REPORT

Genser Energy Ghana Limited, 105km pipeline from Gyegyetreso to Kumasi

Final Environmental Impact Statement

Submitted to:

Genser Energy Ghana Limited

Submitted by:

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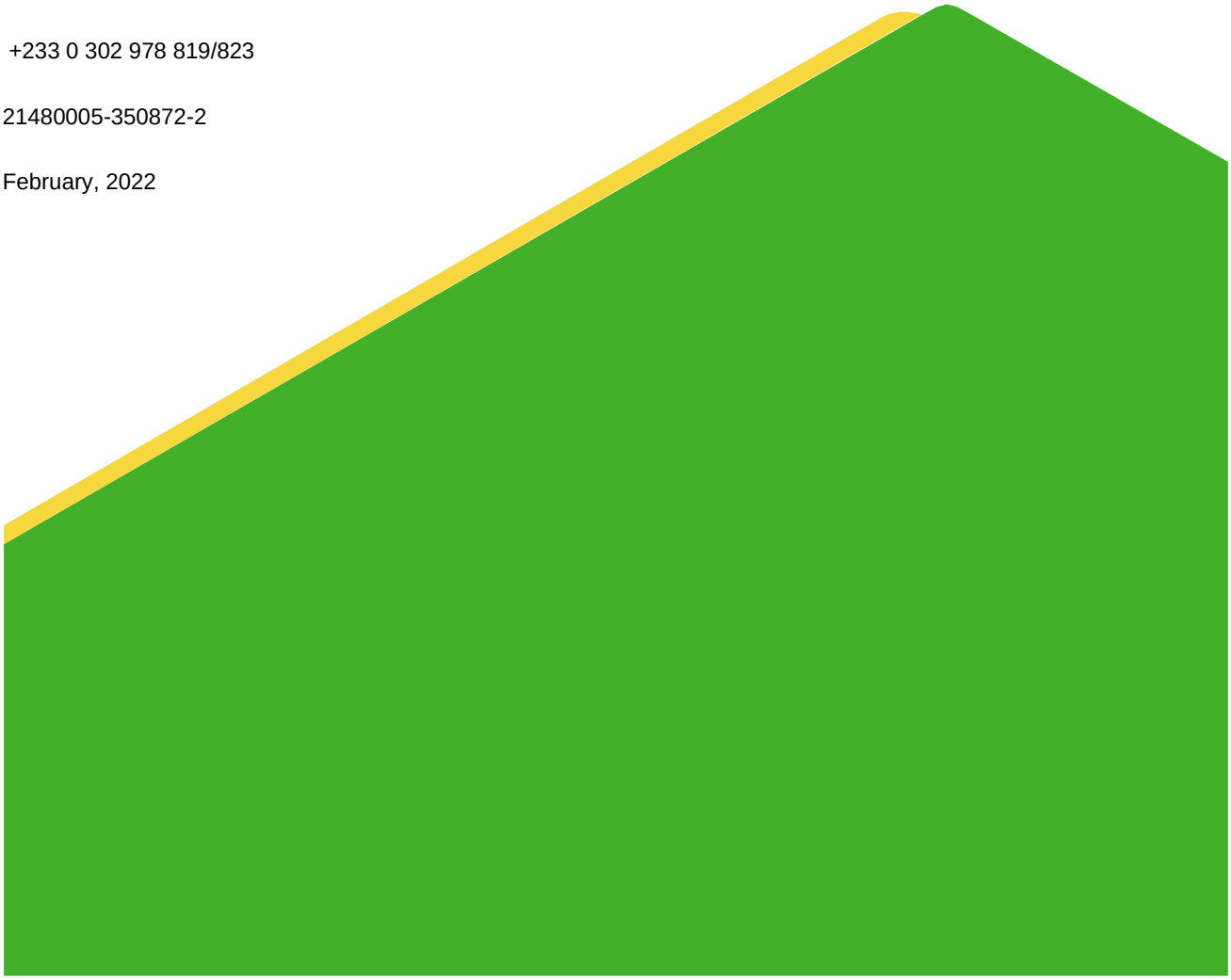

Distribution List

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Executive Summary

Genser Energy Ghana Limited (GEGL) is an energy solution incorporated in Ghana in April 2007 under the Companies Act 1963 (Act 179). Genser Energy Holdings Limited, a Mauritius-incorporated company with two Ghanaians as ultimate beneficiaries, owns 100% of GEGL.

To meet the requirements of the Ministry of Energy, GEGL is proposing to construct and install a 105 km, 24-inch natural gas pipeline from Gyegyetreso to Ejisu-Kumasi in the Ashanti Region of Ghana. This gas pipeline project will connect the existing gas pipeline from the Branch Point Station at Gyegyetreso to a new Branch Metering Station at Ejisu- Kumasi. The construction of the pipeline will facilitate the supply of natural gas from the Prestea Regulating and Metering Station to the Ameri power plant which is proposed to be relocated close to the GRIDCo substation in Ejisu. The main components of the natural gas project are, approximately a 105km 24-inch natural gas pipeline, Block Valve Stations, a Branch Metering Station, and ancillary equipment needed for gas supply.

In compliance with the requirements of the Environmental Assessment Regulations, 1999 (LI 1652), GEGL duly registered the project with the Environmental Protection Agency (EPA). The EPA in a letter dated 16 April 2021, requested that GEGL submit a scoping report and Terms of Reference (ToR) for the project. Following the submission of the Scoping Report and ToR, an Environmental Impact Assessment (EIA) was conducted for the project, and this Environmental Impact Statement (EIS) is being submitted to the EPA to inform the decision on the project's environmental permit.

Project Justification

The project's anticipated benefits include, among other things, improved electricity supply to Ghana's middle belt, in line with the government's vision of providing Ghanaians with reliable, affordable, cleaner, and sustainable electricity supply. The implementation of this pipeline is also expected to result in the emergence of industries along the pipeline's route which will increase the possibility of direct job creation from the project as well as indirect job creation from industrial development and economic opportunities.

Applicable Legislations, Policies and Standards

There are a number of national policies, laws, regulations and guidelines that mainstreams the integration of relevant environmental, social and economic issues regarding the energy production in Ghana. These regulations, policies, laws and guidelines identified for further study in this EIS include:

National Legislations and Policies
a) Constitution of the Republic of Ghana, 1992
b) Environmental Protection Agency (EPA) Act, 1994 (Act 490)
c) Environmental Assessment Regulations, 1999 (LI 1652)
d) Fees and Charges (Amendment) Instrument, 2019 (LI 2386)
e) Energy Commission Act, 1997 (Act 541)
f) Ghana Highway Authority Act, 1997 (Act 540)
g) Land Use and Spatial Planning Act, 2016 (Act 925)
h) Land Commission Act, 1994 (Act 483)
i) Water Resources Commission Act, 1996 (Act 522

National Legislations and Policies
j) Ghana National Fire Service (GNFS) Act, 1997 (Act 537)
k) Local Governance Act, 2016 (Act 936)
l) Electricity Regulations, 2008 (LI 1937)
m) National Energy Policy, 2010
n) Ghana National Environmental Policy, 2014
o) Ghana Forest and Wildlife Policy, 2012
p) National Water Policy, 2007
q) Environmental Sanitation Policy, 2010
r) National Wetlands Conservation Strategy, 1999
s) Ghana Climate Change Policy, 2013
t) Ghana Standards for Environment and Health Protection

The EIS has been prepared in accordance with the following international requirements:

International Standards
IFC Performance Standards (PS 1, PS2, PS3, PS4, PS5, PS6 and PS8)
Equator Principles (Principles 1-10)
IFC Environmental Health and Safety Guidelines

Project Description

The project encompasses the construction of an approximately 105km 24-inch natural gas pipeline from an existing Gyegyetreso Branch Point Station which was constructed as part of GEGL 133km natural gas the Prestea Regulating and Metering Station (RMS). The proposed will terminate a proposed Branch Metering Station (BMS) at Ejisu, near Kumasi. The proposed pipeline will run predominantly through agricultural lands with rural living allotments and horticulture around the region as well as a few private lands.

The associated facilities of the proposed natural gas pipeline infrastructure include three (3) block valve stations (BVS), and one branch metering station at Ejisu. The proposed pipeline will have 2 major (2) road crossings and two (2) river crossings on the Offin and Oda Rivers.

Stakeholder Engagement

The stakeholder engagement process provided the platform for GEGL to share various aspects of the proposed project including project components, while also allowing stakeholders to raise issues and concerns about the development of the proposed project. The engagements were generally conducted through face-to-face interactions with focus groups including representatives of the traditional authorities, religious leaders, regulatory authorities, committee members, non-governmental organisations, members of the various communities and the media.

The engagements took place between 16th July 2021 and 31st August 2021. A total of 101 meetings were held with approximately 3,497 participants in attendance. The process aided in the identification of mitigation measures to address concerns expressed about several aspects of the construction and operational phases of

the project. Details of stakeholder issues and concerns, as well as responses to comments, are also incorporated into the EIS.

Among the key issues and concerns raised by stakeholders during the consultations were queries on pipeline safety measures and insurance coverage, job opportunities for locals, and crop compensation.

Impact Assessment

The impact assessment methodology employed subject matter specialist assessment, existing baseline condition reviews, and interpretation of data collected to inform the assessment. The assessment is presented as a narrative and combined magnitude, duration and extent of the specific impact occurring at the project construction and operational phases. During the impact assessment, importance was placed on social values and concerns of stakeholders. The specialist studies focused on biophysical, socio-economic and traffic situation of the project area.

Air quality

Potential activities and sources of air quality impacts were identified based on construction activities and equipment to be used, and it was determined that the key pollutants of concern were total suspended particles (TSP), particulate matter with diameter 10 micrometers and below (PM_{10}) and particulate matter which are two- and one-half microns or less in width ($PM_{2.5}$).

A dispersion modelling conducted for the construction phase showed that 24-hour concentrations for the pollutants of concern would be below EPA and Ghana Standards Authority (GSA) requirements for ambient air quality and point source/stack emissions (GS 1236:2019).

Noise

The immediate area of influence, in terms of noise, include agricultural activities, mining activities, biomass burning and traffic of vehicles in the vicinity of the project area.

A semi-qualitative assessment including attenuation-over-distance acoustic calculations showed that during the construction phase, noise levels would be below EPA Ghana and the International Finance Corporation (IFC) residential day-time guideline rating levels of 70 dB(A) and 55 dB(A) respectively, 920m from the location of the construction activities. Increase in noise levels (i.e., from baseline noise levels) are predicted to be above the 3 dB(A) threshold for annoyance as per the IFC Noise Regulations at receptors SR4 to SR6, SR9, SR11, SR12, SR22, SR24, SR27, SR29, SR30 and SR32 to SR37 during the day. The largest change was predicted at SR37, located approximately 140 m away from the proposed construction activities.

During the operational phase, noise levels will be below EPA and IFC residential daytime and night-time guideline rating levels of 55 dB(A) and 45 dB(A), respectively, beyond 180m during the daytime and 560m during the nighttime from operational activities. During the day, increases in noise levels as a result of the operational activities are predicted to be well below the 3 dB(A) threshold for annoyance as per the IFC Noise Regulations. During the night increases in noise levels are predicted to be below the 3 dB(A) threshold for annoyance as per the IFC Noise Regulations, except for SR11 (i.e., a change of 4.9 dB(A)), given the proximity of the receptor to the Ejisu Branch Metering Stations (BMS).

Soil and land use

The soil classes identified in the project area are Acrisols, Ferralsols, Plinthosols and Gleysols. These soils were further grouped under Land Capability Classes II, IV and V using the South African soil capability guidelines. From the assessment, the Acrisols in the project area fall under Class IV, the Ferraalsols are under Class II and Plinthosols and Gleysols are under classed under V.

The main activities to impact soil are vegetation clearance and excavation of soil from the pipeline trench which could result in the loss of soil resource, soil erosion, contamination of soil, and soil compaction.

Surface water

The project falls within the Pra Basin in south-central Ghana. The Oda River and its tributaries drain southwest from Kumasi to confluence with the Offin River, one of the main tributaries of the Pra River.

Communities along the pipeline route use water for subsistence agriculture and other domestic uses, and small businesses such as those businesses using clay for pots businesses owners, source clay from the banks of the river.

The main construction phase activities that will impact water resources will be the clearing of the right-of-way (RoW) to excavate the trench for installation of the pipeline at locations where the pipeline crosses water courses, the diversion, the compaction, and rehabilitation thereafter.

Biodiversity

The pipeline runs primarily through off-reserve cultivated landscape, with 1.76 km of the pipeline traversing through sections of the Anhwiaso East Forest Reserve. Parts of the pipeline runs adjacent the Afram Headwaters and Lake Bosomtwe protected areas. The entire length of the pipeline passes through the moist semi-deciduous north-west subtype vegetation zone. The pipeline route is in a landscape that appears to be devoid of any critical habitat or ecologically sensitive areas. There are, however, sections of the pipeline that pass through marshy, seasonally inundated riverine areas that are ecologically sensitive areas, particularly within the Achinakrom section of the pipeline where riverine and extensive marsh areas restricted access to the right-of-way of the pipeline.

The main land use along the pipeline route is cocoa farming, which is more prevalent in the Amansie West and Amansie South districts. Other significant features in the landscape of the pipeline route include previously mined areas, which have resulted in massive landscape alteration and modification.

Remnant patches of the moist semi-deciduous forest vegetation type are generally absent in the landscape except for few characteristic tree species. Being intensely cultivated, secondary forest patches were rarely present. Some of the old cocoa farms in the landscape support a few stands of remnant emergent trees. These appeared to be trees that had been purposely retained to maintain overhead shade on the cocoa farms. The importance of remnant patches of woodland and forest reserves in the area for the support of flora and fauna species of concern in the context of the otherwise degraded landscape should therefore not be understated. This will be of relevance to achieving the requirements of the IFC Performance Standard 6, which requires no net loss of natural habitats, and net gain of critical habitat.

The project will potentially affect biodiversity in three main ways; reduction in the extent/disturbance of vegetation communities, including ecosystems of concern; loss and disturbance of flora and fauna species of conservation concern, and creation of barriers to movement and collision risk for fauna species of concern.

Socio-economic

The study area is dominated by women, children, and the youth with a high proportion of Akans and Christians. The average number of people in household is 5.26. The most common assets owned by households are home appliances such as radios, mattresses, and mobile phones. Most households own their current dwelling units, most of which are built with cement blocks and roofed with aluminum sheets. The vast majority of household kitchens are located outside the dwelling units and are roofed.

The most common method of solid waste disposal is at community dumping sites, while public toilets (KVIPs and open pits) are widely used. The common sources of drinking water are boreholes and sachet water. However, reliance on the latter is more prevalent in urban communities than in rural communities.

The majority of the people are mixed crop farmers who primarily produce cocoa, oil palm, plantain, and maize. However, food is the most expensive item for households, but the overall cost of living in the area is lower than in other parts of the region. Motorcycles are a popular mode of transportation in the Amansie area, which also has a poor road network.

While there are very few senior high and tertiary institutions in the communities along the pipeline route, elementary schools are very common throughout the communities. However, the higher-level institutions are nucleated around the Bekwai-Ejisu stretch of the project affected communities (PACs). This situation is similar in terms of health care services. The commonly used energy sources for lighting and cooking are electricity and firewood respectively.

There are several vulnerable groups in the area; majority of whom are women and children as a result of their low living standards. There is also at least one person with a disability in every four households.

The key socio-economic impacts are loss of land-based livelihoods, threat of food insecurity, cultural dilution, and public health. There will also be increase in employment opportunities.

Traffic

Because the pipes, gas stations, and auxiliary facilities will be transported by road, the long-term traffic impacts to the roadways along the pipeline route will be mostly limited to the construction phase. During the operation phase, however, traffic will be limited to occasional inspections and routine maintenance. These activities will neither have significant impact on traffic on public roads nor on road safety as long as the access of vehicles used for the inspection and maintenance service is located where ingress and egress are visible to other vehicles using road and turning movements are visible from a safe distance.

Along with the delivery of construction equipment and materials for the project, clearing of the right-of-way, construction of trenches for pipeline placement, closing of the trenches, and restoring of the pipeline right-of way will be part of the project's construction activities. Thus, effects of construction impacts could degrade the level of service in two ways. First, the construction team will need to access the pipeline right-of-way from public roads, resulting in a temporary disruption in the flow of traffic while construction takes place at the specified location for several weeks at a time. Second, existing traffic might be impacted where the pipeline crosses road right-of-way.

These impacts will be temporary, limited to the duration of construction at the specified location. The proposed method of road crossing is an open cut trench. However, in areas with high traffic volumes, the jack and bore method is recommended to eliminate the temporary impact.

Mitigation Measures

An Environmental and Social Management Plan, which will serve as the primary monitoring programme with the key additional mitigation measures has been developed as part of this EIS. Mitigation measures to avoid, minimize and manage identified impacts were developed focusing on technical evaluations by discipline-specific experts, issues from stakeholder engagements and industry best practices while leveraging on GEGL's experience in addressing similar impacts for the Pipeline Phase I and II Projects.

Monitoring Programmes

The monitoring programme developed for project implementation will be incorporated into GEGL's overall monitoring plan, allowing GEGL to identify aberrations quickly and apply appropriate mitigation measures. The monitoring programme will include:

- Bi-annual monitoring of TSP, PM_{10} and $PM_{2.5}$ for one hour at peak times during the day over the construction period.
- A one-time bi-annual campaign to measure the concentration of volatile organic compounds (VOCs) in each location over a two-week period. If emissions show concentrations above the EPA and IFC requirements for air quality, this campaign shall be done on a yearly bi-annual basis for the duration of the project.
- A once off bi-annual noise campaign to determine the noise levels at each location will be conducted for for 24 hours during the construction phase
- An audit of the removal of diversion structures and the rehabilitation of disturbed vegetation and habitat at all surface water crossings.

Rehabilitation and Decommissioning

The end of the construction phase will result in the demobilization of machines and equipment from site, as well as the rehabilitation of any remaining laydown areas that will not be required during the operational phase.

The pipeline infrastructure is expected to last at least 50 years. However, if the facility reaches the end of its operational life and must be decommissioned, the pipes, gas stations, and all support facilities will be demolished from the site as part of the rehabilitation process. During rehabilitation, demolition and removal of construction materials and infrastructure, as well as associated demolition waste, would effectively reverse the project's impacts.

Abbreviation and SI Units

ABBREVIATIONS

3LPE	3-Layer Polyethylene
API	American Petroleum Institute
BMS	Branch Metering Station
BPS	Branch Point Station
BVS	Block Valve Station
CBD	Convention on Biological Diversity
CCGT	Combined Cycle Gas Turbine Plant
CHAA	Critical Habitat Area of Analysis
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on the Conservation of Migratory Species of Wild Animals
CNC	Compensation Negotiation Committee
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CRR	Comments and Response Report
EBMS	Ejisu Branch and Metering Station
ECOWAS	Economic Community of West African States
EHS	Environmental health and safety
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
EPC	Engineering, Procurement, and Construction
EPFI	Equator Principles Financial Institution
ESDV	Emergency Shutdown Valve
ESMP	Environmental and Social Monitoring Plan

ESMS	Environmental and Social Management System
GEGL	Genser Energy Ghana Limited
GHG	Green House Gas
GIIP	Good International Industry Practice
GNFS	Ghana National Fire Service
GNPC	Ghana National Petroleum Corporation
GRIDCo	Ghana Grid Company Limited
GSA	Ghana Standards Authority
GWCL	Ghana Water Company Limited
IFC	International Finance Corporation
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for Conservation of Nature
IPP	Independent Power Producer
KVIP	Kumasi Ventilated-Improved Pit
LI	Legislative Instrument
LPG	Liquefied Petroleum Gas
LSA	Local Study Area
NACE	National Association of Corrosion Engineers
NGLs	Natural Gas Liquids
NO_2	Nitrogen Dioxide
O&M	Operations and Maintenance
PAC	project affected communities
PAH	Polycyclic Aromatic Hydrocarbons
PP02	Primary Pipeline 02
PRMS	Prestea Regulating and Metering Station
PS	Performance Standards
PM	Particulate Matter
RMS	Regulating and Metering Station
RoW	Right of Way
RSA	Regional Study Area
SAWH	Submerged-Arc Welding Helix

SAWL	Submerged-Arc Welding Length
SO_2	Sulphur Dioxide
SoCC	Species of Conservation Concern
TSP	Total Suspended Particles
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
USEPA	United Stated Environmental Protection Agency

SI Units

^{o} C	Degrees Celsius
Barg	Gauge Pressure
Bcf	Billion cubic feet
Cm	Centimetres
Ha	Hectares
Km	Kilometre
Mm	Millimetres
mm^2	Square millimetre
M	Metres
m^3	Cubic metre
Mmscfd	Million standard cubic feet per day
MW	Megawatt
MWh	Megawatt hour

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1.0 INTRODUCTION

Genser Energy Ghana Limited (GEGL) is an energy solution incorporated in Ghana in April 2007 under the Companies Act 1963 (Act 179). Genser Energy Holdings Limited GEHL, a Mauritius-incorporated company with two Ghanaians as ultimate beneficiaries, owns 100% of GEGL.

GEGL provides sustainable and cost-effective energy solutions to numerous sectors across Africa. Since its inception in 2007, GEGL has successfully executed seven power generation projects for industrial companies including some well-known mining companies in Ghana. GEGL is now a private owner of natural gas pipelines in Ghana. GEGL engages in the full value chain of energy generation and transmission including the Engineering, Procurement and Construction (EPC) of power plants and natural gas pipeline infrastructure for power generation as well as Operation and Maintenance (O&M) of its assets.

GEGL has over the past 14 years commissioned seven distributed generation plants. The plants are:

- GP Bogoso Plant – 36.0MW Single Cycle Plant fired by distillate on the mining concession of Golden Star Resources, Bogoso mine.
- GP Unilever Plant – 5.5MW Cogeneration of Heat and Power Plant fired by Liquefied petroleum gas (LPG) on the premises of Unilever Ghana Limited, Tema.
- GP Chirano Plant – 30.0MW Steam Turbine Plant fired by natural gas and natural gas liquids (NGLs) on the mining concession of Chirano Gold Mines Limited, Chirano mine.
- GP Tarkwa Plant – 66.0MW Single Cycle Plant fired by natural gas and NGLs on the mining concession of Gold Fields Ghana Limited, Tarkwa mine.
- GP Damang Plant – 25.0MW Single Cycle Plant fired by natural gas and NGLs on the mining concession of Abosso Goldfields Limited, Damang mine.
- GP Wassa Plant- 33.0MW Single Cycle Plant fired by natural gas and NGLs on the mining concession of Golden Star Resources, Wassa mine.
- GP Edikan Plant- 33.0MW Single Cycle Plant fired by natural gas and NGLs on the mining concession of Perseus Mining Ghana Limited, Edikan mine.

