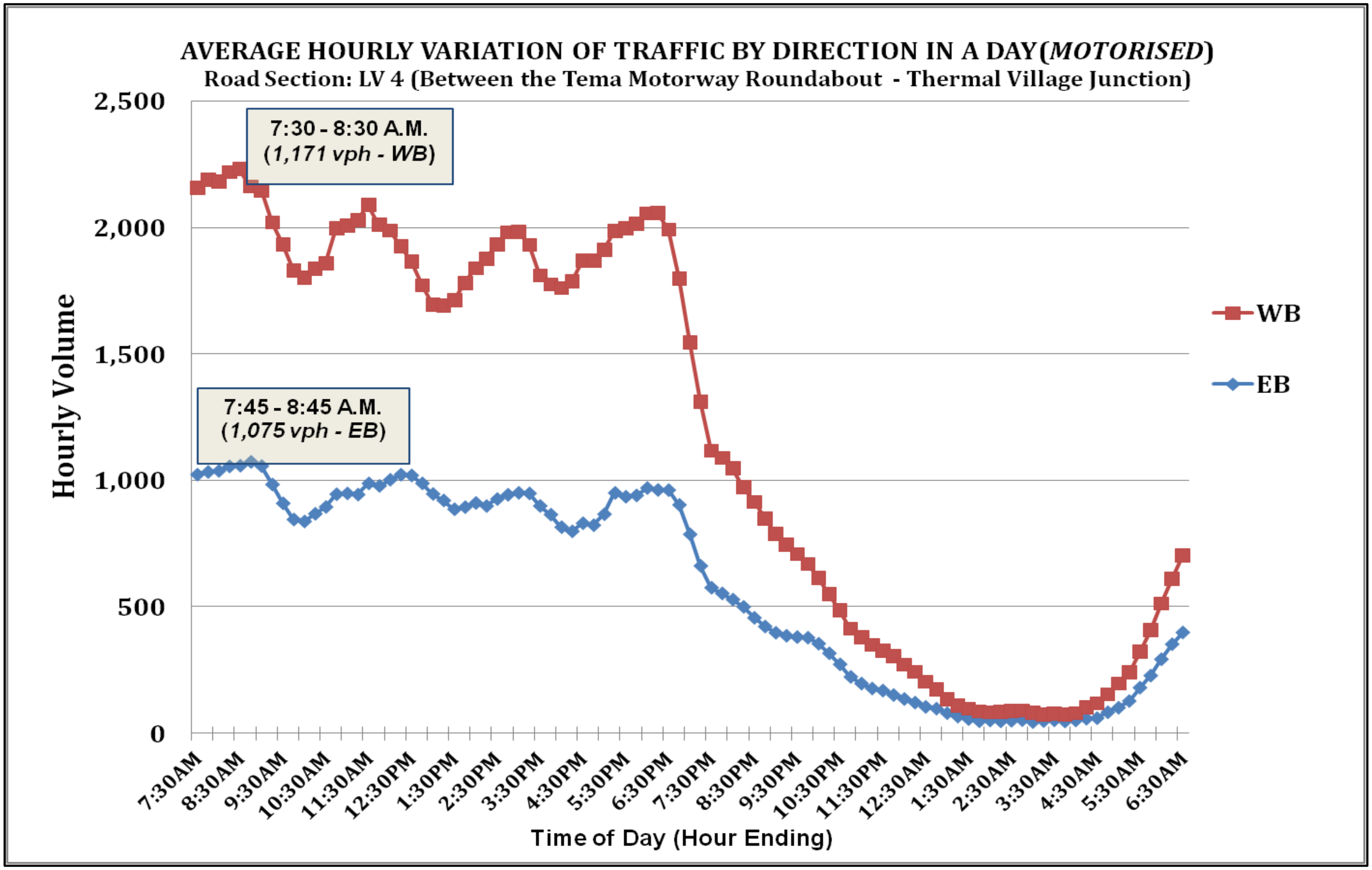

Figure 3.12: Average Hourly Traffic Variation by Direction for Motorised Traffic

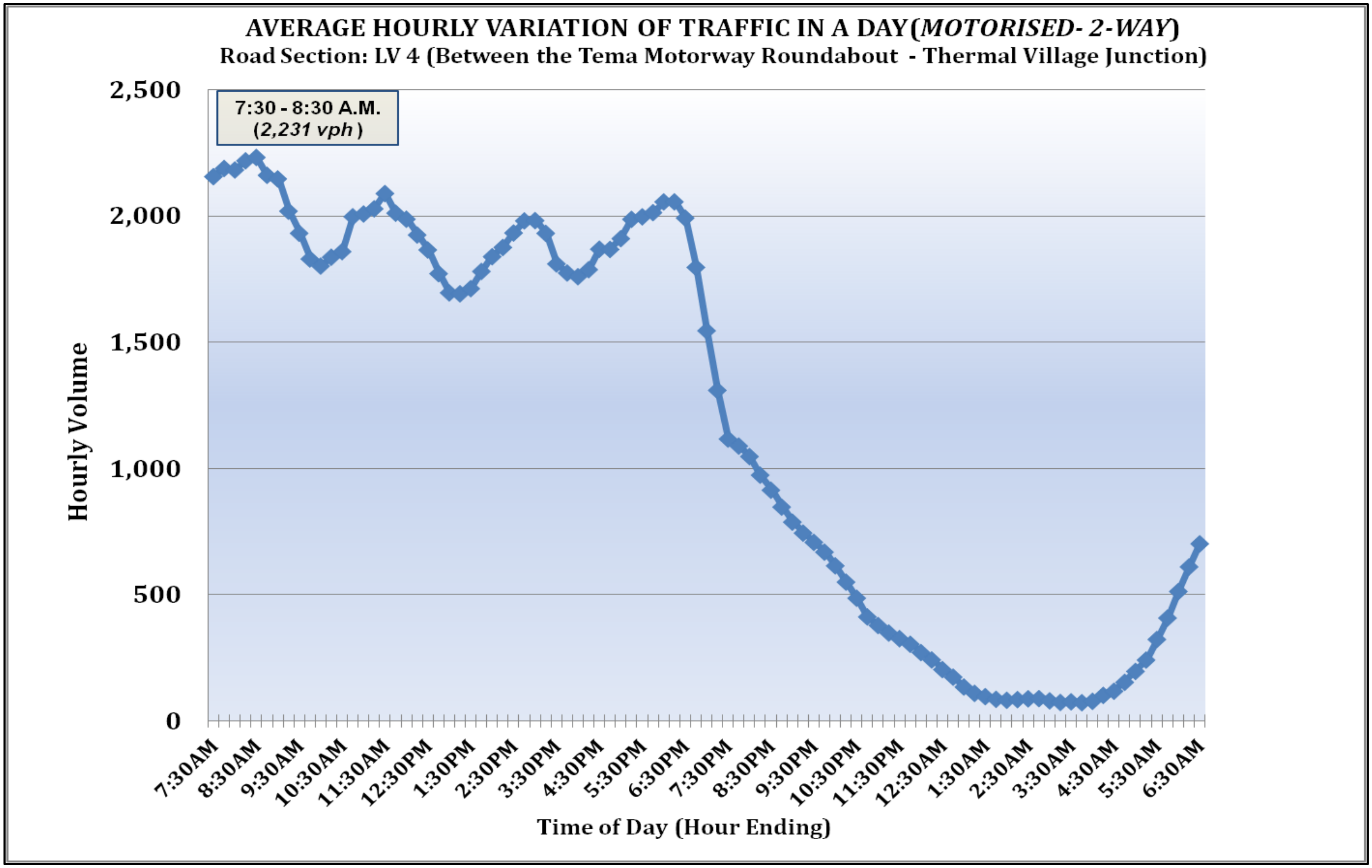

Figure 3.13: Average Hourly Traffic Variation in a Day (Motorised)

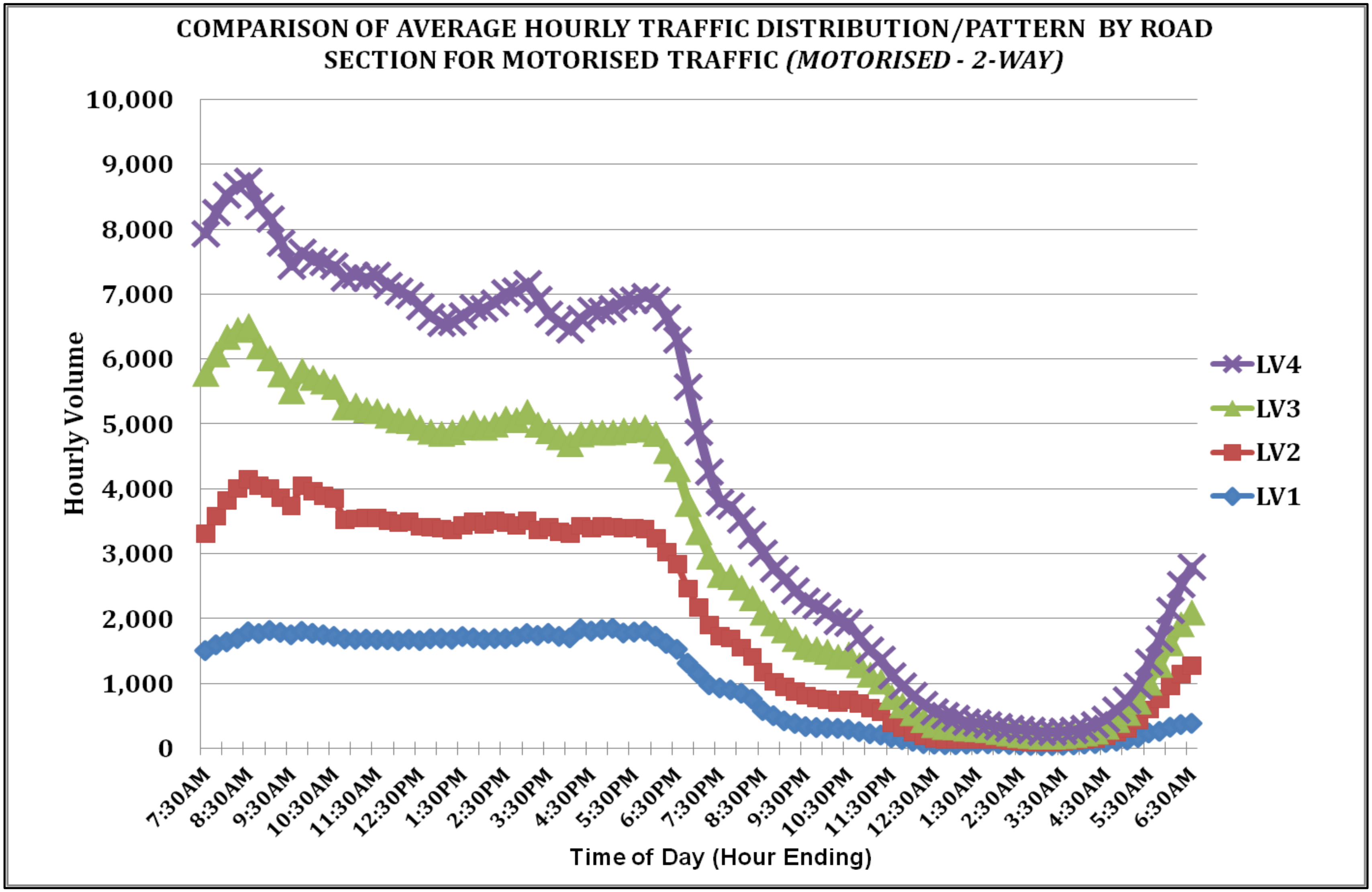

Figure 3.14: Comparison of Average Hourly Traffic Distribution/Pattern by Road Section for Motorised Traffic

3. 3. PEAK HOUR VOLUME (PHV)

The Peak Hour Volume (PHV) comprises the peak hour traffic data for the Morning (AM), Afternoon (AFT), Evening (PM) and 24-hour periods, including composition by vehicle group. Figure 3.15 and 3.16 depicts the comparison of PHV by road sections.

3.3.1 Road Section 1 (LV1): Between Tema Port and the Harbour Roundabout ≈ 1km

Table 3.10 and 3.11 gives the summaries of the Peak hour traffic data for motorised traffic and bicycles respectively.

The following can be observed from Table 3.11:

- The Morning Peak Hour Volume of 1,819 vph occurred during the period 8:00-9:00 a.m.. This is composed of about 89.8 percent Light, 3.5 percent Medium and 6.7 percent Heavy vehicle groups.
- The Afternoon Peak Hour occurred during the period 2:00-3:00 p.m. with a recorded traffic volume of 1,772 vph.
- The Evening occurred during the period 4:00-5:00 p.m. with a recorded traffic volume of 1,852 vph.
- The highest total 3-hour volume of 6,790 vehicles occurred during the Morning (AM) peak period and the lowest volume of 5,151 vehicles occurred during the Afternoon (AFT) peak period.
- The highest percentage of Medium and Heavy vehicle groups occurred during the Afternoon (AFT) peak period. The respective values are 3.5 percent and 13.6 percent.

The following can be observed from Table 3.12:

- The Morning Peak Hour Volume of 28 vph occurred during the period 6:30-7:30 a.m.
- The Afternoon Peak Hour occurred during the period 12:45-1:45 p.m. and that of the Evening occurred during the period 5:30-6:30 p.m. Their volumes are 15 vph and 23 vph respectively.
- The highest total 3-hour volume of 54 bicycles also occurred during the Morning (AM) period

Table 3.10: Summary of Peak Hour Traffic data (Motorised)

SUMMARY OF PEAK HOUR TRAFFIC DATA (MOTORISED TRAFFIC)							
Road Section: Tema Port - Harbour Roundabout							
MORNING Peak Period: 6:30-9:30 AM - AVERAGE DAY							
Direction	**Peak Hour Vol. (veh/h)**	***Percent Light (%)***	***Percent Medium (%)***	***Percent Heavy (%)***	***Percent Total (%)***	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	887	*88.6*	*4.2*	*7.2*	***100.0***	2,336	8:30-9:30 AM
SB	1,026	*91.4*	*3.5*	*5.1*	***100.0***	2,726	7:30-8:30 AM
2-WAY	1,819	*89.8*	*3.5*	*6.7*	***100.0***	6,790	8:00-9:00 AM
AFTERNOON Peak Period: 12:00-3:00 PM - AVERAGE DAY							
Direction	**Peak Hour Vol. (veh/h)**	***Percent Light (%)***	***Percent Medium (%)***	***Percent Heavy (%)***	***Percent Total (%)***	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	888	*84.3*	*2.6*	*13.1*	***100.0***	2,555	2:00-3:00 PM
SB	891	*84.2*	*4.0*	*11.8*	***100.0***	2,595	12:30-1:30 PM
2-WAY	1,772	*82.9*	*3.5*	*13.6*	***100.0***	5,151	2:00-3:00 PM
EVENING Peak Period: 3:30-6:30 PM - AVERAGE DAY							
Direction	**Peak Hour Vol. (veh/h)**	***Percent Light (%)***	***Percent Medium (%)***	***Percent Heavy (%)***	***Percent Total (%)***	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	1,016	*83.7*	*3.2*	*13.1*	***100.0***	2,627	4:45-5:45 PM
SB	1,010	*84.1*	*3.6*	*12.3*	***100.0***	2,243	3:30-4:30 PM
2-WAY	1,852	*84.3*	*3.0*	*12.6*	***100.0***	5,133	4:00-5:00 PM
24 HOURS PEAK HOUR ANALYSIS - AVERAGE DAY							
Direction	**Peak Hour Vol. (veh/h)**	***Percent Light (%)***	***Percent Medium (%)***	***Percent Heavy (%)***	***Percent Total (%)***	**Total 24-hr. Vol. (veh)**	**Peak Hour**
NB	1,016	*83.7*	*3.2*	*13.1*	***100.0***	12,320	4:45-5:45 PM
SB	1,038	*83.5*	*3.9*	*12.5*	***100.0***	12,890	3:15-4:15 PM
2-WAY	1,852	*84.3*	*3.0*	*12.6*	***100.0***	25,211	4:00-5:00 PM

Table 3.11: Summary of Peak Hour Traffic data (Bicycles)

SUMMARY OF PEAK HOUR TRAFFIC DATA (BICYCLES)			
Road Section: Tema Port - Harbour Roundabout			
MORNING Peak Period: 6:30-9:30 AM - AVERAGE DAY			
Direction	**Peak Hour Vol. (veh/h)**	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	12	28	6:45-7:45 AM
SB	16	26	6:30-7:30 AM
2-WAY	28	54	6:30-7:30 AM
AFTERNOON Peak Period: 12:00-3:00 PM - AVERAGE DAY			
Direction	**Peak Hour Vol. (veh/h)**	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	10	24	12:15-1:15 PM
SB	7	13	12:30-1:30 PM
2-WAY	15	37	12:30-1:30 PM
EVENING Peak Period: 3:30-6:30 PM - AVERAGE DAY			
Direction	**Peak Hour Vol. (veh/h)**	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	10	19	5:30-6:30 PM
SB	13	29	5:30-6:30 PM
2-WAY	23	48	5:30-6:30 PM
24 HOURS PEAK HOUR ANALYSIS - AVERAGE DAY			
Direction	**Peak Hour Vol. (veh/h)**	**Total 24-hr. Vol. (veh)**	**Peak Hour**
NB	12	107	6:45-7:45 AM
SB	16	93	6:30-7:30 AM
2-WAY	28	200	6:30-7:30 AM

3.3.2 Road Section 2 (LV2): Road section between the Harbour Roundabout - Community Four Roundabout ≈ 2km

Table 3.12 and 3.13 gives the summaries of the Peak hour traffic data for motorised traffic and bicycles respectively.

The following can be observed from Table 3.12:

- The Morning Peak Hour Volume of 2,349 vph occurred during the period 8:00-9:00 a.m. This is composed of about 87.9 percent Light, 7.3 percent Medium and 4.8 percent Heavy vehicle groups.
- The Afternoon Peak Hour occurred during the period 1:15-2:15 p.m. with a recorded traffic volume of 1,813 vph
- The Evening occurred during the period 4:15-5:15 p.m. with a recorded traffic volume of 1,614 vph.
- The highest total 3-hour volume of 8,255 vehicles occurred during the Morning (AM) peak period and the lowest volume of 4,489 vehicles occurred during the Evening (PM) peak period.
- The highest percentage of Medium and Heavy vehicle groups occurred during the Afternoon (AFT) peak period. The respective values are 7.0 percent and 11.4 percent

The following can be observed from Table 3.13:

- The Morning Peak Hour Volume of 9 vph occurred during the period 6:45-7:45 a.m.
- The Afternoon Peak Hour occurred during the period 12:15-1:15 p.m. and that of the Evening occurred during the period 4:45-5:45 p.m. Their volumes are 15 vph and 7 vph respectively.
- The highest total 3-hour volume of 27 bicycles also occurred during the Evening (PM) period

Table 3.12: Summary of Average Hourly Distribution by direction for Motorised Traffic

SUMMARY OF PEAK HOUR TRAFFIC DATA (MOTORISED TRAFFIC)							
Road Section: Habour Roundabout - Community Four Roundabout (LV 2)							
MORNING Peak Period: 6:30-9:30 AM - AVERAGE DAY							
Direction	**Peak Hour Vol. (veh/h)**	***Percent Light (%)***	***Percent Medium (%)***	***Percent Heavy (%)***	***Percent Total (%)***	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	788	*80.5*	*10.5*	*8.9*	***100.0***	2,146	8:15-9:15 AM
SB	1,591	*91.5*	*4.8*	*3.7*	***100.0***	3,991	7:30-8:30 AM
2-WAY	2,349	*87.9*	*7.3*	*4.8*	***100.0***	8,255	7:30-8:30 AM
AFTERNOON Peak Period: 12:00-3:00 PM - AVERAGE DAY							
Direction	**Peak Hour Vol. (veh/h)**	***Percent Light (%)***	***Percent Medium (%)***	***Percent Heavy (%)***	***Percent Total (%)***	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	835	*77.4*	*9.8*	*12.9*	***100.0***	2,368	1:30-2:30 PM
SB	1,012	*85.0*	*5.2*	*9.8*	***100.0***	2,823	1:15-2:15 PM
2-WAY	1,813	*81.6*	*7.0*	*11.4*		5,191	1:15-2:15 PM
EVENING Peak Period: 3:30-6:30 PM - AVERAGE DAY							
Direction	**Peak Hour Vol. (veh/h)**	***Percent Light (%)***	***Percent Medium (%)***	***Percent Heavy (%)***	***Percent Total (%)***	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	787	*78.6*	*6.6*	*14.8*	***100.0***	2,158	4:45-5:45 PM
SB	856	*83.8*	*5.5*	*10.7*	***100.0***	2,092	3:45-4:45 PM
2-WAY	1,614	*81.6*	*6.4*	*11.9*	***100.0***	4,489	4:15-5:15 PM
24 HOURS PEAK HOUR ANALYSIS - AVERAGE DAY							
Direction	**Peak Hour Vol. (veh/h)**	***Percent Light (%)***	***Percent Medium (%)***	***Percent Heavy (%)***	***Percent Total (%)***	**Total 24-hr. Vol. (veh)**	**Peak Hour**
NB	1,071	*87.5*	*6.1*	*6.4*	***100.0***	12,311	8:45-9:45 AM
SB	1,591	*91.5*	*4.8*	*3.7*	***100.0***	15,505	7:30-8:30 AM
2-WAY	2,349	*87.9*	*7.3*	*4.8*	***100.0***	27,816	7:30-8:30 AM

Table 3.13: Summary of Average Hourly Distribution by direction for Bicycles

SUMMARY OF PEAK HOUR TRAFFIC DATA (BICYCLES)			
Road Section: Habour Roundabout - Community Four Roundabout (LV 2)			
MORNING Peak Period: 6:30-9:30 AM - AVERAGE DAY			
Direction	**Peak Hour Vol. (veh/h)**	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	4	7	6:30-7:30 AM
SB	6	8	6:45-7:45 AM
2-WAY	9	16	6:45-7:45 AM
AFTERNOON Peak Period: 12:00-3:00 PM - AVERAGE DAY			
Direction	**Peak Hour Vol. (veh/h)**	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	4	9	12:30-1:30 PM
SB	3	6	1:15-2:15 PM
2-WAY	7	16	12:15-1:15 PM
EVENING Peak Period: 3:30-6:30 PM - AVERAGE DAY			
Direction	**Peak Hour Vol. (veh/h)**	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	10	15	4:45-5:45 PM
SB	6	11	4:30-5:30 PM
2-WAY	15	27	4:45-5:45 PM
24 HOURS PEAK HOUR ANALYSIS - AVERAGE DAY			
Direction	**Peak Hour Vol. (veh/h)**	**Total 24-hr. Vol. (veh)**	**Peak Hour**
NB	10	52	4:45-5:45 PM
SB	6	41	4:30-5:30 PM
2-WAY	15	93	4:45-5:45 PM

3.3.3 Road Section 3 (LV3): Road section Between the Community four(4) Roundabout - Tema Motorway Roundabout ≈ 3.9km

Table 3.14 and 3.15 gives the summaries of the Peak hour traffic data for motorised traffic and bicycles respectively.

The following can be observed from Table 3.14:

- The Morning Peak Hour Volume of 2,526 vph occurred during the period 7:00-8:00 a.m. This is composed of about 91.1 percent Light, 4.7 percent Medium and 4.2 percent Heavy vehicle groups.
- The Afternoon Peak Hour occurred during the period 2:00-3:00 p.m. with a recorded traffic volume of 1,682 vph.
- The Evening occurred during the period 5:00-6:00 p.m. with a recorded traffic volume of 1,605 vph.
- The highest total 3-hour volume of 8,318 vehicles occurred during the Morning (AM) peak period and the lowest volume of 4,476 vehicles occurred during the Evening (PM) peak period.
- The highest percentage of Medium and Heavy vehicle groups occurred during the Afternoon (AFT) peak period. The respective values are 5.3 percent and 9.7 percent.

The following can be observed from Table 3.15:

- The Morning Peak Hour Volume of 32 vph occurred during the period 6:30-7:30 a.m.
- The Afternoon Peak Hour occurred during the period 12:15-1:15 p.m. and that of the Evening occurred during the period 5:15-6:15 p.m. Their volumes are 15 vph and 53 vph respectively.
- The highest total 3-hour volume of 97 bicycles also occurred during the Evening (PM) period

Table 3.14: Summary of Average Hourly Distribution by direction for Motorised Traffic

SUMMARY OF PEAK HOUR TRAFFIC DATA (MOTORISED TRAFFIC)							
Road Section: Tema Roundabout - Community Four Roundabout (LV 3)							
MORNING Peak Period: 6:30-9:30 AM - AVERAGE DAY							
Direction	**Peak Hour Vol. (veh/h)**	***Percent Light (%)***	***Percent Medium (%)***	***Percent Heavy (%)***	***Percent Total (%)***	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	880	*89.8*	*5.2*	*5.0*	***100.0***	2,478	6:30-7:30 AM
SB	1,680	*92.0*	*4.3*	*3.7*	***100.0***	4,112	7:00-8:00 AM
2-WAY	2,526	*91.1*	*4.7*	*4.2*	***100.0***	8,318	7:00-8:00 AM
AFTERNOON Peak Period: 12:00-3:00 PM - AVERAGE DAY							
Direction	**Peak Hour Vol. (veh/h)**	***Percent Light (%)***	***Percent Medium (%)***	***Percent Heavy (%)***	***Percent Total (%)***	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	680	*82.9*	*5.6*	*11.4*	***100.0***	1,985	2:00-3:00 PM
SB	1,001	*86.4*	*5.1*	*8.6*	***100.0***	2,654	2:00-3:00 PM
2-WAY	1,682	*85.0*	*5.3*	*9.7*		4,638	2:00-3:00 PM
EVENING Peak Period: 3:30-6:30 PM - AVERAGE DAY							
Direction	**Peak Hour Vol. (veh/h)**	***Percent Light (%)***	***Percent Medium (%)***	***Percent Heavy (%)***	***Percent Total (%)***	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	854	*87.6*	*5.1*	*7.3*	***100.0***	2,200	5:15-6:15 PM
SB	872	*86.8*	*5.5*	*7.6*	***100.0***	2,119	3:30-4:30 PM
2-WAY	1,605	*87.8*	*5.0*	*7.2*	***100.0***	4,476	5:00-6:00 PM
24 HOURS PEAK HOUR ANALYSIS - AVERAGE DAY							
Direction	**Peak Hour Vol. (veh/h)**	***Percent Light (%)***	***Percent Medium (%)***	***Percent Heavy (%)***	***Percent Total (%)***	**Total 24-hr. Vol. (veh)**	**Peak Hour**
NB	880	*89.8*	*5.2*	*5.0*	***100.0***	12,359	6:30-7:30 AM
SB	1,680	*92.0*	*4.3*	*3.7*	***100.0***	16,539	7:00-8:00 AM
2-WAY	2,526	*91.1*	*4.7*	*4.2*	***100.0***	28,899	7:00-8:00 AM

Table 3.15: Summary of Average Hourly Distribution by direction for Bicycles

SUMMARY OF PEAK HOUR TRAFFIC DATA (BICYCLES)			
Road Section: Tema Roundabout - Community Four Roundabout (LV 3)			
MORNING Peak Period: 6:30-9:30 AM - AVERAGE DAY			
Direction	**Peak Hour Vol. (veh/h)**	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	15	30	6:30-7:30 AM
SB	19	34	7:00-8:00 AM
2-WAY	32	64	6:30-7:30 AM
AFTERNOON Peak Period: 12:00-3:00 PM - AVERAGE DAY			
Direction	**Peak Hour Vol. (veh/h)**	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	13	29	12:15-1:15 PM
SB	2	3	12:15-1:15 PM
2-WAY	15	32	12:15-1:15 PM
EVENING Peak Period: 3:30-6:30 PM - AVERAGE DAY			
Direction	**Peak Hour Vol. (veh/h)**	**Total 3-hr. Vol. (veh)**	**Peak Hour**
NB	46	85	5:15-6:15 PM
SB	7	12	5:00-6:00 PM
2-WAY	53	97	5:15-6:15 PM
24 HOURS PEAK HOUR ANALYSIS - AVERAGE DAY			
Direction	**Peak Hour Vol. (veh/h)**	**Total 24-hr. Vol. (veh)**	**Peak Hour**
NB	46	216	5:15-6:15 PM
SB	19	81	7:00-8:00 AM
2-WAY	53	297	5:15-6:15 PM

3.3.4 Road Section 4 (LV4): Road section between Tema Motorway Roundabout - Thermal Village Junction ≈ 2.3km

Table 3.16 and 3.17 gives the summaries of the Peak hour traffic data for motorised traffic and bicycles respectively.