In addition, GEGL has implemented a 310km pipeline infrastructure project originating at the Ghana National Gas Company's Prestea Regulating and Metering Station (RMS) to its existing power plants in the Western, Western North, Central and Ashanti regions of Ghana. The pipeline project has allowed GEGL to reach its objective of developing a reliable fuel supply chain for the smooth running and operation of its power plants.

At the request of the Ministry of Energy, GEGL is investing in the construction of a 105 km 24-inch natural gas pipeline infrastructure (Primary Pipeline 02 from Gyegyetreso to Ejisu-Kumasi in the Ashanti Region of Ghana (Figure 1). The pipeline will connect the existing gas pipeline from the Branch Point Station (BPS) at Gyegyetreso to a proposed Branch Point Station (BPS) at Ejisu- Kumasi (Figure 2).

The project will comply with applicable legislation, particularly the Environmental Assessment Regulations 1999 (LI 1652) and international requirements particularly the applicable Performance Standards (PS) of the International Finance Corporation (IFC), to access international funding.

This Draft Environmental Impact Statement (EIS) is being submitted to enable relevant government authorities, particularly the Environmental Protection Agency (EPA) to provide an environmental permit for the implementation of the project.

1.1 Background

The Volta River Authority manages the Ameri power plant, which is a 250MW thermal plant currently located at Aboadze in the Western region of Ghana. The Ameri power plant is fired by natural gas from the Atuabo Gas Processing Plant for power generation onto the national grid. In an effort to stabilise grid supply in the central part of Ghana (Kumasi), the Ministry of Energy has proposed the relocation of the Ameri Power plant to Kumasi. On this basis, the Ministry of Energy has requested GEGL to extend its gas pipeline infrastructure from Gyegyetreso to Kumasi to facilitate the supply of natural gas from the Prestea RMS to the Ameri power plant.

To meet the requirements of the Ministry of Energy, GEGL is proposing to construct a 105km 24-inch gas pipeline infrastructure from the Gyegyetreso BPS to Ejisu BMS in Kumasi for natural gas supply to the Ameri power plant.

It is important to note that GEGL has completed are a number of pipeline projects totaling 310km in length, all of which have been commissioned and are operational. They are as follows:

- Primary Pipeline_01: From the Prestea RMS to Gyegyetreso (completed and operational)
- Branch Pipeline_01: From the Prestea RMS to Tarkwa, Damang and Wassa (completed and operational)
- Branch Pipeline_02: From the Primary Pipeline to the GP Chirano Plant (completed and commissioned)
- Branch Pipeline_03: From the Primary Pipeline to the GP Edikan Plant (completed and commissioned)

The Ghana National Gas Company (GNGC) will produce the natural gas from the offshore fields and GNPC will be responsible for distributing the natural gas to GEGL. Additionally, GNGC will provide technical support for the designing of the pipeline. GNGC will assist GEGL to improve on the project engineering designs to ensure safety by reviewing the engineering design from inception of the pipeline to its terminal point at the plant. Where necessary, GNGC will provide recommendations and improvements for the design. The role of the GNGC will be executed based on close collaborations between GEGL and GNGC through a GNGC-GEGL technical committee.

1.2 Ownership

The pipelines will be owned and managed by GEGL. After conducting a land search at the Lands Commission for all lands along the RoW of the proposed pipeline project, GEGL determined that while sections of the proposed project's lands are owned under customary tenure, particularly in the Amansie South district, other sections, particularly in urban areas within the Bekwai Municipal, Bosomtwe, and Ejisu districts, are owned by individuals. GEGL has engaged the Land Valuation Board of the Lands Commission to conduct land valuation on the RoW to determine the compensation to be apportioned to the land, particularly in areas where lands are owned by individuals. For stool lands, GEGL will secure leases for the pipeline's affected areas. In cases where land is owned by individuals, outright purchase of the affected area and securing a full-proof agreement detailing the acquisition of the land has been considered for this project. Following land acquisition for the project, GEGL shall process land title for land that will have been permanently acquired for the establishment of project infrastructure.

1.2.1 Details of Proponents

The project proponent is GEGL, and their details are as provided in Table 1.

Table 1: Details of the Project Proponents

Item	Description
Proponent	Genser Energy Ghana Limited

Item	Description
Address	Horizon Plaza, First Floor #60 Liberation Road, Airport, Accra-Ghana
Telephone	+233 50 137 1546
Project Manager	Henry Abeiku Oppong
Chief Executive Officer	Baafour Asiamah-Adjei

The details of the EIA team area attached in APPENDIX A.

1.3 Location of the Project

The pipeline will be in the Ashanti Region of Ghana (Figure 1). It will commence from the southwest, at Gyegyetreso BPS and travel Northeast at 31km to the proposed Miawano BVS. It will further run East to the Ntinako BVS, which is 17.8km away. The line will continue again to Adwafo BVS east of Ntinako for 26.4km and terminates at the proposed Ejisu BMS.

The pipeline will travel along major communities such as Antoakrom in the Amansie South district, Ahwiankwanta and Kokofu in the Bekwai Municipality, Kuntanse in the Bosomtwe District and Ejisu-Kumasi in the Ejisu Municipality.

Figure 2 provides a satellite image of the proposed overall gas pipeline, and the GPS coordinates of the stations along the gas pipeline are provided in Table 2.

Table 2: GPS coordinates stations along the gas pipeline

Location	GPS coordinates	
Gyegyetreso BPS	6°19'58.01"N	2° 5'1.91"W
Miawano BVS	6°24'59.03"N	1°48'57.16"W°
Ntinako BVS	6°29'51.68"N	1°31'44.32"W
Adwafo BVS	6°30'34.85"N	1°28'15.58"W
Ejisu BMS	6°41'25.55"N	1°30'52.67"W

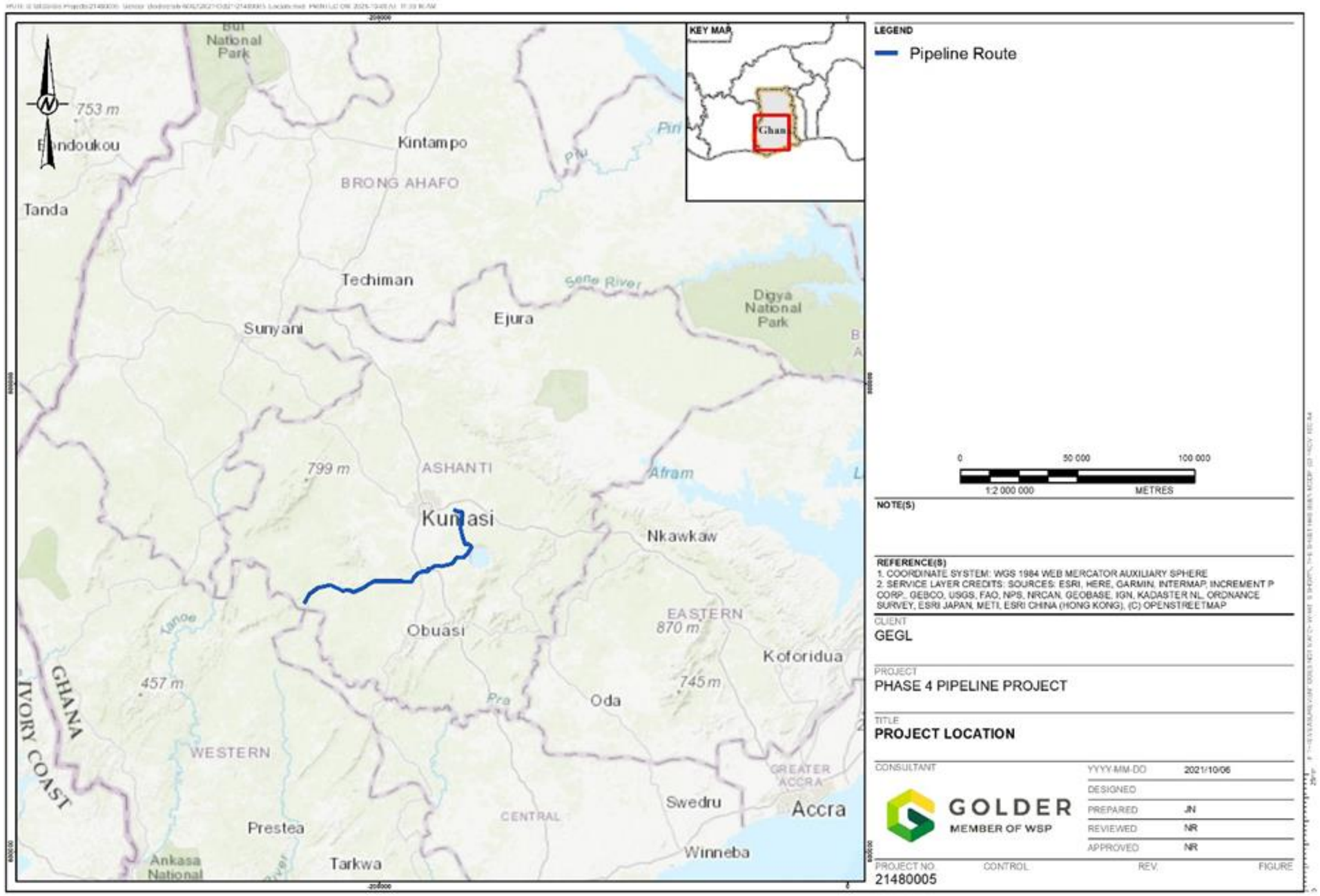

Figure 1: Project Location

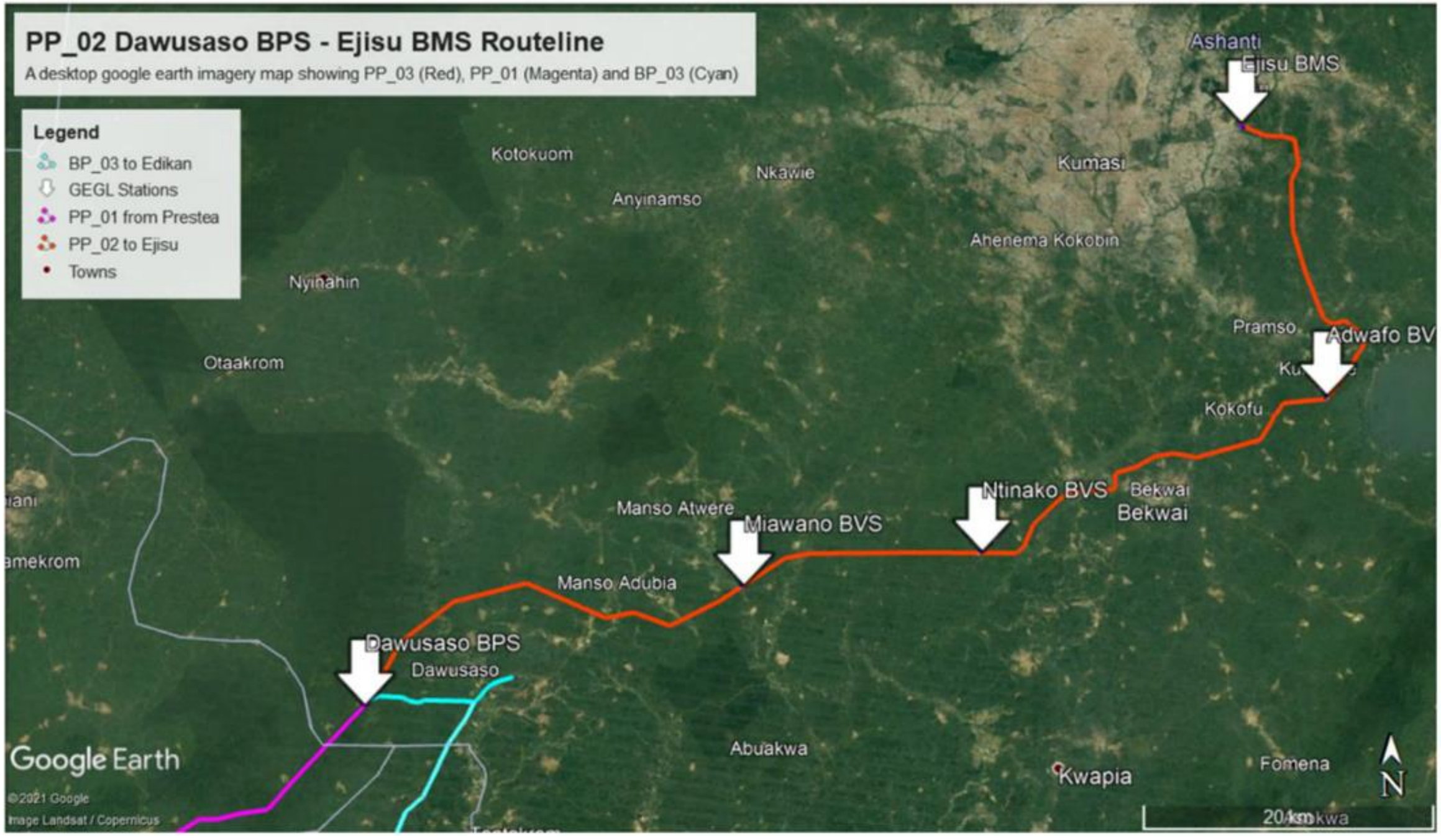

Figure 2: Proposed gas stations along the 105 km pipeline route

1.4 An Analysis of the need for the Undertaking

Ghana discovered its first deepwater oil and gas in 2007. Presently, the most advanced reserves identified are: The Jubilee field, with associated gas reserves estimated at 490 billion cubic feet (Bcf); the TEN fields with associated gas reserves of 363 Bcf and the Sankofa field with non- associated gas reserves of 1,107 Bcf. Plans are underway to develop the Mahogany and Teak fields with estimated total reserves of 120 Bcf as part of the Greater Jubilee Full Field.

Globally, there is a recognition of the benefits of utilizing natural gas over other sources of energy. For a developing country like Ghana which have discovered oil and gas in commercial quantities, there is an opportunity to switch from the use of conventional fuels to natural gas in powering industries. In addition to the advantage of reduced greenhouse emissions that natural gas has over other energy sources, there are cost saving opportunities from its use.

Aside its reliance on hydroelectric and heavy fuel thermal energy, the government of Ghana has shown its support for the use of other energy sources to produce electricity and is committed to developing competitive gas and electricity markets to deliver lower energy prices and varied choices to customers.

With the numerous challenges currently associated with the use of hydroelectric and heavy fuel thermal electricity supply, industries heavily reliant on energy for the running of their daily operations are beginning to consider other options such as natural gas. GEGL aims at addressing the energy supply challenges to these industries by expanding its gas pipeline footprint to cover more areas within the southern and middle belt of Ghana.

This project provides the opportunity for GEGL to expand its gas supply infrastructure which currently terminates at Gyegyetreso to Kumasi. Accordingly, the utilisation of natural gas as an energy source, will create new opportunities and serve as a foundation for a vibrant petroleum and petrochemical industry to evolve, thereby providing new economic opportunities for Ghana.

The following are the envisaged benefits of the project:

- Link the underserved areas to the national gas supply grid and increase the supply of natural gas within the middle belt of Ghana.
- Meet the government of Ghana's vision of increasing the component of cleaner, affordable, and sustainable energy options within the energy mix and to meet the increasing demand for energy in the country.
- Reduce operational costs of industries reliant on energy due to the cheaper cost of gas as compared to other energy sources. The extension of the gas pipeline for natural gas supply to Kumasi will reduce reliance on expensive fossils, such as diesel/ Heavy Fuel Oil for industries within the Ashanti region. The switch from diesel/Heavy Fuel Oil to natural gas will result in significant reduction in the cost of operations for local industries in the region.
- Reduce load and traffic on highways as road transport will be minimized from areas where the pipeline is routed through.
- Serve as a possible key link for natural gas supply from Ghana Gas's distribution terminals to industries with large energy needs located in the southern and middle part of Ghana. This is because the pipeline project will provide the capacity to facilitate the supply of natural gas to these industries.
- Provide industries a more reliable and uninterrupted flow of energy via pipelines as opposed to using other means to transport energy.

- Reduce the wait time for constructing alternative means (e.g., rail, asphalted detour roads) of transporting energy, which is usually guided by topography, climate, manpower, etc.
- Reduce pollution recorded from tanker spillage incidents as the likelihood of leakages in high quantities occurring along pipelines are not as frequent as recorded for tankers.
- Significantly enhance the development opportunities for industries in the southern and middle sectors of Ghana; and
- Enhance creation of jobs directly from the project and indirectly as a result of industrial development and economic opportunities.

1.5 Environmental Impact Assessment Methodology and Objectives

The EIA process became a requirement for project development following the adoption of the Environmental Protection Agency Act, 1994 (Act 490) and subsequently, the Environmental Assessment Regulations in 1999 (LI 1652). According to LI 1652, the objective of the EIA process is to provide a clear assessment of the proposed undertaking by gathering and analysing relevant information, determining the possible direct and indirect impacts of the undertaking on the environment at all project phases, identifying alternatives considered and mitigation measures to ensure the residual effects are minimised or eliminated.

1.5.1 EIA Methodology

The EIA was conducted in line with LI 1652 and followed the procedure shown in Figure 3. GEGL registered the project with the EPA and the EPA in a letter dated 16 April 2021 (APPENDIX A) requested that GEGL conducts an Environmental Impact Assessment (EIA) for the project and subsequently submit an EIS following the submission of a Scoping Report and Draft Terms of Reference (ToR) for the project.

The approach to completing this EIS was done systematically and included: (i) stakeholder engagements (scoping engagements by GEGL); (ii) completion of critical baseline studies (biodiversity and traffic); and (iii) review of available technical information for the project.

1.5.1.1 Scoping Phase

The Golder Project team (the consultants in charge of completing the EIA) visited the project site to obtain a firsthand understanding of the area and become acquainted with site conditions and GEGL personnel working on the project. Existing data and information relating to the project and the project area, as well as other public materials, and reports were reviewed. The goal of this desktop study was to gain an accurate and thorough understanding of the project and the areas which will be potentially impacted by the development.

The stakeholder engagement process associated with the scoping phase was facilitated by GEGL and documentation from the engagements were provided to Golder for review and incorporation into this report. Based on the review of the stakeholder engagement documents, it is noted that GEGL followed due process for the engagements. Appropriate persons and groups with an interest in the project were identified for the project. Consultations were held with traditional leadership, local leaders, community residents and governmental agencies at the local, district and regional levels. The engagements were conducted from 16th July 2021 to 23rd February 2022. A summary of the engagements is as follows:

- All engagements took form of face-to-face interactions and focus group discussions.
- The meetings were conducted in Twi (the local dialect spoken in these communities) and in some cases English and were documented (photographs were taken, attendance registers completed, and notes taken).
- Meetings were held at venues easily accessible to stakeholders.

- Comments and issues raised were captured in a Comments and Responses Report.

1.5.1.2 Baseline Studies and Impact Analyses

A key aspect of the EIA process is to define the existing baseline conditions in the project area. The project team identified vital aspects of the biological and socio-economic environments that required additional studies during the EIA phase. Baseline data including historical data was collated to characterize the physical, biological and socio-economic environments was, which then informed the impact assessment. The impact assessment entails the use of models, and other analytical methods to determine the potential impacts of a project. This impact assessment provided a basis for the development of the required mitigations that may be necessary to meet the various environmental and social standards.

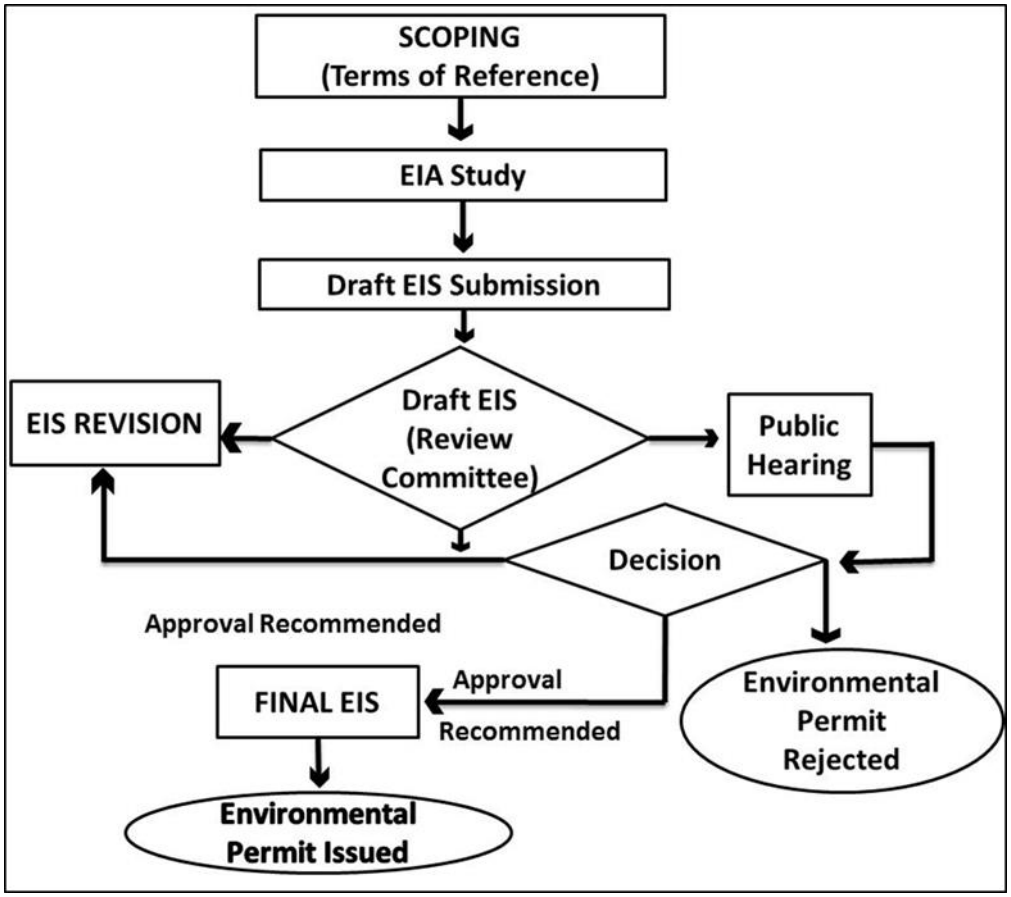

Figure 3: Environmental Impact Assessment Process (EPA, 2015)

1.5.2 Objectives of the EIA

The EIA process aims at identifying potential environmental and social impacts of the project, to inform decision-making, determine compliance with various policies, and aid in the planning of the project. The specific objectives of this EIA were to:

- Document the existing environmental and socio-economic conditions of the project area.
- Present a detailed project description to stakeholders and elicit inputs on the project.
- Identify and assess all the potential environmental and social impacts associated with the project throughout the life of the project.
- Provide appropriate and effective mitigation measures for the management of the impacts and key issues.

- Design management plans to implement and monitor the measures required to mitigate and manage the adverse environmental and social effects of the proposed project.
- Provide a rehabilitation and decommissioning plan for the project.
- Fulfil the requirements of the EPA in the permitting of the project.

1.6 Layout of the Draft EIS

The format of this draft EIS is consistent with the EPA EIS format. Brief descriptions of the various sections of this Draft EIS are presented in Table 3.

Table 3: Layout of Draft EIS

Chapter	Description of Content
Executive Summary	This chapter provides a non-technical description of the entire proposed project, predicted environmental and social impacts, and the mitigation measures proposed.
Chapter 1 Introduction	This chapter contains a brief description of the project background, the justification for, and potential benefits of the proposed project, and the objectives of the EIA.
Chapter 2 – Policy Legal and Regulatory Framework	The chapter entails a review of the relevant policies, laws and regulations which are applicable to the project.
Chapter 3 - Project Description and Alternatives	This chapter describes the proposed project and provides a summary of alternatives considered.
Chapter 4 - Baseline Information	Existing environmental and social conditions in the vicinity of the proposed project are described in this chapter. Biological, physical, and socio-economic resources that potentially could be impacted by the construction and operation of the proposed project are discussed.
Chapter 5 – Public Participation	This chapter provides information on consultations and stakeholder engagement conducted in conjunction with the engagement process for the proposed project.
Chapter 6 – Impact Identification and Prediction	This chapter presents key impacts associated with the construction and operational phases of the proposed project with particular focus offered on assessing potential impacts on the biological, physical, and socio-economic resources.
Chapter 7 – Impact Mitigation	This chapter describes mitigation measures that will eliminate, minimise, and manage potential impacts identified in Chapter 4.
Chapter 8 - Monitoring Programmes	A description of programmes that will be used to monitor various resources during the operation and closure phases of the proposed project is provided in this chapter.
Chapter 9 – Provisional Environmental Management Plan	This chapter includes GEGL's provisional Environmental Management plan (EMP) specific to the proposed project. The plan governs activities that will occur during the initial 18-month period after commencement of operations for the Project.
Chapter 10 - Reclamation and Decommissioning	Methods and measures to be used to rehabilitate and decommission the proposed project site after the cessation of operations are described in this chapter.
Chapter 11 - Conclusion	This chapter presents conclusions reached from preparing this Draft EIS for the proposed project.
References	All references cited in the Draft EIS are included in this section.

2.0 POLICY, LEGAL AND REGULATORY FRAMEWORK

Ghana has well-established laws, policies guidelines and regulations to promote and regulate the energy sector and the environmental landscape. Relevant laws applicable to the project are summarized in the following sub-sections.

2.1 Constitution of the Republic of Ghana, 1992

Chapter 21, Article 257 (section 1) of the Constitution states that: “all public lands in Ghana shall be vested in the President on behalf of, and in trust for, the people of Ghana”. Chapter 6, Article 36, Clause 9, requires the State to take appropriate measures to protect and safeguard and seek the cooperation of stakeholders to protect the environment.

GEGL understands that land is vested in the President of the Republic of Ghana. Thus, GEGL is committed to put in measures to protect the environment, including ensuring that all requisite permits from various government agencies are obtained before project implementation.

2.2 National Policy Framework

The relevant policies and legislations applicable to the project has been presented in Table 4.

Table 4: National Policy and Regulatory Framework Applicable to the project

Framework	Description	Applicability to Project
Policy		
Ghana National Energy Policy, 2010	The National Energy Policy (2010) is the underlying policy guiding governmental actions and strategies in the energy sector. Generally, the policy is targeted at ensuring that Ghana become a major exporter of power in the West African sub-region. This is intended to be achieved through capacity addition, modernization of transmission and distribution infrastructure. The policy also focuses on institutional and regulatory reforms intended to create competitive electricity markets. Ghana’s Energy Policy is premised on the need to increase installed generation capacity to more than 5,000MW and to achieve universal access.	The project aims at providing clean energy and thereby contributing to electrical power increase in the country and to diversify the energy mix in power generation
National Environmental Policy, 2014	The reviewed National Environmental Policy (2014) was first formulated in 1995 to improve the surroundings, living conditions and quality of life of present and future generations. The policy seeks to promote sustainable development by ensuring a balance between economic development and natural resource conservation. It requires the implementation of strategies and programmes for the sustainable management of Ghana's resources.	The project will be aligned with the supporting principles of the policy for the realisation of sustainable outcomes.
National Water Policy, 2007	The National Water Policy (2007) provides the framework for the sustainable development of water resources in Ghana. The overall goal of the policy is to “achieve sustainable development, management and use of Ghana’s water resources to improve health and livelihoods, reduce vulnerability while assuring good governance for present and future generations.”	GEGL understands the importance of water and is committed to put in place appropriate measures to protect water resources. For the construction of pipeline at river crossings, GEGL has in place River Crossing Plan which includes detailed mitigation measures to be

Framework	Description	Applicability to Project
		implemented during pipeline installation. GEGL will ensure that all the necessary permits are obtained from Water Resources Commission (WRC) prior to pipeline construction.
Environmental Sanitation Policy, 2010	The overarching goal of the Environmental Sanitation Policy (2010) is to develop a clear and nationally accepted vision of environmental sanitation as an essential social service and a significant determinant for improving the health of its citizens and quality of life in Ghana.	This policy will guide GEGL in the development of waste management strategies for project implementation.
Ghana Forest and Wildlife Policy, 2012	The Ghana Forest and Wildlife Policy (2012) aims to promote conservation and the sustainable development of forest and wildlife resources. The policy calls for the maintenance of environmental stability and continuous flow of optimum benefits from the socio-cultural and economic goods and services that the forest environment provides to present and future generations. It also helps Ghana to fulfil its commitments under international agreements and conventions.	GEGL and its contractors will ensure that the development of the pipeline project exerts little or no disturbances to forest reserves and other critical and sensitive habitats located along the route of the pipeline. Thus, GEGL undertook biodiversity studies as part of this EIA, was guided by this policy.
National Wetlands Conservation Strategy, 1999	The purpose of this strategy is to protect and drive the sustainable use of wetland resources which occupies approximately 10% of the country's total land surface. Ghana is a signatory to the Ramsar Convention, which seeks to protect all wetlands.	GEGL will comply with the dictates of the strategy for the realisation of intended outcomes.
Ghana Climate Change Policy, 2013	The National Climate Change Policy provides strategic direction and coordinates issues of climate change in Ghana. The three objectives of the Policy are effective adaptation, social development, and mitigation. To address the adaptation issues in Ghana, five areas have been identified, namely, (1) energy, industrial and infrastructure development, (2) natural resources management, (3) agriculture and food security and (4) disaster preparedness and response and (5) equitable social development. In the effort of aligning with its energy strategy, the one of the government's aims includes the development of a local market for the industrial use of natural gas by 2015.	This project will lead to the provision of clean and affordable energy to further strengthen the development of the local market as some heavily industrialized activities will rely on the use of natural gas for their operations.
Acts		
Environmental Protection Agency Act, 1994 (Act 490)	The Environmental Protection Act, 1994 (Act 490) was enacted for the amendment and consolidation of laws relating to environmental protection, pesticides control and regulation, and for other related purposes. Section 12 (1) of the Act mandates the Agency to request an EIA report from any person responsible for an undertaking which, in the opinion of the Agency, has or is likely to affect the environment. Sections 28(1) and	All requirements of the Act will be adhered to.

Framework	Description	Applicability to Project
	(2) of the Act mandate the development of regulations and guidelines for project implementation.	
Ghana Highway Authority Act, 1997 (Act 540)	The Act mandates states that no person shall without the written permission of the Authority make any excavation in a trunk road; or construct access road to link a trunk road. Where a person makes any excavation in a trunk road he shall fill up the excavation and restore the surface of the trunk road to the satisfaction of the Authority as soon as possible after completing the work within such time as the Authority may specify.	The pipeline will cut across some existing roads. This will be discussed with the Ghana Highway Authority in line with the requirements of the Ghana Highway Authority Act,1997 (Act 540). GEGL will obtain all the necessary approval from the Authority before any road crossing is commenced.
Lands Commission Act, 2008 (Act 767)	This Act was enacted to establish the Lands Commission to integrate, subject to Article 258 of the Constitution, the operations of public service and institutions under the Commission in order to secure effective and efficient land administration and to provide for related matters.	The project will result in the economic displacement of some farm owners in the project area. These farmers will be compensated, and the processes will be aligned with the requirements of the Act. The Land Valuation Division under the Commission will be part of the compensation process and will undertake the valuation of affected lands within the project area.
Energy Commission Act, 1997 (Act 541)	The Act mandates the Commission as the only body authorized to license any entity engaging in the processing, transmission, distribution, wholesale supply or sale of electricity and natural gas. The Commission is required by law to prepare, review, and update periodically indicative national plans to ensure that all reasonable demands for energy are met in a sustainable manner. Other functions of the Commission include determination of fees and documents needed to apply for a license to operate.	GEGL will obtain all relevant approvals from the Energy Commission prior to the commencement of construction.
Water Resources Commission Act, 1996 (Act 522)	The Water Resources Commission is empowered by Act 522 to grant water rights. Section 13 prohibits the diversion, damming, and storing of water resources except when in accordance with the provisions of the Act. The Act provides that any person may apply to the Commission in writing for the granting of a water right, which then permits the proponent to dam, store, divert or use water. On receipt of the application, the Commission investigates as it considers necessary, including consultations with the inhabitants of the area of the water resources concerned. Section 24 also provides that: "… except in accordance with the provisions of Act 522, or with the approval of the EPA, a person who interferes with, or alters the flow of water resources beyond such levels as the EPA may prescribe, commits an offence".	A water use permit will be required for the diversion or interruption of river flow are anticipated during construction of the pipeline over the Oda and Offin rivers.

Framework	Description	Applicability to Project
Local Governance Act 2016 (Act 936)	This Act replaces the Local Government Act 1993, (Act 462) and provides for local governance and National Development Planning System for the Districts. The Act also defines and regulates planning procedures of District Assemblies. The Assembly is mandated to initiate programmes for the development of basic infrastructure and provide municipal works and services as well as be responsible for the development, improvement and management of human settlements and the environment in the district. Section 91 (1) states that no physical development shall be carried in a district without prior approval in the form of a written permit granted by the District Planning Authority.	GEGL will work with all MMDAs along the pipeline's ROW to obtain all necessary approvals for the proposed 105 km Natural Gas Pipeline Infrastructure Project.
Land Use and Spatial Planning Authority Act 2016, (Act 925)	The Land Use and Spatial Planning Act was established to revise and consolidate the laws on land use and spatial planning with the objectives to provide for sustainable development of land and human settlements through a decentralised planning system. To achieve its objectives, stipulated functions have been identified in the act such as performing the spatial, land use and human settlements planning functions of the national development planning system established under the National Development Planning Commission Act, 1994 (Act 479) and the National Development Planning (System) Act, 1994 (Act 480); providing directives, issue regulatory notices, guidelines and manuals to ensure compliance with this Act; ensuring the control of physical development in uncontrolled or less controlled but sensitive areas such as forest reserves, nature reserves, wildlife sanctuaries, green belts, coastal wetlands, water bodies, water catchment areas, mining areas, open spaces and public parks.	GEGL will engage applicable authorities and obtain all needed approvals before project implementation.
Factories, Offices and Shops Act, 1970 (Act 328)	The Act spells out the responsibilities of an employer in ensuring a safe and healthy work environment that guarantees the health and safety of employees. It defines a factory to include any premises (whether in or not in a building) in which one or more persons are employed in manual labour in any activity including the work activities for this project. The Act mandates the Factories Inspectorate Department to register such activities and ensure that internationally accepted standards of providing safety, health and welfare of persons are adhered to.	GEGL will engage the Factories Inspectorate Department and obtain the approval prior to the operation of the facility.
Legislative instruments		
Environmental Assessment Regulations, 1999 (LI 1652)	The Environmental Assessment Regulations, 1999 (LI 1652), set out the requirements for environmental permitting/certificates, environmental assessment, and Environmental Management Plans (EMPs). LI 1652 was enacted in 1999 in accordance with the EPA Act, 1994 (Act 490). Schedule 1 of Regulation 1 of LI 1652 lists all activities that require an EIA. Under Schedule 2 of Regulation 3, the construction of offshore pipelines	The dictates of these regulations will be adhered to throughout the project implementation.

Framework	Description	Applicability to Project
	under is classified as an undertaking for which an EIA is mandatory.	
Electricity Regulations, 2008 (LI 1937)	The Electricity Regulations 2008 (LI 1937) provides for the planning, expansion, safety criteria, reliability, and cost effectiveness of the national interconnected transmission system. The LI provides for the regulation of a wholesale electricity market; market operations of the electricity transmission utility; the technical operations of the electricity transmission utility; minimum standards and procedures for the construction and maintenance of facilities and installations; the protection of the mains and electrical installations and services and the protection of life and property and the general safety of the public in respect of electricity services. Other issues include minimum reserve margins to satisfy demand and the development and implementation of programmes for the conservation of electricity.	The dictates of these regulations will be adhered to throughout the project implementation.
Fees and Charges (Amendment) Instrument, 2019 (LI 2386)	The Fees and Charges (Amendment) Instrument 2019 (LI 2386) replaced the Fees and Charges (Amendment) Instrument 2016, (LI 2228). This instrument gives regulation to the Fees and Charges (Miscellaneous Provision) Act 2009 (Act 793), which provides comprehensive rates, fees and charges collectable by Ministries, Departments and Agencies for goods and services delivered to the public. The Ghana Immigration Service, through this instrument, has introduced a residence permit fee to ECOWAS nationals and Ghanaians holding foreign passports. Other nationals entering the country for work will also be required to apply for residence permit and pay the accompanying fees.	GEGL will comply with permit fees and all charges pertaining to the obtaining approvals for the implementation of the pipeline as well fees for resident permit for expatriates hired for the project.
Electricity Regulations, 2008	The purpose of these Regulation includes, among others, the regulation of wholesale electricity market, minimum standards and procedures for the construction and maintenance of facilities and installations.	This Regulation applies to wholesale electricity suppliers, such as GEGL Ghana, and distributors (who are expected to be licensed by the Energy Commission under sections 25 and 26 respectively of this Act), duly authorized bulk customers and the Electricity Transmission Utility.

2.2.1 Guidelines and Standards

Several guidelines have been developed to support the sound design and management during Project implementation. Some of the guidelines relevant to an EIA include:

- Environmental Assessment in Ghana, A Guide (1996) and Environmental Impact Assessment Procedures (1995) are EPA guidance documents which outline procedures to be adhered to when undertaking an EIA
- Standard for Health Protection - Requirements for Ambient Noise Control (GS 1222:2019)

- Standard for Water Quality – Specification for Drinking Water (GS 175:2017)
- Standard for Environment and Health Protection – Requirements for Ambient Quality and Point Sources/Stack Emissions (GS 1236:2019)
- Natural gas Access Code

2.3 International Environmental Treaties and Conventions

The Government of Ghana is a party to several international treaties relating to the environment, notably:

- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) – a treaty signed by Liberia and other countries which prevents species from becoming endangered or extinct because of international trade.
- Convention on Biological Diversity (CBD) – a treaty established by the United Nations aimed at preserving biological diversity around the world.
- Convention on the Conservation of Migratory Species of Wild Animals (CMS) – also known as the Bonn Convention, the main objective of this international agreement is the conservation and sustainable use of terrestrial, aquatic and avian migratory animals and their habitats.

2.4 International Standards and Guidelines

The IFC Performance Standards and Equator Principles are the benchmarks for good internal environmental practice for many organisations. They are often applied to evaluate EIAs and Environmental and Social Management System (ESMS) proposals when considering a project and provide a level of assurance for investing partners. The principles have been designed to allow a project and its backers to understand the implications of environmental and social issues associated with the project and assess whether good practice for managing potential impacts is in place or can be developed. These Principles are supplemented by additional industry focused EHS Standards for selected sectors.

There is a range of international organisations that have variants of these requirements. Many have been prepared in line with the IFC standards and the principal interests remain common among them. The principles set out expectations that the environmental and social issues pertinent to a project have been adequately studied and assessed, and that management and mitigation measures will meet appropriate levels and systems.

2.4.1 IFC Performance Standards on Social and Environmental Sustainability

Of the eight Performance Standards (PS) issued by IFC (Published January 1, 2012 (updated June 14, 2021)), seven PSs (PS1, PS2, PS3, PS4, PS5, PS6 and PS8) have been defined as applicable to the project and thus will be adhered to throughout the EIA.

Performance Standard 1[1] establishes the importance of:

- Integrated assessment to identify the social and environmental impacts, risks, and opportunities for projects
- Effective community engagement through the dissemination of project related information and consultation with local communities on matters that directly affect them
- The management of social and environmental performance throughout the life of the project

[1] (International Finance Corporation, 2012b)

Performance Standard 2[2] establishes the importance of:

- Employment creation and income generation being accompanied by protection of fundamental rights of workers
- Constructive worker-management relationships, treating workers fairly and providing them with safe and healthy working conditions as this may enhance efficiency and productivity
- The protection of workers, including vulnerable categories of workers such as children, migrant workers, workers engaged by third parties, and workers in the Client's supply chain
- Ghana's local content policy and GEGL's employment plan are aligned to this PS.

Performance Standard 3[3] establishes the importance of:

- The avoidance or minimising adverse impacts on human health and the environment by avoiding or minimising pollution from project activities
- Promoting sustainable use of resources, including water and energy
- Reducing project related GHG emissions.

Performance Standard 4[4] establishes the importance of:

- The anticipation and avoidance of adverse impacts on the health and safety of the affected community during the project life from both routine and non-routine circumstances.
- Ensuring that the safeguarding of personnel and property is carried out in accordance with relevant human rights principles and in a manner that avoids or minimises risks to the Affected Communities.

GEGL's HSE policy is aligned to this PS.

Performance Standard 5[5] establishes the importance of:

- The avoidance of involuntary resettlement wherever possible and to minimise its impact on those displaced through mitigation measures such as fair compensation and improvements to living conditions.
- Actively engaging community throughout the land acquisition and involuntary resettlement process.

Performance Standard 6[6] establishes the importance of:

- Biodiversity conservation and sustainable management of living natural resources.
- Protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development.
- How developer can sustainably manage and mitigate impacts on biodiversity and ecosystem services throughout the project's lifecycle.

Biodiversity management plan developed as part of the project studies is aligned to this PS.

[2] (International Finance Corporation, 2012c)
[3] (International Finance Corporation, 2012d)
[4] (International Finance Corporation, 2012e)
[5] (International Finance Corporation, 2012a)
[6] (International Finance Corporation, 2012e)

Performance Standard 8[7] establishes the importance of:

- Protecting cultural heritage during the project activities for current and future generations.
- Providing mitigation measures to address impacts to cultural heritage during the project life cycle and applying the provisions of Convention Concerning the Protection of the World Cultural and Natural Heritage.

2.4.2 Mitigation for Cultural Heritage impacts is in line with this PS.IFC Environmental Health and Safety Guidelines

These guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP) as defined in IFC's Performance Standard 3 on Pollution Prevention and Abatement. The EHS Guidelines contain the performance levels and measures that are normally acceptable to IFC and are generally considered to be achievable in new and existing facilities at reasonable costs. The dictates of the guidelines will be adhered to during the EIA process.

2.4.3 Equator Principles

Financial institutions adopting the Equator Principles establish their own environmental guidelines, through which IFC PSs, and World Bank and IFC Environmental Guidelines by Sector are applied. The principles will be adhered to throughout the EIA process.

Principle 1 establishes the need for the Equator Principles Financial Institution (EPFI) to categorise the project based on the magnitude of its potential environmental and social risks and impacts as part of its internal environmental and social review and due diligence.

Principle 2 requires the client to conduct an Assessment process to address, to the EPFI's satisfaction, the relevant environmental and social risks and impacts of a proposed project. It is required that the Assessment documentation will propose measures to minimize, mitigate, and offset adverse impacts in a manner relevant and appropriate to the nature and scale of the proposed project.

Principle 3 established that the Assessment process should firstly address compliance with relevant host country laws, regulations and permits that pertain to environmental and social issues.

Principle 4 requires an EMP to be prepared by the client to address issues raised in the assessment process and incorporate actions required to comply with the applicable standards.

Principle 5 requires clients to demonstrate effective Stakeholder Engagement as an ongoing process in a structured and culturally appropriate manner with affected communities and, where relevant, other stakeholders.

Principle 6 requires the client to establish a grievance mechanism designed to receive and facilitate resolution of concerns and grievances about the Project's environmental and social performance as part of the EMS.

Principle 7 requires that an Independent Environmental and Social Consultant, not directly associated with the client, will carry out an Independent Review of the Assessment Documentation, including the EMPs process documentation to assist the EPFI's due diligence, and assess Equator Principles compliance.

Principle 8 requires that the client pledge its commitment to complying with all relevant host country environmental and social laws, regulations and permits in all material respects in the financing documentation.

[7] (International Finance Corporation, 2012e)

Principle 9 requires the appointment of an Independent Environmental and Social Consultant or requires that the client retain qualified and experienced external experts to verify its compliance with the Equator Principles and monitoring information which would be shared with the EPFI.

Principle 10 deals with the client's reporting requirements in addition to the disclosure requirements in Principle 5. This principle states that the client will ensure that, at a minimum, a summary of the EIA is accessible and available online and the client will publicly report Green House Gas (GHG) emission levels (combined Scope 1 and Scope 2 Emissions) during the operational phase for Projects emitting over 100,000 tonnes of CO_2 equivalent annually.

The dictates of these principles will be adhered to throughout the EIA.

2.4.4 IFC Environmental Health and Safety Guidelines

These guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP) as defined in IFC's Performance Standard 3 on Pollution Prevention and Abatement. The EHS Guidelines contain the performance levels and measures that are normally acceptable to IFC and are generally considered to be achievable in new and existing facilities at reasonable costs. The dictates of the guidelines will be adhered to during the EIA process.

3.0 PROJECT DESCRIPTION AND ALTERNATIVES

GEGL proposes to construct a 105 km, 24-inch branch natural gas pipeline from GEGL's existing BPS from Gyegyetreso to Ejisu (Figure 2). As part of the pipeline infrastructure, GEGL also intends to construct three BVS and one BMS. The BVSs will be in the Miawano, Ntinako and Adwafo communities, while the BMS will be located at Ejisu-Kumasi. These facilities will all be linked to the gas pipeline network.

The installation of the three BVS along the pipeline route will ensure effective interconnection of the gas pipeline. The gas pipeline will allow for the supply of natural gas from the RMS managed by the Ghana National Gas Company in Prestea to the Ameri power plant via GEGL's existing pipeline infrastructure to Gyegyetreso.