The following can be observed from Table 3.16:

- The Morning Peak Hour Volume of 2,231 vph occurred during the period 7:30-8:30 a.m. This is composed of about 90.1 percent Light, 5.1percent Medium and 4.7 percent Heavy vehicle groups.
- The Afternoon Peak Hour occurred during the period 2:00-3:00 p.m. with a recorded traffic volume of 1,981vph.
- The Evening occurred during the period 5:15-6:15 p.m. with a recorded traffic volume of 2,055 vph.
- The highest total 3-hour volume of 8,175 vehicles occurred during the Morning (AM) peak period and the lowest volume of 5,514 vehicles occurred during the Afternoon (AFT) peak period.
- The highest percentage of Medium and Heavy vehicle groups occurred during the Afternoon (AFT) peak period. The respective values are 6.0 percent and 8.6 percent

The following can be observed from Table 3.17:

- The Morning Peak Hour Volume of 22 vph occurred during the period 7:00-8:00 a.m.
- The Afternoon Peak Hour occurred during the period 1:45-2:45 p.m. and that of the Evening occurred during the period 5:30-6:30 p.m. Their volumes are 8 vph and 28 vph respectively.
- The highest total 3-hour volume of 56 bicycles also occurred during the Evening (PM) period

Table 3.16: Summary of Average Hourly Distribution by direction for Motorised Traffic

SUMMARY OF PEAK HOUR TRAFFIC DATA (MOTORISED TRAFFIC)							
Road Section: Tema Roundabout - Thermal Village (LV 4)							
MORNING Peak Period: 6:30-9:30 AM - AVERAGE DAY							
Direction	**Peak Hour Vol. (veh/h)**	***Percent Light (%)***	***Percent Medium (%)***	***Percent Heavy (%)***	***Percent Total (%)***	**Total 3-hr. Vol. (veh)**	**Peak Hour**
EB	1,075	*88.2*	*7.2*	*4.7*	***100.0***	2,995	7:45-8:45 AM
WB	1,171	*93.0*	*2.6*	*4.4*	***100.0***	3,322	7:30-8:30 AM
2-WAY	2,231	*90.1*	*5.1*	*4.7*	***100.0***	8,175	7:30-8:30 AM
AFTERNOON Peak Period: 12:00-3:00 PM - AVERAGE DAY							
Direction	**Peak Hour Vol. (veh/h)**	***Percent Light (%)***	***Percent Medium (%)***	***Percent Heavy (%)***	***Percent Total (%)***	**Total 3-hr. Vol. (veh)**	**Peak Hour**
EB	952	*86.7*	*6.2*	*7.1*	***100.0***	2,812	2:00-3:00 PM
WB	1,035	*84.1*	*5.6*	*10.3*	***100.0***	2,702	1:45-2:45 PM
2-WAY	1,981	*85.4*	*6.0*	*8.6*		5,514	2:00-3:00 PM
EVENING Peak Period: 3:30-6:30 PM - AVERAGE DAY							
Direction	**Peak Hour Vol. (veh/h)**	***Percent Light (%)***	***Percent Medium (%)***	***Percent Heavy (%)***	***Percent Total (%)***	**Total 3-hr. Vol. (veh)**	**Peak Hour**
EB	971	*88.4*	*5.9*	*5.7*	***100.0***	2,732	5:00-6:00 PM
WB	1,092	*88.7*	*5.6*	*5.7*	***100.0***	2,883	5:15-6:15 PM
2-WAY	2,055	*88.6*	*5.7*	*5.7*	***100.0***	5,855	5:15-6:15 PM
24 HOURS PEAK HOUR ANALYSIS - AVERAGE DAY							
Direction	**Peak Hour Vol. (veh/h)**	***Percent Light (%)***	***Percent Medium (%)***	***Percent Heavy (%)***	***Percent Total (%)***	**Total 24-hr. Vol. (veh)**	**Peak Hour**
EB	1,075	*88.2*	*7.2*	*4.7*	***100.0***	15,423	7:45-8:45 AM
WB	1,171	*93.0*	*2.6*	*4.4*	***100.0***	15,750	7:30-8:30 AM
2-WAY	2,231	*90.1*	*5.1*	*4.7*	***100.0***	31,173	7:30-8:30 AM

Table 3.17: Summary of Average Hourly Distribution by direction for Bicycles

SUMMARY OF PEAK HOUR TRAFFIC DATA (BICYCLES)			
Road Section: Tema Roundabout - Thermal Village (LV 4)			
MORNING Peak Period: 6:30-9:30 AM - AVERAGE DAY			
Direction	**Peak Hour Vol. (veh/h)**	**Total 3-hr. Vol. (veh)**	**Peak Hour**
EB	17	34	7:00-8:00 AM
WB	7	13	7:30-8:30 AM
2-WAY	22	47	7:00-8:00 AM
AFTERNOON Peak Period: 12:00-3:00 PM - AVERAGE DAY			
Direction	**Peak Hour Vol. (veh/h)**	**Total 3-hr. Vol. (veh)**	**Peak Hour**
EB	5	11	1:30-2:30 PM
WB	4	8	2:00-3:00 PM
2-WAY	8	19	1:45-2:45 PM
EVENING Peak Period: 3:30-6:30 PM - AVERAGE DAY			
Direction	**Peak Hour Vol. (veh/h)**	**Total 3-hr. Vol. (veh)**	**Peak Hour**
EB	9	18	5:00-6:00 PM
WB	19	37	5:30-6:30 PM
2-WAY	28	56	5:30-6:30 PM
24 HOURS PEAK HOUR ANALYSIS - AVERAGE DAY			
Direction	**Peak Hour Vol. (veh/h)**	**Total 24-hr. Vol. (veh)**	**Peak Hour**
EB	17	90	7:00-8:00 AM
WB	19	79	5:30-6:30 PM
2-WAY	28	168	5:30-6:30 PM

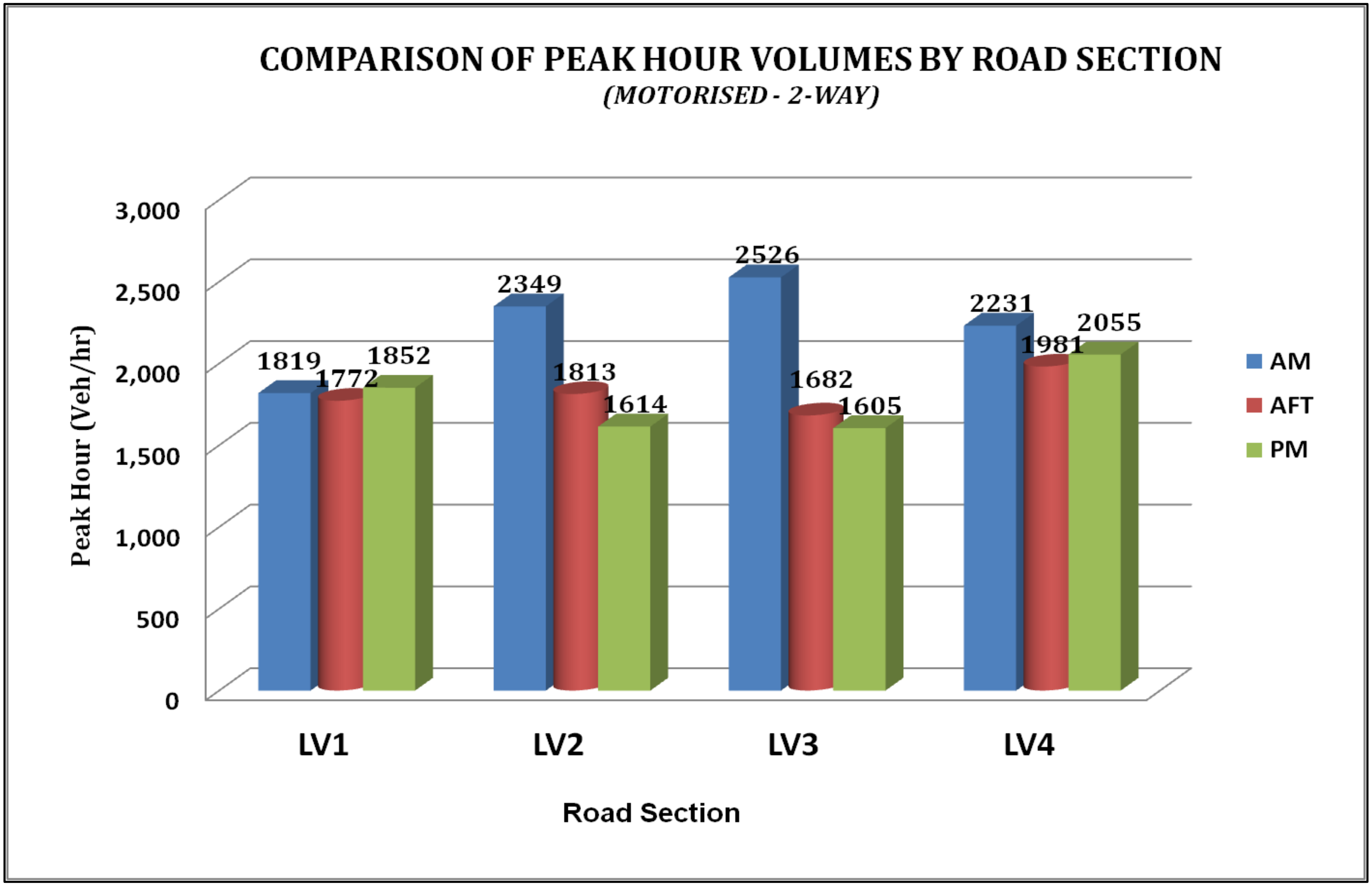

Figure 3.15: Comparison of Peak Hour Volumes by Road Section (Motorised)

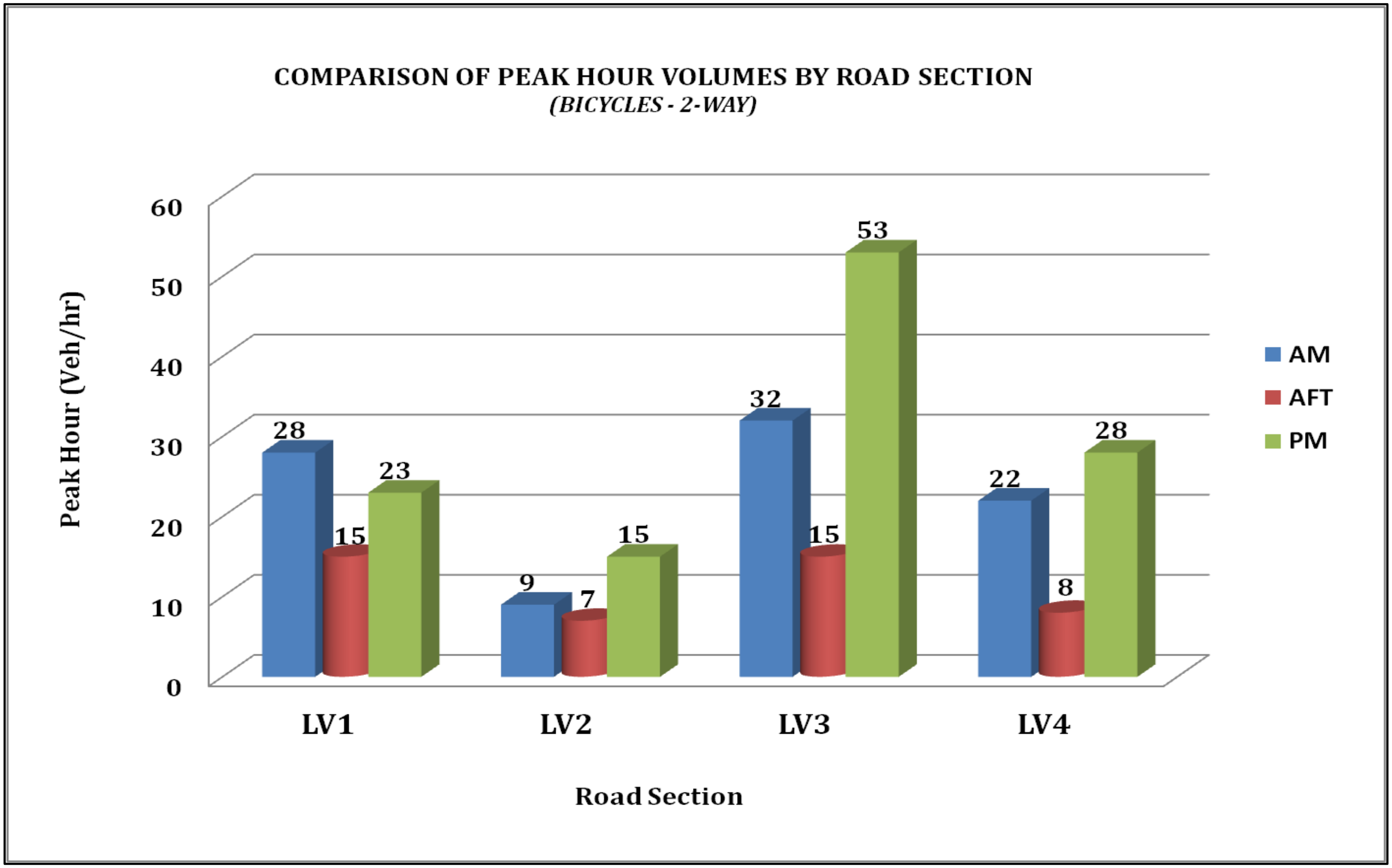

Figure 3.16: Comparison of Peak Hour Volumes by Road Section (Bicycles)

4. CONCLUSIONS AND RECOMMENDATIONS

This Chapter presents the conclusions for the studies carried and some recommendations regarding the suitable period to move materials to the thermal plant site.

4.1. CONCLUSIONS

The following can be concluded from the fore-going results and analyses:

- The road corridor under consideration is steadily busy with traffic between 5:30 a.m. and 8:30 p.m.
- The road section between the Tema Roundabout and the Thermal Village junction has the highest traffic volume of 31,342 vpd. The corresponding peak hour periods recorded were 7:30 a.m. – 8:30 a.m. (Morning peak), 2:00 p.m. – 3:00 p.m. (Afternoon peak) and 5:15 p.m. – 6:15 p.m. (Evening peak)
- The period between 9:00 p.m. and 5:00 a.m. has very low vehicular movements
- The highest number of vehicles under the Medium and Heavy group uses the road corridor during the afternoon peak period (12:00 p.m. to 3:00 p.m.)

4.2. RECOMMENDATIONS

- It is recommended that the best period for transporting the items from the Tema Port to the Plant Site is during the off-peak period (9:00 p.m. to 5:00 a.m.).
- On the other hand, if the items are to be transported during the day, it is recommended that it should be between 10:00 a.m. and 3:00 p.m.

Appendix E2

Delivery Route Survey Report

GHANA BRIDGE POWER PROJECT – DELIVERY ROUTE SURVEY REPORT

1.0 Introduction

The Consultant was requested to advise the Client on the best possible delivery route to the project site based on the knowledge of the area and the existing traffic situation.

A route survey was therefore undertaken on Friday 16th May 2015 to identify the conditions on the routes identified by the Client as well as alternative routes, if any.

The findings from this survey are presented in the following sections.

Figure 1: Proposed Delivery Routes

LEGEND

Delivery Route to the Tank Farm

Delivery Route to the Power Site

Alternative Delivery Route to the Power Site

2.0 Proposed Delivery Route to the Tank Farm (via Valco Road)

- This route is approximately 8.4km long from the Tema Port to the Tank Farm.
- The section between the Port and the Valco Roundabout (Harbour Road) is a 2-lane dual carriageway asphaltic concrete road with generally good riding quality.

- Approximately 300m length of the Valco Road (from the Valco Roundabout) is a 2-lane dual carriage asphaltic concrete road with good riding quality.
- Beyond the dual carriageway section, the Valco Road narrows into a single carriageway asphaltic concrete road approximately 1.4km long then a surface dressed carriageway approximately 1.6km long. Potholes were observed along the surface-dressed section of the route.

Figure 2: Dual carriage-way section of Valco Road (PIC 1)

- The section of the route off the Valco Road is a gravel road approximately 1.1km to the tank farm. This section has a relatively poor riding surface characterized by muddy areas when it rains.

Figure 3: Intersection of surface-dressed and gravel sections of the route (PIC 2)

Figure 4: Muddy area on gravel section of the route (PIC 3)

- Generally, traffic is heavy on the Harbour Road section during the peak periods. Major intersections along this section are rotary and are characterised by congestion and queuing at the approaches.
- Traffic volumes on the Valco Road section is relatively low compared to the Harbour Road particularly during the weekends.

3.0 Proposed Delivery Route to the Power Site - (via Harbour Road and Aflao Road)

- The route is a 12.3km 2-lane dual carriageway beginning from the Port through the Harbour Road and the Aflao Road to the Power Site.
- The route is paved with asphaltic concrete and has a good riding surface.
- There are five (5) rotary intersections along the route several of which pose major bottlenecks to traffic flow on an average weekday. The Motorway Roundabout in particular is congested everyday of the week for the greater part of the day.

- Traffic volumes on the corridor during weekends are relatively lower compared to the weekdays.
- Congestion at the major intersections was observed during the Morning (6:30 am – 9:00am), Afternoon (12:00pm – 2:00pm) and Evening (5:00pm – 9:00pm) peak periods.
- Traffic volumes on the corridor during the night time (from 9:00 pm) are relatively lower.

Figure 5: Section of the Harbour Road

4.0 Alternative Delivery Route to the Power Site (via Steel Works Road)

- This route is approximately 12.2km long via the Valco Road.
- The route begins from the Port through the Harbour Road and Valco Road which are paved with relatively good riding conditions.
- The Steel Works Road section of the route begins about 1km from the Valco Roundabout and runs parallel to the Harbour Road and then the Aflao Road until it meets the access road to the Power Site (near GRIDCo).
- The Steel Works Road is paved with surface dressing for the first 1.72km and unpaved (gravel road) for another 2.5km.

Figure 6: Surface dressed section of the Steel Works Road (PIC. 4)

- Riding quality of the paved section of the Steel Works road is generally good. Portions of the gravel section have poor riding quality with some muddy areas observed.

Figure 7: Gravel section of the Steel Works Road (PIC. 5)

Figure 7: Potholes on the gravel section of the Steel Works Road (PIC. 6)

- Traffic on the Steel Works Road is generally very low compared to the proposed route.

5.0 Comparison between the Proposed and Alternative Routes to the Power Site

Item No.	Proposed Route (via Harbour Road)	Alternative Route (via Steel Works Road)
1.	Paved with asphaltic concrete along the Harbour Road and Aflao Road	1.72km paved with bituminous surface dressing and the remaining 2.5km unpaved (gravel surface)
2.	Generally good riding quality	Relatively good riding quality along paved sections but poor riding quality along unpaved section
3.	Several rotary intersections along route which pose major bottlenecks to traffic flow	No major bottlenecks along the Steel Works Road
4.	Relatively high traffic volume along the route	Low traffic volumes along the route
5.	Average travel time is generally high due to congestion at approaches to major intersections	Average travel time is relatively low

6.0 Conclusion and Recommendation

The following can be concluded from the findings/observations:

- The proposed delivery route to the Tank Farm via the Valco Road is a feasible route. The Harbour Road and Valco Road sections which make up the greater part of the route are paved with generally good riding quality, and the 0.7km unpaved section has a relatively poor riding quality.
- The proposed route to the Power Site via the Harbour Road and the Aflao Road has very good riding quality however it is characterized by heavy traffic and congestion particularly at the major rotary intersections along the route.
- The alternative route to the Power Site via the Steel Works Road is paved from the Port through the Valco Road and about 1.72km of the Steel Works Road with generally good riding quality although the remaining 2.5km of the route is unpaved with generally poor riding quality. The route also has lower traffic volumes compared with the proposed route resulting in shorter average travel time.

It is recommended that the alternative route via the Steel Works Road should be used, since it would be more practicable compared with the proposed route to the Power Site.

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Jacobs Consultancy
Petroleum, Chemicals & Energy Practice
Tower Bridge Court
226 Tower Bridge Road
London SE1 2UP

ENDEAVOR

SAGE Petroleum Limited

Ghana Bridge Power Project

Environmental and Social Impact Assessment

Appendix F - EPA Screening Response

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

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667524 / 0289673960 / 1 / 2
Fax: 233 (0302) 662690
Email: info@epa.gov.gh

Environmental Protection Agency

P. O. Box MB 326
Ministries Post Office
Accra
Website: http://www.epa.gov.gh

Our Ref: CE: 4956/01/02

February 19, 2015

The Project Representative
Early Power Limited
Stanbic Heights
Airport City, Accra

Dear Sir,

APPLICATION FOR ENVIRONMENTAL PERMIT
PROPOSED GHANA BRIDGE POWER PROJECT

We acknowledge receipt of the completed Environmental Assessment Registration Form (EA1) submitted to the Agency on the above proposal for the purpose of obtaining approval in accordance with the Environmental Assessment Regulations 1999 (LI 1652).

The Application is currently being processed and the outcome would be communicated to you in due course.

Do not hesitate to consult with the EPA Head Office (Room 305) for further guidance.

Yours faithfully,

JOHN LEONARD DOGHLE
PO/EAA
FOR: EXECUTIVE DIRECTOR

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Environmental Protection Agency
P. O. Box MB 326
Ministries Post Office
Accra
Website: http://www.epa.gov.gh

Our Ref: CE: 4956/01/03

February 23, 2015

The Project Representative
Early Power Limited
Stanbic Heights
Airport City, Accra

Dear Sir,

PRELIMINARY ENVIRONMENTAL ASSESSMENT (PEA)
PROPOSED GHANA BRIDGE POWER PROJECT LOCATED AT TEMA IN THE TEMA METROPOLIS OF THE GREATER ACCRA REGION

We acknowledge receipt of the completed Environmental Assessment Registration Form (EA1) submitted on the above proposal to the Agency for the purpose of obtaining environmental permit, in accordance with the Environmental Assessment Regulations, 1999 (LI 1652).

The project application has been reviewed and you are required to undertake a Preliminary Environmental Assessment (PEA) to facilitate understanding of the likely implications of the proposal, the relevant alternatives and mitigations to consider, in order to ensure sound decision-making and sustainable implementation of the project.

The following areas/issues among others must be considered in the study:

- Detailed description of proposed project
- Public health and safety issues
- Occupational safety and hazards
- Impact on the environment as well as air quality
- Impact on socio-economic activities

This must include air modelling in order to understand emission levels and the state of the air shed. The information must be packaged in a Preliminary Environmental Report (PER) and eight (08) copies of the report submitted to the Agency in line with LI 1652, and the Ghana EIA Procedures.

Please find attached a format to guide the preparation of a PER.

Do not hesitate to contact the Agency for any further guidance or clarification you may require in this regard.

Yours faithfully,

KWABENA BADU-YEBOAH
Ag. Director/EAA Division
For: Executive Director

FORMAT FOR PRELIMINARY ENVIRONMENTAL REPORT

1. Non-Technical Executive Summary

- Brief description of the project and the environment,
- Brief Description of the main impacts and mitigation measures to be undertaken

2. Introduction

- Description of the purpose and objectives of the undertaking
- Overview of relevant policy, legislative and regulatory framework

3. Description of the Undertaking

- Description of the nature, scope and scale of the development
- Detailed description of the project components and stages including description of production processes where applicable with flow diagrams.
- Description of the nature and duration of construction and operational phase activities
- Estimation of the number of workers and materials required for various stages of the project and their sources.
- Other relevant information provided

4: Baseline Information

- Description of the proposed site including the immediate adjoining landuses and zoning status
- Definition of the land area taken by the development (provide site plan/map)
- Description of the allocation of different activities/uses to which the proposed land would be put (this must be presented in a clearly labeled block plan)
- Description of the relevant baseline environmental quality information (e.g. air quality, water quality, noise, traffic, services, socio-economic information etc.)
- Alternative sites considered and evaluated and the main reasons for the selection of the preferred option
- Other relevant information

5. Identification, Analysis and Evaluation of Impacts

- Description of the potential impacts of the proposed undertaking including the methodology used for impacts identification (e.g. checklists, matrices, impact networks etc.). Impacts must be described (in terms of their nature (Direct and indirect, positive, negative), duration (short, medium, long term), magnitude, areal extent, frequency etc.) and categorized into all phases of project (pre-construction, construction, operation and decommissioning)
- Occupational Health and Safety Risks
- Other Risks and Hazards

6. Mitigation Measures

- Description of mitigation measures for significant impacts. Measures must be defined in practical terms (e.g. costs, manpower, equipment, technology needs etc)

7. Environmental Monitoring Plan

- Environmental Monitoring Plan including parameters to be monitored, frequency of monitoring, reporting etc.

8. Consultations

9. Conclusions

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Environmental Protection Agency
P. O. Box MB 326
Ministries Post Office
Accra
Website: http://www.epa.gov.gh

Our Ref: CE: 4956/01/06

April 16, 2015

The Project Representative
Early Power Limited
(91 Osu Badu Street, West Airport)
P. O. Box CT 3064
Accra

Attn: Mr Kingsley Asare

Dear Sir,

RE: UPDATED ESIA SCREENING DOCUMENT FOR THE BRIGE POWER PROJECT TEMA

We acknowledge receipt of your letter dated 25th March, 2015 on the above subject.

We have taken note of the design changes indicated in the updated screening document especially change of the power plant layout from two sites to a single site and the addition of an LPG Tank farm.

However, you are still required to go ahead and conduct the Preliminary Environmental Assessment (PEA) as per our earlier letter dated February 23, 2015 referrenced CE: 4956/01/03

We are available for any further consultation and discussions on this matter.

Yours faithfully,

KWABENA BADU-YEBOAH
Ag. DIRECTOR/EAA DIVISION
FOR: EXECUTIVE DIRECTOR

Jacobs Consultancy
Petroleum, Chemicals & Energy Practice
Tower Bridge Court
226 Tower Bridge Road
London SE1 2UP

Ghana Bridge Power Project

Environmental and Social Impact Assessment

Appendix G - Socio-economic Appendix

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

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Petroleum, Chemicals & Energy Practice
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ENDEAVOR GE SAGE Petroleum Limited

Ghana Bridge Power Project

Environmental and Social Impact Assessment

Appendix G1 - Socio-economic Baseline Report

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

SOCIO-ECONOMIC BASELINE CONDITIONS

OF THE

GHANA BRIDGE POWER PROJECT

UPDATED REPORT

PRESENTED BY ALICE ADDAI-YEBOAH

JUNE 2016

TABLE OF CONTENTS

ACRONYMS

CCGT	Combined Cycle Gas Turbine
CSR	Corporate Social Responsibility
DA	District Assembly
EA	Environmental Assessment
EHSG	Environmental, Health and Safety Guidelines
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
ESIA	Environmental and Social Impact Assessment
ESMF	Environmental and Social Management Framework
FGD	Focus Group Discussions
GBP	Ghana Bridge Power
GE	General Electric
GES	Ghana Education Service
GHS	Ghana Health Service
GIIP	Good International Industry Practice
GRIDCo	Ghana Grid Company
GSS	Ghana Statistical Service
IFC	International Finance Corporation
JHS	Junior High School
KKD	Kpone-Katamanso District
KVIP	Kumasi Ventilated Improved Pit
LEAP	Livelihood Empowerment against Poverty
LI	Legislative Instrument
LPG	Liquefied Petroleum Gas
MoT	Ministry of Transportation

MW	Mega Watts
NGO	Non-Governmental Organizations
OCCTG	Combined Cycle Turbine Gas
O&M	Operations and Maintenance
OP	Operational Policy
PAPs	Project Affected Persons
PLHIVS	Persons Living with HIV/AIDs
PMTCT	Pre Maternal Counselling and Testing
PP	Pit Pans
PWD	Persons With Disability
SBS	Social Baseline Survey
STDs	Sexually Transmitted Diseases
TMA	Tema Metropolitan Assembly
TDC	Tema Development Corporation
TOR	Tema Oil Refinery
UNICEF	United Nations International Children's Emergency Fund
VALCO	Volta Aluminium Company
VRA	Volta River Authority
WAGP	West African Gas Pipeline
WC	Water Closet

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

This Socio-Economic Baseline Report forms part of the preparation of an Environmental and Social Impact Assessment (ESIA) and it is required by Ghana law / Environmental Protection Agency (EPA) for the ***GHANA BRIDGE POWER PROJECT (GBP)***. The contract was awarded to Associated Consultants Limited of 33 Royal Castle Road, Kokomlemle - Accra, Ghana. The study has been compiled to provide baseline information about the area or zone in which the project will be sited.

The Ghana Bridge Power Project is the brainchild of the Early Power Limited (EPL) to help address the need for a short term solution to Ghana's power problems. EPL has been formed by a consortium of Endeavour Energy, General Electric (GE) and SAGE upon the request of the Minister of Power for Ghana to develop the project and contract with the Electricity Company of Ghana in an attempt to address the current energy crisis the country is facing. The objective of the GBP project is to deploy electrical energy as quickly as possible to support Ghana's short term strategy to increase the power capacity available to the country, with expected substantial completion before the commencement of quarter four 2016.

The Bridge Power Project is required to be commercially available in two phases, first phase commercial operation date (COD) is planned to be 31st March 2016 and second COD date is slated for 30th September 2016.

The Ghana Bridge Power (GBP) project is to be located on brownfield within the Volta River Authority (VRA) Tema Thermal Power Complex (TTPC), in Tema, Ghana. The power plants are to be located on two sites within the VRA TTPC. The project includes the development of power plant facilities in 3 phases. The final net electricity capacity of 344MW will be achieved through a three-phase development; 138MW developed in Phase 1, 1,60MW in Phase 2 and 46MW in Phase 3. The electricity capacity of each phase is as shown below:

- Phase 1: Six TM 2500+ GT'
- Phase 2: Four LM 6000 Sprints
- Phase 3: Four Heat Recovery Steam Generators (HRSG's) and One Steam Generator

Initially, the plant will generate electricity utilising Liquefied Petroleum Gas (LPG) which will be delivered at the Tema Oil Refinery (TOR) jetty and pumped to fuel storage tanks within TOR via a proposed new 10 inch line. All pipelines will be within existing TOR and VRA rights of way (ROW). The project will require potable water and process demineralised water for the steam generation components with and for the emissions control of oxides of nitrogen (NOx) in the flue gases. The raw water will be supplied by a new 1.2 km connection to Ghana Water Company network to site water storage tanks.

The objectives of this assignment are to conduct a Social Baseline Survey (SBS) and undertake a Socio-economic Evaluation to determine the potential impacts of the project on the socio-economic well-being of the communities.

The Consultant utilized qualitative methods of social research to gather and analyze information relevant to the preparation of the Social Baseline Survey. Research included:

1. Review of project and other background documents.

2. Reconnaissance survey

3. Consultations with the Tema Traditional Council and other relevant businesses and government stakeholders.

4. Focus Group Discussions with interest groups at the community level (e.g. traditional authority/ opinion leaders, religious, youth and women's groups)

5. Manual data collation and analysis for businesses that could be directly impacted by the project.

As mandated, the study considered the legal and regulatory framework for the project including review of various landholding in Ghana to inform land acquisition for the project.

The study also gathered some background information on the Tema Metropolis and the Kpone-Katamanso District since these were identified as areas of potential socio-economic influence for the project. The closest communities to the project i.e. Tema Manhean, communities 4, 7 and 9 and Kpone were studied.

Background information covered the general demographic characteristics of this area showing an estimated population of a hundred and nine thousand, eight hundred and sixty-four persons (109,864) made up of 48.7% and 51.3% males and females respectively for the Kpone district while a total of two hundred and ninety-two thousand, seven hundred and seventy-three (292,773) also made up of 47.8 percent males and 52.2 females in the Tema Metropolis. Agriculture, Industrial activities and Commerce/Service are the three main economic activities engaged in by the people, although the numbers involved in each activity varied. Other background information discussed are access to water supply and sanitation, education facilities, health facilities and other utilities such as mobile networks, telephone landlines, churches, electricity, markets etc.

In addition, up to six businesses are located along the project pipeline or the tank farm area and could potentially be impacted by the project. Socio-economic survey data was collected on potentially affected persons and their businesses, income and expenditure and land tenure. Information gathered shows that five (5) of the project-affected persons are not the actual owners of the lands on which they operate their businesses.

Potential impacts of the project, both positive and negative were discussed by the participants. The positive impacts mentioned include job creation, boost in local economic activities, enhanced skills of local artisans, an improved power supply in the nation and increased revenue for the Tema Metropolitan Area.

On the other hand, some negative impacts include demolition of some structures, impacts to livelihood, noise and dust pollution, pollution effects of water bodies, risk of occupational health and safety and increased social vices in the area. By way of mitigating some of these negatives, suggestions made included payment of due compensation to likely Project Affected Persons (PAPs), reduction in dust and noise level by the contractor, supervision and monitoring, boosting security on the site, provision of more social amenities, measures to mitigate impact on water bodies and the creation of a fire station on the premises.

1.0 INTRODUCTION

As part of the requirements of the Ghana laws/ Environmental Protection Agency for the preparation a Preliminary Environmental Report, this social baseline report has been prepared for the Ghana Bridge Power Project. This contract was awarded to Associated Consultants located at 33 Royal Castle Road, Kokomlemle - Accra, Ghana.

1.1 Project Description

The Ghana Bridge Power Project was conceptualized by Early Power Limited (EPL) to address the need for a short-term solution to Ghana's power problems. EPL has been formed under a local name by a consortium of Endeavour Energy, General Electric (GE) and SAGE upon the request of the Minister of Power for Ghana to develop the project and contract with the Electricity Company of Ghana in an attempt to address the current energy crisis the country is facing. The Bridge Power Project is required to be commercially available in two phases, first phase commercial operation date (COD) is planned to be 31st March 2016 and second COD date is slated for 30th September 2016.

Table 1 Phases of the Bridge Power Project

ITEM	GROSS CAPACITY (MW)*	CONSTRUCTION	COD
Site 1	96	4 months	31/03/16
Site 2	216	4 months	30/09/16
Operation life	20 years		

Source: Environmental and Social Impact Assessment; Screening Report, 2015

The project comprises the following key components:

- A new Power Plant;
- New LPG pipelines (from Tema jetty to TOR, from TOR to the tank farm and power plant);
- A new tank farm for LPG storage; and,

- A new pipeline to transport water to the power plant forms the Ghana Water Company Limited (GWCL) municipal supply network.

The project includes the development of power plant facilities in 3 phases. The final net electricity capacity of 344MW will be achieved through a three-phase development; 138MW developed in Phase 1, 1,60MW in Phase 2 and 46MW in Phase 3. The Power will be a mix of open and combined cycle gas turbine (OCGT and CCGT) generating stations compromising mobile Trailer Mounted (TM) turbine units and sprint turbo shaft gas turbines (LM units). The electricity capacity of each phase is as shown below:

- Phase 1: Six TM 2500+ GT'
- Phase 2: Four LM 6000 Sprints
- Phase 3: Four Heat Recovery Steam Generators (HRSG's) and One Steam Generator

Initially, the plant will generate electricity utilising Liquefied Petroleum Gas (LPG) which will be delivered at the Tema Oil Refinery (TOR) jetty and pumped to fuel storage tanks within TOR via a proposed new 10 inch line. A new 8 inch line will be constructed to transfer LPG from the main TOR fuel storage vessels to Bridge 2 Site. All pipelines will be within existing TOR and VRA rights of way (ROW). It is expected that within 5 years of completion of phase 3, the plant will switch to operation using Natural Gas (NG). The project will require potable water and process demineralised water for the steam generation components with and for the emissions control of oxides of nitrogen (NOx) in the flue gases. The raw water will be supplied by a new 1.2 km connection to Ghana Water Company network to site water storage tanks. All waste effluent including sewage will be treated prior to discharge by dedicated waste water treatment units to meet limits as defined by EPA and International Standards.

1.2 Project Objectives

General Objective:

- To deploy electrical energy as quickly as possible to support Ghana's short term strategy to increase the power capacity available to the country, with expected substantial completion before the commencement of quarter four 2016.

Specific Objectives:

- Provide continuous, reliable, high efficiency and low cost gas and subsequently energy;
- Providing emergency power into the Tema Industrial zone economy;
- Contribute to national energy requirement for sustainable development;
- Contribute to regional energy requirements;
- Provide economic and social benefits on both a national and regional level;
- Provide employment opportunities to the community residing in the region and near-by;
- Contribute to the local economy, social and technical infrastructure.

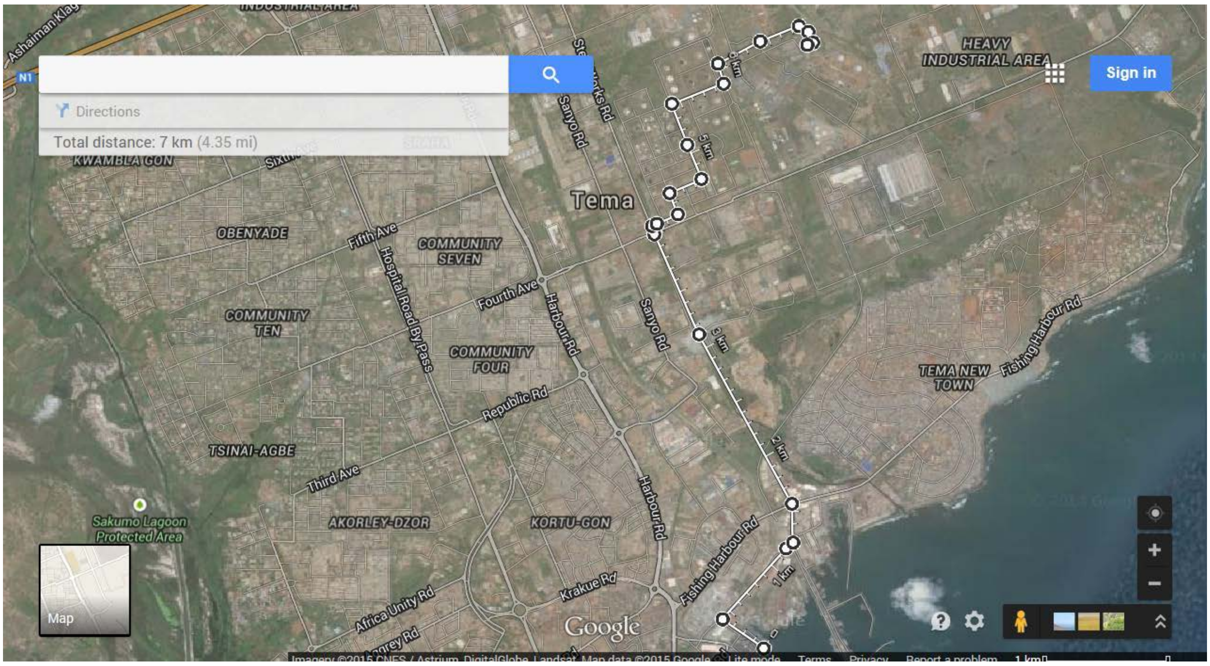
1.3 Project Location

The Ghana Bridge Power (GBP) project is to be located on brownfield within the Volta River Authority (VRA) Tema Thermal Power Complex (TTPC), in Tema, Ghana. The power plants are to be located on two sites within the VRA TTPC. The location of Site 1 is adjacent to the existing Mines Reserve Plant while Site 2 is located adjacent to the existing Trojan Power Plant. The project site will be accessed by the main Harbour Road from Tema port, then Tema Aflao Road, before turning south into the main TTPC access road. The distance from the port via this route is approximately 11km. the road is suitable for heavy loads as required for delivery for the major equipment to the site (i.e. gas turbines, transformers etc.) There are also existing industrial concerns such as Volta River Authority (VRA), Cirrus Oil, Sentuo Steel, Trojan Power, Goil and the Tema Oil Refinery. Additionally, there are commercial developments on the proposed project site.

1.4 Project Map

Figure 1: Location of Power Plant

Figure 2: Pipeline Route along existing TOR/ VRA RoW



2.0 Legal and Regulatory Framework

LAND TENURE SYSTEMS IN GHANA

This project is expected to involve the intake of some portions of land as project site for the construction and development of the infrastructure. Much of the land take will involve government, community and individual property and Ghana laws provide that acquisition of private property (by whatever approach) must be done in accordance with laid down statutory procedures.

In the area of land administration, one of the outstanding policies of the government of Ghana is that fair and adequate compensation is paid or in the alternative resettlement assistance is provided for eligible persons who for the sake of national interest have to surrender their interest in land or landed properties to the state for development.

The various interests and/or particular pieces of land that may be impacted as well as the different laws on land that come into focus need to be considered accordingly

2.1 Land Tenure Systems

Various landholding interests and/or rights exist in Ghana. Five main interests categorization in land are discussed below:

- Allodial Title
- Customary Freehold
- Customary Tenancies
- The Common Law Freehold, and
- The Leasehold

2.1.1 Allodial Title

In the Ghanaian context, this is the highest interest capable of being held in land. The Allodial title is customarily communally owned and is generally held or vested in stools or skins. In some traditional areas, it is held by clans, families or individuals. Being generally in the form of communal interest in land it accrues to the entire community and is administered by the recognized traditional authority. The owner of the allodial title has complete and absolute freedom to use and dispose of the land only subject to the restrictions, or limitations or obligations as may be imposed by the general laws of the country. The mode of acquisition of the allodial title is by: discovery by hunters or pioneers of the stool etc. of unoccupied land and subsequent settlement thereof and use by the subject; conquest, purchase or gift.

2.1.2 Customary Freehold

The customary freehold is an interest or title which a member of the larger community which holds the allodial title acquires in the communal land. It is an interest which is held as of right by virtue of being a member of the community. It is of indefinite duration and thus potentially subsists forever. The member who holds such interest has the right of beneficial occupation; unfettered use (also subject to the laws of the country). Upon death, the interest devolves on his/her successors in title and infinitum. This interest prevails against the whole world including the allodial title from which it was derived. The customary freehold may however be terminated by the occurrence of any of these occasions; failure of successors, compulsory acquisition by the state; sale or gift by owner, abandonment or forfeiture in rare circumstances where for example the holders denies the absolute title of the allodial owner.

2.1.3 Customary Tenancies

These are lesser interests in land and are created by the holder of the allodial title or customary freehold (or common law freehold). These types of tenancies are in nature share cropping arrangements. They are quite common in Ghana and occur when a tenant-farmer gives a specified portion of the farm produce to the land owner at each harvest time in consideration for use of the land. The two popular tenancy arrangements are the 'Abusa' and 'Abunu' schemes.

Other forms of customary tenancies in which the consideration from the tenant is not sharing of crops but cash or a combination of crops and money exist. The customary license is in this category.

2.1.4 The Common Law Freehold

This is an interest held for an indefinite period. It is derived from the rules of common law. The holder of this interest has the right of beneficial occupation and may subject to the laws of the land use in any manner.

This type of freehold is created only by express grant. The grantor may thus impose terms on the grantee provided such terms are reasonable and not contrary to public policy or unconscionable. Currently, the laws of the land forbid non-Ghanaians from acquiring freehold in lands in Ghana

2.1.5 The Leasehold

This type of interest is also a creation of the common law and not Ghanaian customary law. It is an interest in land for a specified period. The leasehold may be granted by the allodial holder in respect of lands in which no conflicting interest exists; or by a customary freeholder; or common law freeholder.

In Ghana, leasehold may be for a maximum duration of 99 years. (Again non-Ghanaians can only acquire leases up to 50 years). Various terms and conditions may be imposed by the grantor including the payment of rent as consideration for the grant.

2.2 Land Acquisition

In Ghana lands are acquired either by private treaty or compulsorily using the enabling legislations. The appropriate method is determined upon giving due consideration to such factors as the nature of the project, land requirements and/or the complexity of the tenurial arrangements

2.2.1 Private Treaty Acquisition

This is the usual mode of land acquisition. It involves direct negotiation between the grantor (owner) and grantee (purchaser). The terms of grant are agreed upon normally after arm's length negotiation. Private treaty acquisition follows conveyancing principles. There are laws which however guide the process. The Conveyancing Decree (1973) provides that the transfer of an interest for a term of more than three (3) years must be in writing and signed by the grantor.

Again the laws on Stamping (Stamp Act) and registration need to be followed. Thus it is necessary that a document evidencing acquisition of an interest in land need to be stamped and registered at the Lands Commission in accordance with the Lands Commission Act (2008) Act 767.

However, Private treaty acquisition is not suitable where the project area is large and0or involves the interest of a number of owners. Where there are conflicting ownerships and0or some of the owners are reluctant releasing the lands for the project, private treaty acquisition becomes problematic.

2.2.2 Ghana Laws on Compulsory Acquisition

The legal regime allows the state to compulsorily acquire land especially for public purposes or in the public interests. This is the most reliable approach to securing access to land where private treaty would not be feasible or would be so challenging.

3.0 POLICY FRAMEWORK/ LEGAL AND REGULATORY FRAMEWORK

3.1 Constitution of the Republic Of Ghana

The Constitution of the Republic of Ghana (1992) upholds the principle of private ownership of lands. Adequate safeguards from deprivation of private property rights have been provided for, in the 1992 Constitution. Even the state's inherent powers to compulsorily take possession of or acquire private property rights have been considered and somewhat controlled. Article 20 of the constitution prescribes that under no circumstance should private properties be compulsorily taken unless there are weighty and justifiable grounds for such acquisition, which invariably must be in the public interest. It is expressly provided in Article 20 (Section 1(a) and Section1 (b)) that "No property of any description or interest or right over any property shall be compulsorily taken possession of or acquired by the state unless:

(I) The taking of possession or acquisition is necessary in the interest of defence, public safety, public morality, public health, town and country planning or development or utilization of property in such a manner as to promote public benefit and (ii) the necessity for the acquisition is clearly stated and is such as to provide reasonable justification for causing any hardship that may result to any person who has an interest in or right over the property."

Section 2 (a) notes that sufficient provision must be made for the prompt payment of fair and adequate compensation and Section 2 (b) indicates that aggrieved persons must have right of access to the High court for redress. Article 20 (2) expressly stipulates that where the compulsory acquisition involves the displacement of any inhabitants the state shall resettle them on suitable alternative site having regard to their Socio-cultural values and economic wellbeing.

3.2 Lands Act

The Lands Act, 1963 is a constitutional act that provides for an entry on any land for the purpose of the construction, installation and maintenance of works of public utility, and for the creation of rights of way and other similar rights in respect of such works and for purposes connected with these matters. The Act can be described as a form of legal backing that provides an individual, group or organization with the necessary permit onto a specified piece of land property to undertake certain acts. Assented on the 16^{th} of July, 1963, the Land Act prescribes criteria's and adherences that must be followed in conjunction with the law before any engagement can be done. These adherences are structured into nine (9) basic sections.

3.3 Administration of Lands Act 1962 Act 123

Act 123 of 1962 was enacted to facilitate the management and administration of stool lands (and other lands). The Act empowers the Minister responsible for the lands to manage stool lands in accordance with the provision of the law. The entitlements are however to be assessed by giving due consideration to the values of the land (and other losses suffered) and the benefits to be derived by the people in the area (by way of the use to which the state is going to put the land).

3.4 The Ghana Land Policy 1999

The Government of Ghana in 1999 put together the above policy to serve as a broad framework and policy guidelines aimed at enhancing land management systems, land use, conservation of land resource and enhancing environmental quality. All these are intended to ensure coordinated and orderly use of land, a vital resource, by present and future generations. Ultimately the policy seeks to give protection to proprietary rights and promote the concept of prompt payment of adequate and fair compensation for compulsorily acquired lands and also create the enabling environment for community participation in sustained land management.

3.5 IFC's Performance Standards on Environmental and Social Sustainability.

In January 2012, the IFC introduced its revised set of eight Performance Standards on social and environmental sustainability. The IFC applies the Performance Standards to evaluate and manage social and environmental risks and impacts in its private sector financing. The eight

Performance Standards establish standards that the client is to meet throughout the life of an investment by IFC are:

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

Performance Standard 1 underscores the importance of managing social and environmental performance throughout the life of a project. Specifically, the objectives of Performance Standard 1 are:

a) To identify and assess social and environment impacts, both adverse and beneficial, in the project's area of influence
b) To avoid, or where avoidance is not possible, minimize, mitigate, or compensate for adverse impacts on workers, affected communities, and the environment
c) To ensure that affected communities are appropriately engaged on issues that could potentially affect them
d) To promote improved social and environment performance of companies through the effective use of management systems.

Performance Standard 5 recognizes that project-related land acquisition and restrictions on land use can have adverse impacts on communities and persons that use this land. Therefore the standard requires that clients are encouraged to use negotiated settlements in meeting the requirements of this Performance Standards, even if they have the legal means to acquire land without the seller's consent. It has the following objectives;

a. To avoid, and when avoidance is not possible, minimize displacement by exploring alternative project designs.

b. To avoid forced eviction.

c. To anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land acquisition or restrictions on land use by (i) providing compensation for loss of assets at replacement cost and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected.

d. To improve, or restore, the livelihoods and standards of living of displaced persons.

e. To improve living conditions among physically displaced persons through the provision of adequate housing with security of tenure at resettlement sites.

The other standards (Performance Standards 2-8) spell out the requirements to avoid, minimize, mitigate or compensate for impacts on people and the environment, and to improve conditions where appropriate. While all relevant social and environmental risks and potential impacts should be considered as part of the assessment, Performance Standards 2 through 8 describe potential social and environmental impacts that require particular attention in emerging markets. Where social or environmental impacts are anticipated, the client is required to manage them through its Social and Environmental Management System consistent with Performance Standard 1.

3.6 Environmental Assessment

This policy requires environmental assessment (EA) of projects proposed for IFC financing to help ensure that they are environmentally sound and sustainable, and thus to improve decision making. EA is a process whose breadth, depth, and type of analysis depend on the nature, scale, and potential environmental impact of the proposed project. EA evaluates a project's potential environmental risks and impacts in its area of influence; examines project alternatives; identifies ways of improving project selection, siting, planning, design, and implementation by preventing, minimizing, mitigating, or compensating for adverse environmental impacts and enhancing positive impacts; and includes the process of mitigating and managing adverse environmental impacts throughout project implementation.

The policy takes into account the natural environment (air, water, and land); human health and safety; and social aspects (involuntary resettlement, indigenous peoples and cultural property); and trans-boundary and global environmental aspects. EA considers natural and social aspects in an integrated way. It also takes into account the variations in project and country conditions; the findings of country environmental studies; national environmental action plans; the country's overall policy framework and national legislation; the project sponsor's capabilities related to the environment and social aspects, and obligations of the country, pertaining to project activities, under relevant international environmental treaties and agreements. IFC does not finance project activities that would contravene such country obligations, as identified during the EA. EA is initiated as early as possible in project

3.7 Private Sector Activities

The performance standard under this section offer guidelines for projects that are being implemented by the private sector or private sector activities. The Performance Standard 3 requires Private Entities to avoid, or where avoidance is not possible, minimize adverse impacts on human health and the environment with good international industry practice ("GIIP"), as reflected in various internationally recognized sources, including the World Bank Group ("WBG") Environmental, Health, and Safety Guidelines ("EHSGs"). Use of WBG EHSGs, or other

GIIP, is mandatory under IFC Performance Standard 3. However, taking into account country legislation and local conditions, an environmental assessment may recommend alternative emission levels and approaches to pollution prevention and abatement for the Private Sector Activity. The environmental and social assessment report prepared by the Private Entity should provide full and detailed justification for the levels and approaches chosen for its project.

In some cases involving Private Sector Activities supported by the Bank and IFC or MIGA, the responsibilities for managing environmental and social risks and impacts of the Private Sector Activity are shared by the Private Entity and government.