3.1 Project Scale

The natural gas pipeline will commence from the southwest, at Gyegyetreso BPS and travel northeast at 31km to the proposed Miawano BVS. It will further run East to the Ntinako BVS, which is 17.8km away. The pipeline will continue again to Adwafo BVS east of Ntinako for 26.4km and terminate at the proposed Ejisu BMS. The pipeline has a length of 105km and a diameter of 24-inch. A 25 m RoW (12.5 m on each side) has been acquired for the pipeline route out of which a corridor of a 9m width will be used.

The pipeline will travel along major communities such as Antoakrom in the Amansie South district, Ahwiankwanta and Kokofu in the Bekwai Municipality, Kuntanse in the Bosomtwe District and Ejisu in the Ejisu Municipality.

Figure 2 provides a satellite image of the Primary, branch pipeline stations and route lines, and GPS coordinates of the stations along the gas pipeline and the total land-take are provided in Table 5. The pipeline will have a production capacity of 135mmscfd (million standard cubic feet per day).

Table 5: GPS coordinates of stations along the natural gas pipeline

Location	GPS coordinates		Total Land-Take
Gyegyetreso BPS	6°19'58.01"N	2° 5'1.91"W	0.40
Miawano BVS	6°24'59.03”N	1°48'57.16"W°	0.39
Ntinako BVS	6°29'51.68"N	1°31'44.32"W	0.39
Adwafo BVS	6°30'34.85"N	1°28'15.58"W	0.39
Ejisu BMS	6°41'25.55"N	1°30'52.67"W	1.93

3.2 Project Components and Design

3.2.1 Project Components

The pipeline development will include the following major components:

- 105km 24-inch natural gas pipeline
- Gas stations consisting of 3 BVS and 1 BMS
- Camps serving as housing and temporary workstations for the EPC team

105km Primary Pipeline

GEGL will extend a 24-inch primary gas pipeline from GEGL's existing 133km primary pipeline via the Gyegyetreso BPS. The natural gas to be supply through the proposed pipeline will be sourced from the Ghana

National Petroleum Corporation through Prestea RMS and GEGL existing natural gas pipeline infrastructure from Prestea to Gyegyetreso.

It should be noted that prior to the Project's registration with the EPA, GEGL conducted preliminary desktop studies that determined the total estimated distance from the Gyegyetreso BPS to the pipeline's final termination point would be 102km. Reconnaissance studies conducted during the scoping process and prior to the acquisition of an Energy Commission Siting Permit confirmed that the pipeline's distance from the initial point at Gyegyetreso is 105km, resulting in a change in pipe length in the scoping report and Siting Permit application. The Energy Commission has been notified of the change, and new applications for a Construction Permit have been submitted.

According to the agreed-upon timeline with the Ministry of Energy, the pipeline to Kumasi is expected to be completed by July 2022. However, there is a scarcity of 20-inch pipelines on the market, and GEGL made efforts to contact suppliers from diverse sources (including the United States and China). After searching with several pipe suppliers, GEGL discovered a pipe dealer in the United States who had all 105 kilometers of the pipeline but in 24-inches pipe sizing already built-in storage. The Ministry of Energy (MoE) and the Technical Committee of Ghana National Petroleum Corporation (GNPC) were notified, and with the approval of the MoE and GNPC, the decision was made to purchase the 24-inch pipes. Since then, GEGL has been collaborating on pipeline details with the MoE, GNPC, and Ghana Gas. This primarily influenced the change in pipe size from 20 to 24 inches. GEGL has also engaged the technical committee of Ghana National Gas Company Limited (Ghana Gas) to discuss the pipeline routing and designs, which have been presented and shared with the team.

In addition to the above, the proposed pipeline to Kumasi will be a mainline transmission pipeline for the delivery of natural gas for power generation; thus, in the future, if the demand for natural gas increases through the proposed mainline transmission line to Kumasi, the thickness of the pipeline will accommodate the increased demand for natural gas.

GEGL will ensure that all components that ensure the efficiency and reliability of a system that delivers natural gas year-round are operational 24 hours a day, seven days a week (except for scheduled and unscheduled maintenance).

Gas Stations

Branch Metering Stations

GEGL will construct one BMS at Ejisu to receive and forward the natural gas supply to the Ameri power plant. At the Ejisu BMS, natural gas will be compressed to a minimum pressure of 41bar for use by the Ameri power plant. The BMS will serve as a termination point of the primary pipeline and branch point for future tie-in connections and metering points. The BMS will mainly consist of a station skid, power generation systems, fire protection systems, Control Room to house the control systems, and a warehouse for the storage of spare parts to be used for maintenance works. Table 6 provides a description of the various equipment and materials which will be used in each BMS. The layout of the BMS is attached in APPENDIX B.

Table 6: BMS Components

Item	Description
Skids in the station	DN600 Pig receiver, 2X DN300 Pig Launcher, 2X DN500 filter separator, 2X DN300 metering package and accessories, 22 skids, control system
Installation Materials	Lightning Protection Equipment Grounding Vent Pipes, fiber hardware connection, flanges, steel pipes, pipe fittings, inlet and outlet station connection elbows.
Power Generation System	Solar Power Generating Unit

Item	Description
	Lightning System
Fire Protection System	Fire extinguisher
Container Room	A 20’ Container to house the Control System

Block Valve Stations

GEGL will install three Block Valve Stations (BVS) along the pipeline route, between the BPS at Gyegyetreso and BMS at Ejisu to ensure effective interconnection of the gas pipeline. The three BVS will be and will be located at Miawano, Ntinako and Adwafo. The purpose of the BVS is to isolate any part of the pipeline in case of a leak, to vent the gas and to allow repairs. The BVS will mainly consist of a station skid, power generation systems, fire protection systems, control room to house the Control Systems, and a warehouse to house spare parts used for maintenance works. Table 7 provides a description of the various equipment and materials which will be used in each BVS.

Table 7: BVS Components

Item	Description
Skids in the station	DN600 Gas-Liquid Linkage Ball Valve The Skid Control Systems Instruments and Accessories such as Pressure Indicators
Installation Materials	Lightning Protection Equipment Grounding Vent Pipes, Flanges, Steel Pipes, Pipe fittings, Inlet and Outlet station Connection Elbows. (DN 600)
Power Generation System	Solar Power Generating Unit will be used to provide power for the station. Lightning System
Fire Protection System	Fire extinguisher
Container Room	A 20’ Container to house the Control System

3.2.2 Project Design

In the design of a natural gas distributed system, the principal factor influencing the size of pipelines is the maximum hourly volumes of gas that the system is required to transport. Accordingly, to ensure that the system design meets the requirement of the consumer served by the system, peak hour design loads have been derived and applied to the system design.

The following aspects were also taken into consideration in the design of the pipeline:

a) Appropriate cathodic protection system to prevent leakages resulting from the effects of external corrosion of the pipe.

b) External and internal pipeline coating system to prolong the service life of the pipeline.

c) Measures to protect the internal layers of the pipeline from the detrimental effects.

d) The ability of the pipeline to remain in place on sediment and not float, even if empty or filled with gas rather than liquids).

e) Proposed operating pressures.

f) Adequate provisions to protect other pipelines the proposed route crosses over.

g) Compliance with all applicable regulations.

The design and construction of the pipeline will be aligned to the requirements of international codes and standards such as the American Petroleum Institute (API), the American Society of Mechanical Engineers, the National Association of Corrosion Engineers and British Standards.

The pipeline will consist of lengths of carbon steel pipe which will be welded together and buried with a depth of cover of at least 1.5m. The pipeline will be designed to operate at a maximum permissible pressure of 7.5MPa. The buried section of the pipeline will be coated with an anti-corrosion agent to prevent corrosion and supplemented with a cathodic protection system.

The parameters of the pipeline are as provided in Table 8, and the mechanical data of the pipeline are also provided in Table 9.

Table 8: Pipeline Design Parameters

Design Parameter		Specification
Fluid		Lean gas
Pipeline installation		Buried
Pipeline length		105 km
Pipe nominal diameter (main line)		24”
Corrosion allowance		1.5 mm
Pipe specification / material grade		API 5L PSL2 X65 Carbon Steel
Maximum allowable operating pressure		72.00 barg
Hydro test pressure		84.38 barg
Design Temperature		0-50^{o}C
Operating temperature	Maximum	50^{o}C
	Minimum	10^{o}C
Ambient temperature	Maximum	40^{o}C
	Minimum	18^{o}C
Product densities	Maximum	97.0 kg/m^{3}
	Minimum	55.1 kg/m^{3}

Table 9: Pipeline Mechanical Data

Parameter	Specification
Inside diameter	600 mm
Wall thickness tolerances	+15%/-12.5% (as per API 5L specs)

Parameter	Specification
Material standard of line pipe	API5LX52M
Line pipe manufacturing process	SAWH/SAWL
Lengths	Fixed (average 12.0m)
Ends	30 +5º, 0º
External Coating	3LPE
Concrete Coating	For mechanical protection where required on alignment sheets

3.3 Construction Fleet

A construction fleet including excavator, compactor, concrete truck, and wheel loader will support the construction works. Details of the construction equipment and machines are presented in Table 10.

Table 10: Construction Fleet

Equipment Type	Equipment Brand/ Model	Specification	Average Use (h/Month)	Shifts/ day	Availability (%)	Utilization Frequency (%)	No.
Pick-ups/ Trucks	Nissan Hard body (NP300) & Toyota Hilux	YD25, 2488 cc, 98 kW @ 3600 rpm, 304 Nm @2000 rpm	6,820	1 x 9 - hour shifts	95.1	95.1	44
Cranes	CAT CH55	Multidocker CH55, 213 kW, 6 cylinders	1,584	1 x 9 - hour shifts	95.7	95.7	6
Pipe Jacking Generators	TBD	100 -200 kVA, 50 Hz, 240 - 420L fuel capacity, 3 phase	8	1 x 9 - hour shifts	66.7	66.7	1
Bull dozers	SDLG/ CAT D7	C9.3B diesel Engine, 127-160 kW 50733 lb weight	4,752	1 x 9 - hour shifts	95.0	95.0	18
Excavators	SDLG/CAT	25 ton, 1.2 m3 bucket capacity,7 m dredging depth, 120 kW engine power	4,752	1 x 9 - hour shifts	94.6	94.6	18
Buses	Toyota Hiace	15/ 16 seats 2694 cc, 106 kW @ 4800 rpm, 224 Nm @ 3600	588	1 x 9 - hour shifts	94.8	94.8	4
Welding Generators	TBD	220A DC Engine Driven Welder 5 0/220 kVA/V Auxiliary Power Welding Current Range 40 – 220A	1,116	1 x 9 - hour shifts	98.6	98.6	4

3.4 General Construction Procedures

The proposed pipeline construction will make use highly specialized and qualified workgroups, each made up of different crews with their own set of responsibilities. After receiving relevant project approval/permits from the EPA, the Energy Commission, and the various MMDAs along the pipeline's RoW, as well as the easement agreements, the pipeline construction process will begin. The details of the construction activities for the 105km natural pipeline are provided below.

Clearing and Grading

The pipeline RoW will be cleared of vegetation. Hillsides that are so steep will be lowered and leveled. Sandbags will be placed within trenches to restrict water flow and to support the pipes. Temporary erosion control measures will be installed prior to any earth-moving activities.

Trenching

The trench for the pipeline will dug after the RoW is cleared. Topsoil will be removed from the work area and stockpiled separately in agricultural areas. Trenching machines will be used to excavate the pipeline trench. The soil that is excavated during ditching operations is temporarily stockpiled on the non-working side of the trench.

Pipe Stringing

Individual joints of pipe will be strung along the RoW adjacent to the excavated ditch and arranged so they are accessible to construction personnel. A mechanical pipe-bending machine will be utilized to bend individual joints of pipe to the desired angle at locations where there are significant changes in the natural ground contours or where the pipeline route changes direction.

Welding and Coating Pipe

After the stringing and bending are complete, the pipe sections will be aligned, welded together, and placed on temporary supports along the edge of the trench. All welds will then be visually, and radio graphically inspected. Prior to the final inspection, the entire pipeline coating will be electronically inspected to locate and repair any coating faults or voids.

Lowering Pipe in and Backfilling

The pipe assembly will be lowered into the trench. The trench will be backfilled using a backfilling equipment without the inclusion of foreign materials in the trench.

Testing

Following backfilling of the topsoil, the pipeline will be hydrostatically tested in accordance with EPA regulations and under the supervision of a qualified engineer. Water for testing will be obtained and discharged in accordance with EPA and local regulations. Prior to the commencement of operation of pipeline, GEGL will submit a hydrotest to the EPA for consideration of a Hydrotest Permit.

Restoration

GEGL’s policy is to clean up and restore the work area as soon as possible. After the pipeline is backfilled and tested, disturbed areas will be restored as close as possible to their original contours. Restoration measures will be maintained until the area is restored, as closely as possible, to its original condition. Agricultural lands will be properly restored using approved, modern mitigation techniques designed to ensure full productive reuse of the agricultural lands.

3.5 Construction Approach to the River Crossings

The approach that will be taken for construction of the pipeline at the river crossings is detailed in Document No HT02 entitled Phase 2 GEGL NGP, Construction Plan for River Crossing, Rev No. 2.0, Jingmen Hongtu Special Aircraft Manufacturing Co., Ltd. Ghana Project Department, dated February 11, 2020. A copy of the detailed approach is included as APPENDIX B.

Considering that the geology of river crossings is a mixed layer of humus soil and sand, different methods will be selected to suit site specific conditions. The types, summary of the method and the work process is set out in Table 11.

GEGL will continue to engage the meteorological stations to be aware of any weather changes before construction commences at river crossings.

Table 11: River Crossing Types

Selection of river crossing method	Characteristics of river	Method	Work process
Interception (Figure 4)	Water surface width < 20m Slow water flow speed Non-navigation	Once intercepted, the water level will not rise significantly. If the upstream water level rises slightly or there is a need for water downstream after the closure, a water pump will be equipped to pump water from upstream to downstream. Simple and convenient to restore the landform.	Construction preparation Surveying and setting out Access Road Construction Cofferdam Construction Dredging and RoW extension Pipeline assembly and welding Non-Destruction Testing Joints Repair Pipe trench excavation Pipe lowering in trench (Communication optical cable in place) Pipe trench backfill Ground leak detection Landform restoration
Figure 5	Wide water surface width Large water flow Non-navigation	The cofferdam diversion method constructs a cofferdam on the upstream and downstream of the river and the ditch to pass through the cofferdam to prevent the accumulation of upstream river water. A diversion ditch is excavated through the downstream side of the pipeline outside the embankment to make the river and ditch inside. Water flows through the diversion canal.	Construction preparation Surveying and setting out Access Road Construction Diversion canal excavation Cofferdam construction RoW development Pipe trench excavation Embedded concrete casing Pipe trench backfill Pipeline prefabrication Non-Destruction Testing Pipe back-dragging Pipeline tie-in construction Landform restoration

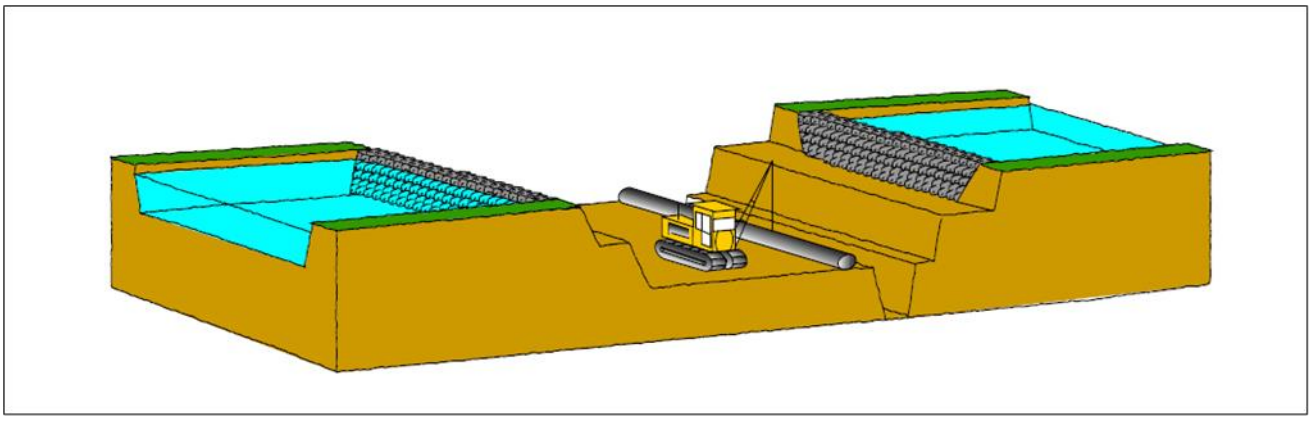

Figure 4: Figure illustrating the Interception method

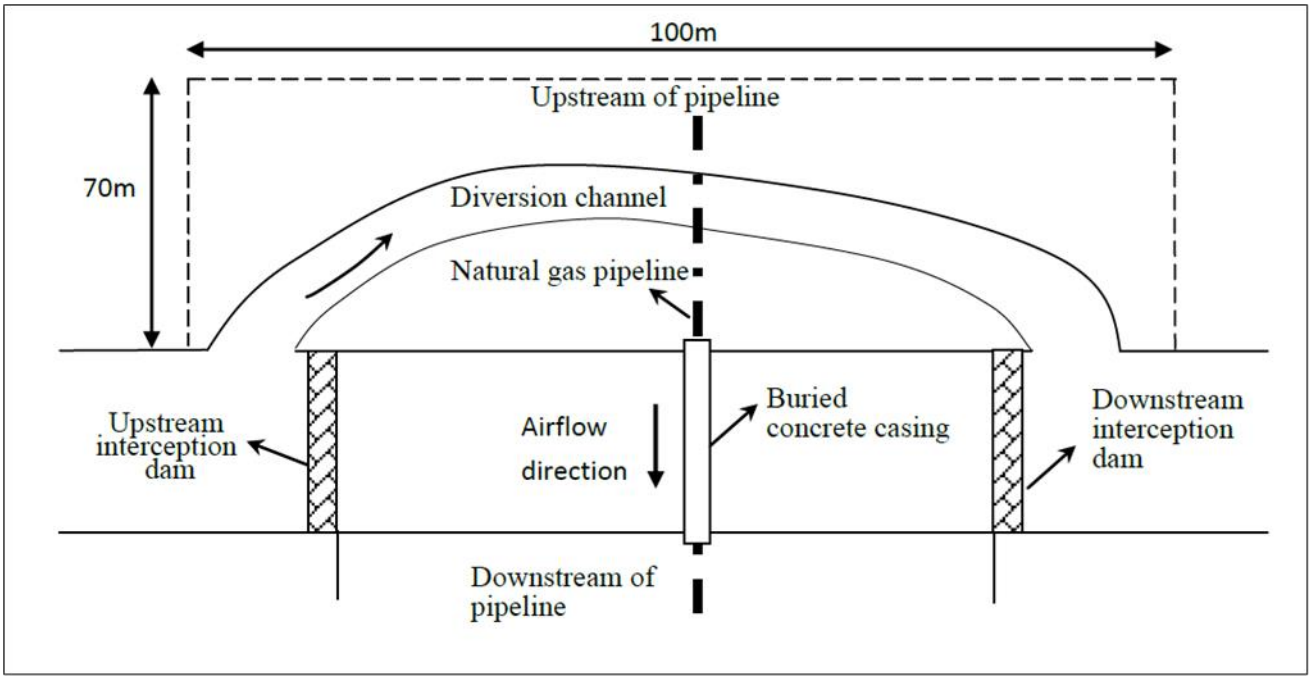

Figure 5: Figure illustrating the cofferdam method

3.6 Project Services

3.6.1 Accommodation Facilities

There will be camps constructed at approximately every 25km along the pipeline route to accommodate the project tea, as well as serve as temporary work area for the EPC team. A total of four camps will be constructed and the components will be the same as shown in Figure 6 which is the proposed camp layout design for the Ejisu BMS. Similar designs will be constructed at Miawano, Ntinako, Adwafo and Ejisu. For existing projects visitors are normally accommodated in hotel facilities close to the working locations and this will be the case for the proposed project. Due to the project area spanning Gyegyetreso to Kumasi, it is anticipated that the construction team will be accommodated at the relevant camp and will move as they progress with the construction of the pipeline.

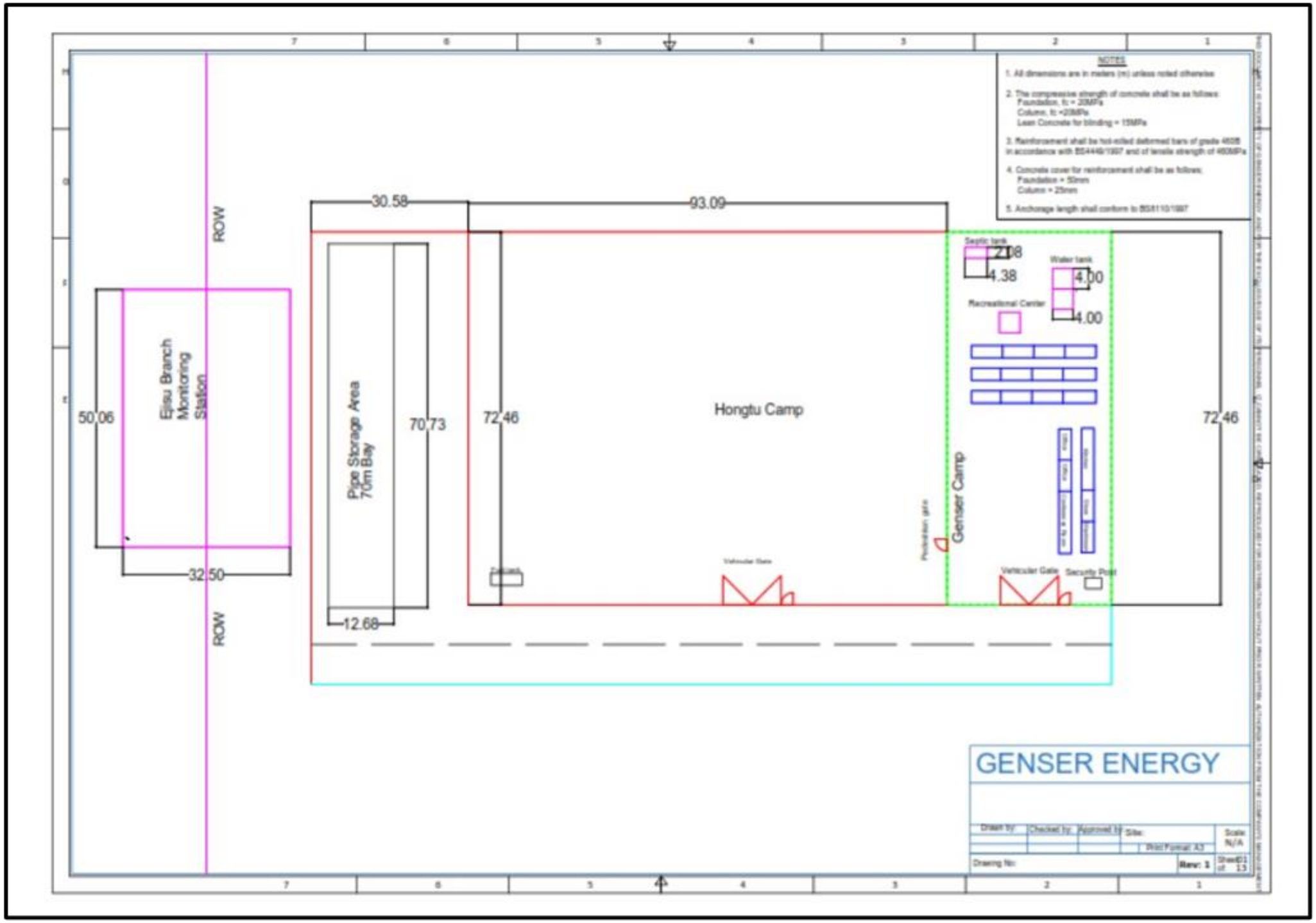

Figure 6: Proposed Camp Layout for the Pipeline Project

GEGL will allocate spaces at each camp for the construction of an administration block. The administration will consist of offices, a conference room, washroom, a kitchen, and a storeroom. The administration block will be built with containers and will be located at 5m from the housing units. The allocated area for GEGL's camp is 2,315.82m^2.