3.8 Labour Act, 2003 (Act 651)

The Labour Act, 2003 (Act 651) consolidates existing laws relating to labour, employers, trade unions and industry. The Act provides for, among others, the rights and duties of employers and workers; what is a legal or illegal strike; guarantees trade unions freedom of association. The Act led to the establishment of the Labour Commission to mediate and act in respect of all labour issues. Under Part XV (Occupational Health, Safety and Environment), the Act explicitly indicates that it is the duty of an employer to ensure that every worker employed works under satisfactory, safe and healthy conditions. The Act also stipulates several working conditions including the following:

- The hours of work shall be a maximum of eight hours a day or forty hours a week. However, workers may be required to work after the normal hours of work fixed by the contractor to enhance speed at the constructional phase. The additional hours done shall be regarded as overtime.
- The wage level shall be determined by the kind of work engaged in with regard to the general wage rate of that particular work in the country. Overtime shall also be paid to workers who work for extra hours.

- The contractor will appoint a properly qualified person (or persons) whose special and main responsibility is the promotion of safety and health. Whoever is appointed will perform the following duties:
    - – the organization of information to be passed from management to workers, including those of subcontractors;
    - – the organization and conduct of safety training programmes, including induction training for all workers on the site;
    - – the investigation and review of the circumstances and causes of accidents and occupational diseases so as to advise on preventive measures;
    - – acting as consultant and technical adviser on safety to workers;
    - – participation in pre-site planning.
    - - construction and installation of safety signs;
    - – testing of lifting machinery such as cranes and goods hoists, and lifting gear such as ropes and shackles;
    - – inspection and rectification of access facilities e.g. scaffolds
    - - inspection and cleaning of welfare facilities such as toilets, clothing and safety shoes;
    - – transmission of the relevant parts of the safety plan to each work group;
    - – emergency and evacuation plans.

To carry out these functions the safety officer should have experience within the industry and should be properly trained and qualified and, where such exists, should be a member of a recognized professional safety and health body

3.9 Water Resources Commission Act, 1996 (Act 522)

The Act established the Water Resources Commission and grants it authority to regulate and manage the utilization of water resources in Ghana. The Act also empowers the Water Resources Commission to coordinate any national policy that relates to water resources. Section 13 (a and b) of the Act prohibits the diversion, damming, storage, abstraction, construction or maintenance works for the use of water resources without prior approval by the Water Resources Commission. Besides, section 28 authorizes the Commission to request information required for the efficient performance of its functions from a person, who shall, subject to any other law, comply with the request.

3.10 Livelihood Restoration and Resettlement Planning and Implementation

In accordance with the World Bank Group and IFC Performance Standards, the client conducted a census level survey of socio-economic baseline data to identify the persons whose livelihood or residence could be directly affected by the project. This survey is intended to be used as the basis for determining who will be eligible for compensation and assistance including an established a cut-off date for eligibility.

The client will develop a livelihood restoration plan/resettlement action plan to address economic or physical displacement of people based on the findings of this study and in accordance with the applicable requirements of the Performance Standards. The plan will be designed to address the impacts of displacement for all affected persons. Documentation of this process and associated compensation and livelihood restoration and resettlement measures will also be made publicly available by the client.

3.11 Displacement

Displaced persons may be classified as persons: (i) who have formal legal rights to the land they occupy, (ii) who do not have formal legal rights to land, but have a claim to land that is recognized or recognizable under the national laws or (iii) who have no recognizable legal right or claim to the land they occupy. The census will establish the status of the displacement persons.

The project may result in the physical displacement of people as well as their economic displacement. As a result, requirements for both physical displacement and economic displacement may apply

4.0 METHODOLOGY

In consideration of the fact the project is proposed in a mostly industrial area and given that very few environmental impacts were identified based on studies included in the PER for the project, targeted focus groups and surveys of businesses that could be impacted by the project as well as targeted stakeholder consultation were conducted to understand the socio-economic impacts of the project. For the Social Baseline Survey the following activities were conducted: a reconnaissance study, secondary data collection, primary data collection, consultations with key stakeholders, and the manual data collation as well as its analysis.

4.1 Reconnaissance Visit

As part of the social impact assessment of the Ghana Bridge Power project, a reconnaissance visit was made to the project site located in Tema by a team of Social and Environmental experts. This visit was done on August 20, 2015. The purpose of the visit was for the team to identify and familiarize themselves with the communities involved as well as to gain insight into potential socio-economic effects of the project. The objective of was also to help identify the various stakeholders that might be affected by the project as well as establish contact with the community coordinator who were to assist in organizing community members for consultations and focus group discussions.

Figure 3: Social and Environmental team during Reconnaissance visit

Source: Field Survey Pictures

4.2 Preparation for Data Collection

A questionnaire on general socio-economic characteristics of the community was developed by Jacobs Consultancy for the project. Upon the receipt of questionnaires and guidance for focus group discussions and census surveys tools for impacted businesses, the team also prepared for various interpretations of questions and for conducting interviews during Focus Group Discussions (FGDs) in the local dialect. The FGDs and interviews with stakeholders and survey of potentially affected persons were conducted in English as well as both the Ga and Akan local dialects to promote an effective communication between both participants and consultants.

4.3 Data Collection

4.3.1 Review of Secondary Data

Secondary data reviewed included relevant documents obtained from various sources such as the Kpone-Katamanso District profile, Website of Ghana Statistical (GSS) and Analytical Reports on the Tema Metropolitan Assembly. Other sources include statistics from the Ghana Health Service (GHS) and project background documents. This provided key information on the project and the social setting. Documents reviewed included:

- IFC's Performance Standards on Environmental and Social Sustainability
- District Profile for Kpone-Katamanso District.
- Social Baseline Studies. Ghana 1000 Gas to Power Project, One Energy, Ghana.
- Ghana Statistical Service (GSS), 2014. 2010 Population and Housing Census; District Analytical Report for the Tema Metropolitan Assembly.
- O P 4.01 Environmental Assessment
- Ghana Health Service (GHS), 2012. 2010 GHS Facts and Figures; District Analytical Report for the Tema Metropolitan Assembly.

- www.ghanadistricts.com

4.3.2 Surveys of Likely Affected Project Persons (PAPs).

As part of the project's socio-economic baseline studies, six (6) potentially impacted businesses were surveyed and census level socio-economic data was collected for each potentially affected person. Data collected included information on their background and household, economic activities, finances, health, challenges likely to be faced as a result of the project and the impact of potentially relocating their businesses.

4.3.3 Focus Group Discussions

One Focus Group was conducted for each of the potentially impacted communites: Kpone, Tema directly West of the project and Tema New Town were held with representatives from the youth, women and religious groups as well as some identifiable community leaders in the Tema and Kpone-Katamanso communities respectively. Communities to the north of the project were more than 3 kilometers away and across a motorway and were therefore considered unlikely to be within the project area of influence. The main purpose of these meetings was to ascertain their perceptions concerning the project and to assess how the project will affect the community as a whole and how these might be mitigated.

Overview of FGDs

#	Location	No. of Participants	Male	Female
1.	Tema Mahean	5	3	2
2.	Tema communities (4, 6,7)	6	5	1
3	Kpone	11	8	3
	Meeting with Tema Traditional Council	12	12	0

Again, a stakeholder's meeting was held with the Tema Traditional Council; as the community's recognized first point of call. This was done in accordance with the traditions and customs of the Tema traditional community. It was also to help provide first-hand information on the District perspectives and to elicit their input into the study. Twelve elders, all male attended the meeting. They were briefed about the project and shown site maps and allowed to make initial comments. The Council expressed their delight about the project and the consultation and promised to visit the site later and advise the project on the way forward.

Figure 4: Discussion with Tema Traditional Council

4.4 Data Collation

Case studies and Focus Group Discussions (FGD) and stakeholder consultations were manually collated. Qualitative data collated and transcribed focused on:

- Biodata of likely affected individuals and communities
- Socio-economic activities and health
- Expected impacts and mitigation measures.

5.0 SOCIAL SETTINGS

This section describes the social conditions in the project area (i.e. Tema Manhean (Newtown), Tema Communities and the Kpone-Katamanso District). Although the focus is on the project site, reference will be made to information on the wider Tema East Sub-Metro and Kpone District Assembly. Kpone-Katmanso falls under Tema Metropolitan Assembly and as such, information captured in this section covers both areas.

5.1 Kpone-Katamanso District

The Kpone-Katamanso District is located in the eastern part of the Greater-Accra Region and stretches from the coast to the southern lower slopes of the Akuapem Mountains with its District capital as Kpone. It shares boundaries with Shai-Osudoku and Ningo-Prampram District Assemblies on the East, Adentan Municipal Assembly, La-Nkwantanang and Ashaiman Municipal Assembly, and Tema Metropolitan Assembly on the West, Gulf of Guinea on the south and Akuapem North Municipal Assembly on the North. The Kpone-Katamanso District is only 38 kilometers drive from Accra, the capital city of Ghana and falls on longitude 004'0E and latitude 5^{0} 40' 60N. the topography of Kpone is generally flat topography, Kpone is generally flat and forms part of the coastal plains that ranges from 0m (South) to 35m (North) above sea level. The district has become a flood prone zone as a result of its flat nature and this creates a high cost for the construction of drainages.

5.1.1 Physical Development Planning

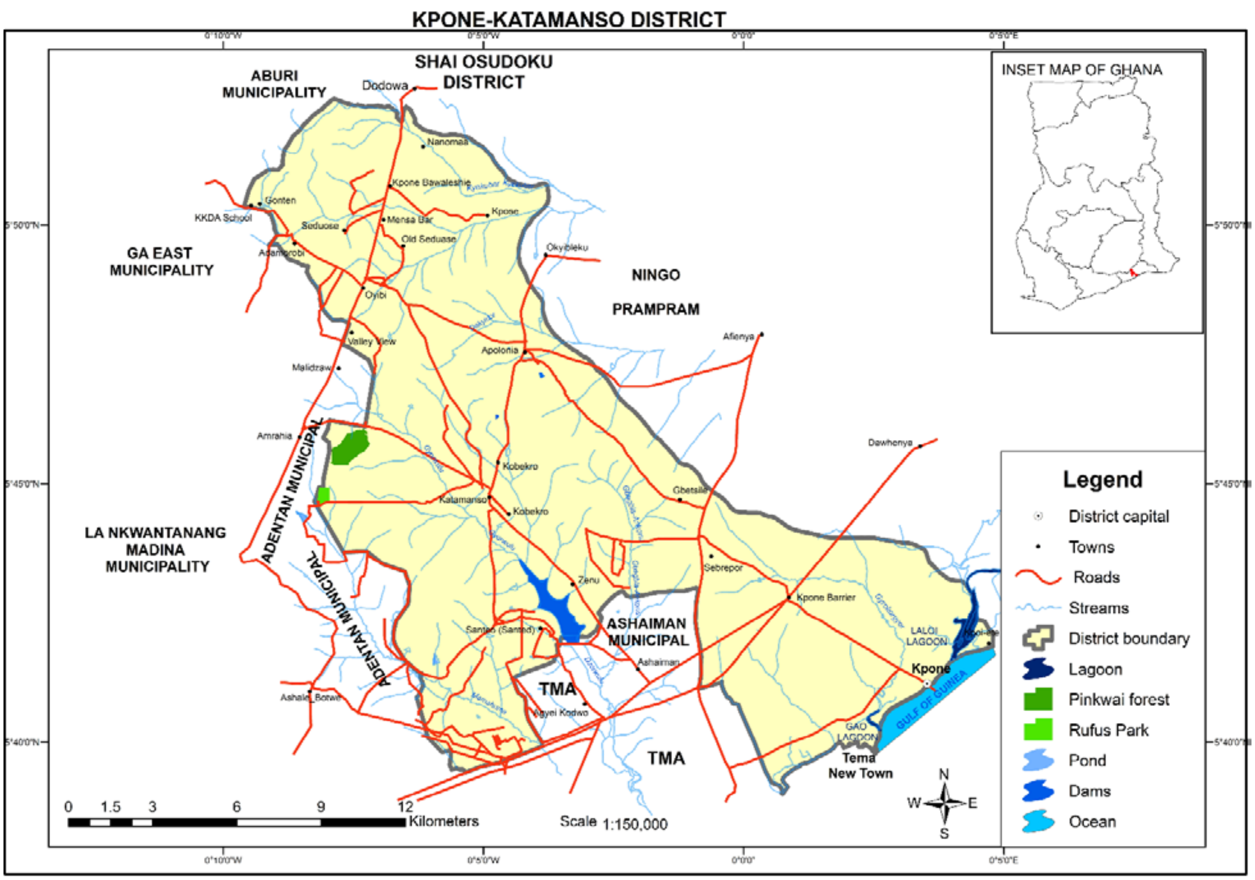
The District is challenged with well-designed planning schemes for some communities and in the other communities there are no planning schemes. This has led to haphazard development in most communities and other problems in the District such as:

- Building without development permits
- Multiple land sales
- Acquisition of land title problem.
- Encroachment on right of ways and public spaces.

5.1.2 Roads and Drains

Accessibility to roads in the Kpone-Katamanso district is generally poor as communities along major roads are the only areas that can boast of tarred roads. As a result, during the raining season, most communities are not accessible due to the deplorable nature of the road. The development of potholes on major roads such as the dam road that links Santoe to Ashaiman compounds to the problem of long hours when travelling on these roads. Again, there is difficulty in accessing communities that are not linked to major roads. However, there are ongoing collaborations by the district and urban roads to upgrade and open up most of the minor roads linking the communities. This has helped linked the communities to each other and also to other districts.

Figure 5: Kpone-Katamanso District Map

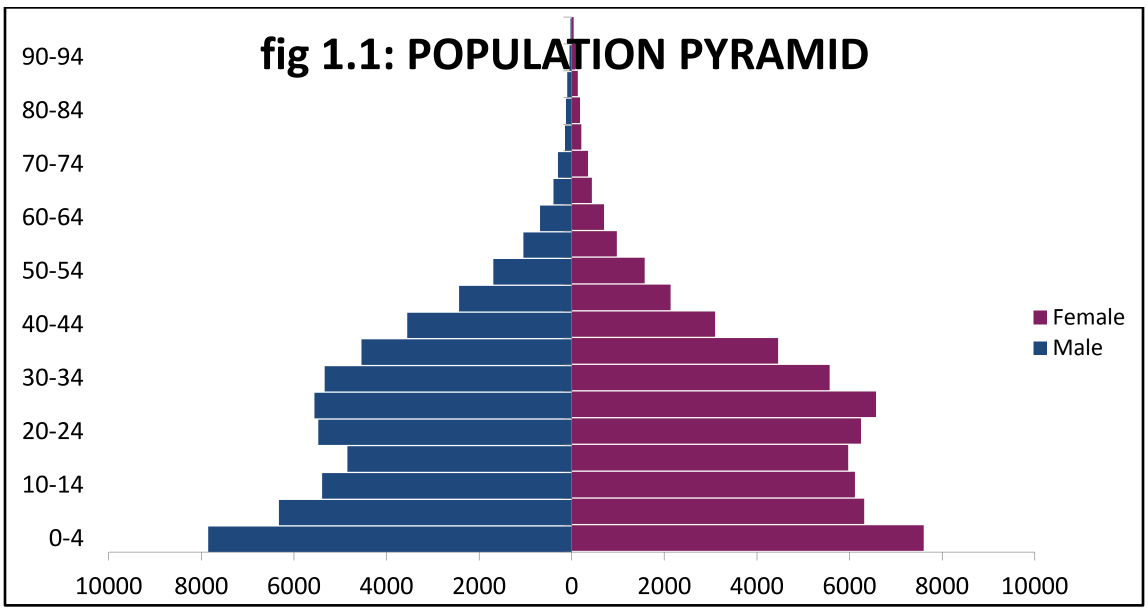


Source: District Town and Country Planning Unit, Kpone

5.2 Demographics/ Population

The Population and Housing census conducted by the Ghana Statistical Census in 2010 revealed a population figure of **109,864**- constituting **48.7 percent males** and **51.3 percent females** for the Kopne-Katamanso District. One of the major contributors of this population figure is the industrial agglomeration and current trend of real estate developments within the district, which has attracted a lot of migrants into the district. Out of the total population of 109,864 in the district, 70.4 percent were migrants. In terms of age and sex; i.e. the number and proportion of males and females in each group, the district, from the 2010 PHC conducted manifests more males at the lower ages than females, but as the population grows within the various age groups the male population falls, especially at the older age level. As a result, it can be concluded that women outlive men in the district as shown below in Figure 4.

Figure 6: Age-sex composition of Kpone Katamanso District Assembly



Source: Ghana statistical service, 2010 Population and Housing Census

5.3 ECONOMIC ACTIVITIES

Industries, agriculture and commerce, sand and gravel for construction and human resource make up the economic resources in the Kpone-Katamanso district.

5.3.1 Agriculture

Agricultural activities in the district are very prominent and can be grouped into three main areas; crop production and livestock production, fishing and agro-processing. Whereas crop farming is predominant in the northern part of the district, fishing dominates in the south. Major crops produced in the District are maize, cassava, tomatoes, onions, pepper and okro etc. Vegetables like cabbage, carrots, green pepper, spring onions, cucumber, lettuce, 'Ayoyo' and 'Gboma' are cultivated in the district. Tree crops such as mango, citrus, and pawpaw can also be found in areas such as Katamanso, Gbetsile and Appolonia. However, these farming activities continue to dwindle due to rapid urbanization and the activities of Real Estate Developers. Therefore there has become the need for farmers to adopt modern farming techniques to ensure an efficient use of the available land. Another challenge has also been the deterioration of most irrigational dams.

Another area that is gradually taken over from crop production is animal rearing. The type of animals reared include poultry (local and exotic fowls, ducks, geese, turkey, guinea fowls etc.) cattle, sheep, goats, pigs, rabbits and grass cutter. These animals are produced on both subsistence and commercial basis. Meanwhile, industrialization and estate development has become a major challenge in this area as well as several poultry farms are either relocating to other parts of the region or folding up.

Fishing and its related activities play a vital role in the economic development of the District**.** Fishing is predominant in the Kpone area as the community is one that is closer to the sea. The type of fishing practiced includes ring net fishing, hooking and wide net fishing. The fishermen use local canoes operated by outboard motors for fishing. However, the fishing sector is bewildered with some challenges which if addressed, could go a long way to improve the sector as well as the income levels of the people. These challenges include:

- high cost of outboard motors
- high cost of pre-mix fuel
- interference from Pair trawlers and
- lack of storage facilities
- broken dams

5.3.2 Industry

KKD can boast of both big and small industries. These industries offer employment to the local people as well as some neighboring communities. These include manufacturing, processing and refinery industries. For instance, 'Kokompe' is one of such light industrial areas in the district which has most of its resident artisans involved in various activities like car spraying, welding, fitting and vulcanizing. In addition, stone quarrying and sand winning activities are carried out in the District; notable among them are the stone quarry and sand winning sites at Kpone, Santeo, Zeenu, Katamanso and Appolonia. The district can boast of the ASOGLI thermal plant and GRIDCO as being seated in its territory and the West Africa Gas Pipeline that passes through the district. Other industries are the transport and haulage services and banking services which contribute to the internally generated revenue of the district. These contributions form a greater part of the Assembly's development agenda. Currently, the district is struggling with boundary disputes with its sister Assemblies (Tema, Adentan, Ashiaman and Prampram) over some of these revenue collections from certain industries. Nonetheless, it should be noted that the Assembly is working very hard to resolve its boundary issues by having dialogues with the sister Assemblies to reach a consensus. For instance, the Assembly and Ningo-Prampram have reached a consensus on their boundaries.

5.3.3 Commerce

Most of the district's commercial activities are tied to the outside markets of Tema, Accra, Kasei, Ashaiman, Agomenya and Kasoa as the district does not have any functional market. The fairly good nature of the roads in the area has resulted in good commercial linkages with these markets. However, the district is working hard to construct traditional market stalls in Kpone. The main commodities traded in are smoked fish, okro, palm nut and vegetables. A good proportion of the women in the district are also engaged in baking and its related activities. The service sector is also popular in the district. For instance, there are business centres, small communication centres (Space to Space), photo shops, drinking spots and several others.

5.4 Water Supply and Sanitation

This section presents the main sources of water supply for domestic use to the various households in the district as well as the methods adopted in disposing both liquid and solid waste materials.

5.4.1 Sources of Water Supply

Most of the communities in KKD have access to either pipe borne or borehole in the district. Accessibility to potable water is not much of a problem in the district. In 2004, the Danish International Development Agency (DANIDA) through the Community Water and Sanitation Agency (CWSA) established the Oyibi Water Scheme to provide water for rural communities in and around Oyibi area. Thus, about 62 percent of the households in the district have access to pipe borne water from the Kpong Dam and Oyibi water scheme whereas the remaining 38 percent who do not have access to pipe borne water depend on water tanker services, dams, rivers, streams and lagoons as their source of water. Some of these areas are Katamanso, Kubekro 1&2, Zeenu, part of Gbetsile, Santeo, Adigon and Gonten.

However, out of the 62 percent who have access to potable water, 30 percent do not have regular flow of water and therefore have to rely on private water tanker services due to low pressure during the dry season. The residents also harvest rainwater during the rainy seasons. In view of this, there has not been any the outbreak of water related diseases in the district is minimal. Notwithstanding the above, the district is fast developing with people constructing new houses, hence, the need to extend potable water to newly developing areas. There is also the need to encourage residents to construct boreholes and hand-dug wells in their various homes.

5.4.2 Bathing and Toilet Facilities

Due to its rural and urban nature, the district has both public and domestic bathing and toilet facilities. According to the 2010 Population census, public toilets; i.e. the Water Closet (26.1%), KVIP (14.4%) and Pit Pans (7.5%) are the most patronized by members of the community as compared to the other types of toilet facilities. On the other hand, open defecation (bush/beach/field) is also very high (23.9%). This is evident in the rural part of the district. In totality the district has 10 public toilets. Out of these 10 public toilets, 5 are situated in Kpone whiles 2 are in Oyibi and the remaining 3 are in Kakasunanka. Although community members have a high access to public toilets, most do not patronize these public toilets because of the monies they have to pay and thus defecate in open spaces (‘free range’) especially along the beaches. This has been a pending challenge for the district in dealing with sanitation problems.

5.4.3 Methods of Waste Disposal

- **Solid Waste Disposal**

Residents in the district dispose of solid waste mostly by Public dump (refuse containers). The 2010 Population census indicates that, 32 percent of households use the public dump (container) to dispose-off waste while 29.2 percent of households also use the collection method whereas 5.2 percent of households dispose their rubbish indiscriminately in the district. The complaint of residents has been about the inadequacy of refuse containers which has resulted in some residents creating unauthorized dumping sites for their personal use. Also within the district is a land fill site that is currently serving the district and other areas including the Tema Metropolis, Accra Metropolis and Ashaiman Municipality. A major challenge facing the district is the stench that emanates from this site which is nothing to write home about and has become an eyesore.

- **Liquid Waste Disposal**

The 2010 Population Census indicates that, 37.5 percent of households throw liquid waste onto their compound whilst another 29.2 percent also throw liquid waste onto the street/outside. This destroys the already deplorable nature of roads in the district. Again, one out of ten people throw the liquid waste into the gutter whilst the other methods (through the sewerage system, through drainage into a pit (soak away), through drainage system into a gutter) are less than 10 percent.

- **Industrial Waste Disposal**

The district houses a myriad of industries and therefore faces a lot problems with respect to industrial waste. The Environmental Protection Agency (EPA) of the Tema Metropolitan Assembly classifies industries in Kpone into the following;

1. Food, Beverages and Tobacco
2. Textiles, Weaving Apparel and Leather Goods
3. Sawmill and Wood Products
4. Paper Products and Printing
5. Petroleum Refinery
6. Chemical Products other than Petroleum
7. Cement and other Non-Metallic Mineral Products
8. Non-Ferrous Metal Basic Industries
9. Cutlery and other Non-Ferrous Metal Products
10. Iron and Steel Products
11. Electrical Equipment and Appliances

Currently, the EPA has succeeded in ensuring that most of these industries treat their waste before disposing them off into the environment. Contrarily, there are some industries that do not properly discharge their waste into the water bodies. For instance, reports have revealed that about 10 percent of industries in the district do not properly treat their waste before disposing them. It is however worth nothing that through the activities of EPA, most of the plastic producing industries have a recycling plant that recycles plastics

5.5 Health

The district has a number of public and private health facilities which allow residents to benefit from various government policies and interventions such as the free maternal healthcare, NHIS and other important healthcare policies being implemented in the country. There are three health centres and eleven private clinics/hospitals in the district.

Table 2: Statistics and Type of Health Facilities, Kpone-Katamanso District

Health facility	**Public**	**Private**
Hospital	-	5
Clinic	-	4
Health Center	3	-
CHPS	17	-
Quasi-Gov't	1	-
Total	**21**	**9**

Source: District Health Directorate, 2014

Despite the presence of these facilities, the district cannot boast of a district hospital, hence, referral cases are sent to other hospitals outside the district. Also in existence are herbal practitioners such as Dua ma Aduro – Sebrepor, Adom Herbal-Sebrepor, Abotare Clinic – Bethlehem, New Crystal Clinic- Kakasunanka among others, whose services also complement the above mentioned facilities. There is also an Adolescent Reproductive Center (funded by the Urban Poverty Reduction Project) in the District that caters for Adolescent health. Health facilities in the district render services like laboratory, pharmacy, family planning, reproductive and child health and maternal services to the people. On the other hand, there are a number of chemical and pharmacy shops in the district. Residents with minor illness resort to these shops for drugs. Almost all the communities in the district have access to chemical shops. This prevents long travel to distant places for first aid drugs.

Table 3: Incidences of Diseases in the District

DISEASES	2013	
	CASES	%
MALARIA	14,400	37.4
ARTI	4,726	12.3
SKIN DISEASE AND ULCERS	1,961	5.1
ANAEMIA	1,839	4.8
DIARRHOEA DISEASES	1,807	4.7
ACUTE URINARY TRACT INFECTION	1,693	4.4
RHEUMATISM	1,411	3.7
HYPERTENSION	1,347	3.5
TYPHOID	1,223	3.2
INTESTINAL WORMS	765	2.0
TOTAL	31,172	80.9
ALL OTHER TOTAL	7,336	19.1
GRAND TOTAL	38508	100.0

Source: District Health Directorate, 2014

Table 3 highlights the top ten diseases evident in the district. Top on the list is malaria for the period 2013 as the most reported disease at the Out-Patient Departments (OPD) in health centres followed by other sanitation diseases.

Table 4: Health Staff in the District

Staff	Number
Doctor	1
Physician Assistants	3
Public Health Nurses	3
Professional Nurses	19
Midwives	10
CHN	30
Enrolled Nurses	20
Pharmacist	3
Biomedical scientists	2
Technical Officer (laboratory)	2
Health Service Administrators	1
Administrative Managers	1
Accountants	2
Technical Officers (Disease Control/Field Technician)	3
Technical Officers (Nutrition)	1
Others	20

Source: District Health Directorate, 2014

From Table 4, it is realized that the entire district has no doctor. This implies that cases that require a doctor's attention are mostly referred to Tema and its environs. This is a serious problem as it increases the chances of untimely death in situations that demand the attention of a doctor. At present, the ratio of a nurse to a patient stands at 1:1356.

The challenges of the Health Directorate at Kpone-Katamanso district include:

The Health Directorate is faced with the following challenges:

- Inadequate staff
- Inadequate Financing
- Chronic water shortage
- Poor volunteer participation in health programmes due to lack of incentives
- No Ambulance for Transportation of Emergency/Referred cases for further management
- Lack of Permanent Office Accommodation for District Health Directorate
- Lack of Operating Theatre to Manage Medical/Surgical Emergencies Cases
- Lack of Fence Wall at all Public Health Facilities in the District
- Absent of National Health Insurance Office

5.6 HIV/AIDS

Data on HIV/AIDS in the District is not very comprehensive since the District is relatively new, having been established in 2012. A report from the Kpone Health Center indicates that, there is no Anti-Retroviral Therapy (ART) practitioner at the center hence cases are more often referred to the Tema General and LEKMA Hospitals. PLHIVS in the District always face the problem of non-attendance at the nearby hospitals. Data from the Kpone Health Center on HIV and AIDS shows that, PMTC Anti Natal registrants as at 2012 tested was 472 pregnant women and 7 of them tested HIV positive. PMTCT Anti Natal registrants as at 2013 tested was 1802 pregnant women and 30 tested positive. The 2012 and 2013 age trend analysis shows that the highest frequencies age groups are 25-29. This implies that, it is the economically working group that is mostly affected. Also a 2013 report by the Health Directorate indicates that, 258 people were tested for HIV/AIDS; out of this 37 were positive, male 28 and female 9. This means that, the Assembly needs to develop more of education and sensitization programmes to create awareness for its citizenry to have the understanding the realities of HIV/AIDS statistics.

5.7 Education

Kpone-Katamanso has 213 educational facilities in the district of which 56 are public and 157 are private. Out of this number, there are 22 public primary schools, 19 Junior High School and one private tertiary institution (Valley View University) in Oyibi. However, the district cannot boast of a public Senior High School (SHS) although there are seven (7) private SHS to partly fill that gap. Bases on this, students who graduate from Junior High School (JHS) have to move to other districts to access SHS education. The table below shows the distribution of educational facilities in the district.

Table 5: Educational facilities in Kpone Katamanso District

S/N	LEVEL	NUMBER OF SCHOOLS		
		PUBLIC	PRIVATE	TOTAL
1	**KG**	15	55	70
2	**Primary**	22	52	74
3	**JHS**	19	42	61
4	**SHS**	0	7	7
5	**TERTIARY**	0	1	1
TOTAL		56	157	213

Source: Ghana Education Service, 2014

The overall school enrolment in the district is 14,807. About 54 percent of the total enrolments are girls and the remaining 46 percent are boys. This confirms that, parents have taken girl-child education seriously. The district also has 389 trained teachers and 3 untrained teachers. The current pupil-teacher ratio for pre-school and primary is 30:1 and 49:1 respectively. This is higher than the national average of 20:1 for pre-school and 40:1 for primary school. This has led to poor supervision due to congestion in the classrooms. However, the situation is different at the Junior High School level with a pupil teacher ratio of 29:1 and this is very good compared to the national standard of 35:1 as seen in the table below:

Table 6: Pupil/Teacher Ratio for Private Schools

PUBLIC	**PRIVATE**		
	ENROLMENT	**STAFFING**	**PTR**
KG	1107	175	7:1
PRIMARY	3180	273	12:1
JHS	1044	304	4:1

Source: Ghana Education Service, 2014.

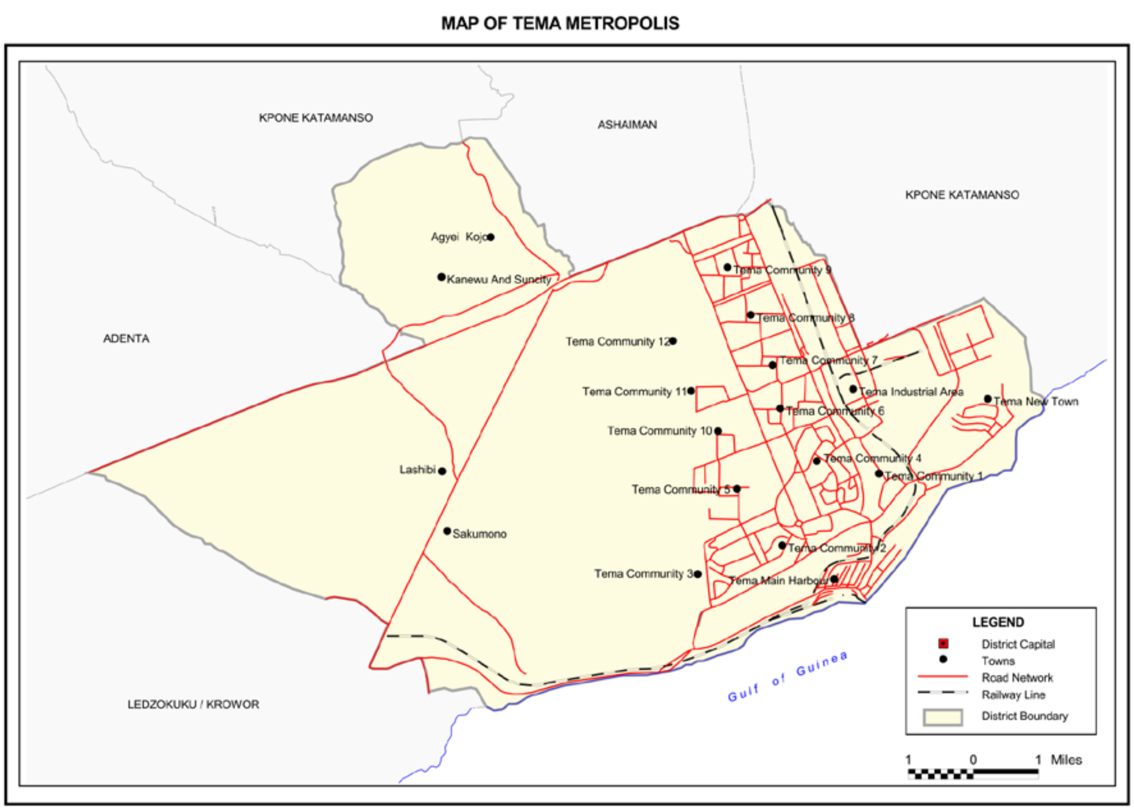
Among the challenges that the educational sector of Kpone-Katamanso faces includes:

- High enrolment in some schools
- Inadequate furniture in some schools
- Encroachment on school lands e.g. Zenu cluster of schools and Kpone Presby JHS
- Lack of electricity in some schools e.g. Kpone Presby JHS
- Cracked walls, leaking roofs and ceiling e.g. Kpone Methodist '1' Basic
- Temporal Office accommodation
- Lack of vehicle for the Directorate

5.8 Background Description of Tema Metropolis

The Tema Metropolis was created from the erstwhile Tema Municipality in 2007 with the promulgation of Legislative Instrument (LI) 1929. In 2012, the Kpone-Katamanso Sub-Metropolitan Council was carved out of the Tema Metropolis to establish the Kpone-Katamanso District. The Tema Metropolis has three Sub-Metropolitan Councils namely; Tema West, Tema East and Tema Central. Tema Metropolis is a coastal district situated about 30 kilometers East of Accra, the Capital City of Ghana. It shares boundaries in the northeast with the Dangme West District, south-west by Ledzokuku Krowor Municipal, north-west by Adentan Municipal and Ga East Municipal, north by the Akuapim South District and south by the Gulf of Guinea. The Ashaiman Municipal is an in-lock enclave within the Tema Metropolis. The Metropolis covers an area of about 87.8 km2 with Tema as its capital.

Figure 7: Map of Tema Metropolis



Source: Ghana Statistical Service

5.8.1 Vegetation/ Geology

The metropolis lies in the coastal savannah zone. The Greenwich Meridian (i.e. Longitude 0º) passes through the Metropolis, which meets the equator or latitude 0° in the Ghanaian waters of the Gulf of Guinea. The Metropolis proximity to the sea with its low lying terrain which projects into the sea makes it a natural endowment for a harbour. This evidently informed the decision of the construction of the Tema Harbour in 1957, making the Metropolis "the Eastern Gateway of Ghana". The topography of the Tema Metropolis is generally flat and forms part of the coastal plains. The terrain of the district barely rises up to 35m above sea level. Rainy season in the metropolis is usually from April to July (major rainy season) and from September to November (minor rainy season).

The vegetation zone in the Metropolis comprises of the following; shrub land, grassland and few patches of semi-deciduous forests. Soils in Tema Metropolis are composed of sand, clay, humus, gravel and stone. The sandy and humus nature of the soil support the cultivation of vegetables whiles the clayey nature, though support the production of brick, could also have adverse effects on general construction activities.

5.8.2 Land management

The Tema Metropolis comprises of two district planning areas – the Tema "Acquisition Area" which is administered by Tema Development Corporation (TDC) and the "Non-Acquisition Area" which, though owned by the various traditional authorities, is managed by the Town and Country Planning Department of the Tema Metropolitan Assembly (TMA). Currently this area also falls under the jurisdiction of TMA. This situation has resulted in the overlapping of planning functions which continues to breed a lot of conflict on issues between the two planning authorities

5.9 Demographics and Population of Tema Metropolis

According to the 2010 PHC, the population figure of Tema Metropolis is 292,773 representing 7.3 percent of the region's total population. Males constitute 47.8 percent and females represent 52.2 percent. The table below shows this representation:

Table 7: Population of Tema Metropolis

SEX	FREQUENCY	PERCENTAGE %
Males	139,95	47.8
Females	152,823	52.2
Total (100%)	292,773	

Source: Tema Metropolitan Analytical Report, (Ghana Statistical Service, 2014)

The average household size in the Metropolis is 4.1 persons per household with children constituting the largest proportion of the household composition with 34.1 percent. The Metropolis has a migrant population of 166,506 (75.3%). In terms of nationality, 94.5 percent of the populations are Ghanaians by birth, 0.7 percent by naturalization and the remaining 2.5 percent constitute foreigners. The highest proportion of the population is in the 25-29 year age group and declines with age such that the oldest age group (95-99 years) is the smallest proportion of the population. Tema Metropolis has a youthful population. In terms of the proportion of age and sex of the population,

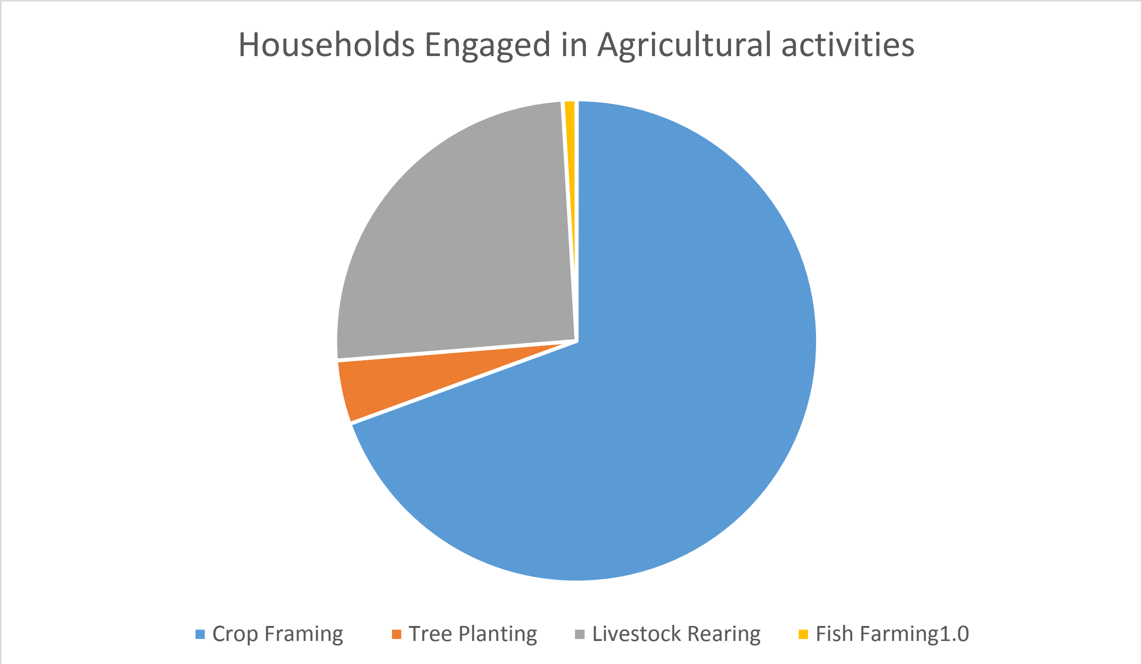
5.10 Economic Activities

Industries, agriculture and commerce make up the economic resources in the Tema Metropolis.

5.10.1 Agriculture

Although agriculture is recognized as the mainstay of the Ghanaian economy, agricultural activities are not very common in the Tema Metropolis due to its predominantly urban characteristics. Crop farming and livestock rearing are the main agricultural activities. The main livestock reared include chicken, which is the most dominant followed by goats and cattle. According to the 2010 PHC, about 3.6 percent of households are engaged in agricultural activities. Out of this, 74.7 percent engage in crop farming, 27.3 percent rear livestock, 4.6 percent are in tree planting and 1.0 percent are engaged in fish farming as shown in the figure below:

Figure 8: Households engaged in agricultural activities in Tema Metropolis.



Source: Ghana Statistical Service, 2010 Population and Housing Report.

5.10.2 Industry

The Tema Harbour was officially opened in February 1962 and is the hallmark of economic activities in the Metropolis. The Metropolitan Area serves as the industrial hub of Ghana with over 500 industries that produce chemicals, clothing, consumer electronics, electrical equipment, furniture, machinery, refined petroleum products, steel and tools. Tema houses the country's biggest port and harbour facilities. Although these contribute substantially to the revenue of the state, not much can be said about its contribution to the Tema Metropolitan Assembly. In order to reverse this trend, the Assembly is collaborating with businesses in the shipping industry to mobilize enough revenue from the Port. Tourism and hospitality sectors play an important role in the economy of the Metropolis. The Tema Metropolis has a number of tourist attractions, such as, the Meridian Stone, Greenwich Meridian and the Sakumono beach. Furthermore, there are 350 hotels and guest houses in the Metropolis.

5.10.3 Commerce

There are over 20 financial institutions, such as, Ecobank, Zenith Bank, Ghana commercial Bank, Barclays Bank among others with branches spread throughout the Metropolis. The Metropolis has access to more than ten (10) major free-on-air television stations including, TV3, GTV, Metro TV, NET 2, Viasat 1, Crystal TV, ETV, UTV and TV Africa. All the six (6) main mobile telecommunication companies (i.e. Expresso, MTN, Tigo, Airtel, Glo and Vodafone) operate in the Metropolis. Also, almost all the major communities within the Tema Metropolis have market facilities, and this is due to the fact that the city was planned using the Neighbourhood Concept of Town Planning.

5.11 Water Supply and Sanitation

This section presents the main sources of water supply for domestic use to the various households in the district as well as the methods adopted in disposing both liquid and solid waste materials.

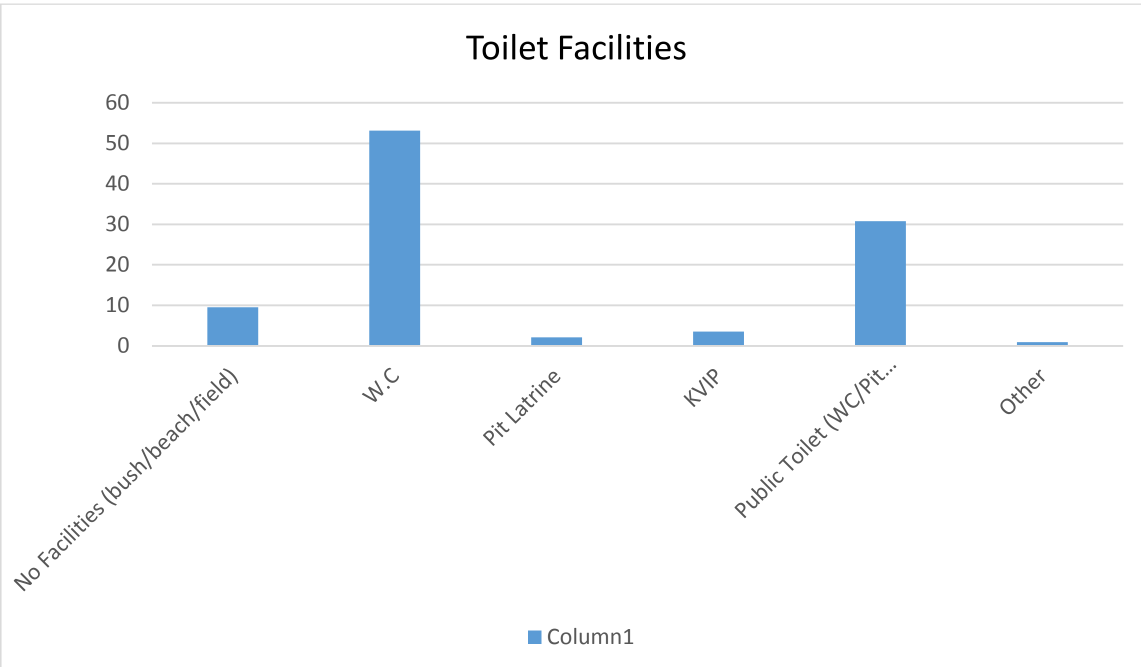
5.11.1 Sources of Water

The availability of and accessibility to improved drinking water is an important aspect of the health of household members. The UN Millennium Development Goal Seven (MDG 7) aim at reducing by half, the proportion of people without sustainable access to safe drinking water by 2015 based on 1990 levels. The Tema Metropolis has its main source of water supply from the Kpong water works. According to statistics, about 49.4 percent of households use pipe-borne inside dwelling unit, followed by pipe-borne outside dwelling unit (25.4%), public tap/standpipe (16.0%), and sachet water (6.5%) as their sources of drinking water. On the other hand, 81.4 percent of households rely pipe-borne water both inside and outside dwellings for domestic purposes while the remaining 16.6% rely on public tap /standpipe. Occasional breakdown of activities at the water works, however, causes a nightmare in terms of water supply to the people in the Metropolis.

5.11.2 Bathing and Toilet Facilities

Figure 7 shows the type of toilet facilities used by households in the metropolis. About 53.1 percent use WC, 30.8 percent use public toilets and 3.5 percent use KVIP. Meanwhile, 9.5 percent of the households have no access to toilet facility and therefore use bush/beach/field. Also, in terms of bathing facilities, about 40.5 percent of households have their own bathroom for exclusive use, 25.6 percent share separate bathroom in the same house, 11.8 percent use share an open cubicle, 3.2 percent use private open cubicle and 2.4 percent use open space around house.

Figure 9: Toilet Facilities patronized in Tema Metropolis



Source: GSS, 2010 PHC

5.11.3 Sanitation/ Methods of Waste Disposal

In the early 1960's, the government of Ghana in the development of the Tema Township built a large water carriage system referred to as the Tema Central Sewerage System. The system is composed of a network of pipes of various sizes that convey sewerage into three (3) pumping stations and two ejector stations. These pumping/ejector stations pump sewerage through a detention basin into the sea.

In recent times, the Assembly has introduced private sector participation in the collection, transportation and disposal of solid waste. This initiative is to expand the coverage of solid waste collection in the Metropolis. Presently, the Assembly has privatized the collection and disposal of solid waste (except Tema New Town) and this development has reduced the financial burden of solid waste collection on the Assembly. Under this new arrangement, contractors (service providers) are required to collect solid waste and associated approved fees directly from households.

5.11.4 Solid Waste Disposal

The most common method of disposal of solid waste is by the collection method which is used by 56.2 percent of households. Breaking this down, about 21.8 percent dump solid waste in public containers, 10.7 percent of households' dispose of solid waste through public dump (open space) and 6.7 percent burn their solid waste.

5.11.5 Liquid Waste Disposal

Statistics from the Ghana Statistical Service (PHC, 2010) indicates that about 39.5 percent of household's dispose of liquid waste through the sewerage system, followed by 26.6 percent of households who throw liquid waste into gutter, 13.8 percent dispose of liquid waste through drainage system into gutter and 9.9 percent throw liquid waste onto compound.

5.12 Education

The Ghana Education Service (GES) implements approved policies made by the Ministry of Education (MoE). In the Tema Metropolis, educational concerns are addressed by the Metropolitan Education Directorate. The Metropolis has many public and private tertiary and pre-tertiary educational institutions. Out of the 338 schools in the Metropolis, 185 are private and 153 are public schools. Also the Metropolis has one full fledge private university, the Datalink University, and satellite campuses for three other universities, namely, Presbyterian University, GIMPA and KNUST. In spite of the advancements of education in the Metropolis, the budget allocation for the education sector by the Metropolitan Assembly is always inadequate to meet the demands of the Education Unit to carry out infrastructural development of schools

5.13 Health

Tema has both public and private health facilities that are spread across the entire Metropolis and their classification by type of facility is based on their functions and the range of services they provide. Some of the health facilities include the Tema General Hospital, Nabita Hospital and the Port Clinic. The total number of health facilities in the public sector is 46 (54.2 %), is higher than that of private health facilities 16 (38.9%). This means that in terms of accessibility to health facilities in the Metropolis, the public sector has a wider coverage in the provision of healthcare. However, due to rapid increase in the population of the Metropolis, expansion of health facilities both public and private has become necessary to meet the needs of the population.

In addition, there is also the Tema Metropolitan Mutual Health Insurance Scheme which was established in March 2004 as an intervention in the health sector. The purpose of the scheme is to provide a pool of resources to reduce the monetary stress on health acquisition. The scheme provides out-patient, in-patient, oral health, eye care, maternity care and emergency services.

6.0 Survey OF AFFECTED PERSONS AND BUSINESSES

This section presents information gathered on the eligible projected affected persons and businesses. It provides information on their background, economic activities and the challenges that they are likely to face as a result of this project. Detials of the 6 PAPs are presented below:

6.1 Lottery Kiosk

Noble Adzraku is a thirty-one year old lottery agent and a native of Anlo in the Volta Region. Currently, Noble resides at Bankuman in the Tema Newtown Community. His mother tongue is Ewe. He is a Christian and worships with the Top Outreach Church located in Tema. He is single with no children. Noble works as a lottery agent and is the owner of a four metre squared kiosk located on the premises of the Tema Oil Refinery. Although, he is not the actual owner of the kiosk, he however is the sole owner of his business and has been in business for the past eight months. Also, he is not the actual land owner of the piece of land on which his kiosk is found. He explained that he did not have any clue as to whom the land owner was; as no land owner had come around to claim the land.

The lotto business according to him is a seasonal business as customers patronized as and when they had money to. Also, business sales boomed during dry seasons but went on a low turn during rainy seasons and holidays. Noble's customers are the workers found at the Tema Oil Refinery (TOR) area.

His kiosk is a wooden structure made of wood for both the walls and floor with aluminum sheets for the roofing. He does not have access to electricity, water and toilet facilities. As such, he goes to toilet in the bush. He does not own any means of transport but has sheets of paper, pens, pencils, carbon sheets and receipt books as his work tools. Whereas he earns a minimum of hundred Ghana cedis on the average for a day's business; on a good day, he earns about a hundred and fifty Ghana cedis. As a lottery agent, his income is thirty percent (30%) of his weekly sales. The remaining seventy percent (70%) is given to the officials of the lottery organization for the payment of taxes to the Tema Metropolitan Assembly (TMA). However, Noble is not aware of the amount paid as taxes as these payments are made on his behalf by the lottery authorities. He incurs an expenditure of one Ghana cedi daily on chalk and water which he used in cleaning the writings of lottery numbers.

Although, a driver by profession, Noble does not engage in any other work aside his current job. He has not gone in for any loans from either friends or banks. He has personal savings with micro finance “susu” groups of which he makes a weekly contribution of twenty Ghana cedis. He buys sachet water which he uses as drinking water but relies on pipe borne water for other domestic purposes at home.

Noble’s parents are deceased and at the moment is living alone. In terms of accommodation, he lives in Tema Manhean or New Town, in a standard 2-rooms (chamber and hall) which he built himself on a rented parcel of land. He has access to electricity and water at his place of residence but has no toilet facility. He pays a monthly bill of fifteen Ghana cedis (15gh) while he spends eight Ghana cedis (GHC8.00) on feeding per day. Noble has good health as he hardly falls ill or visit the hospital. There are no persons with disability in his family. He is not a beneficiary of any training or income from any governmental of Non-governmental organization. Noble migrated in 2005 from Anloga in the Volta Region of Ghana to his current settlement in search of a job.

He has had no prior information or knowledge about the upcoming Ghana Bridge Power Project. He expressed challenges of finding a new site to relocate his kiosk in order to continue his business and also does not know how the relocation was going to affect the patronage of lottery tickets by customers.

Figure 10: Pictures showing Noble Adzraku in his lotto kiosk

Findings from our recent site visit, in May 2016 indicate that Noble is now driving his taxi full time and has given the lotto operations to a relative of his, 29 year old Richard Kwaku Sepah who is a student of the College of Distance Education, University of Cape Coast. Richard works throughout the week except on weekends when he attends lectures. The lotto kiosk can be moved back to make way for the pipeline during the construction.

Table: Bio data of PAPs

Number	Structure	Owner	Gender	Age	Occupation	Hometown	Marital Status	Duration of Business
1.	Lotto Kiosk	Noble Adzraku	Male	31 years	Lottery Agent	Anlo	Single	8 months
2.	Snack Business	George Gyabaah	Male	33 years	Petty Trader	Dormaa Ahenkro	Married	One year
3.	Banku and Snack Business	Hannah Sosu	Female	35 years	Food Vendor	Agbozume	Single	6 years
4.	Block Maker	Lawson Ocloo	Male	45 years	Businessman	Gbator	Married with four children	12 years
5.	Food Kiosk	Victoria Agbelkpeh	Female	40 years	Food Vendor	Agbozume	Married with three children	4 years

Source: Field notes

6.2 Snack Business

George Nana Gyabaah is a thirty-three year old businessman. He is a native of Dormaa Ahenkro in the Brong-Ahafo Region but currently resides in the Tema Industrial area. George is married with one child and is the sole owner of his business. He professes Christianity and worships with the Church of Pentecost in Tema. He is a trader and operates a provision shop where he sells items such as biscuits, soft drinks, chalk, toffees and sachet water.