3.6.2 Workspace

A workspace will be provided at each of the camps for the maintenance of project equipment. The area for the workshop will be situated within the space allocated to the EPC subcontractors for the construction of the pipeline (Hongtu). The space allocation for the Hongtu team is estimated to be 6745.30m^2.

3.6.3 Health Care

GEGL will build an infirmary at each of the camps to cater for the health needs of the employee. The infirmary would have resident nurse and offsite medical personnel who will attend to the sick. Also, will identify public health facilities along the Gyegyetreso-Kumasi area where staff could get medical attention in the event of illness beyond the capacity of the infirmary.

The construction and pipeline installation teams will have specific work standard first aid kit to respond to injuries and other ailments until individuals are attended to at a medical facility (where required).

3.6.4 Monitoring Facilities

It is anticipated that the Ejisu BMS will have a weather station with data processing installed. The equipment will mainly record rainfall and temperature. An air quality equipment will also be installed for daily monitoring.

GEGL has a centralized control room at Damang, with a dedicated team to monitor the functioning of equipment and operations at all natural gas stations, as well as operations parameters. This enables the early detection of a break whenever an emergency shutdown valve at any of the stations is shut. All emergency valves and buttons could be operated (i.e., shut or opened) from the Damang control room to prevent accidents, and for the safe running of the gas pipeline. This centralised control room will cover the Ejisu BMS during operations. Moreover, the Ejisu BMS will also be equipped with a control room to perform the same function.

A fiber optic cable will be provided beside the underground pipeline to ensure long distance and high-performance communication along the pipeline. Any rupture along the pipeline or change in flow parameters will be communicated through the fiber optic cable to the control room.

3.7 Water Needs

The camps will be connected to the Ghana Water Company Limited (GWCL) water supply system to cater to the water needs of the project. There will be a borehole with attached overhead tank at each of the camps. The water will be treated and tested to meet the Ghana Standards for Water Quality - Specification for Drinking Water (GS 175: 2017) before use. A water storage tank of 5m^3 capacity will be provided to supplement water needs in the case there is no flow from GWCL.

3.8 Waste Management

GEGL will classify wastes into streams to enable appropriate segregation, handling, transport, disposal, and recycling/recovery in a manner appropriate to the waste materials. Colour coded waste receptacles will be provided by GEGL at vantage points at the camps to enable waste segregation and subsequent management.

Hydrocarbon wastes, mostly from waste oils and lubricants, will be managed as part of GEGL's hazardous waste management plan and will utilize the waste hierarchy framework of mostly prevention, reduction, recycle, recovery and the least of all, disposal.

Domestic wastewater and sewage will be channeled to a septic tank located at the camps. The sewage built up will be removed by a vacuum truck sourced from Ejisu and the other camps sites to be transported to appropriate and approved waste disposal site.

Training will be provided to staff and the workforce to increase familiarity with competence in appropriate waste handling and disposal methods.

3.9 Scheduling and Activities

GEGL plans to complete the construction and commissioning of the project in 10 months once the environmental permit is obtained. The proposed schedule for the gas pipeline construction is attached in APPENDIX B.

3.10 Staffing and Employment

Due to GEGL having several operations in the country, it is anticipated there will be a pool of qualified and experienced nationals available to support this project during the construction and operational phases. However, GEGL will employ approximately 300 people during the construction phase of the project. The people to be employed will consist of 100 skilled labour and 200 unskilled labour. The skilled labour group will include professionals such as Engineers and Medical personnel. The list of technical people required for the project are:

- Project Manager
- Construction Supervisors
- QA/QC Engineers
- HSE Engineers
- Community Relations Officers
- Doctors
- Nurses
- Local subcontractors
- International subcontractors for specialized work

The medical staff will include two doctors (one doctor assigned to two camps) and two nurses for each camp.

During the operational phase, approximately skilled 23 people unskilled labour will be outsourced. The list of technical people required for the operational phase of the project are:

- Fuel Supply Manager
- Operations Superintendent
- Mechanical Reliability Engineers
- Electrical & Instrumentation Engineers
- Civil Engineers
- Human Resource Personnel
- Supply Chain Personnel
- HSE personnel

- Community Relations personnel
- Operations Engineers
- Operations Mechanics and Technicians

3.11 Economic Displacement and Compensation

Because the gas pipeline runs through various agricultural lands with rural living allotments and horticulture practices as well as urban centers, the development of the proposed project will impact farmlands along the RoW. Thus, all project affected persons (PAPs) will be compensated for crops to be destroyed on their farmlands. Land compensations will, however, be paid to the custodians of the lands. The compensation process will be in line with the Land Commission Act, 2008 (Act 767). This law together with the regulatory guidelines promulgated by the Commission establish minimum requirements for accessing or acquiring land before any site-related activities commence. This law also requires that the rights and needs of the PAPs are assessed and mitigated. The National Land Valuation Board will be consulting during the determination of crop rates for the compensations and all payments will be aligned to their requirements.

A Compensation Negotiation Committee (CNC) will be formed to foster the interactions between GEGL and PAPs. It is anticipated that the CNC will be commissioned when approval to proceed with the project is obtained. The CNC will oversee the compensation negotiation for all issues in relation to economic displacement. The committee will be responsible for addressing the following:

- Key issues related to economic displacement.
- Processes to be used for negotiations.
- Preparations and steps to be taken to ensure readiness to undertake and conclude negotiations.

The CNC will consist of representatives from GEGL, Land Valuation Board, PAPs leadership, traditional leadership, and other governmental agencies. The CNC will be chaired by an independent Moderator who will be nominated by the PAPs leadership and agreed on by GEGL.

The PAPs will also be given the opportunity to appoint a suitable valuer whose role will be to provide objective and fact-based technical and other relevant expertise and advice to the PAPs.

Interactions between GEGL and the PAPs throughout the compensation process will be conducted in a manner that fosters trust and mutual respect. The process to be employed by GEGL will adopt appropriate mitigation measures and livelihood re-establishment programmes to address impacts associated with economic displacement.

Based on initial survey by GEGL, it is anticipated that approximately 1200 persons, who are independent farmland owners in the project area will be affected. A compensation framework will be developed for implementation, and this will include:

- Details of compensation eligibility and entitlements
- Grievance procedure to manage complaints in a planned and systematic manner
- Budget and implementation schedule following conclusion of compensation negotiations

3.12 Alternatives to Proposed Undertaking

3.12.1 Pipeline Route Alternatives

3.12.1.1 Route Selection

The route selection criteria for the pipeline were informed by the following:

- The shortest possible distance from inception to termination point.
- Minimal number of water bodies, road and railway crossings.
- Easy constructability and access to route line.
- Terrain of the pipeline route (relief features, swampy areas etc.).
- Potential substrate of geological formation (rock, soils, etc., associated with burial).
- Adherence to applicable laws and regulations.
- Avoidance of pipeline proximity to population centers and communities.
- Utilization of existing utility and RoW corridors.
- Avoidance of environmental and social sensitive sites.

A detailed report on the Alternative Route Analysis for the proposed pipeline to Kumasi is attached as APPENDIX C to this EIS.

Prior to the final selection of the current 102km pipeline design route, the following constraints and issues were considered.

Active mining areas

The initial pipeline route traversed the Asanko mining concession's active mining area and covered a total length of 24.154km. After engagement with management of Asanko mines, it was agreed that the route be diverted into an inactive mining area within the Asanko mining concession. The total route in the mining concession after the diversion increased by 2.8km (Figure 7).

Small scale mining areas

A number of illegal mining areas were identified on the RoW that posed construction challenges and hindered pipeline safety. The route line was diverted from the major small scale mining areas, and this resulted in increased length 0.3km of the route line.

Proximity to communities

There were communities around Bekwae and Kuntenase which identified in proximity to the initial pipeline route. After community stakeholder consultations, the route line was diverted away from these areas. The original route line around the community had a length of 7.7km but was increased to 7.9km after the diversion; a difference of approximately 0.2km (Figure 8).

Sacred areas

Key sacred areas (cemetery, shrines and royal burial grounds) were identified as traversed by the initial pipeline route design. This necessitated the diversion of the pipeline from these sacred areas to ensure compliance with cultural norms and values associated with the siting of these sacred areas. As part of community cultural and religious engagements, these traditional standards and constraints resulted in the increase of the pipeline route length after classification studies to meet the standard criteria for route selection. As depicted in Figure 9, the

original route line had a length of 6.7km but reduced to 6.23km (a difference of approximately 0.47km) after the diversion.

Overall effects of constraints and diversion

The total effects of constraints and diversions which affected a change in the pipeline routing is depicted in Figure 10. These effects have been summarised as follows:

- The mining area resulted in total increase of 2.8 km in the entire route line
- The sacred area diversion resulted in a total of 0.47 km reduction in the pipeline route length from the original
- The populated areas diversion resulted in a total of 0.2 km increase in the original route line.
- The illegal mining areas resulted in a total increase of 0.3km in the original route line.

The total accumulated increase was 3.3 km and decrease of 0.47 km in the original route after diversions and optimization. Resultant net effect was an increase in the pipeline route from 102km to 104.85km; approximately 105km.

Selected Alternative Route Summary

After a consideration of all the needed factors and issues from stakeholders' engagements, the most suitable alternative route (Figure 11) was selected.

Figure 7: Mining area constraint and diversion

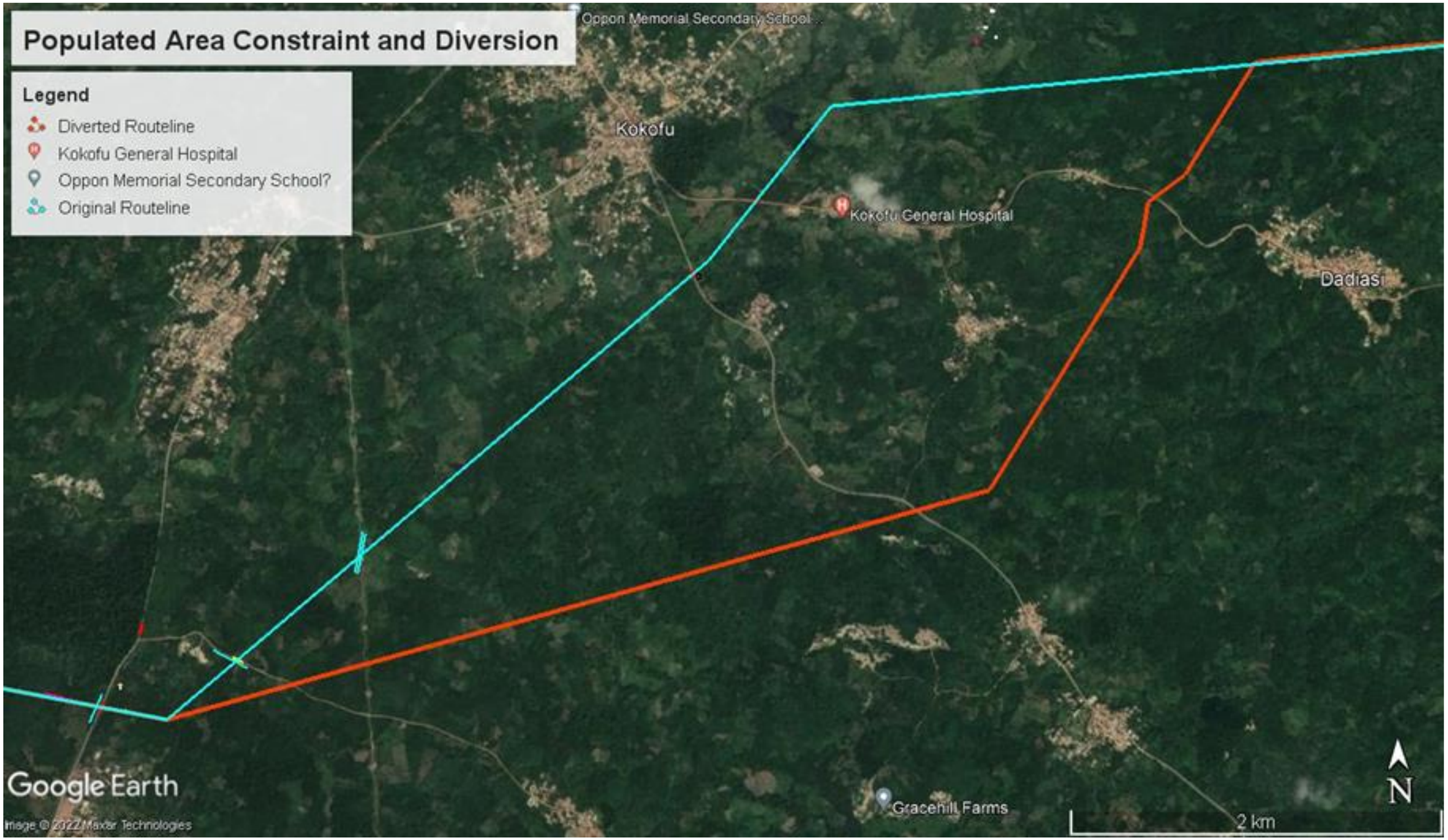

Figure 8: Populated area constraint and diversion

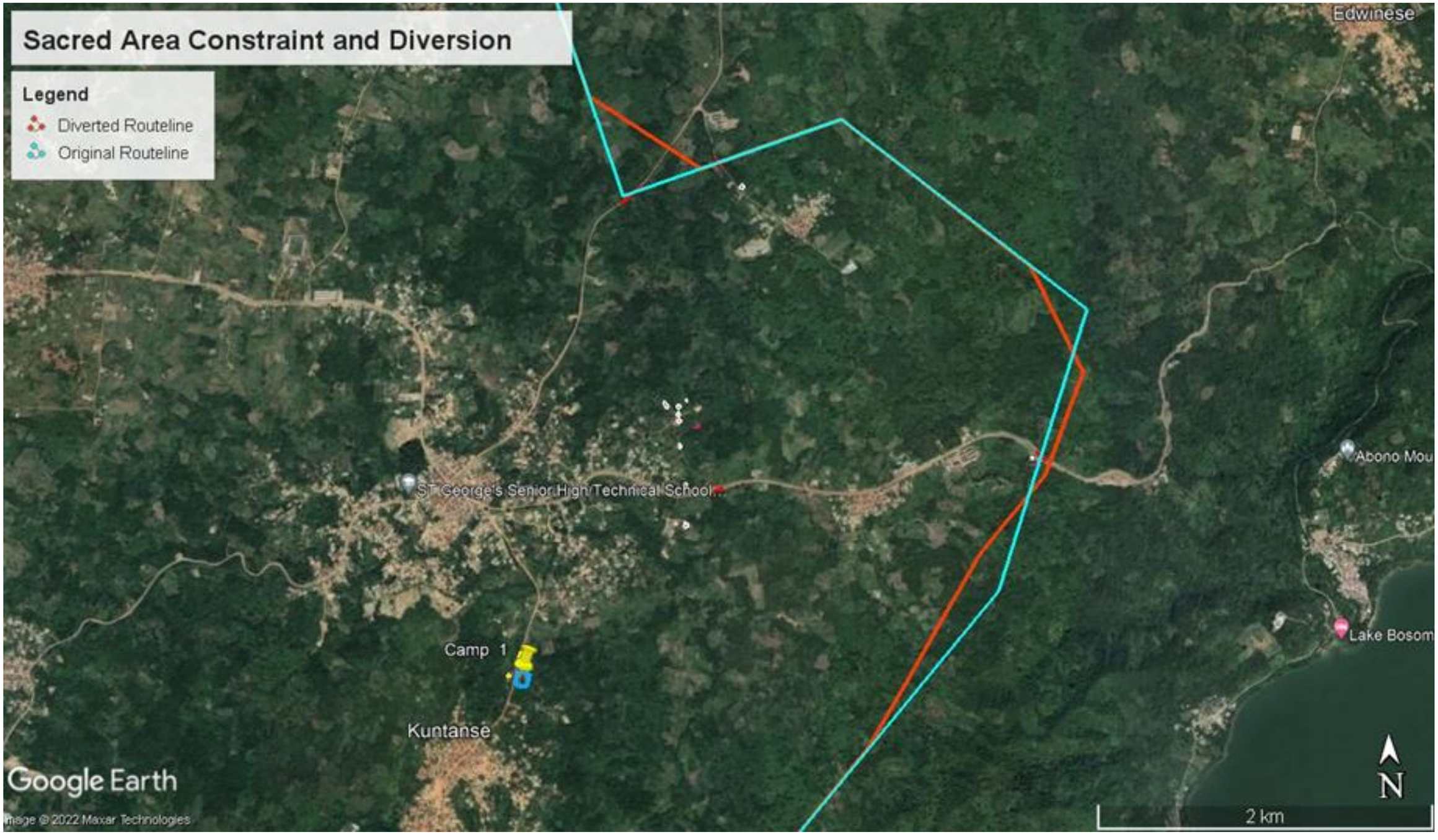

Figure 9: Sacred area constraint and diversion

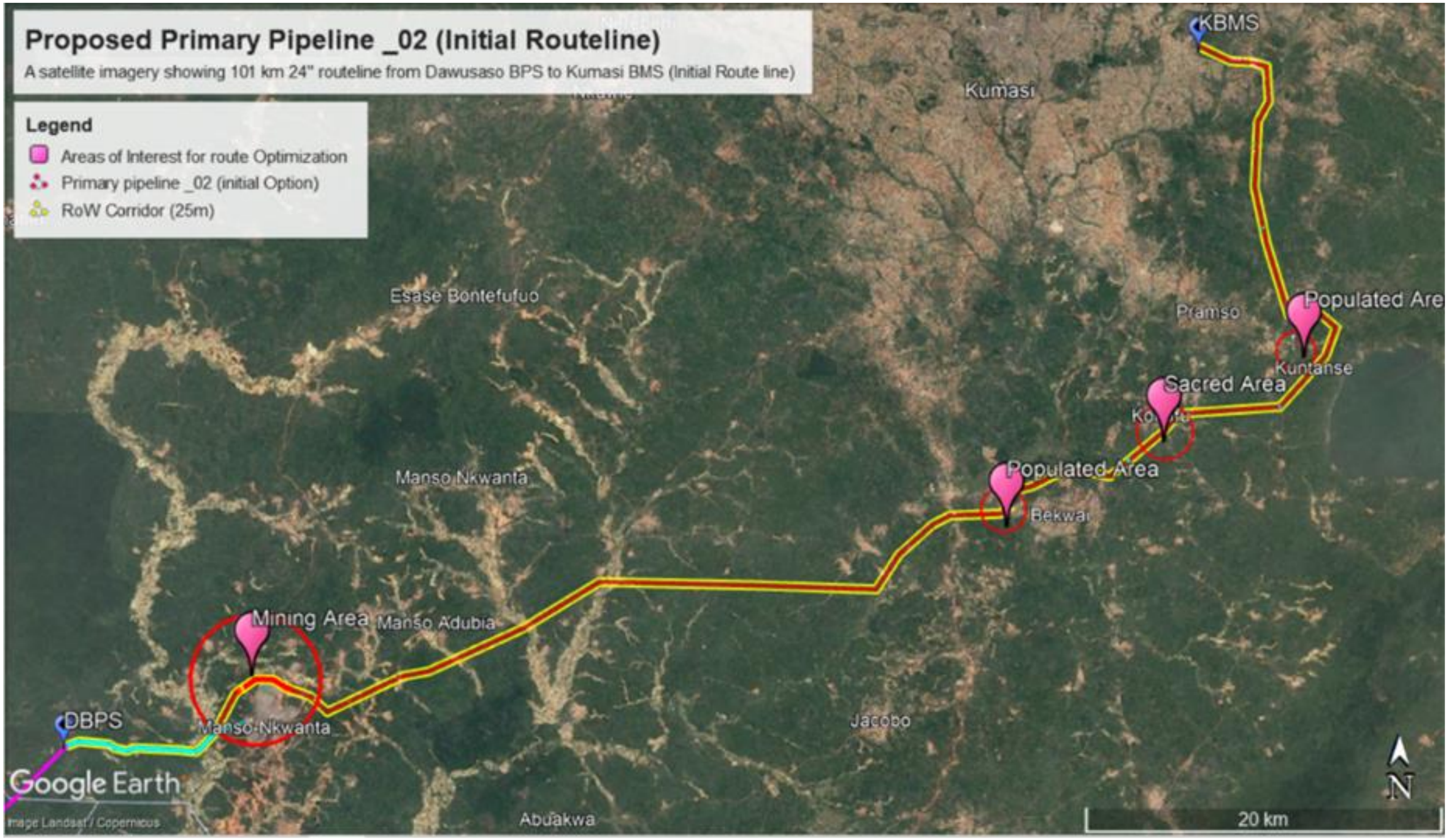

Figure 10: Initially Proposed alternative route line with identified constraints (red circles)