George has been in his business for more than a year after he acquired the shop from a friend. Also, he is not the actual owner of the land on which his business is operated on. According to him, the land is owned by a private individual to whom he pays a monthly charge of five Ghana cedis (GHC 5.00) as rent of which no receipts are given.

George's goods are patronized by all the workers within the premises who constitute his primary customers. Business is good during the weekdays when all the workers are available but slow during holidays and weekends. He sells his provisions in a kiosk which doubles as his bedroom. The kiosk is made up of plywood, glass and roofed with aluminum sheets. He is also the owner of a metal tent, three wooden benches and a wooden table. He does not have access to electricity, water and toilet facilities at his location and as such uses the bush for his toileting and bathing activities. He disposes of liquid waste off by pouring on the ground. He also uses his shop as his kitchen where he prepares his meals. He does not own any private means of transportation but uses public transport to convey his goods when he goes to buy them from the market.

When asked if he had any other sources of income, George replied in the negative. He is not a beneficiary of any program from either government or non-governmental organization. He also has not gone in for any loans from either friends or the bank. He is not an owner of any investment or shares and has no savings. George makes a daily sale of about seventy Ghana cedis from his provision shop but makes earns eight Ghana cedis as his profit on a daily basis. His expenditures include repairs on his generator, purchasing new padlocks for the shop as a result of constant theft issues, transportation and fuel which costs him about fifteen Ghana cedis weekly. For George, provision sales increase during the dry season than in the rainy season.

Currently, he assists some of his nieces and nephews with an amount of fifty Ghana cedis every month while he spends five Ghana cedis daily on his feeding. In terms of his health, he hardly pays a visit to the hospital but spends about twenty Ghana cedis on medication when he falls ill occasionally. There are no Persons with Disability (PWD) in his household. George is one of the many migrants who leave their hometowns to Accra in search for greener pastures. It has been nine years since he left his hometown to Accra to find a job. His mother is deceased while his father lives in Cote D'Ivoire. According to George, his main ambition was to further his education but after having a hard time, he settled for his current job which he hopes to stop should he find one that is better than his current one.

Before the team's encounter with George, he explained that he had heard some information about the project but lacked the details. He expressed his concern about finding a place to relocate his business to but in the event where he is unable to, he may have to abandon the business altogether. He further explained that he may have some of his property damaged during the relocation and all this could have adverse effects on him as this business was his only source of livelihood.

Figure 11: Interview with George Nana Gyabaah

Figure 12: Kiosk belonging to George

George's wife, Cynthia Kwaah 28 years, has joined him from Nkoranza in the Brong-Ahafo Region and prepares local food (banku and soup) for sale. Aside from the food she sells at the project site, Cynthia has also learnt to bake. However, she lacks the needed baking equipment such as the oven and utensils. Cynthia hopes to be assisted with an oven and a place to set up her baking business. The couple will also need some furniture. They live with their three year old daughter, Blessing Kwabia.

Figure 13: George's wife preparing banku for sake

On the 1st of June 2016, a visit was made to the land that George hopes to buy if assisted with some money. The land is sited at Bankuman in Tema Newtown; a suburb of Tema Manhean. The team met the Surveyor who is also a member of the Tema Traditional Council and Vincent Mbortey, a representative of the land owners. At the moment, George cannot afford the cost of the land which is about GHc5,000.00 per quarter of a plot and he will need about half a plot to build a three-room structure to accommodate his family and business.

Figure 14: The new site George hopes to relocate

Figure 15: Temporary structure on rented land

He has the option to rent land from the same area at a monthly rent of GHc50.00. However, he can only put up a temporary structure, because the actual landowner can request for the land at any time. This arrangement is thus unreliable. As such, he hopes to be given some assistance that will enable him to buy the land and put up a permanent three-room structure. In addition, George will also need support in transporting his belongings from their current location.

6.3 Petty Trader- Banku and Soft Drinks

Hannah Sosu is a thirty three year old young lady and a native of Agbozume in the Volta Region. She is a petty trader who sells banku and soft drinks on the premises of the TOR power enclave. She has been engaged in this business for the past six (6) years. She is the eldest of three children. Hannah is a self-employed business woman with no employees at the moment. However, currently she is being supported by her younger sister in her business of whom she gives an allowance of ten Ghana (10gh) cedis daily. Her primary customers are mainly the workers in and around the TOR power enclave. According to her, business is seasonal and in most cases, there is a boom in business during days when there are a lot of activities in the area.

Although Hannah may not be the immediate owner of the land, she has the permission of the land owner; one Alhaji, to operate her business. She does not pay any rent or tax for engaging her business on the land. The land on which Hannah operates her business is about a half plot. Hannah operates her business in a wooden kiosk which is made up wood and roofed with aluminum sheets. This wooden kiosk also serves as a temporary bedroom for Hannah and her siblings during the week when they do not go home to their residence at Lapaz. She does not have access to electricity, water and toilet facilities at her business location. She relies on pipe borne water from Western World Company in operating her business. Waste water from cooking are disposed into the nearby bushes. The bushes also serve as a bathroom and toilet facility for her siblings and herself during their weekend stays on the premises. Her business equipment includes a coal pot, utensils, wooden tables, plastic barrels, wooden benches, a gas stove, plates and plastic bowls. Also, on the premises is a bathroom made of cement blocks. However, at her residence in Lapaz, she has access to electricity, water and toilet facilities. The building is made up of a chamber and hall. She spends twenty Ghana cedis on electricity bills monthly.

Although she does not own any means of transport, she uses the bus when she purchases her foodstuffs from the Tema Community One market. She makes a daily sale of about one hundred and fifty Ghana cedis to two hundred Ghana cedis on a good business day. She works on every day of the week except on weekends and holidays. Her expenses are mostly on charcoal and gas which she uses in preparing her meals. On a good business day, Hannah makes a profit of about fifty Ghana cedis (50gh) daily after all expenses have been deducted and she has paid a ten Ghana cedis (10gh) allowance to her younger sister who serves as a helping hand.

As a woman, her roles have to do with housekeeping and cooking for the family. She has not made any investments, shares or savings for the future. She is not a beneficiary of any government or non-governmental programs and has no support from elsewhere. She is also not on any loan or borrowed from any friend or family member.

Although she does not visit the hospital on a regular basis, she spends about two hundred Ghana cedis (200gh) when her health fails her. There are no persons with disability (PWD) in the Sosu family.

According to Hannah, she has had prior information about the project from the workers but the details about the project are limited. A main challenge she expressed was in finding a place to relocate her business to but not on their household.

Figure 16: Interview with Hannah Sosu

Source: Field Pictures

Hannah Sosu and Akua Amoako who were located on the project site, have now relocated from the project site. In early March 2016, she was asked to move and she relocated to a piece of land opposite the proposed project site. She moved her kiosk and a few other belongings without any assistance from the project. She also hopes to put up a two room temporary structure and have access to water at her current location. She also has expectations of developing/dressing-up her new place and hopes to be supported with that.

Figure 17: New location of Hannah and Akua's Business

6.4 Block Maker

Mr. Lawson Ocloo is a forty-five year old businessman who owns chains of businesses. He is married with four children aged between fifteen and two years. He is self-employed with four employees. He has been in construction business since 2003. He is the sole owner of his business; however, he is not the owner of the portion of land on which he operates his business. The land is the property of the Tema Development Corporation (TDC) of which he is taxed an amount of two hundred and fifty Ghana cedis (250gh) to both the Tema Municipal Assembly and TDC annually. Mr. Lawson chose this site for his construction business because the location is advantageous for business sales as passerby's' mostly form his primary customers. A wooden shed, block plant machinery, a washing bay and a vehicle are among his business assets. At his worksite, Mr. Lawson has access to electricity and water facilities.

He does not have own any shares, investments or savings in his name. Also, he has not borrowed any loan in the form of monies or properties from any bank or individual. As a family man, he lives with his wife and children at their residence in Tema where they have an access to electricity, water and toilet facilities. According to Mr. Lawson, his wife is responsible for the household and is somewhat the breadwinner while he uses his earnings for philanthropical works. Again, he is currently not benefitting from any programs under the auspices of the government or non-governmental organization. There are no persons with disability (PWD) in his household.

According to Mr. Lawson, he is unaware of the Ghana Bridge Project. However, he complained bitterly about such projects and how they adversely affected businesses like his. He explained that a previous project that was undertaken in the area cost him several of his employees and almost run down his business as the duration given for the project surpassed and took longer than it was timed for. He requested that due compensations should be paid to the eligible project-affected persons. Also, necessary relocation plans should be put underway for such persons as well as the taxes that may be charged at these new places.

Figure 18: Mr. Lawson Ocloo in a conversation with the social team

6.5 Food Kiosk

Victoria Agbelkpeh is a forty year old mother of three of ages twenty-eight, twenty-six and fourteen respectively. She resides at Tema West in Adjei Kojo, one of the major Tema towns. She is a native of Agboume in the Volta Region of Ghana. She is the owner of a small food joint where she sells banku, fufu, rice and akple. She has been in this business for the past four years with just one employee who earns a monthly allowance of two hundred Ghana cedis. Victoria is not the owner of the parcel of land where she is currently operating her business. However, this portion of land which is the property of GLICO was given to Victoria to operate on based on an arrangement.

Victoria is the first lady to have been allowed into the premises of the Tema Industrial enclave to operate a food joint. Formerly, she sold sachet water at the premises but later progressed to selling food to the workers as there were no food joints operating in the area. All the workers; especially men who work or operate a business in and around the TOR power enclave constitute her primary customers. According to Victoria, business been slow and is not as lucrative as in previous times. At her business centre, she does not have any access to electricity, toilet facilities and water. However, she fetches water from the pipes at Amandi Company; a company adjacent her business area and disposes water into the main gutter running in front of her food joint.

Victoria's business equipment's include three plastic chairs, three plastic stools, three plastic tables, cups, bowls, cooking utensils, a shelf and two water gallons. She sells the food she prepares on a shelf which is made up if wood, aluminum sheets for the roof and glass for the windows. She relies on a taxi cab as her means of transport to and fro her business site.

Her main source of income is the food joint she operates now where she makes a profit margin of about six hundred Ghana cedis a month. She works on every day of the week except on weekends and public holidays. She makes a daily expense of about thirty Ghana daily on her transport. However, she also spends about two hundred and fifty Ghana cedis on her environmental license which is renewable every five years. She does not own any shares, investments or treasury bills she can rely on in the future. Again, she is not a beneficiary of any loan, governmental and non-governmental organizational program.

Mr. Edward Akrobo; a teacher by profession coupled as Victoria's husband and Household Head. They are the owners of a three bedroom house which is fully furnished with electricity, toilet and water facilities. As a mother, Victoria is responsible for the upbringing of her children as well as other housekeeping duties. She also performs familial duties to her extended family members by catering for the educational needs of her nephews and nieces. On a daily basis, she spends about twenty Ghana cedis (20gh) on feeding her household.

In the area of healthcare, Victoria averagely spends an amount of thirty Ghana (30gh) cedis on medical bills annually. On the other hand, she spends approximately five thousand four hundred Ghana cedis (5400gh) on her youngest daughter education.

In a conversation with Madam Victoria, it was revealed that she has no prior knowledge or information about the project. However, she expressed positive sentiments towards the project and explained that it will help boom up her business as the new workers would add to the numbers of her customers. On the other hand, she also complained that the project may slow down her business during the period of the construction.

Figure 19: Interview with Madam Victoria Agbelkpeh

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Figure 20: Images of some of the structures on the proposed site.

Source: Field Pictures

Farmer (on new project site)

Mustafa Moro is a twenty year (20) old welder who currently farms on the project's new site. He hails from the Northern Region of Ghana but presently lives alone at Tema Community 10. The closest relative he has is a brother, who lives in Accra. At the time of the visit, Mustafa had cultivated green pepper, maize and some okro on the site. However, only his green pepper and okro plants will be affected since he had already harvested the maize. According to Mustafa, he went into small-scale farming because he cannot afford tools for his welding business. He needs about GHc5000.00 to purchase these tools. However, with about GHc2500.00 he will be able to buy the most urgently needed tools to start his welding business.




7.0 FOCUS GROUP DISCUSSIONS

Separate focus group discussions (FGDs) were held with leaders/representatives of Tema Manhean community and Tema Community 4, 7 and 9. Participants included representatives of youth, women and religious groups within these communities. Perspectives shared by participants at the FGDs are summarized in the following sub-sections:

7.1 FGD Held with Members from the Tema Manhean Community (Tema Newtown)

- **Background History of Community**

Tema Manhean is the native name of the Tema Newtown Community. According to the locals, the people of Tema migrated from Israel through to Ile-Ife in present day Nigeria. From Ile-Ife, the early settlers then migrated in batches to the current location of the Meridian Hotel. Several years after becoming inhabitants of the Tema land; the late Dr. Kwame Nkrumah, the then President of Ghana acquired the land of Tema for industries and development activities. The industrialization of the area created the need for the locals to resettle across all over Tema especially around the Harbour area. The main occupation at the time was fishing and farming. However, in later years, farming activities in the area have dwindled due to constant industrialization that has taken over the area. Although Tema Manhean belongs to the native Ga people, in recent times it has become a cosmopolitan community being dominated by the Akans, Ewes and Ga-Adangbes. Due to the falling standards of the economic activities in the area, poverty is pre-dominant. About eighty percent (80%) of the inhabitants live in poverty while the remaining twenty percent (20%) will be shared among the average and wealthy. Most residents in the area live in kiosks with no proper settlements.

- **Positive and Negative Aspect of the Community**

Inhabitants of Tema Manhean pride themselves in the how industrialized and developed the community is. Inhabitants can boast of various industries and major companies such as Tema

Oil Refinery, Ghana Ports and Harbour (Ghana's main harbour), Ghana Textiles Limited as having their location in the community. Sadly, with all these major industries thriving in the community, members of the area do not benefit as much they deserve. Whereas all the derived wealth from the industries is taken out without any reservation for the locals, the inhabitants are the most affected from all the fumes and pollutions of these industries. For instance, the Chemu River is one of such water bodies that have become highly polluted due to the chemicals and sewage from industrial operations while the quality of the air is unwholesome. This has gone a long way to affect fishing activities which is one of the main economic activities for the local people, thereby depreciating the standards of living of the people. Although there are periodic external conflicts between the Tema Manhean community and other communites like Nungua over the ownership of some water bodies, internally, conflicts are non-existent. There are twenty-four clan houses of which one person can belong to several of these clan houses. This reduces internal conflicts because of the intermarriages that take place and helps promote unity.

- **Health**

Sanitation in the Tema Manhean community is very poor. Most of the houses are closely built together resulting in poor ventilation and an increase in diseases. During rainy seasons, illnesses like typhoid and cholera are predominant.

- **Decision-Making Process**

The traditional council is one of the main decision-making bodies. This council consists of several stakeholders in the form of representatives from the various associations like the Canoe Owners Association, Fisher-folks, women and youth groups. In the making of a decision, consultations are held among these stakeholders form which a final decision is made.

- **Migration**

There's a high rate of migration into the community. Jobs and marriages are the main reasons for these migrations. As a result of this, the locals are in contact with several other communities like Kpone, Teshie and Nungua. For example, football matches and festivals are organized between these communities. Outward migration is minimal among the inhabitants of Tema Manhean. Mostly, fishing expeditions and occupational transfers are the main factors of outward migration.

- **Vulnerable Groups/Existent Associations**

Vulnerable groups in the community are mostly made up of the aged and unemployed youth. Associations and community organisations that can be found within the community include the Akyem Association, Milllionaire groups, Peace and Love group and Ghaba. These associations constitute of welfare groups, musical groups and tribal groups.

Community lands are designated for various uses. Whereas some parcels of land are for residential purposes, others are for commercial and industrial uses and fish processing activities. Meanwhile other lands are demarcated as untouchable. For example, Bankuman and Mantey are designated for residential purposes.

- **Women/Children**

In the Tema Manhean community, women engage in fish processing, petty trading and market activities. In most households, women are the breadwinners and are responsible for catering for the needs of their families. Even though, fish processing is considered as the main role of women, they are also seen to play a role when it comes to conflict resolutions and the organization of communal labours. Some women organizations are that of Ghana Beauticians Associations (Ghaba) and the Fish Processors Association.

- **School Enrollment**

About seventy percent (70%) of children in the community attend basic school. The community can boast of two (2) Basic schools and a Senior High School; the Manhean Senior Technical School and the Anglican Basic School. There is also a clinic (St. John’s Clinic) and a health post within the community.

- **Youth**

There is a base youth group recognized under the Traditional Authority of Tema Manhean. There are also several other youth groups found within the residences of the community. Youth groups act as community militants and work as active agents in projects. Thus, they can make or unmake a project depending on their support towards a project. They also mobilize other youths for clean-up exercises and educational programs.

- **Aspirations**

The aspirations of community members are to promote higher education among the youth and to improve the image of the Tema Manhean Community. They believe that if the youth are able to attain education to its highest, they would become competent and capable in protecting and fighting for the rights of the local people of the community. Also, members aspire to be greatly involved in future projects that would occur in the community.

- **Perceptions**

Members mentioned an increase in indirect employment through business operations as one of the main positives of the project. This is because a bridge in the gap of the country's current power crisis would help revive most of the industries that have been affected or shut down by this energy crisis.

However, gas emissions from the establishment would affect the quality of air in the area. Members expressed concerns about these pollutions and advised that experts should ensure that the necessary safety precautions are applied to ensure their safety. Also, eligible project-affected persons should be duly compensated.

7.2 FGD with Members of the Tema Communities 4, 7 And 9

- **Background History**

Tema was initially built and developed by the Tema Development Corporation (TDC). This organization started with the housing scheme and later decentralized to the district levels.

Presently, TDC owns part of the lands and thus needs to certify ownership of some portions of lands that falls under their jurisdiction. Land ownership within the Tema Communities can be spread out under three main divisions; i.e. the Traditional Authority, the Tema Development Corporation and the Tema Municipal Assembly (TMA). In recent political times, TDC falls under the Ministry of Works and Housing while TMA is under the Local Government. Although Tema is sub-divided into several communities, the township should not be viewed as such but be recognized as one unified body. One participant disclosed that even though the Tema communities may have undergone some form of modernization, all these communities have their locally assigned names. For example, Community One is locally known as Kotugon. The township is made up of eight different towns that all form part to make Tema. These towns are Ashaiman, Sakumono, Dodowa, Saasabi, Klubleklo Number 1 and Klubeklo Number 2, Adjei Kojo, Zeanu and the popular Tema Manhean.

- **Economic Activities**

As an industrial hub, most of the socio-economic activities are industrially related. Most community members work as industrial hands at companies such as the Tema Oil Refinery (TOR), Crocodile Matchet, Aluworks, Pioneer Foods and various others. On the other hand, a handful, mostly women, are engaged in trading, hairdressing, fish processing and dressmaking. A significant feature of the Tema Communities is that most of the women are operating their own restaurants and food joints.

Poverty is on the rise in Tema due to the unproductivity of most industries and its accompanied redundancy as a result of the current power crisis the country is facing. In the last four years since the power crisis, several of the people have lost their livelihoods as most of the residents are engaged in industrially related works. An interesting development has to do with an increasing number of women as breadwinners for their families as the men are losing their jobs every single day. Tema has been categorized into classes and scaled A-D with the wealthiest being classified as A and those living below the poverty line as D. This structure is according to the Tema Municipal Assembly’s grading system and this grading has been done with respect to the average standards of living found in the community.

- **Positive/Negative Aspects**

The Tema Communities are well planned and structured in terms of the tarred streets, sewer system and the availability of electricity, toilet facilities and portable water. The availability of all these essential social amenities has promoted cleanliness and good sanitation. Also, access to transport in the area is high and very easy.

However, the high cost of living is one of the major challenges in the community. For example, the prices of food and housing cost twice in Tema as compared to other localities like Teshie. This can be attributed to the industries found within the community.

- **Conflict**

The only conflict between the community and other surrounding towns has to do with disputes concerning political boundaries. These are however being addressed by the higher level of authorities of the region; which is the Regional Coordinating Director. Among the communities there are conflicts.

- **Health**

There is a lot of environmental pollution in Tema as a result of the constant industrial activities taking on the township. Members are gradually being affected by these pollutions and emissions from the industries. Aside these, the community only faces the normal health challenges such as malaria and a periodic outbreak of cholera. In terms of the environment, Tema is undergoing a changing phase. Most of the infrastructure are deteriorating and have become environmental hazards. For instance, several of the sewage systems have exceeded their fifty-year life span without any repairs and are now broken down causing choked drains and spills all over.

- **Decision-Making**

There are two main bodies in charge of decision-making within the community. These are the Traditional Authority and the General Assembly. The General Assembly is constituted by several stakeholders such as Assembly Members and a representative from the traditional council.

Decisions on the concerns of community members are made by these two bodies but final implementations are done by the Municipal Chief Executive and his technocrats.

- **Migration**

There is a huge influx of migrants from all over Ghana especially from the Northern-most part of the country into the Tema Community for the purpose of economic activities. Although, there is an evidence of migrations out of Tema, the numbers are minimal as compared to those coming in. The high cost of living in Tema and congestion can be said to form the basic reasons of migrations out of Tema.

- **Vulnerable Groups**

Comparatively, the sites of Tema Manhean can be described as having more vulnerability as compared to the Tema Communities. Persons with Disability (PWD), orphaned children and widows also constitute another group of vulnerable groups in the area.

- **Groups/Organizations**

Tema is a cosmopolitan area with mixed ethnic groups. In terms of numbers, the Akans have the highest number of people living in the community followed by the Ewes, Northern people and Gas respectively. There are political, religious, welfare and socially oriented groups found within the community. For example, there are Resident Associations, youth clubs, women organizations and some non-governmental organizations running in the community.

- **Gender**

The roles of women in the community are mainly geared towards performing welfare related activities such as childcare, housekeeping and catering for their households. There's an approximate increase of about sixty percent (60%) in the numbers of women acting as breadwinners in the community.

- **School Enrollment**

Though no statistics were given, participants could say with certainty that the number of school-going children is increasing in the community due to programs such as the School

Feeding Program, Free Compulsory Basic Education and the shift school system. It is difficult to see a child in Tema without having basic education. However, as they climb higher to secondary and tertiary education, the numbers drop drastically. Nonetheless, several of them go into craftsmanship and trading. There are enough schools and health facilities in Tema. The community can boast of schools like Data Link University College, GIMPA, Methodist University College, the Presbyterian University College and health facilities such as NaBita Hospital, the Tema General Hospital and several others.

- **Perceptions about Project**

The Ghana Bridge Power Project would boost economic activities in the Tema Community which will in turn help to improve the livelihoods of most households.

- **Community Recommendations**

The client should take a cue from the recent mishaps between the locals form the Kpone community and the authorities at the Asogli Power Project and be cautious of the kind of terms to enter into with the local people of the Tema. Also, the client must ensure that promises made in the terms of agreement (to be negotiated) with the community stakeholders are fulfilled. Again, security on the pipelines at TOR should be boosted to help check thefts that could result in great mishaps. There should also be a fire station within the premises of the project as part of safety measures. Priority must also be given to the local people and employment quotas must be cut for them during the construction of the project. Lastly, the client must ensure that during their time of operation, they will perform their Corporate Social Responsibility (CSR) to the community.

7.3 FGD with Members from the Kpone-Katamanso Community

- **Background History**

The people of Kpone initially migrated from Israel through Ile-Ife and finally settled in Ghana. In Ghana, they first settled at the Akwamufie in the Eastern Region of Ghana for a long time and then to Tema Sikagonnor near VALCO. In later years, little political struggles led the people of

Kpone to their present day location. In the past, Kpone was called “Kpone on sea” just to differentiate them form the people of Kpong, another little town in the Eastern Region near Akosombo. The town is divided into two maor suburbs namely Jorshie and Alata. Prior to the central governance in Ghana, the Kpone area was ruled and controlled by the traditional authority. The hierarchical order of the traditional authority is as follows: the Mantse, the Amanklado, the Mannii, the Shipi, the Wulormor, the Wornyei, the Agbaa (headed by Agbaafoi atse), and the Woloi atse.

- **Socio-Economic Activities**

The main socio-economic activities of the inhabitants are fishing and farming. However, in recent times, farming activities have diminished while fishing activities are declining. This has been as a result of an increase in the population of the area as well as increasing estate developing and industrial activities. About ninety percent (90%) of the indigenes live below the poverty line with only ten percent (10%) being average.

- **Positive/Negative Aspects**

Kpone is blessed with peace and unity. Members of the community live in a peaceful co-existence with little or no conflicts among inhabitants. However, clans have suffered several divisions as a result of the increasing population. Again, employment opportunities for indigenes are very low as most of the companies only employ indigenes as temporary factory hands. Another major challenge the community faces is the failing of most companies located within the community in performing their Corporate Social Responsibilities

- **Relationships/Contacts**

There are no existing conflicts; however, there is a potential emerging conflict with the people of Tema over a political boundary and land encroachment. Nonetheless, attempts are being made by the various authorities to resolve this issue. An example of such conflicts is the extension of powers by the TMA into the territory of the Kpone district to collect revenue from a landfill site and cemetery that have their location on Kpone soil. Meanwhile, such revenue collections are not used for the benefit of the Kpone people but are made to bear the environmental hazards.

- **Health**

In the past, health problems were not predominant in Kpone community as seen in modern times. However, presently, there has been an increased health problem especially among the youth due to constant environmental pollution from the industries. For example, cancer cases were not familiar diseases to the indigenes but now even children as young as fifteen years are suffering and dying of cancers. Youthful deaths were not predominant in the community in the past, however, most of the youth are now dying at the age of thirty. The life span of the locals has been cut off by these pollutions.

- **Decision Making**

In decision making, the traditional authority is the first point of call for all issues related to the Kpone community. The composition of the traditional council includes men, women and the youth. On the other hand, the Kpone-Katamanso District Assembly (KKD) is responsible for all development related activities that affect the area.

- **Contact/Relationships**

The community is in good contact with towns such as Tema, Prampram and Dorwenya.

- **Migration**

On a daily basis, the community witnesses a lot of migrants moving into the community. Industrialization of the area is one of the main reasons for these increased migrations. Migration out of the area is minimal and temporary and is especially common among the fishermen. Most fishermen as part of their fishing expeditions move out to other areas but mostly return home after a period of time.

- **Vulnerable Groups**

These are mostly made up of Persons with Disability (PWD), orphans, widows and the aged. Programs such as the Livelihood Empowerment Program, the District Assembly Common Fund for PWDs and HIV/AIDs programs have been put in place for these vulnerable groups.

- **Groups/Organizations**

Ethnic groups living in the community include the Akans, the Ewes, the Northern people and the Gas. In terms of numbers, the Gas are the most dominant group of people living in the area, followed by the Akans, Ewes and Northners respectively. Active community organizations include the Fish Processors Association, the Fishermen Association, the Concerned Youth Association, the Dangbe Youth Association, the Hairdressers Association and the Association for the Aged.

- **Land Designation**

Lands are partitioned for residential and industrial uses but the implantation of laws that govern these lands are not as comprehensive as they should be. As a result of this, a lot of farmlands have been lost and this has gone a long way to affect the livelihoods of most of the indigenes.

- **Gender**

The roles of women in the community has been split mainly into vegetable farming and fish processing activities, housekeeping and childcare. Previously, education among women was minimal but in recent times, women have become determined to attain the highest form of education.

- **School Enrollment**

About ninety-five percent (95%) of children are enrolled in school. At least, basic education can be said to be very common among children of school going age. However, as they progress to the secondary and tertiary levels, most of them drop out of school due to financial challenges.

The community can boast several basic schools; although private owned, a senior high school, a polyclinic and a private owned clinic.

- **Youth**

Youth groups are very active in the Kpone-Katamanso community. Currently, there are three main recognized youth groups operating in the area. These are namely; the Ga-Dangbe Youth Association, the Kpone Youth Association and the Concerned Youth Association. These youth groups champion the concerns of the youth of the community and involve themselves in all forms of decision-making that affects the youth as a whole.

- **Future Aspirations**

One of the main aspirations of the local people of Kpone is to build and own a University in the area as part of championing education among the people Also, it is the aspiration of the indigenes to reserve and maintain the town's parcels of land for future generations. Again, community members aspire to be involved in all forms of development that affect their lives as well as benefit from these developments.

- **Perceptions/ Positive & Negative Impact**

The Ghana Bridge Power Project will bring employment to the inhabitants of the Kpone community. It will also enable the community to have access to power and electricity. Members expressed a general concern in terms of safety measures to be put in place during the construction of the project.

8.0 ANALYSIS OF PROJECT IMPACTS AND MITIGATION

With reference to the likely impacts the project will cause, respondents indicated some of the impacts the project was likely to have on them for both the constructional and operational phase of the project. This section highlights more on the constructional phase as that is where this ESIA report focuses on. These responses have been grouped into positive and negative impacts:

8.1 Potential Positive Impacts – Construction Phase

8.1.1 Job Creation

This is one of the major positive impacts that will result from the project. From our field observations, it is believed that the proposed project will generate a lot of employment opportunities, especially for local residents within the project location. This is because there are a large number of people with artisanal skills such as masonry, carpentry, welding, driving, auto mechanics and heavy machinery operating skills and that of the unskilled labour force available as workhands for the purpose of this project. This could go a long way in reducing the current unemployment rate in the area as well as improve the standard of living in the locality.

8.1.2 Boost trading activities

The proposed could also enhance the trading activities especially among food vendors and traders who operate within the industrial area. It will not only help increase the income of these traders but also open more avenues for women to provide various services for the contractors and their workers such as…. It is expected that with the completion of the project, more businesses as well as customers will be attracted to the area than before. Businesses that depend solely on electricity (such as) will make more profits due to the improvements in the supply of electricity.

8.1.3 Enhance skills of local Artisans

Again, many local artisans who have never engaged themselves in construction activities will gain the expertise and skills as they will get to be trained by the contractors before being engaged on the site. This training will enable them enrich their skills on the job and push them to a higher level in their field or career.

8.1.4 Improve power supply:

This is the main objective behind this project; to bridge the gap between the current energy crises the nation is facing. An adequate power supply would mean improved economic activities and increased productivity especially for industries within the project environs for the betterment of the livelihoods of the locals who work in these industries. More electricity will also be distributed to some areas which are not connected to the national grid. The proposed project will help address the challenges the economy is facing on the frequent power outages as known by many Ghanaians as ***"Dumsor***". It is expected that at the implementation stage, the project will go a long way to support the existing sources of power supply and boost the energy sector in the country

8.1.5 Increase Revenue for the Host District

As the project is being held in the Tema Metropolis, it is hoped that the payment of taxes and permits that are required by the assembly will add up to the revenue and internally-generated funds.

8.2 Enhancement of the Positive impacts – Construction Phase

In order to improve upon the above mentioned positive impacts, the following enhancements were recommended by FGD participants:

- ✓ The issue of employing the locals can be enhanced by ensuring that specific clauses are included in the contract that will guarantee the employment of local people during the construction phase
- ✓ There should be equity during recruitment such that 'outsiders' will not outnumber the local content during the constructional period
- ✓ There should be a better structured working conditions for workers to avoid low remuneration and misunderstanding

- ✓ Workers should be ready to learn from the contractors and work diligently.
- ✓ Create or provide space for women to sell food to the construction workers.

8.3 Expected Negative Impacts

8.3.1 Economic Displacement

Although the 6 kiosks in the project vicinity are located illegally in their present location, project construction would result in the need to relocate these structures in order to commence the proposed project. This exercise would have an adverse effect on 6 businesses and livelihoods for the kiosks located on the pipeline and the tank farm and the loss of property. Other affected property includes wooden tables, benches and sheds which will need to be relocated and will result in extra costs for the vendors.

The project could therefore result in the relocation of some businesses located on the proposed site. These relocations will have an effect on the daily earnings of most of the food vendors and traders as they may lose some of their customers. Also, finding a new place to relocate to is one of the major challenges that the project-affected persons would face. This impact will be addressed via a livelihood restoration plan to be prepared by One Energy.

Residential Relocation

One of the kiosks also serves as the residence of one of the business managers and his residence would also need to be relocated. This could result in negative economic effects and hardship during this process.

8.3.3 Community Noise and Dust Pollution

There is the likelihood of noise pollution resulting from heavy machinery and equipment to be used at the site. Drilling, hammering, movement and of truck during loading and offloading are also factors that may contribute to the high noise level. High levels of noise are known to cause stress, headaches and when persistent, hearing impairment. In addition, dust may rise up because of clearing of the land, offloading of sand or stones at the site and could be exacerbated by wind. When air quality is poor there is an increase in upper respiratory tract infections, asthmatics have more attacks and dust also causes eye irritation. The increase in dust levels could increase the incidence of colds and other upper respiratory infections in the general populace in the corridor. Fumes from obsolete heavy machinery and equipment could impact nearby neighbours.

Although an increase in noise and dust can lead to health problems for members in the nearby communities, most residences are located approximately 2-3 kilometers from the project. Therefore impacts would be unlikely to be significant and would be considered negligible.

8.3.4 Occupational Health and Safety Risks

In the field of construction, workers will be exposed to many occupational hazards that can cause harm or adverse health effect under certain conditions. Some of these include cuts, shock, inhaling of toxic substances and fever. Workers can also be exposed to electrocution as a result of touching a naked wire while using electrical gadgets. Workers will also be exposed to high levels of noise and dust that can be detrimental to their health. Also some people expressed their fear about the use of gas for the projects as accidental leakages could lead to explosions and fire outbreaks as gas is highly inflammable. This could lead to loss of human lives, loss of aquatic life, damaged properties and other serious health implications. Again, fumes and other toxic emissions emanating from the processing of the gas to generate power implicate respiratory infections to workers as well as residents around the project site. However, occupational health and safety standards require measures to address these risks and protect workers on site.

8.3.5 Impact on Water Bodies and exposed pipelines

The sea and its aquatic features are likely to suffer from the project since some aspect of the construction may be carried out on the sea (eg. For maintenance works). Likely chemical spillage and other hazardous materials falling into the sea could result in death of fishes, affecting the fishing industry which is the main economic activities of a substantial section of the population. There were also concerns about the likely explosions resulting from criminal activities on the exposed pipeline which could endanger the people.

8.3.6 Social Vices and Impact on Public Health

Construction work such as this usually brings influx of additional persons into areas where the construction is being carried out. The construction crews are mainly made up of men who are separated from their regular partners. Such persons will tend to indulge in risky sexual behaviours with locals and prostitutes, which tends to increase the incidence of teenage pregnancy, sexually transmitted diseases (STDs) and HIV/AIDS. The communities will also be exposed to criminal activities due of the influx of foreigners to the community.

8.4 Mitigation Measures

This section discusses the possible mitigation measures that can be adopted to reduce the negative impacts identified that can be detrimental to the success of the project.

8.4.1 Payment of Compensation

A livelihood restoration plan will be prepared consistent with IFC Performance Standard 5. Those who are likely to lose their properties would be informed and consulted early enough to start gathering their valuables for relocation. Adequate compensation and relocation for the businesses would be detailed in the Livelihood Restoration Plan to enable them relocate to a desirable location. If possible, some of block factory workers could also be engaged as workers during the project construction or could be offered training in alternative livelihoods. Compensation would also be paid to the households whose livelihoods would be impacted.

8.4.2 Reduction in Noise and Dust Level

An increase in noise and dust can lead to health problems for members in the nearby communities. However, most residences are located approximately 2-3 kilometers from the project. Therefore, impacts would be unlikely to be significant and would be considered negligible.

Although no noise or dust impacts on the surrounding community anticipated, the contractor should be required to take measures to control dust and noise pollution. This would include regular services or maintenance of machinery and equipment, frequent clean-up of the site and watering of possible exposed surfaces which might cause dust. In addition, the use of noise generating machinery should be used within stipulated working hours. Work should mostly be conducted at non-peak hours to minimize disturbances of the surrounding communities.

8.4.3 Safety and Hazard Reduction Measures

Proper and regular maintenance of equipment should be employed to ensure effective running to avoid accidental leakages and explosions. As an extra safety precaution, it is advised that a fire station be placed at the project site to reduce the risk of fire outbreaks.

Again, toxic waste and emissions generated from the process must be routed or channelled to a safe and separate place that will not have effect on the environment. The design of the pipeline must meet relevant international and local standards. Finally, to safeguards against any environmental unrest, the EPA must ensure that all the environmental policies regarding this project are adhered to thoroughly. Security should also be boosted especially at the TOR pipe routes as there are major concerns of theft in the area.

8.4.4 Supervision and Monitoring

The contractor should be closely supervised and monitored at the constructions phase to minimize the risk of accidents at site. The contractor must educate and caution against mishandling of tools and machines. Safety wear should as well be provided to each construction worker to reduce the risk of accidents at the project site. Delicate materials must be stored at safe and sound place or room with securities post guiding them. Mounting of regulatory and other important warning signs will alarm workers to restrain themselves from getting accidents.

8.4.5 Public education and Police Presence

As regards the incidence of social vices, education programs should be organised to sensitize both workers and locals, especially females on the dangers of indiscriminate and unprotected sex. This could be actively done by the Ghana Health Services in the Tema Metropolis and the Kpone-Katamanso District. The distribution of condoms to construction workers could also go a long way to reduce unwanted pregnancies and STIs.

On the issue of robberies, the suggestion was made for the provision of well-resourced and motivated police force at security threat areas in the metropolis. A vigilant police patrol coupled with security personnel should as well be made available to guard against any crime or irregularities in the area especially during the night.

8.4.6 Provision of more Social Amenities

By way of mitigation to the additional pressure on existing facilities, it was proposed that the Government should provide more social amenities and improve on the existing ones to accommodate the significant population growth. In addition, the people expect the project to provide some basic amenities as the project's corporate responsibility.

9.0 SUMMARY AND RECOMMENDATION

9.1 Summary

The Socio-economic Baseline Studies was conducted to provide baseline information and social impact assessment of the project area. The report reveals that, the completion of the project will help “bridge” the gap in the country’s current power supply crisis with an increase of 344MW with a mix of open and combined cycle gas turbine (OCGT and CCGT) generating stations compromising mobile Trailer Mounted (TM) turbine units and sprint turbo shaft gas turbines (LM units).

The study was focused on the Tema Manhean, Tema Communities (4, 7, and 9) and the Kpone-Katamanso district; all 2km away from the proposed project site. In all, three different Focus Group Discussions were conducted with opinion leaders, women, youth and religious groups within these communities and interviews with eligible project-affected persons. A stakeholder consultation was also held with the Traditional Council of Tema.

The study determined the perceptions of the local people concerning the project, potential impacts of the project on power, employment generation and other parameters for the socio-economic well-being of the impacted communities and the country as a whole.

9.1.1 Expected Positive Impacts

Among the likely positive effects to evolve from this project includes an increased in the nation’s power supply, job creation, boosting of local economic / trading activities, improved livelihoods of community members, enhancing the skills of local artisans and revenue generation for the host district.

9.1.2 Expected Negative Impacts

On the contrary, some of the negative impacts likely to result from the project includes; demolition of structures, loss of means of livelihood of project-affected persons, noise and dust pollution, environmental pollution, pressure on existing social amenities and a possible increase in social vices.

9.1.3 Mitigation Measures

Some suggested measures in mitigating the aforementioned negative effects include the payment of due compensations to eligible project-affected persons, reduction in noise and dust level, the application of internationally recognized safety measures, supervision and monitoring of activities, provision of fire stations on project site, regular maintenance checks of project and the use of eco-friendly and modernised equipment.

9.2 Conclusion

The study recommends that when all the suggested mitigation measures are adhered or met, the Ghana Bridge Power project will be realized in addressing the challenges or crises affecting the Power Supply in the country and further accrue other benefits to the surrounding project communities.

9.3 Recommendation

Based on the findings and observations made from the conduction of exercise, the following recommendations are outlined which when utilized by the client will ensure a long term success of the Ghana Bridge Power project. These recommendations are as follows:

First and foremost, to the extent feasible local workers should be utilized during the construction phase of the project. This could benefit both the client and the community as a whole as community members will feel a part of the project and put in their full support for the project. On the other hand, it will save the client the stress of finding human resources as labour will be brought at their doorstep.

Again, the client would ensure that due compensations are paid to the eligible project affected persons to avoid future disputes. The client should take note of the recent disputes that have ensued between community members of the Kpong-Katamanso district and Asogli Power. With regards to this, the client should honor their commitments to the community as failure to do this could result in conflicts between the client and members of these communities.

In addition, it is important that the client considers some form of Corporate Social Responsibility to the communities (CSR). CSR could be used to address some of the challenges of these communities and could come in the various forms such as scholarships to support the youth in education and in other areas of health and towards community development. This is highly recommended as it establishes and helps to build a strong relationship between the community and the client.

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www.ghanadistricts.com

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Ghana Bridge Power Project

Environmental and Social Impact Assessment

Appendix G2 – 2017 Focus Group Representatives Meeting

Early Power Limited

JACOBS CONSULTANCY PROJECT NO: 60K36301

Bridge Power Project

Early Power Limited

COMMUNITY CONSULATION FOCUS GROUP MEETING

MINUTES OF MEETING

Date: Thursday June 22nd, 2017

Venue: Kpone Traditional Council, Conference room

Time: 10:45am

Minutes taken by: Ms Marian Mingle, Associated Consultants (ACON)**Video recorded by:** Ms. Gloria Allotey (ACON)

ATTENDANCE:

No.	Name	Organisation	Position
1.	Mr. Kingsley Asare	Early Power Limited (EPL), Accra	Project Manager (Chairman)
2.	Mr. Kow Ainoo-Ansah	Sage Petroleum	Representative
3.	Mr. John Paul Wale	JACOBS	Lead Environmental Consultant
4.	Ms. Marian Mingle	Associated Consultants (ACON)	Environmental Consultant (Local)
5.	Ms. Gloria Allotey	ACON	Environmental Consultant (Local)
6.	Mr. Spyros Dagres	METKA S.A.	HSE Coordinator
7.	Mr. Apostolus Fouros	METKA S.A	HSE Manager
8.	Nii Tetteh Otu II	Kpone Traditional Council	Paramount Chief
9.	Shippi Agblezee III	Kpone Traditional Council	Member
10.	Okyeame Ogwee	Kpone Traditional Council	Member
11.	Mr. Moses Tettey Kwao	Kpone Traditional Council	Member
12.	Asafoiatse Botway IV	Kpone Traditional Council	Representative
13.	Mr. Joseph Kojo	Tema Comm. 9	Assembly Member
14.	Mr. Kwesi Asomani	Tema Comm. 7	Assembly Member
15.	Mr. Godfred Tetteh Abbey	TMA	Assembly Member

16.	Mr. Richard Aning	TMA	Assembly Member
17.	Mr. John Djorgadjor	TMA	Assembly Member
18.	Patience Serwaa Odom	TMA	Representative
19.	Mr. Richard Aning	TMA	Assembly Member
20.	Mr. Lord Ahumor	Unit Committee (Tema, Comm. 7)	Member
21.	Mr. Joel Boateng	Unit Committee (Tema, Comm. 7)	Member
22.	Lily Tekyi	Unit Committee (Tema, Comm. 7)	Member
23.	Ofori- Duodu	Unit Committee (Tema, Comm. 7)	Member
24.	Mr. Joel Ashitey	Tema New Town	Representative
25.	Mr. Martin Agbogedenu	Tema New Town	Representative
26.	Mr. Martin Agbogedenu	Tema New Town	Representative
27.	Ms. Leonie Dede Ashitey	Tema New Town	Representative
28.	Nuumo Akpiteorkor IV	Tema New Town	Representative
29.			
30.	Dinah Kuntu Blankson	Tema Comm. 9	Representative
31.	Mr. Emmanuel Osafo	Tema Comm. 9	Representative
32.	Mr. Andrew K. Ashrifie	Tema Comm. 9	Representative
33.	Mercy B. Mensah	Tema Comm. 4 Republic Road	Representative
34.	Mr. Ibrahim Nii Adjeitey	Tema East	Representative
35.	Mr. John Tetteh Kabutey	Tema East	Representative
36.	Mr. Yetteh Adjetey	Tema East	Representative
37.	Mr. James Amarfio	Tema Manhean	Representative

38.	Alhaji Quaye	Kpone	Representative
39.	Mr. Clement A. Mensah	Kpone	Representative
40.	Mr. Shadrach Tetteh	Kpone	Representative
41.	Mr. Ebenezer Aning-Sarpong	Tema Comm. 4 Horticulture	Representative

Item	Discussion
1.0	**FOCUS GROUP MEETING** Representatives from Kpone, Tema New Town and Community Areas from Tema main town had been invited by Early Power Limited (EPL) to a focus group meeting to discuss the EPL Bridge Power Project. The purpose is to disclose results from the latest Environmental and Social Impact Assessment (ESIA) studies, update the community on the project changes and latest timing for development, disclose other key information such as the grievance mechanism and construction phase plans for management of environmental and safety issues, and collect updated socio-economic baseline data. The meeting started at 10:45am at the Kpone Traditional Council, Conference room and lasted for approximately two hours.
2.0	**OPENING** Mr. Kingsley Asare of EPL declared the meeting open. A brief statement was made to set out the objectives of the meeting, and introduce the presenting teams, namely EPL, Jacobs, ACON, METKA S.A. and Sage Petroleum.
3.0	**AGENDA** The agenda was as follows: • deliver a presentation on Bridge Power project including project changes and latest schedule; • provide an update of latest progress and disclose findings of the ESIA; • summarise the actions going forwards, towards completing the ESIA process;

	• summarise the plans for managing environmental and social risks during the construction phase • summarise the Social Investment Strategy and grievance mechanism process; and • invite feedback on the above from attendees. Following the meeting, a subset of the attendees was invited to complete questionnaires as part of the updating of the socio-economic baseline data.
4.0	**FOCUS GROUP PRESENTATION** After a brief description of the Bridge Power project, the Chairman invited attendees to introduce themselves. A short presentation was made, as follows: **PROJECT DESCRIPTION** – Mr. Asare • The project infrastructure will include: ➢ power plant facilities across two sites (PPS1 and PPS2) ➢ a fuel storage tank farm ➢ fuel delivery pipelines from Tema Oil Refinery (TOR) jetty ➢ water delivery pipeline from Ghana Water Company municipal supply • Project would be developed in two stages: Stage 1 and 2 ➢ Stage 1: Installation of 5No. TM2500. Stage 1 will first be developed in ‘open cycle’ mode (Stage 1a), then upgraded to ‘combined cycle’ mode (Stage 1b). ➢ Stage 2: Installation of 4No. GE LM 6000 Sprint in combined cycle mode • Liquefied Petroleum Gas (LPG) will be imported from Tema port to TOR and then to a new, purpose-built tank farm for storage. • All Project infrastructure is within the Tema Heavy Industrial Area (THIA)
5.0	**ESIA PROCESS** - Mr. Wale / Ms. Mingle 1. EPA Screening – EPA decides level of assessment required 2. Scoping / Agreement of Terms of Reference 3. Baseline surveys 4. Impact assessment and compilation of ESIA report 5. Disclosure of ESIA findings to communities and other stakeholders for comment 6. Submission to EPA for approval and issue of Environmental Permit 7. Construction Management Plans – including traffic and emergency response 8. Operation Management Plans Attendees were encouraged to visit the Early Power Limited (EPL) website for access to

	available documents (from approximately mid-July) at: http://www.earlypowerltd.com/resources/ **ESIA CURRENT STATUS** - Mr. Wale / Ms. Mingle • February - April 2015: Screening • December 2015: ESIA Revision 1 submitted to EPA • January 2016: EPA permit issued in relation to Revision 1. • June 2016: ESIA Revision 2 submitted to EPA. • June 2017: Final project design developed, and Revision 3 of ESIA updated to incorporate the changes, and provide updated assessment. **KEY IMPACTS** - Mr. Wale / Ms. Mingle Impacts with community consideration: • Displacement (mainly economic, but also some physical displacement) of people – residents, farmers on Stage 1 and Stage 2 sites and along short sections of the pipeline; • Air impacts – from EPL and also “cumulative impacts” from other new plants; • Noise impacts on the community; and, • Community Safety – Traffic and TOR pipeline RoW.
6.0	**GRIEVANCE MECHANISM** - Ms. Mingle Attendees were encouraged to express any concerns about the Project through the Project Manager at EPL, Mr. Kingsley Asare, to which the Project would respond between 2 to 10 days, depending on the urgency of the situation. Contact details were provided to all, along with the EPL website. **SOCIAL INVESTMENT STRATEGY** – Mr. Kingsley Asare • Mr Asare summarised the current draft SIS, which will be updated before finalising. Current activities included in the draft are: • Technical training for the community youth; • Institutional support; and • Employment opportunities for locals. **CONSTRUCTION MANAGEMENT** • The Metka representatives briefly summarised the issues of local development, engagement with local authorities, and Environmental Management Plans (EMPs) that have been prepared for the construction phse of the project. • The EMP is part of Metka’s Health, Safety and Environment (HSE) plan, which

	includes procedures on waste management, and safety on and off site including emergency response and traffic management procedure.
7.0	**<u>NEXT STEPS</u>** - Mr. Asare / Mr. Wale • Ongoing consultation with Project Affected Persons (PAPs) regarding resettlement. • The draft ESIA will be submitted to the EPA in July and posted on the EPL website for review and comment by the community and other stakeholders. • The formal Notice to Proceed for construction phase is likely to be issued within two weeks of EPL approval of the updated ESIA. • Construction of Stage 1a expected to be around 9 months, and a further 15 months for Stage 1b. • Expected commercial operation of Stage 1a – March 2018 • Expected commercial operation of Stage 1b – June 2019 • Expected commercial operation of Stage 2 is currently April 2020
8.0	**Q & A** **Richard Anning** **(Assembly member, TMA)** • Mr Anning asked if there had been any discussions with Ghana Gas Ltd. for gas procurement instead of importation of LPG for plant operations. Mr. Asare answered that discussions have been held with Ghana Gas Ltd in this regard. However that option was found not to be viable as the Ghana Gas pipelines currently do not extend to Tema, but only to Takoradi. Also gas flow from Nigeria is currently not considered sufficiently reliable and other fuels such as liquefied natural gas (LNG) are not yet as readily available as LPG in Ghana. The Government of Ghana is however understood to be working to make the gas available. The project will switch to NG when it is available. It was also noted that LPG is a cleaner fuel than the fuels used by all the other plants in Tema currently, apart from those operating only on gas. • Mr Anning expressed concern about air quality, and the proximity of pollutants to surrounding communities Mr. Wale advised that the Project's emissions when firing on LPG meet the limits set by the EPA. He commented that regulation of impacts from industrial plants in the wider airshed is outwith the control of EPL, and lies with the EPA. EPL can only design its plant to deal with its own impacts and those other plants that are known to likely be operating once EPL project is commissioned. This is covered in the ESIA.

8.1	**Ofori Duodu** **Unit Committee, Member** • The Unit Committee Member asked about the occurrence of sulphur in natural gases and if there would be monitoring will be done daily or biannually, as was the case during the preliminary assessment periods. Mr. Wale explained that sulphur more of a concern when with fuels such as diesel, HFO and LCO than LPG, but that ambient air quality monitoring will be conducted consistently throughout the lifetime of the project. Regular monitoring will be carried out, especially during the early stages of the Project (c. 2/3 years), expected to be at 1-3 month intervals. Monitoring may then be less in future depending on results of earlier monitoring. • The team was asked if monitoring should not be done more regularly before it poses a significant threat. Mr. Wale explained that in addition to monitoring of ambient air quality in the community, there would be a continuous check of emissions from the stacks by a continuous emissions monitoring system (CEMS). In terms of time taken to address a problem identified, Mr. Wale commented that, due to the practicality of running a plant there is a period of time where steps are taken to find a solution before a problem can be addressed.
8.2	**Mercy Mensah** **Tema Comm. 4 Republic Road, Rep** • Ms. Mensah commented that the diagrams particularly the 'grievance mechanism' are not legible as print is too small. Mr Asare apologised for the illegibility of the diagrams, which was a result of trying to conserve paper. Full details of the mechanism will be disclosed on the EPL website. • She asked if the SIS would be made available to the whole country or to just one community. Mr Asare advised that the project will benefit the whole country through provision of power. Technical training would be made available to communities as Project would allow; however, priority would be for those closest and most affected by the Project impacts. • Ms Mensah asked about the use of wind turbines as an alternative to the burning of gas. Mr Asare agreed that renewable power initiatives are definitely advantageous and that the government should encourage renewable energy.