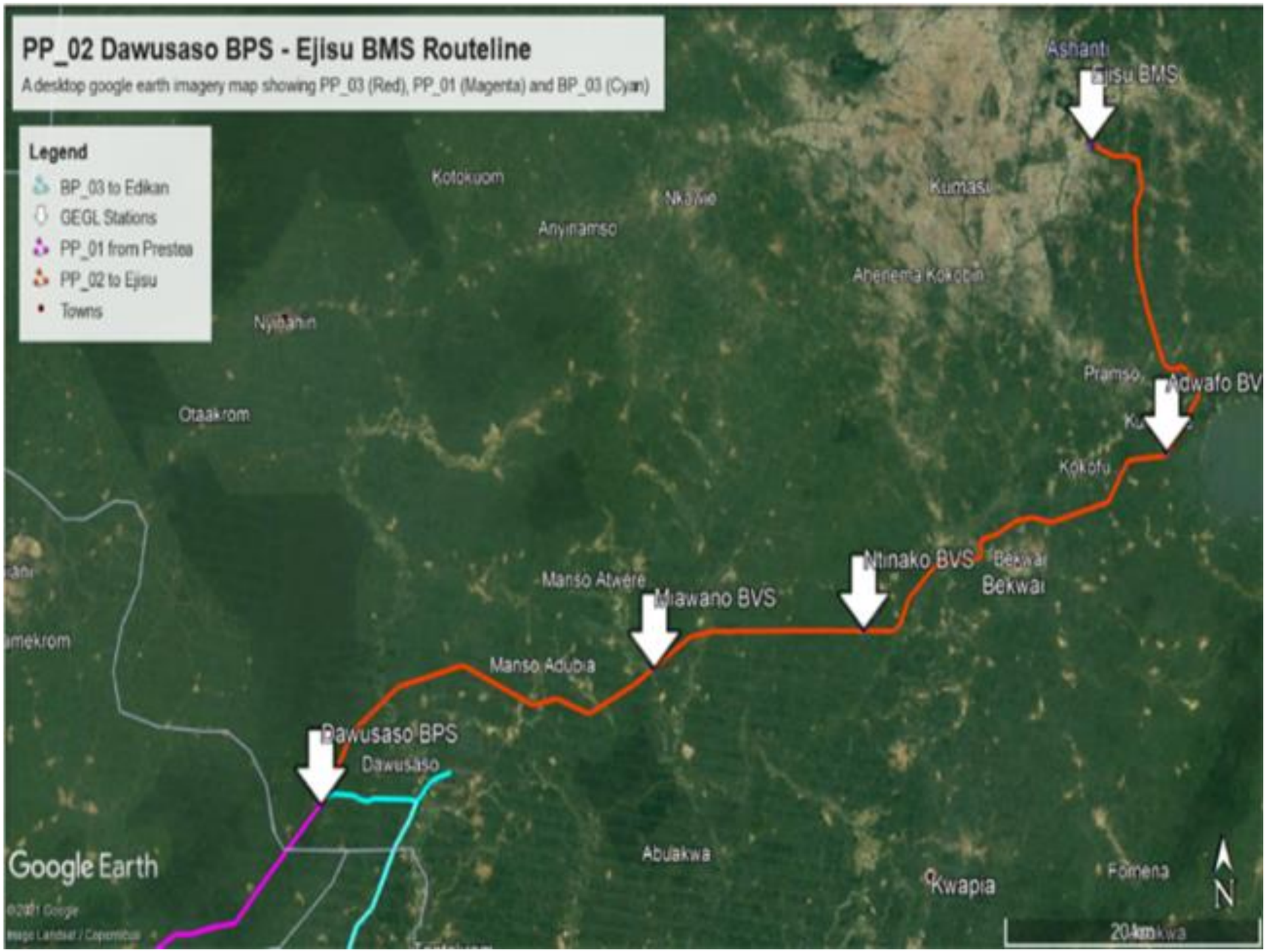

Figure 11: Final route line for Primary pipeline

Site Analysis for the Location of the Pipeline

GEGL conducted a reconnaissance study to investigate the pipeline route that could suit the project's objectives. The availability of land, terrain of the area, accessibility, mining activities, water crossing point and distance from residential facilities were a few of the factors utilized in evaluating the pipeline route options. At the end of the study, 2 pipeline routes (including the proposed route) were settled on. The alternative gas pipeline route considered was a 102km route originating from the Gyegyetreso BPS and spanned through a number of communities till finally terminating at Ejisu-Kumasi. The route is similar to the current proposed pipeline line route.

This alternative pipeline route ran through an active mining concession managed by Asanko Gold Mines. Following due diligence and correspondence, this route was diverted from the active mining zone (approximately 25km away), resulting in a 3km increase in the initial length of the route line.

Site Analysis for the Location of the Gas Stations

In the preliminary analysis for the gas stations along the pipeline route, two BVS were proposed to be installed at Anloakrom and Kokofu (35m apart), as well as an RMS at Ejisu. However, because the BVSs were planned to be approximately 25km apart, the location of the BVSs were changed to Miawano, Ntinako, Adwafo, in order to achieve a balance in the separating distance between the gas stations. The RMS was also changed to a BMS.

3.12.2 No-Go Project Alternative

The high volatility of the national grid is largely due to the concentration and proximity of generation assets in the coastal areas of Ghana. The relocation of the Ameri power plant to the middle belt of Ghana, will reduce large power draws over long distances to the central belt.

A power system and network analyses have shown that the creation of a generation enclave in Kumasi would result in significantly reduced transmission losses due to reduced line loadings between Kumasi and the coastal areas (GEGL, 2021). Power supply for the middle belt will be sourced mainly from the Ameri power plant and Bui Power Authority thereby reducing power transmission losses over the grid from exporting power from the hydroelectric and thermal power plants located in the coastal and southern belts. According to the 2021 Electricity Supply Plan by the Power Planning Technical Committee, siting a 360MW plant in Kumasi would result in a total reduction in system losses by 24.9MW. The use of natural gas to power the Ameri power plant also presents environmental benefits through the reduction of CO_2 emissions in line with recent global calls for decarbonization. Thus, the need for the pipeline project cannot be overemphasized.

If the project were not to advance all the anticipated benefits of the project will not be realised, and the following would occur:

- There will be no further investment by GEGL in the project and no realisation of returns for GEGL
- Potential employment and skills transfer/development would be lost
- There would be no project related taxes paid to the government
- There would still be over dependence on imported fuels and continued contribution of greenhouse gases emissions
- Continued high volatility of national grid and high operational costs for industries
- All the benefits in section 1.4 under project justification will not be realized

4.0 BASELINE INFORMATION

The purpose of baseline data collection is to provide credible data and information on the existing conditions of the project area to support engineering design of project components and the EIA process. Findings from these studies informed the impact assessments, supported development of proposed mitigation measures, and provided indicators against monitoring programmes.

The methodology applied in completing the baseline studies consisted of desktop review of existing data and information, historic and recent imagery. Following the review of desktop data, a field sampling strategy was developed for aspects requiring the collection of additional data for the project. Fieldwork was undertaken for biodiversity, socio-economic and traffic studies.

A summary of the baseline information is presented in the following sections.

4.1 Physical Environment

4.1.1 Topography and Drainage

The topography of the project area is variable and characterised by subparallel mountain ranges with a north-east to south-west trend and forms part of the hills of the Sefwi Basin. The hills of the Sefwi Basin rise to elevations of 300-350 m above the adjacent low-relief plains with average elevations of 200 m above mean sea level (amsl) (Geomatrix, 2007b). The project area's landscape is undulating, with a network of rivers, small streams and ephemeral drainages transecting a few scattered hills and low mountains. A typical topographic sequence consists of a summit/crest with a slope gradient of 0-1 percent, upper slope with a gradient of 3-5 percent, a middle slope with a gradient of 2-4 percent, a lower slope with a gradient of 0-2 percent and a valley bottom with a gradient of 0-1 percent. The surface flow pathways have a straight concave shape at the summit, upper, middle, and lower slopes but exhibit convex shapes in the valleys.

The Oda River and its tributaries drain southwest from Kumasi to confluence with the Offin River, one of the main tributaries of the Pra River. With the large number of drainages illustrated in Figure 19, the cross section of the topography of the route is quite inconsistent ranging from 139masl to 297masl.

4.1.2 Climate

Climate and Meteorology Overview

Ghana is located along the Atlantic coast and is dominated by the interaction of the equatorial trough and the associated Inter Tropical Boundary (ITB) or Inter-Tropical Convergence Zone (ITCZ) and the West African Monsoon seasons. The ITCZ is a belt of low pressure which circles the Earth, generally near the equator where the trade winds of the Northern and Southern Hemispheres come together. The ITCZ is a critical link in global circulation patterns and the redistributing solar energy from the tropics toward the poles. The ITB/ITCZ influences the movement of the alternate air masses from the north and the south, termed the tropical continental (northeast trade winds) and the maritime continental (southwest monsoon) winds, respectively. The tropical continental winds are associated with a dry cool wind known as the "Harmattan" which affects most part of the country during the months of December to February. Beyond this period, the climate of the project area is influenced largely by the rain-producing tropical maritime air mass.

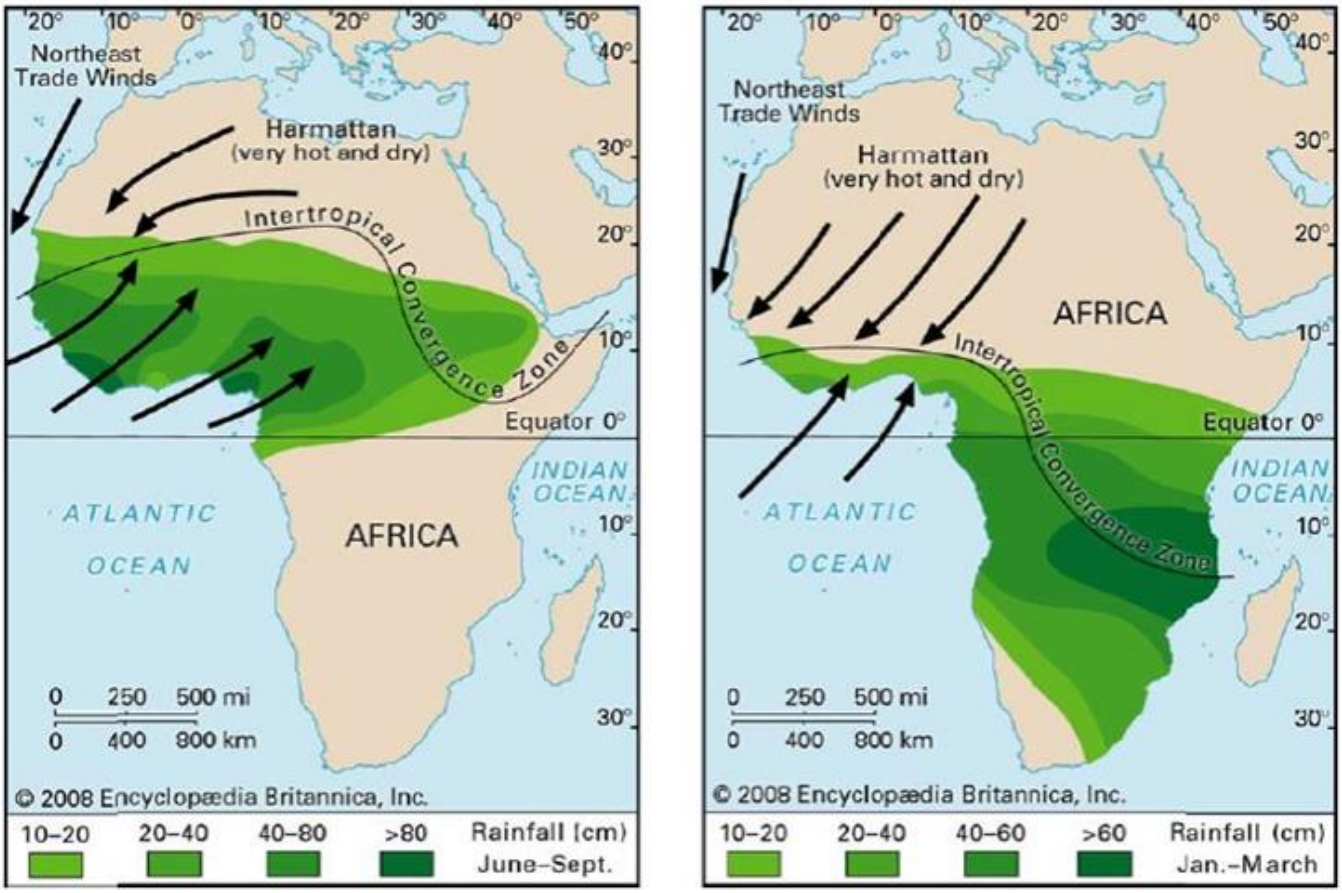

Figure 12: Movements of the ITCZ and West African Monsoon (USAID, 2011)

The climate of Ghana and its alternating wet and dry seasons is largely driven by the movements of the ITCZ and West African Monsoon seasons. During the warmer months (June to September), the ITCZ lies near the Tropic of Cancer. The dominant wind direction in regions to the south of the ITCZ is south westerly, bringing in warm, moist air from the Atlantic Ocean onto the continent, resulting in the Ghanaian wet season. During the cooler months (January to March), the ITCZ moves southwards towards the Tropic of Capricorn. The dominant wind direction in the regions to the north of the ITCZ is north easterly, bringing hot, dry, and dusty air from the Sahara Desert, resulting in the Ghanaian dry season.

Further, the Project region indicated winds predominantly from the south-western sector (Air Quality Impact Assessment for the proposed expansion of the Tarkwa, Damang and Chirano Plants and Natural Gas Pipeline, MM5 modelled wind rose data for 2016 to 2018, Golder, July 2020).

Average monthly temperatures range between 24.4 °C to 27.9 °C. The average annual rainfall for Kumasi is 1,147 mm with the highest rainfall during May and June and September and October. The month with the highest relative humidity is October (83.62 %) and the lowest relative humidity is recorded in January (54.33 %).

4.1.2.1 Temperature

The variation in temperatures throughout the year is 3.7 °C. Average monthly temperatures range between 24.4 °C to 27.9 °C (Table 12).

The highest average maximum temperatures are recorded during the months of January and February, with the minimum temperatures being fairly stable in the region of 21.7 °C to 23.0 °C. The most sun hours are recorded during the months of December to April.

Table 12: Average monthly temperatures for Kumasi

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. Temp (°C)	27.4	27.9	27.5	27.1	26.2	24.8	24.2	24.2	24.4	24.9	25.5	26.5
Min. Temp (°C)	22.7	23.6	23.9	23.9	23.4	22.4	21.8	21.7	22	22.3	22.4	22.5
Max. Temp (°C)	33.1	33.7	32.9	32	30.8	28.7	27.8	27.8	28.3	28.9	29.8	31.6
Avg. sun hours (hours)	7.9	7.4	6.6	6	5.3	4.4	3.8	3	3.9	4.6	5.3	7

4.1.2.2 Rainfall

Rainfall occurs all year; however, the lowest rainfall occurs from November to February, and the highest rainfall occurs in May, June, September, and October (Table 13).

Humidity levels are lowest in December, January, and February, ranging from 54% to 66%. For the rest of the year, humidity levels will range between 71% and 84%.

The variation in the precipitation between the driest and wettest months is 129 mm (Figure 13). The month with the rainiest days is September, which has 24.97 days. The month with the lowest number of rainy days is January, which has with 4.43 days.

Table 13: Average monthly rainfall and humidity

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall mm	24	47	100	109	125	140	119	106	153	131	67	26
Humidity (%)	54	61	71	76	79	83	81	80	83	84	80	66
Rainy days (d)	3	6	12	13	15	17	16	16	19	17	10	4

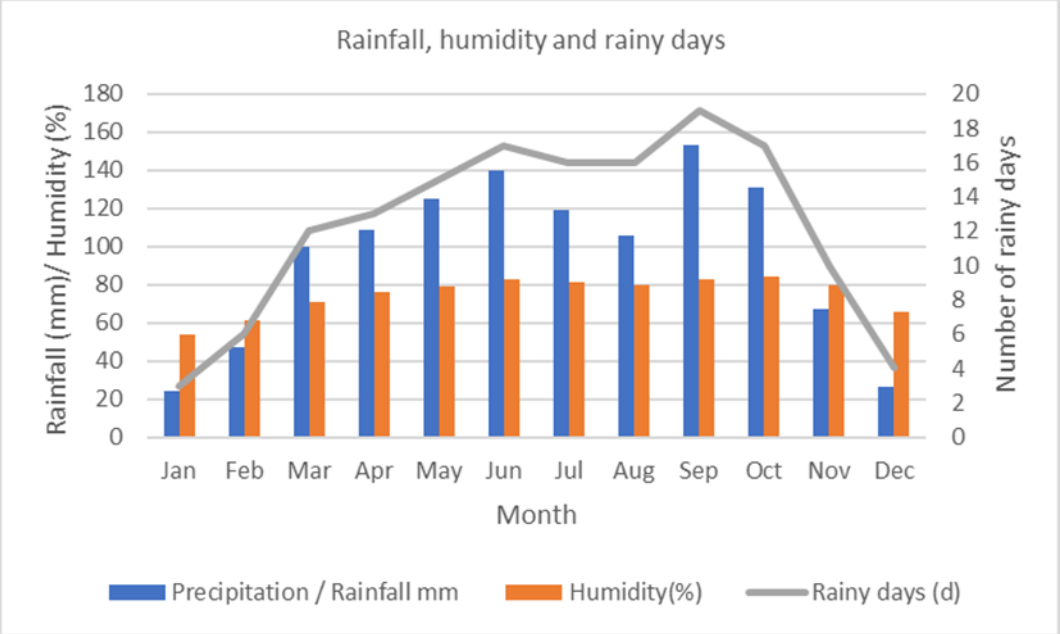

Figure 13: Average monthly rainfall and evaporation

4.1.3 Air Quality

4.1.3.1 Sensitive Receptors

Sensitive receptors are defined by the United Stated Environmental Protection Agency (USEPA) as areas within the surrounding project environment where occupants are more susceptible to the adverse effects of exposure to pollutants. These areas include:

- Residential areas
- Hospitals/clinics
- Schools and day care facilities
- Elderly housing

For the purpose of this study the following sensitive receptors for the proposed operations were identified in close proximity to the proposed pipeline route and are presented in Table 14 and Figure 14.

Table 14: Sensitive receptors for the Project operations

Receptor ID	Receptor Name	Longitude (°W)	Latitude (°N)	Distance to Proposed Pipeline Route (km)
SR1	Agroyesum	-1.87757	6.409295	2.76
SR2	Anloakrom	-1.80944	6.433862	1.84
SR3	Anwia	-1.63419	6.403285	4.6
SR4	Anwia Nkwanta	-1.63847	6.457596	0.59
SR5	Bekwai	-1.60599	6.456872	0.45
SR6	Bemang	-1.63502	6.448979	0.41
SR7	Bone	-1.65391	6.453096	0.97
SR8	Calvary Methodist Church Odaho (Manso)	-1.82517	6.354972	5.38
SR9	Dadiasi	-1.49969	6.493742	0.84
SR10	Dawusaso	-2.0346	6.352472	3.29
SR11	Domeabra	-1.50437	6.682347	0.37
SR12	Ebiram	-1.97011	6.387761	0.72
SR13	Edwinese	-1.43042	6.564022	2.69
SR14	Fahiakobo Roman Catholic Church	-2.04935	6.345336	2.68
SR15	Huntado	-1.67142	6.443279	1.52
SR16	Kokofu	-1.5273	6.49275	1.95
SR17	Kuntanse	-1.46713	6.540503	2.42
SR18	Kyekyewere	-1.63911	6.419228	2.92
SR19	Manso Adubia	-1.93194	6.397105	1.79
SR20	Manso Keniago	-2.02087	6.3733	2.32

Receptor ID	Receptor Name	Longitude (°W)	Latitude (°N)	Distance to Proposed Pipeline Route (km)
SR21	Mim	-1.8555	6.416796	2.13
SR22	Odumasi	-1.91628	6.374385	0.92
SR23	Poano	-1.67326	6.433037	0.95
SR24	Residential Area 1	-2.01525	6.387951	0.71
SR25	Residential Area 2	-1.9966	6.410556	1.13
SR26	Residential Area 3	-1.98669	6.388619	1.53
SR27	Residential Area 4	-1.94505	6.382034	0.23
SR28	Residential Area 5	-1.89429	6.385693	1.11
SR29	Residential Area 6	-1.61174	6.456442	0.15
SR30	Residential Area 7	-1.45736	6.555196	0.42
SR31	Residential Area 8	-1.46319	6.566578	0.94
SR32	Residential Area 9	-1.47634	6.567269	0.5
SR33	Residential Area 10	-1.47833	6.639693	0.67
SR34	Residential Area 11	-1.49113	6.642436	0.74
SR35	Residential Area 12	-1.47437	6.663869	0.49
SR36	Residential Area 13	-1.48382	6.67817	0.31
SR37	Residential Area 14	-1.48961	6.683169	0.14
SR38	Titrifu	-1.51312	6.623064	3.09
SR39	Yaw Henekrom	-1.7912	6.443425	2.86

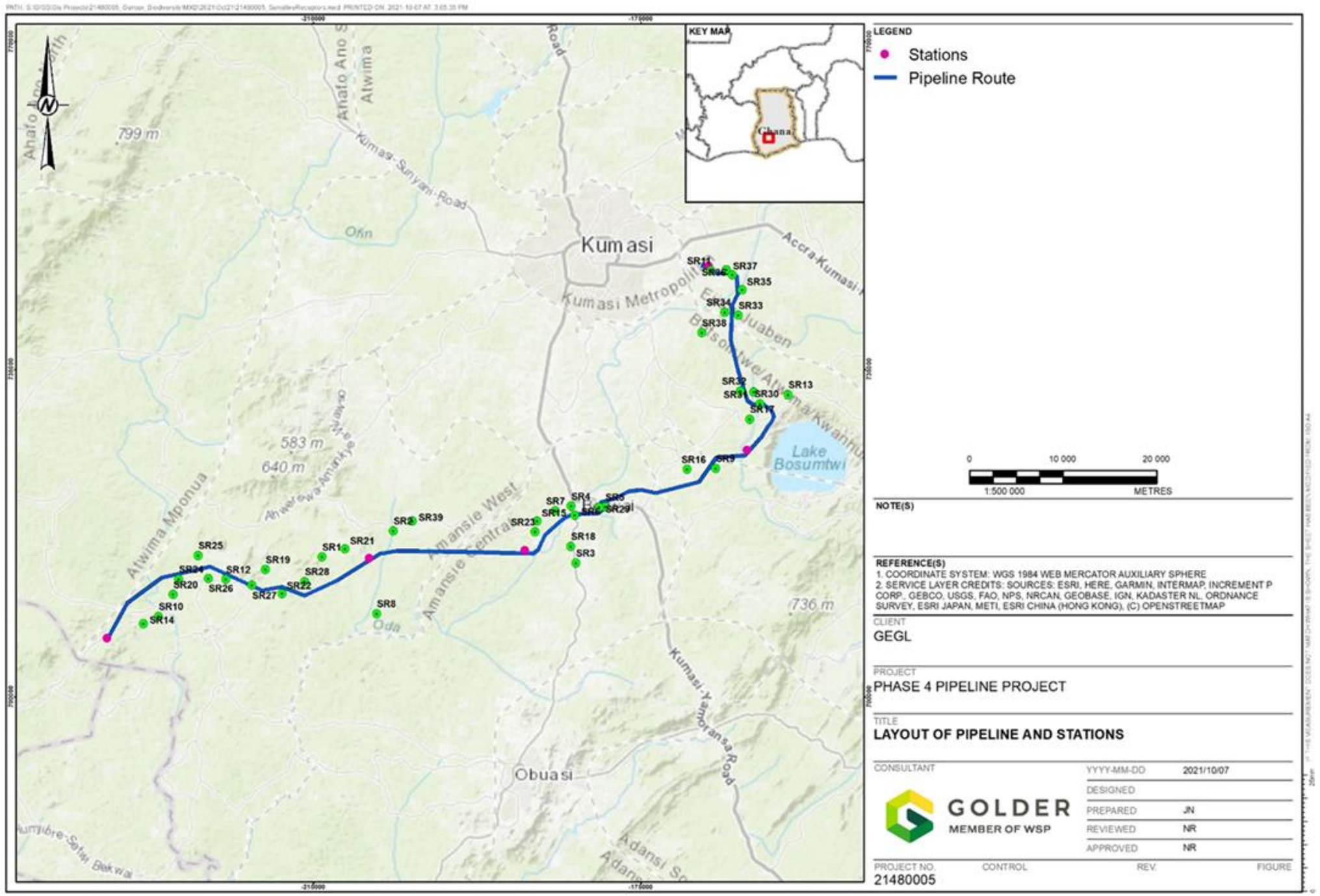

Figure 14: Sensitive receptors for the proposed Project

4.1.3.2 Climate and Meteorological

Atmospheric Dispersion Potential

Meteorological characteristics of a site govern the dispersion, transformation, and eventual removal of pollutants from the atmosphere. The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. Dispersion comprises vertical and horizontal components of motion. The vertical component is defined by the stability of the atmosphere and the depth of the surface mixing layer. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume "stretching". The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction and the variability in wind direction, determine the general path pollutants will follow, and the extent of crosswind spreading.

Pollution concentration levels fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field. Spatial variations, and diurnal and seasonal changes, in the wind field and stability regime are functions of atmospheric processes operating at various temporal and spatial scales. Atmospheric processes at macro-scales and meso-scales need therefore be considered to accurately parameterise the atmospheric dispersion potential of a particular area.

Boundary Layer Properties and Atmospheric Stability

The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere and is directly affected by the earth's surface. The earth's surface affects the boundary layer through the retardation of air flow created by frictional drag, created by the topography, or as result of the heat and moisture exchanges that take place at the surface.

During the day, the atmospheric boundary layer is characterised by thermal heating of the earth's surface, converging heated air parcels and the generation of thermal turbulence, leading to the extension of the mixing layer to the lowest elevated inversion. These conditions are normally associated with elevated wind speeds, hence a greater dilution potential for the atmospheric pollutants.

During the night, radiative flux divergence is dominant due to the loss of heat from the earth's surface. This usually results in the establishment of ground-based temperature inversions and the erosion of the mixing layer. As a result, night-time is characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds, hence less dilution potential.

The mixed layer ranges in depth from a few metres during night times to the base of the lowest elevated inversion during unstable, daytime conditions. Elevated inversions occur for a variety of reasons, however typically the lowest elevated inversion occurs at night during winter months when atmospheric stability is typically at its maximum. Atmospheric stability is frequently categorised into one of six stability classes, these are briefly described in Table 15.

The atmospheric boundary layer is normally unstable during the day as a result of the turbulence due to the sun's heating effect on the earth's surface. The thickness of this mixing layer depends predominantly on the extent of solar radiation, growing gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. This situation is more pronounced during the winter months due to strong night-time inversions and a slower developing mixing layer. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

Table 15: Atmospheric stability classes

Designation	Stability Class	Atmospheric Condition
A	Very unstable	Calm wind, clear skies, hot daytime conditions
B	Moderately unstable	Clear skies, daytime conditions
C	Unstable	Moderate wind slightly overcast daytime conditions
D	Neutral	High winds or cloudy days and nights
E	Stable	Moderate wind slightly overcast night-time conditions
F	Very stable	Low winds, clear skies, cold night-time conditions

For elevated releases, the highest ground level concentrations would occur during unstable, daytime conditions. The wind speed resulting in the highest ground level concentration depends on the plume buoyancy. If the plume is considerably buoyant (high exit gas velocity and temperature) together with a low wind, the plume will reach the ground relatively far downwind. With stronger wind speeds, on the other hand, the plume may reach the ground closer, but due to the increased ventilation, it would be more diluted. A wind speed between these extremes would therefore be responsible for the highest ground level concentrations. In contrast, the highest concentrations for ground level, or near-ground level releases would occur during weak wind speeds and stable (night-time) atmospheric conditions.

4.1.3.3 Air Quality Overview

Potential activities and sources of air pollution which may impact on the ambient air quality within the airshed include:

- Agricultural activities
- Mining activities
- Domestic fuel burning
- Biomass burning
- Vehicle emissions (tailpipe and entrained emissions)

Agricultural Activities

Emissions from agricultural activities are difficult to control due to the seasonality of emissions and the large surface area producing emissions (US-EPA, 1995). Most of the agricultural activities in the project region appear to be of a subsistence nature thus emissions are not anticipated to significantly influence the air quality in the area. Although particulate emissions may increase during drier periods, when fields are ploughed in preparation for planting and/or due to seasonal wildfires on fallow farmlands.

Mining Activities

Dust emissions from typical mining operations is commonly generated by wind erosion from waste rock dumps, tailings facilities (slimes dams, ash dumps etc.), open mining pits, unpaved mine access roads and other exposed areas. Dust emissions occur when the threshold wind speed is exceeded (Cowherd, Muleski G, & Kinsey, 1988). Factors which influence the rate of wind erosion include surface compaction, moisture content, vegetation, shape of storage pile, particle size distribution, wind speed and rain. Dust generated by these sources is termed ‘fugitive dust’ as it is not emitted to the atmosphere in a confined flow stream (US-EPA, 1995). These emissions are often difficult to quantify as they are very diffuse, variable and intermittent. Mining activity

within the Project area is limited and is not expected to have a significant impact on air quality, as mining is artisanal in nature (i.e., sand and stone/aggregate extraction).

Domestic Fuel Burning

Domestic fuel burning of coal emits a large amount of gaseous and particulate pollutants including Sulphur dioxide (SO_2), heavy metals, PM_{10}, $PM_{2.5}$, TSP, nitrogen dioxide (NO_2), carbon monoxide (CO), polycyclic aromatic hydrocarbons (PAH), and benzo(a) pyrene. Pollutants arising due to the combustion of wood include PM_{10}, $PM_{2.5}$ and TSP, inorganic ash, PAH, benzo(a) pyrene, NO_2, CO, and formaldehyde. The main pollutants emitted from the combustion of paraffin include PM_{10}, $PM_{2.5}$, TSP, CO, PAH, and NO_2. Most of the housing within the project area is informal and thus it is highly likely that most households within the communities are likely to use charcoal, wood and paraffin for space heating and/or cooking purposes. Emissions from these communities are anticipated to impact the ambient air quality however as the density of households is not significant the impacts are likely to be limited and disbursed.

Biomass Burning

Biomass burning may be described as the incomplete combustion process of natural plant matter with CO, Methane (CH_4) and NO_2 being emitted during the process. During the combustion process, approximately 40% of the nitrogen in biomass is emitted as nitrogen, 10% remains in the ashes and it is assumed that 20% of the nitrogen is emitted as higher molecular weight nitrogen compounds. In comparison to the nitrogen emissions, only small amount of SO_2 and sulphate aerosols are emitted. With all biomass burning, visible smoke plumes are typically generated. These plumes are created by the aerosol content of the emissions and are often visible for many kilometres from the actual source of origin.

The extent of emissions liberated from biomass burning is controlled by several factors, including:

- The type of biomass material
- The quantity of material available for combustion
- The quality of the material available for combustion
- The fire temperature
- Rate of fire progression through the biomass body

Crop-residue burning and general wildfires in the study area represent significant sources of combustion-related emissions associated with these agricultural areas. Given that the region is dominated by subsistence farming rather than large scale commercial farming, it is anticipated that general wildfires are likely to be more important than controlled burning related to the agricultural activities as emission sources.

Vehicle Emissions

Air pollutants generated from vehicle engines (including motorised boats) may be classified as primary and secondary pollutants. Primary pollutants are emitted directly into the atmosphere as tailpipe emissions, whereas secondary pollutants are formed in the atmosphere as a result of atmospheric chemical reactions such as hydrolysis, oxidation, or photochemical reactions. The primary pollutants emitted typically include CO_2, CO, hydrocarbons (including benzene, 1.2-butadiene, aldehydes, and PAH), SO_2, NO_x and particulates. Secondary pollutants formed in the atmosphere typically include NO_2, photochemical oxidants such as ozone, hydrocarbons, sulphur acid, sulphates, nitric acid, sulphates, and nitrate aerosols. The quantity of pollutants emitted by vehicles depend on specific vehicle-related factors such as vehicle weight, speed, and age, as well as fuel-related factors such as fuel type (petroleum or diesel), fuel formulation (oxygen, sulphur, benzene and lead replacement agents), and environmental factors such as altitude, humidity, and temperature. Vehicle

entrainment of particulates from roads is anticipated to be one of the dominant sources of particulate emissions in the region.

4.1.3.4 Ambient Air Quality Monitoring

There has been no monitoring of ambient air quality in the project areas. The following sources of air pollution have a cumulative impact and are contributing factors to ambient air quality:

- Mining and processing activities
- Combustion engines
- Domestic fuel burning
- Clay brick manufacturing
- Charcoal production
- Biomass burning

4.1.4 Noise

4.1.4.1 Sensitive Receptors

The sensitive receptors for noise are the same for air quality and are as provided in Section 4.1.3.1.

4.1.4.2 Existing Noise Sources

The immediate area of influence, in terms of noise, include agricultural activities (i.e., from tractors, forage harvesters, silage blowers, chain saws, skid-steer loaders, grain dryers, etc., are some of the most typical sources of noise on the farm), mining activities (i.e., from heavy mobile equipment and processing plant equipment (crushers, screens, etc.), biomass burning and traffic of vehicles in the vicinity of the project area.

4.1.4.3 Noise Monitoring

There has been no historic or current baseline noise monitoring for the study area. In the absence of ambient noise data, as a conservative approach, the IFC residential daytime and night-time guidelines of 55 dB(A) and 45 dB(A), respectively, will be used to represent the baseline noise levels.

4.1.5 Soil

4.1.5.1 Soil Classification

From a Geotechnical site investigation that is being undertaken for the project (Golder, 2021), photographs of soil profiles taken and descriptions of the pits dug along the pipeline route provided by the Geotechnical Engineer, have aided the Soil Scientist with the soil descriptions provided in the following sub-sections.

Acrisols

These are soils with a clay-rich subsoil and are associated with humid, tropical climates. Acrisols are typically characterised by a shallow A-horizon, over a yellowish E-horizon over a red or yellow B horizon. Acrisols often support forested areas. Examples of these were identified during the geotechnical survey of the pipeline route as shown in Figure 15.

Figure 15: Acrisols along the Pipeline Route

Ferralsols

Based on the information provided by the photographs and descriptions of the pits dug along the pipeline route, the site appears to be dominated by what are termed Oxidic soils or Oxisols, depending on which classification system one uses. Soils that are described as Oxisols in one system can be described as Ferralsols in another. These terms broadly describe weathered, clay-rich soils of the humid tropics that are red or yellow and dominated by kaolinitic clays. These soils do not show signs of wetness. Examples of these were identified during the geotechnical survey of the pipeline route as shown in Figure 16.

Figure 16: Ferralsols along the Pipeline Route

Plinthosols

Plinthosols are also present along the pipeline route. These soils form under a variety of climatic and topographic conditions and are defined by a subsurface layer containing an iron-rich mixture of clay minerals (chiefly kaolinite) and silica that hardens on exposure into ironstone concretions known as plinthite. They typically display red-mottled clay. A soft plinthic horizon usually merges to a gleyed horizon and often underlies an E horizon. These soils do show signs of wetness. Examples of these were identified during the geotechnical survey of the pipeline route as shown in Figure 17.

Figure 17: Plinthosols along the Pipeline Route

Gleysols

Gleysols were identified in some of the lower-lying positions along the pipeline route. These are soils that are saturated for long enough to develop a 'gleyic colour pattern' made up of red, brown or yellow colours in the upper horizons and grey colours deeper in the soils. These soils are typically found in shallow depressions and low landscape positions. Examples of these were identified during the geotechnical survey of the pipeline route as shown in Figure 18.

Figure 18: Gleysols along the Pipeline Route

4.1.5.2 Soil Capability

The South African soil capability guidelines (Scotney *et al.,* 1987) was used to assess this aspect of the baseline study. The soils identified in the project area were classified into three land capability classes (Classes II, IV and V) based on varying characteristics provided in Table 16.

Table 16: Land Capability Classes

Soil Classification	Land Capability Class	Description
Acrisols	IV	Acrisols can be assigned to Land Capability Class IV but this class pose severe restrictions to arable use. Acrisols tend to lack adequate plant nutrients, can cause aluminium toxicity, can crust and are highly susceptible to erosion. They perform best under acid-tolerant crops. They can be used for (in order of increased intensity of use) 'Wildlife, Light Grazing and Moderate Grazing'.
Ferralsols	II	Ferralsols can be assigned to Land Capability Class II, as they have 'Slight limitations' and 'Low erosion hazards' and

Soil Classification	Land Capability Class	Description
		can be used for (in order of increased intensity of use) 'Wildlife, Forestry, Light Grazing, Moderate Grazing, Intensive Grazing, Light Cultivation, Moderate Cultivation and Intensive Cultivation.
Plinthosols	V	Plinthosols can be assigned to Land Capbility Grou "Land Capability Class V, as they have 'Watercourse and land with wetness limitations' and can be used for (in order of increased intensity of use) 'Wildlife, Light Grazing and Moderate Grazing'. Arpad (2013) states that the fluctuating water table that produces a plinthite layer restricts the use of these soils to grazing or forestry.
Gleysols	V	The land capability of the Gleysols was established as Land Capability Group 'Grazing' and Land Capability Class V, as it has 'Watercourse and land with wetness limitations' and can be used for (in order of increased intensity of use) 'Wildlife, Light Grazing, Moderate Grazing, Intensive Grazing and Light Cultivation'

Table 8.1, Scotney *et al.,* 1987

4.1.6 Surface Water

4.1.6.1 Water Users

The water users in the catchment area along the pipeline route are those communities using water for subsistence agriculture and other domestic uses, and small businesses such as those businesses using clay for pots, where the clay is taken from the banks of the river.

4.1.6.2 Catchment Description

The project falls within the Pra Basin located between Latitudes 50 N and 70 30' N, and Longitudes 20 30' W, and 0 0 30' W, in south-central Ghana. The Pra River, together with its tributaries, forms the largest river basin of the three principal south-western basins systems of Ghana (i.e., Ankobra, Tano and Pra). It has a total basin area of approximately 23,200 km² extends through almost 55% of Ashanti, 23% of Eastern, 15% of Central and 7% Western Regions.

4.1.6.3 Local Hydrology

The Oda River and its tributaries drain southwest from Kumasi to confluence with the Offin River, one of the main tributaries of the Pra River.

Figure 19 illustrates the proposed pipeline route showing the rivers and small tributaries that will need to be crossed. All of the tributaries that are crossed drain to the Oda River, however many of the small tributaries are non-perennial, flowing only when it rains.

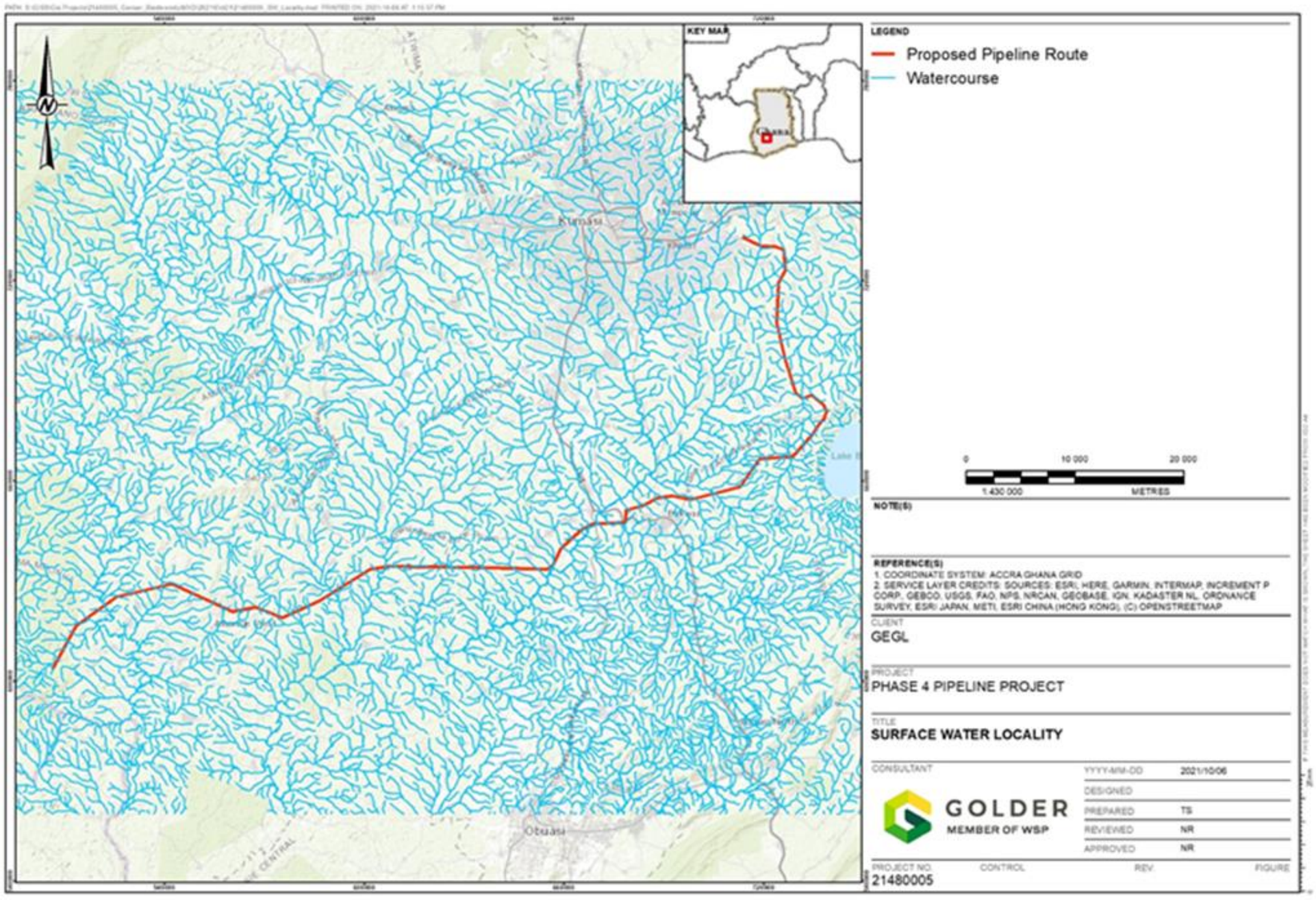

Figure 19: Pipeline route showing river course crossings

4.2 Biological Environment

The biological characteristics of the project area were determined through the review of existing information on the project area and completion of field surveys for flora and fauna in the project area. For the study, the spatial boundaries or area of influence of project were set as follows:

- Biodiversity Local Study Area (LSA) – a 1 km buffer around the infrastructure to capture all potential direct effects, including those from noise, dust, and changes to surface water quality in streams and wetlands being crossed by the pipeline (Figure 20).
- Regional Study Area (RSA) / Critical Habitat Area of Analysis (CHAA) - an ecologically appropriate area of analysis to consider the anticipated extent of the project's influence, including broader or regional effects from the project, in association with other anthropogenic activities (such as other projects) and natural factors (Figure 21).