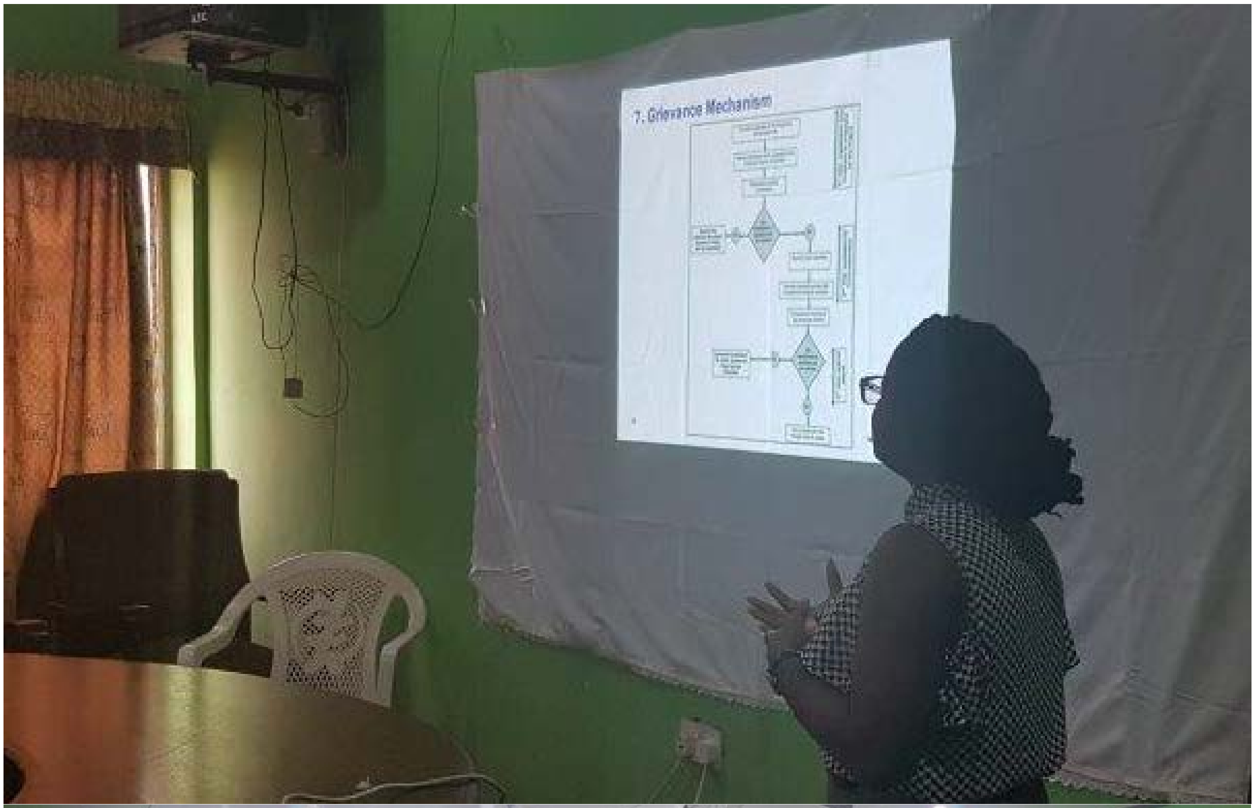
8.3	**Godfred T. Abbey** **TMA, Assembly Member** • The Assembly Member asked about safety mechanisms at the EPL tank farm in case of an explosion. Mr Asare explained that the sites will have security perimeter with physical barriers. The sites will also have appropriate fire control mechanisms in place, such as the provision of fire water storage, and water sprinkler systems attached to tanks. Mr Wale added that where TOR pipeline route crosses beneath road, the EPL project is installing crash barriers to improve safety and reduce potential for accidents. • The possibility of a Resettlement Action Plan for Tema New Town was raised. Mr Asare responded that there will not be any large scale resettlement for the project. Resettlement has been implemented for affected farmers on the power plant site and will be done for the small number of affected vendors along the pipeline route in the next phase of work. • The Assembly Member noted that employment for skilled labour was accounted for during the presentation and wanted to know what opportunities were available for unskilled labour. Mr Asare responded that the project is already employing local people for the site preparation works. The project has a clear local content policy and will work with KKDA and others to provide opportunities during the construction phase, but these jobs will be on a merit basis.
8.4	**Joel Boateng** **Unit Committee, Member** Mr. Asaare answered the questions with the following comments marked (KA). • Mr Boateng advised that resettlement should be done well with the help of good PR so no issues would arise. KA: This is noted by the Project Team. He asked if power generation would be commercialised and if so how it would be done and whether it would be company to final consumer, or company to the government to the community. ie. Would this be a downside effect for consumers in terms of increased rates. KA: EPL has a Power Purchase Agreement with the ECG and they will in turn supply power and bill consumers. Contract is between with EPL and ECG. Rates are determined by power generators with additions by ECG and regulated by

	PURC. EPL would be charging one of the lowest rates by a private company in the country so is helping to bring the rates down and not raise it. • He asked if EPL has EPA approval prior to this meeting or does the session feed in to the approval form EPA. KA: EPL already have an EPA permit, but as a result of the project changes and assessment results, the ESIA must be updated and communities have to be reengaged from time to time. This session follows on from previous sessions that took place before the permit was issued to EPL in the middle of last year. This session is to get current view of the community and to update on the current project status. The ESIA is being updated currently to reflect EPL's project changes, and information from these engagements will be included in the report. • Mr Boateng asked if this meeting was key to the progress of the EPA status or just a tick on the checklist? KA: The meeting is important to EPL and it does not take lightly the organisation and attendance of such meetings. Community members had taken their time to attend and as such notes and recordings were being taken of all concerns expressed at the meeting. • He asked about traffic control especially in Tema when such developments come about. Advised that bypasses could be properly developed to ease congestion in the Team area KA: This is noted by the Project Team. • Mr Boateng requested that it be ensured that if there is a ratio for benefits distribution for the project for the whole country that a larger chunk is allocated to the Tema area so that it is easier to convey news of the project to their fellow community members and make good PR for EPL. Mr Boateng also advocated for the use of local media for public education about the project, pollution and control mechanisms in regard of social responsibility so that the entire area would be involved and aware of EPL's presence, instead of EPL limiting their partnerships and interactions to a small community or church. He thought this would be helpful to all parties involved. KA: Expressed his thanks to Mr. Boateng for his comments and reiterated that these contributions and comments were the reason why the meeting was being held; to obtain information that EPL would otherwise have been unable to learn on their own about how things worked within the community.

8.5	**John Tetteh Kabutey** **Tema East, Rep** • The attendee expressed his happiness about the focus group session and enquired whether only oil and gas engineers were going to be employed, or whether engineers from other fields would be involved as well. Mr Asare explained that there will be opportunities for electrical, mechanical, civil and other required skills. He emphasized that the most important benefit would be training, as the number of people employed long term for the project is quite small. There would be more people employed during construction but fewer for operation, hence training was vital and would help the communities. The industrial community in Tema is growing and will need more skilled labour. Work will be done with the appropriate institutions to support programmes currently run as well as new ones, as required. Mr Asare mentioned that engineering is key in the project and enquired whether there was a particular branch of engineering Mr Tetteh felt was not being well served. No response was provided. • Mr Kabutey was concerned due to technical students being unemployed and unable to further their training and education due to financial challenges. Mr. Asare replied, sharing that EPL hopes to help in that regard by helping to provide employable training skill, practical technical training. • Mr Kabutey enquired if any JSS (Junior Secondary School) leavers had been employed. Mr. Ainoo-Ansah (Sage Petroleum / EPL) answered explaining that limited construction has begun and this was the time that semi-skilled labour was employed. These people are trained, tested and certified, and taken on site. Any such requests can be forwarded to Mr Asare and then to the EPC Contractor. Prospective staff would be assessed and selected for work following due process and based on merit. There are currently people living in the town that are working for the project.
8.6	**Lord Ahumor** **Unit Committee,Tema Comm 7** • Lord Ahumor enquired if the construction was ongoing. Mr. Ainoo-Ansah explained that some material had been brought on site and some initial preparatory works have begun. • He enquired about the certainty of the model on air quality Mr. Ainoo-Ansah continued by saying that the air quality assessments have been done over 2.5 years as well as studies on wind direction. Therefore apart from dust, there will be very little impact on air quality during construction. During operations there will be regular monitoring, and mechanisms such as the use of water injections will reduce

	NOx. • Communities should be briefed as and when construction and operation of the plant begin. This was noted that this meeting is part of that information sharing, and Mr Ansah commented that any community complaints around air quality would be dealt with accordingly.
9.0	**AOB:** • As part of the ESIA updates a sample of attendees were invited to complete questionnaires in a one-on-one discusseion with a member of the presentation team. • These questionnaires were completed, with a number of remaining attendees to be contacted by telephone. •
10.0	**CLOSING** In the absence of any other matters, the meeting ended at 12:40pm.
11.0	**Distribution of Minutes:** - JACOBS - Early Power Ltd Request for presentation copies via Email. These were subsequently provided.

Photographs of Community Consultation Focus Group Meeting, June 2017



Bridge Power Project
Early Power Limited

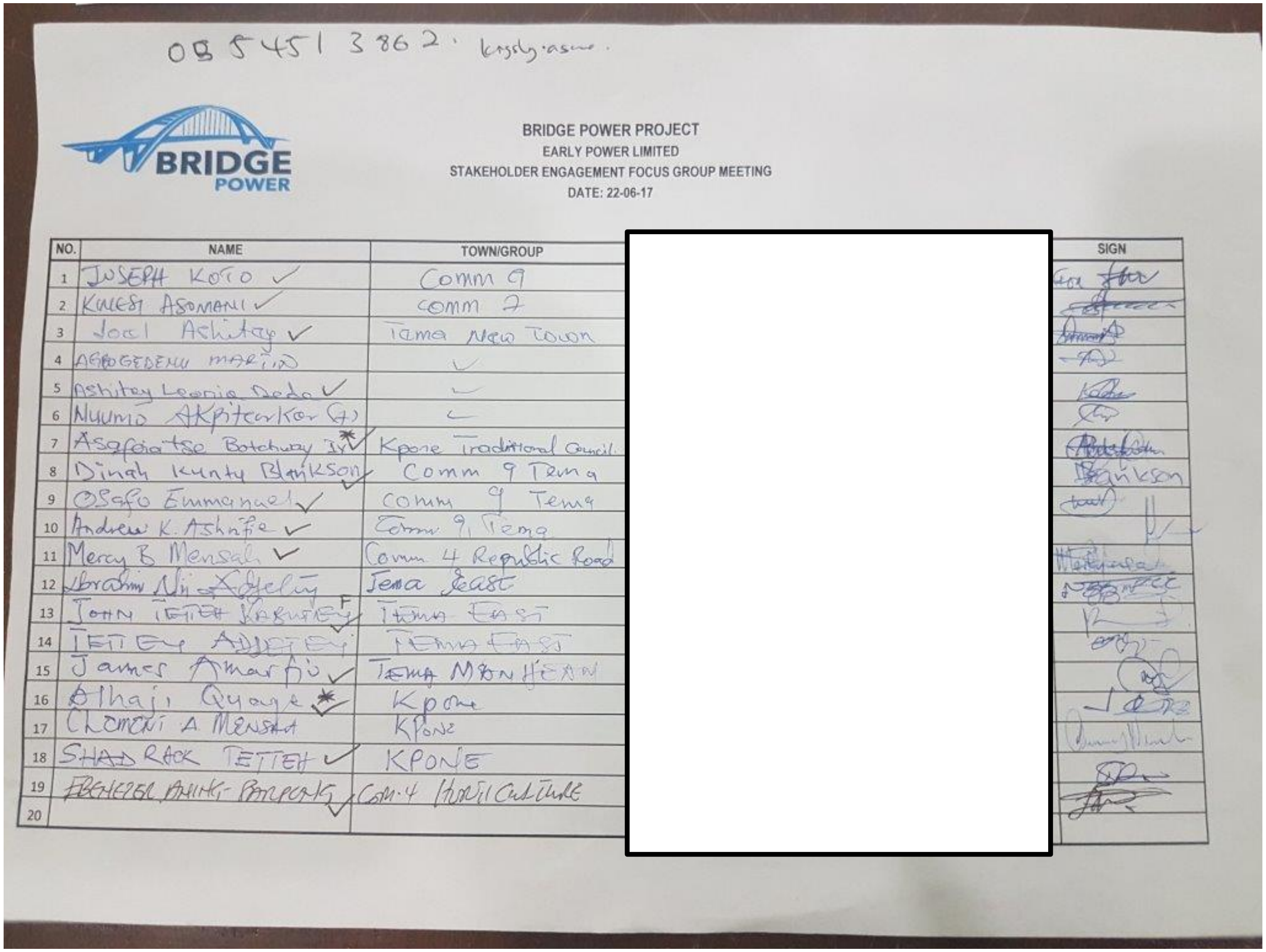
COMMUNITY CONSULATION FOCUS GROUP MEETING

Bridge Power Project

Early Power Limited

COMMUNITY CONSULATION FOCUS GROUP MEETING

Attendance Record from Community Consultation Focus Group Meeting, June 2017 (Contact details redacted)



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BRIDGE POWER PROJECT
EARLY POWER LIMITED
STAKEHOLDER ENGAGEMENT FOCUS GROUP MEETING
DATE: 22-06-17

NO.	NAME	TOWN/GROUP	[redacted]	SIGN
1	JOSEPH KOTO ✓	Comm 9	[redacted]	
2	KWESI ASOMANI ✓	Comm 2		
3	Joel Ashitey ✓	Tema New Town		
4	AGBOGEDENU MARTIN	✓		
5	Ashitey Leonia Dede ✓	✓		
6	Nuumo Akpitevkor (4)	✓		
7	Asafoatse Botchway IV ✓	Kpone Traditional Council		
8	Dinah Kunty Blankson ✓	Comm 9 Tema		Blankson
9	Osafo Emmanuel ✓	Comm 9 Tema		
10	Andrew K. Ashifie ✓	Comm 9, Tema		
11	Mercy B Mensah ✓	Comm 4 Republic Road		
12	Ibrahim Nii Adjeley	Tema East		
13	JOHN TETTEH KABUTEY	TEMA EAST		
14	TETTEY ADJETEY	TEMA EAST		
15	James Amarfio ✓	TEMA MANHEAN		
16	Alhaji Quaye ✓	Kpone		
17	CLEMENT A MENSAH	KPONE		
18	SHADRACK TETTEH ✓	KPONE		
19	EBENEZER AMING BORLEY ✓	Com. 4 Horticulture		
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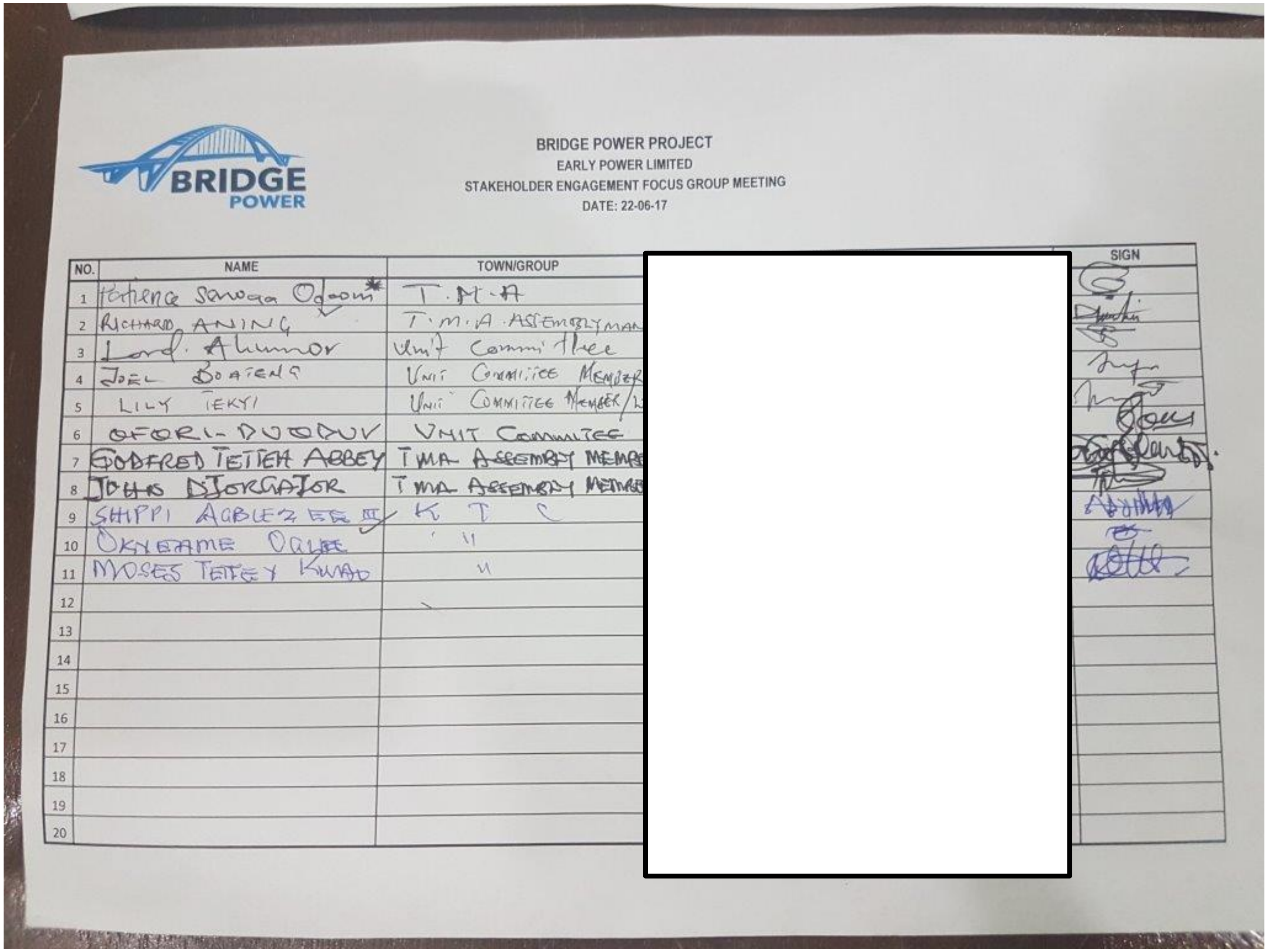
Bridge Power Project

Early Power Limited

COMMUNITY CONSULATION FOCUS GROUP MEETING



BRIDGE POWER PROJECT
EARLY POWER LIMITED
STAKEHOLDER ENGAGEMENT FOCUS GROUP MEETING
DATE: 22-06-17

NO.	NAME	TOWN/GROUP	SIGN
1	Patience Sewaa Odoom*	T.M.A	
2	RICHARD ANING	T.M.A. ASSEMBLYMAN	
3	Lord. Ahumor	Unit Committee	
4	JOEL BOATENG	UNIT COMMITTEE MEMBER	
5	LILY TEKYI	UNIT COMMITTEE MEMBER/	
6	OFORI-DUODU	UNIT COMMITTEE	
7	GODFRED TETTEH ABBEY	TMA ASSEMBLY MEMBER	
8	JOHN DJORGATOR	TMA ASSEMBLY MEMBER	
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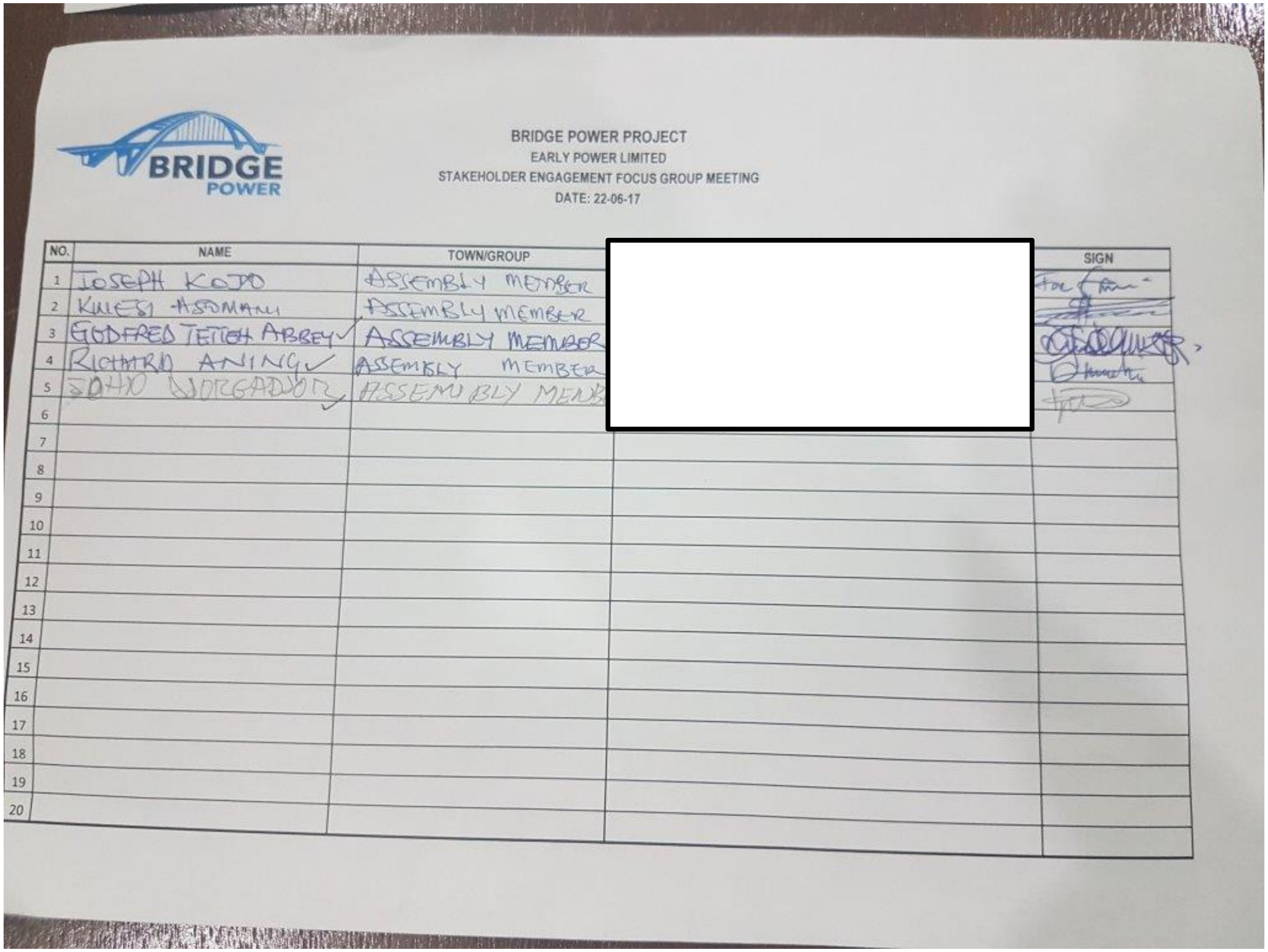
Bridge Power Project

Early Power Limited

COMMUNITY CONSULATION FOCUS GROUP MEETING



BRIDGE POWER PROJECT
EARLY POWER LIMITED
STAKEHOLDER ENGAGEMENT FOCUS GROUP MEETING
DATE: 22-06-17

NO.	NAME	TOWN/GROUP		SIGN
1	JOSEPH KOJO	ASSEMBLY MEMBER		
2	KWESI ASOMANI	ASSEMBLY MEMBER		
3	GODFRED TETTEH ABBEY	ASSEMBLY MEMBER		
4	RICHARD ANING	ASSEMBLY MEMBER		
5	JOHN NORGADZOR	ASSEMBLY MEMB		
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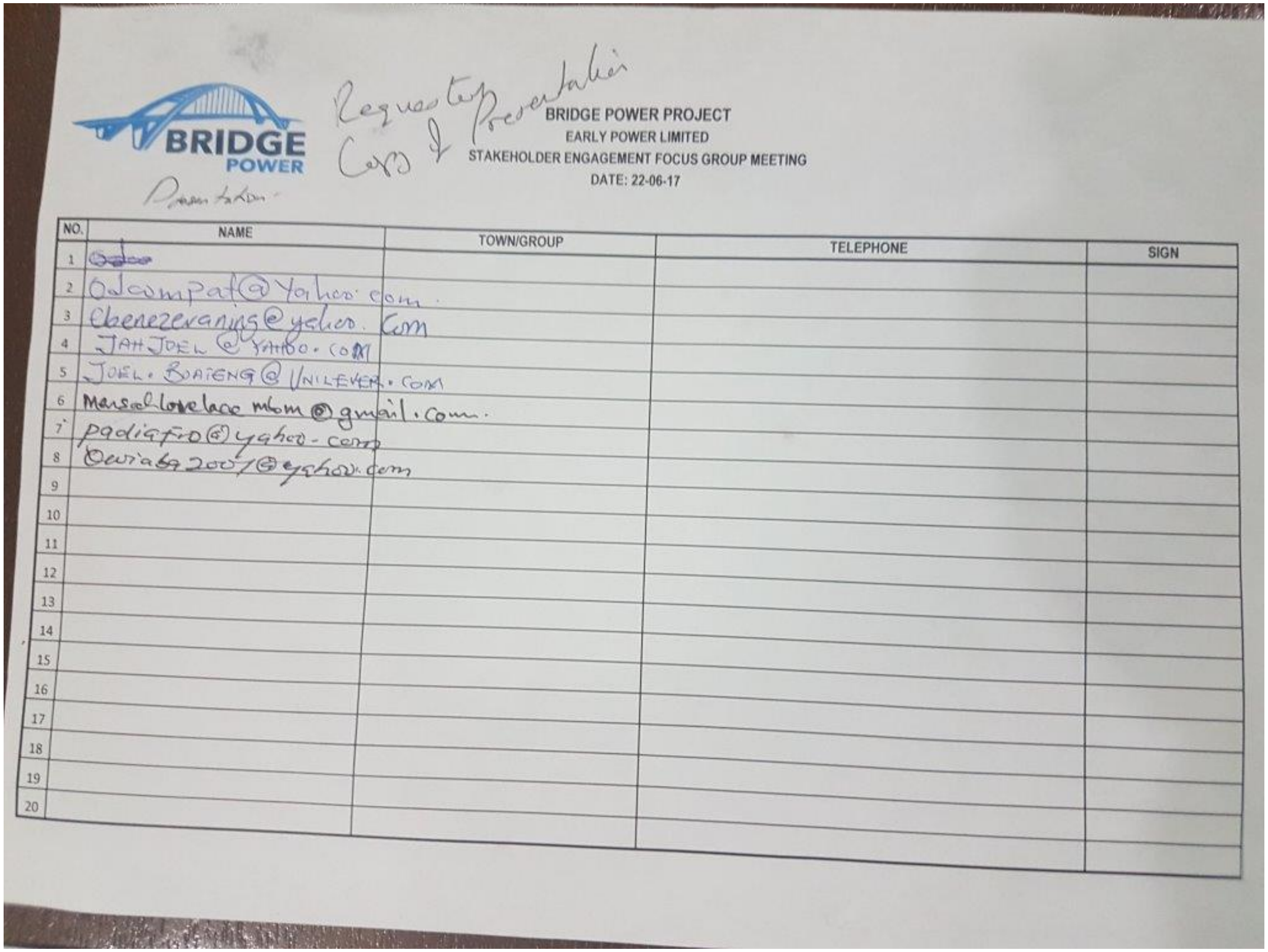
Bridge Power Project

Early Power Limited

COMMUNITY CONSULATION FOCUS GROUP MEETING



Request for Presentation
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BRIDGE POWER PROJECT
EARLY POWER LIMITED
STAKEHOLDER ENGAGEMENT FOCUS GROUP MEETING
DATE: 22-06-17

Presentation

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