Field surveys of the LSA were undertaken for flora and fauna from August 06 to August 11, 2021. The following sections presents the baseline biodiversity descriptions of the project area. The Biodiversity Baseline Report is attached in APPENDIX C

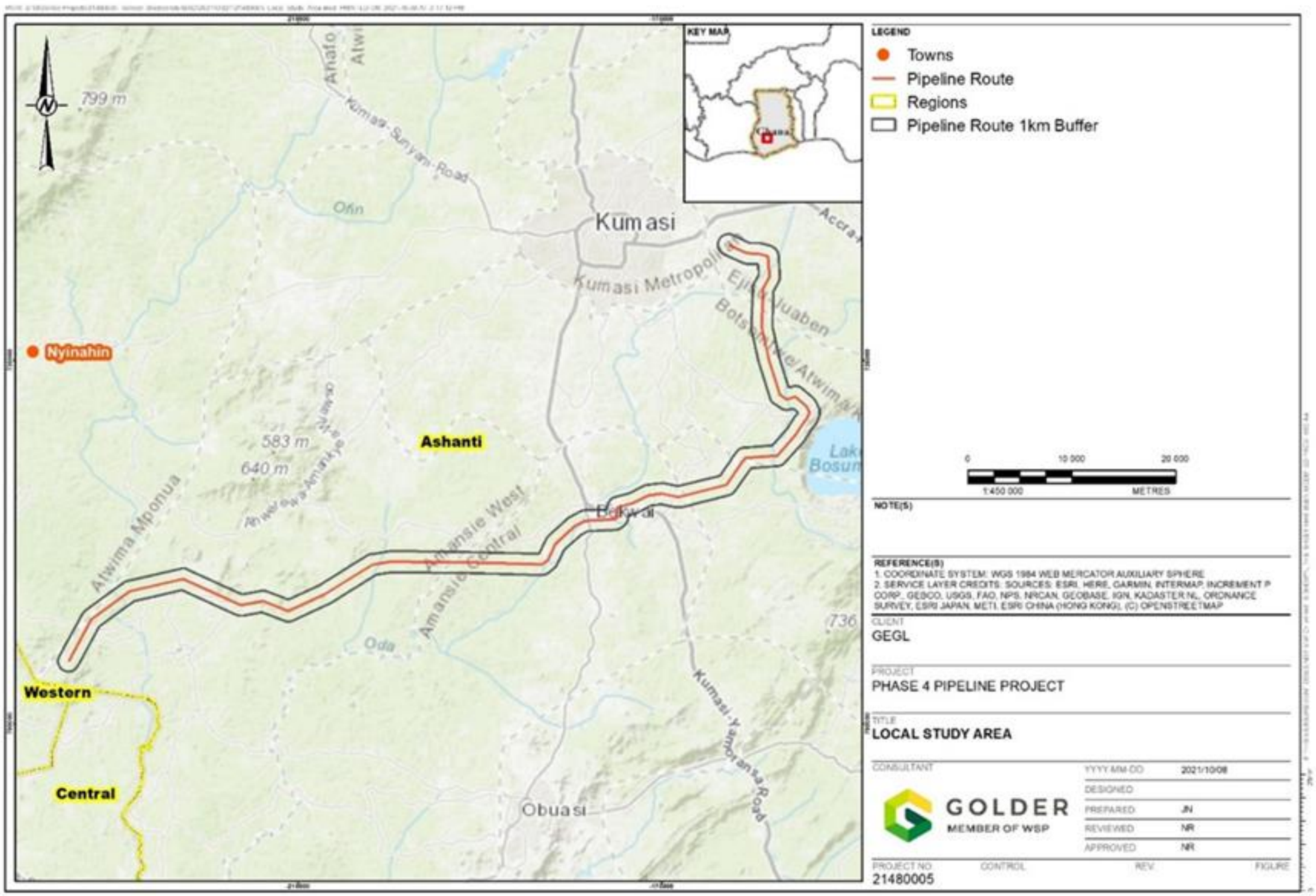

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Figure 20: Local Study Area

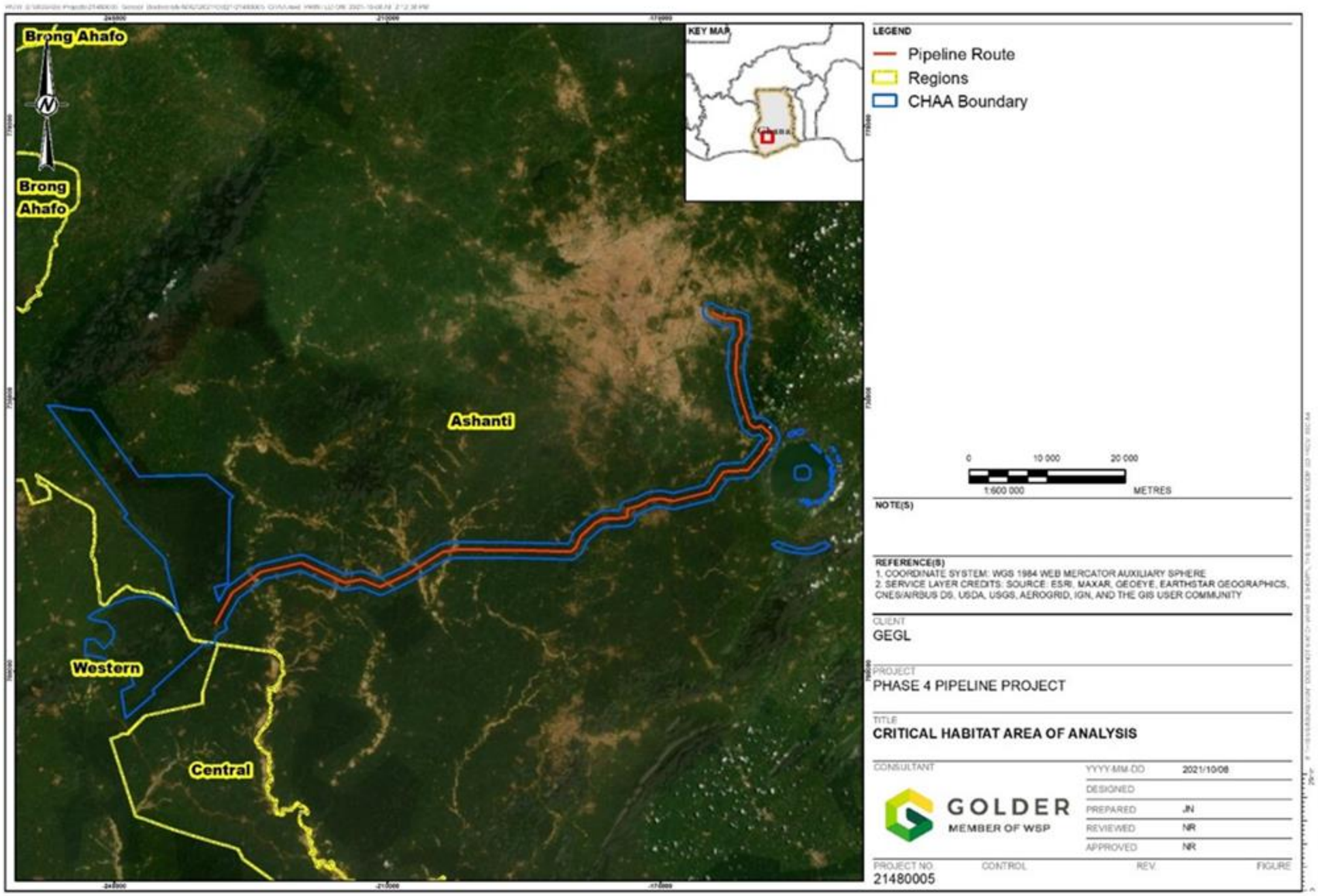

Figure 21: Critical Habitat Area of Analysis

4.2.1 Landcover Classification

The land cover/land use classification of the pipeline route plus a 1 km buffer is illustrated on the drawings provided in APPENDIX C, and the area covered by the various categories summarised in Table 17.

A greater portion of the lands within 500 m of the proposed pipeline route consists of medium-low bush (approx. 34.65%), followed by tall-medium, dense / closed wood – both of which consist of secondary regrowth of woodland and forest areas that have been previously cleared for cultivation purposes.

The next most prominent land cover feature is tall, dense / closed woodland and forest, which is aligned with the Moist Semi-deciduous South-East Forest subtype of the Tropical and Subtropical Moist Broadleaf Forest Biome (Hall and Swaine 1981) that originally characterised the region, and accounts for approximately 15% of the RSA. The other distinguishable natural vegetation type is open grassland (natural – altitudinal) which occurs at higher altitudes in 0.03% of the lands within 500 m of the proposed pipeline route.

All other landcover categories consist of modified habitat, including cultivated areas, palm plantations, settlements, and artisanal mining.

Table 17: 17-class land cover classification of the pipeline plus a 1 km buffer

Class	Class Name	Description	Total Area (ha)	%	Loss within RoW (ha)
1	Tall, dense / closed woodland & forest	Tall, dense closed canopy woodland and forest. Typically representative of long-term, undisturbed areas, although may still represent well-established 2nd regrowth from original forest cover.	1645.53	15.69	42.45
2	Tall-medium, dense / closed woodland (2nd regrowth)	Tall – medium height, dense closed canopy woodland., highly likely to represent long-term, undisturbed areas of well-established 2nd regrowth from original forest / woodland cover.	2723.85	25.98	68.14
3	Medium-low, dense / closed bush (2nd regrowth)	Medium – low height, dense closed canopy woodland and bushland, highly likely to represent established 2nd regrowth from either original forest / woodland cover, or previously cleared areas.	3632.70	34.65	91.54
4	Low, semi-open (cleared) bush (regrowth)	Low, semi-open canopy bushland, highly likely to represent regrowth from recently cleared (or re-cleared) forest and woodland areas.	206.90	1.97	5.42
5	Low, open (cleared) bush (regrowth / old fields	Low, open canopy bushland and bush-clump dominated areas, highly likely to represent short-term regrowth from recently cleared areas used for small-scale crop production.	844.59	8.06	20.27
6	Low, sparse (cleared) bush / fields	Low, sparsely distributed bushland and bush-clump dominated areas, highly likely to represent short-term regrowth from recently cleared areas used for small-scale crop production.	464.81	4.43	10.72
7	Semi-bare / non-vegetated / incl fields	Areas of semi-bare, non-vegetated surfaces, including, but limited to areas associated with recent small-scale crop cultivation activity.	1.22	0.01	0.10
8	Bare non-vegetated	Bare, non-vegetated areas that do not appear to be associated directly with small-scale crop cultivation activities, which could be natural and/or man-made surfaces.	1.62	0.02	0.07

Class	Class Name	Description	Total Area (ha)	%	Loss within RoW (ha)
9	Open grassland (natural - altitudinal)	Areas dominated by open grasslands with few or no additional woody content or cover. Typically associated with areas cleared for current or recent small scale crop production; as well as peripheral areas surrounding settlements.	3.39	0.03	-
10	Water (natural)	Areas of naturally occurring surface water features, typically associated with rivers, streams and wetland areas.	17.82	0.17	0.37
11	Water (man-made)	Areas of artificially occurring surface water features, typically associated with flooded mining activities, dams and sewage management etc.			
12	Bare river sand	Bare, non-vegetated areas that are specifically associated with dry river and stream channels.	5.48	0.05	0.19
13	Settlements / structures	Areas containing significant concentrations of built structures for both residential, commercial and/or industrial activities.	162.12	1.55	1.79
14	Palm / other tree orchards (mature)	Areas that appear to be dominated by mature (planted) palm plantations. This class may contain some tall indigenous vegetation content, but it is primarily palms.	386.20	3.68	9.42
15	Palm / other tree orchards (young)	Areas that appear to be dominated by young (i.e. lower and/or less dense canopy cover) planted palm plantations. Note that this class may also include some indigenous woody vegetation content as well as a result of image separation challenges.	188.88	1.80	5.43
16	Roads and tracks	Image detectable road and prominent track networks.	14.90	0.14	0.32
17	Artisanal mining	Bare ground & flooded pits.	131.91	1.26	3.03

4.2.2 Vegetation Communities and Flora Species

The Gyegyetreso- Anwomaso gas pipeline Right of Way (RoW) traverses the Moist Semi-deciduous South-East Forest subtype of the Tropical and Subtropical Moist Broadleaf Forest Biome (Hall and Swaine 1981) (Figure 22 and Figure 23). Taylor, 1960, had earlier classified this vegetation type as Celtis-Triplochiton Association of the Moist Semi-deciduous forest. According to Taylor,1960, The Celtis-Triplochiton Association is numerically rich in tree species, some of the common tree species being *Celtis mildbraedii, Celtis Zenkeri, Celtis adolfi-frederici, Tripolchiton scleroxylon, Cola gigantea, Nesogordonia papaverifera*, *Sterculia oblonga and Sterculia tragacantha*. According to Hall and Swaine, 1981, the characteristic species of the Moist Semi-deciduous South-east subtype are *Turraeanthus africanus, Daniellia ogea, Khaya ivorensis, Illigera pentaphylla, Pteris togoensis, Chytranthus macrobotrys and Cola nitida*. Both Taylor (1960) and Hall and Swaine (1981) report that this forest type has soil ideal for most forest zone crops, including cocoa. Cocoa and other farms occupy most of the zone.

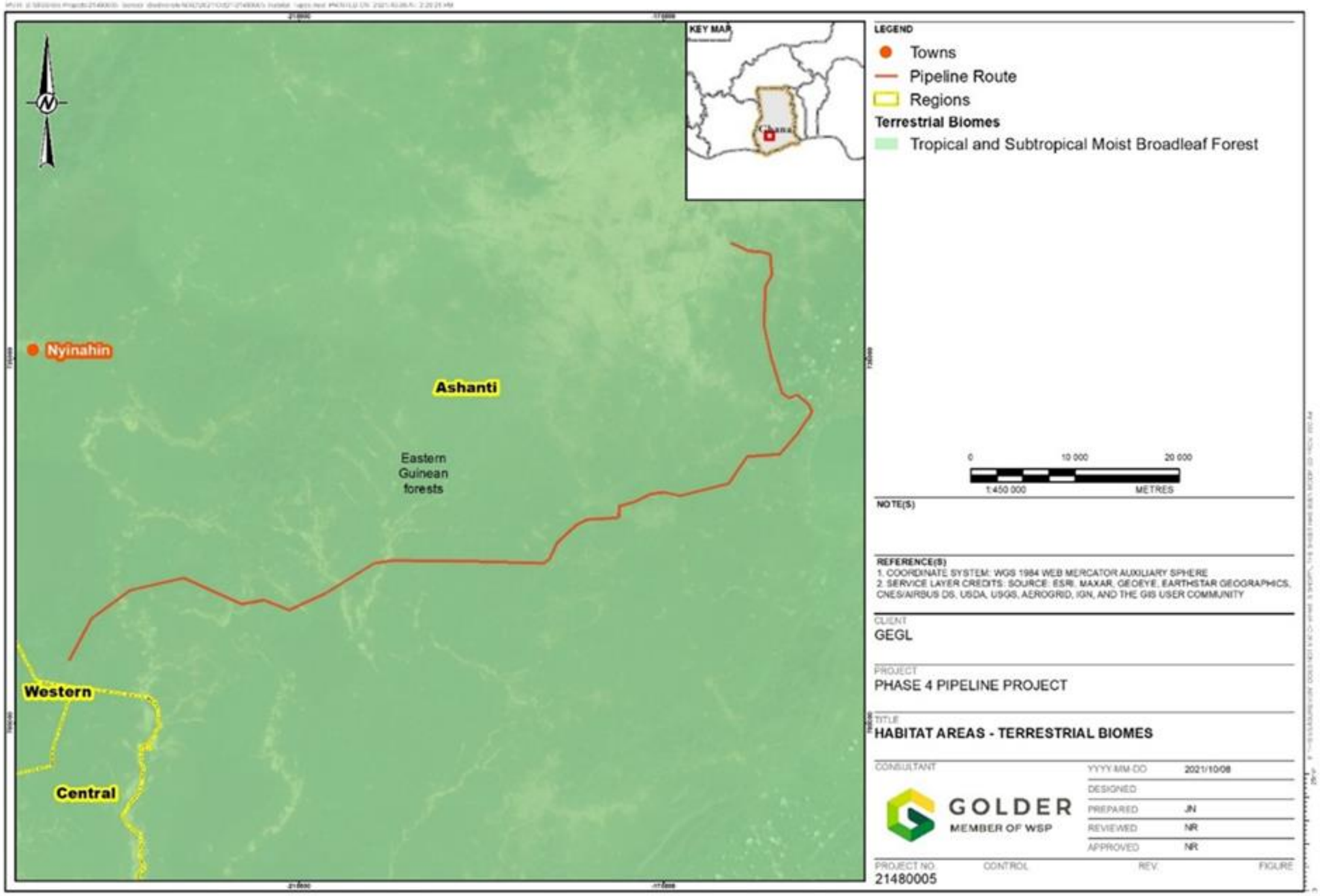

Figure 22: Habitat Types within the Study Area

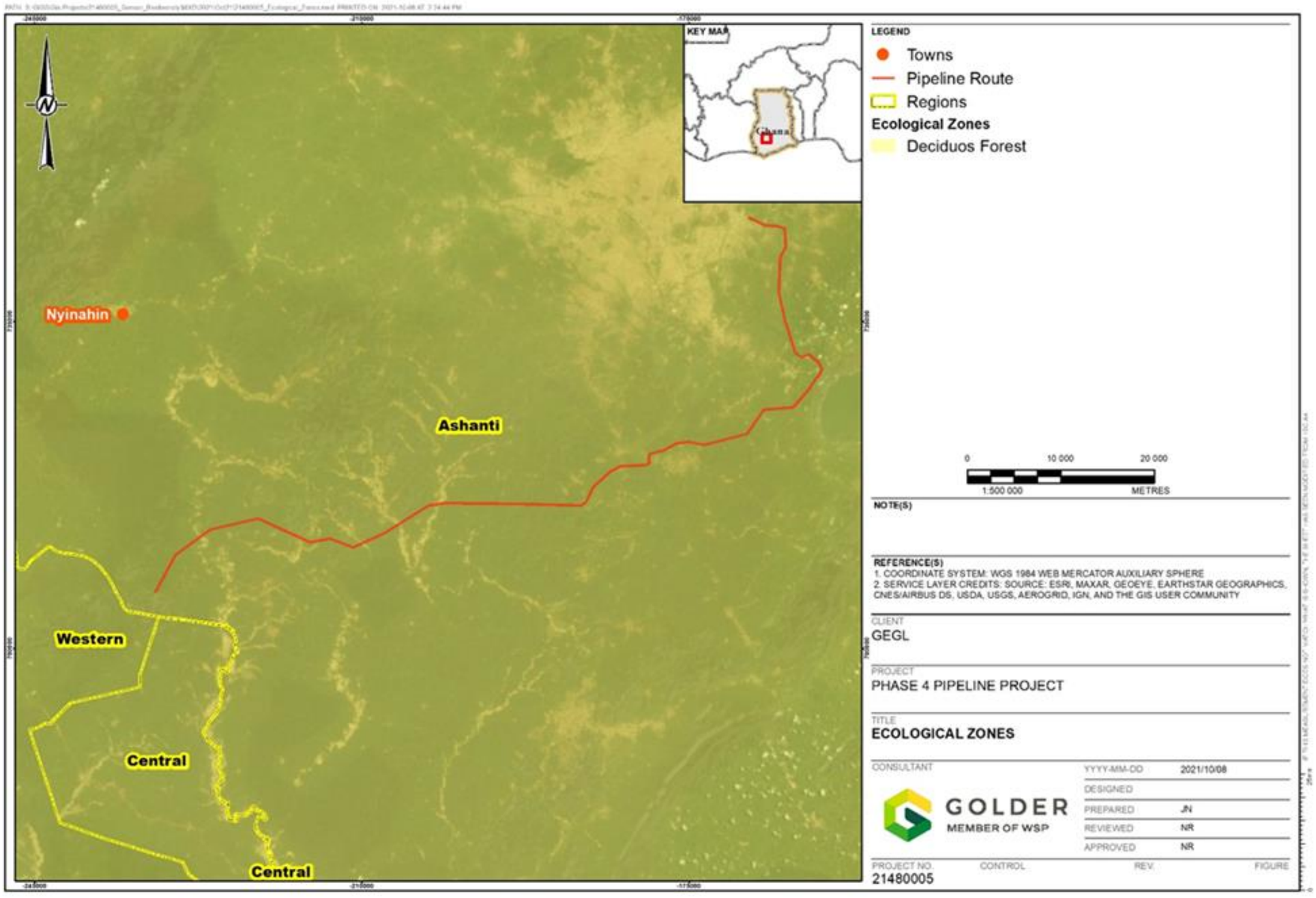

Figure 23: Ecological regions within the Study Area

4.2.3 Vegetation of the Pipeline Right-of-Way

The pipeline RoW passes a mosaic of farmlands, farm re-growths or secondary thickets, secondary forests, freshwater swamp forests and wetlands. Some sections of the RoW traverse areas under small scale alluvial gold and sand mining. The major tree cash crops cultivated within the pipeline RoW are cocoa, oil palm and citrus, while the dominant food crop farms included plantain, cassava, maize and rice were the dominant food crop farms encountered.

Farm re-growths or fallow lands (secondary thickets) and isolated patches of secondary forest give the landscape its mosaic or fragmented appearance. The farm regrowths and secondary thickets have species such *as Chromolaena odorata, Mezoneuron benthamianum, Secamone afzelii, Ficus sur, Dioscorea smilacifolia,* and *Phyllanthus muellerianus*.

Several sections of the proposed pipeline pass marsh, seasonally inundated riverine areas that are ecologically sensitive areas. In areas of freshwater swamps that could be surveyed, tree species including *Raphia hookeri*, *Alchornea cordifolia, Hallea ledermannii and Hallea stipulosa* occur along the pipeline RoW. The herbaceous flora included *Crinum jagus*, *Costus afer*, and species of Marantaceae such as *Hypselodelphys poggeana*.

Some of the trees encountered on the Cocoa farms were *Terminalia superba, Albizia zygia, Ficus exasperata, Milicia excelsa, Sterculia tragacantha Funtumia elastica,* and *Myrianthus arboreus*. The oil palm plantations were mostly devoid of large trees.

Floristic Analysis of the Pipeline Right-of-Way

The species lists for the thirty-eight (38) samples and the floristic analyses of the pipeline RoW are presented in Biodiversity Baseline Report attached in APPENDIX C. A total of 161 species in 137 Genera belonging to 56 families were recorded during the field survey. The families with high species representation were the Fabaceae (27), Malvaceae (12), Euphorbiaceae (10), Poaceae (9), Apocynaceae and Rubiaceae (7 each), Asteraceae (6) and Moraceae (5). These eight families (out of total of 56) accounted for 45.3% of the species recorded. The rest of the families had less than five species.

The Life Form composition of the flora (Table 18) showed a dominance of the Tree Life form (about 41%). The Herb, Shrub and Climber life forms followed in decreasing order of representation. The dominance of the tree life form could be due to trees in the Cocoa farms and patchy secondary forests, while the farms and farm re-growths and fallows, with climber tangles, explain the significant presence of the herb, shrub and climber life forms in the flora. The cocoa farms, with isolated trees, make important contribution to biodiversity conservation along the pipeline route.

Table 18: Life form composition of the flora

Life form	No.	%
Climber	21	13.0
Herb	47	29.2
Shrub	27	16.8
Tree	66	41.0
Total	161	100

The ecological guilds of the species, which gives an indication of the developmental stage of the vegetation recorded across the entire route, shows a dominance of the pioneers (Table 19). The dominance of pioneers (57.1%), which are secondary species, indicates that the vegetation along the pipeline route is highly disturbed. The primary species (shade-bearing and non-pioneer light demanders) constituted only 18.7%, a further

indication of the disturbed nature of the vegetation. The isolated patches of secondary forest and cocoa farms mostly harbour the primary species. The major drivers of vegetation disturbance along the pipeline route were Agriculture (cultivation of food and cash crops), alluvial gold mining and sand weaning.

Table 19: Ecological guilds of the flora

Guild	No.	%
Not Assessed	27	16.8
NFS/P	7	4.3
Non-Pioneer Light Demander	17	10.6
Shade-bearing	13	8.1
Swamp	5	3.1
Pioneer	92	57.1
Total	161	100

Species of National Conservation Concern

Most of the species (about 90%) recorded are of no conservation concern, being either Green starred or species not yet assessed. Most of the species not yet assessed are weeds of waste places and open areas. Sixteen species (10% of the species recorded) of national conservation concern were recorded along the pipeline route (Table 20).

Table 21 shows the species of national conservation concern encountered in the study area. The two Gold star species (*Cussonia bancoensis* and *Schumaniophyton problematicum*) are rare both locally and globally and require urgent conservation action. The Pink and Scarlet Star species are under moderate to heavy exploitation for commercial purposes e.g., *Piptadeniastrum africanum*, *Pycnanthus angolensis*, *Terminalia superba* and *Milicia excelsa* are heavily exploited timber species, while *Aframomum melegueta* is a spicies of commercial interest.

Table 20: Star Rating Composition of the flora

Star	No	%
Blue	3	1.9
Gold	2	1.2
Green	95	59.0
Not Assessed	50	31.1
Pink	8	5.0
Scarlet	3	1.9
Total	161	100.1

Table 21: Species of national conservation concern

Species	Family	Life Form	Star Rating
Millettia thonningii	Fabaceae	Tree	Blue
Sansevieria liberica	Dracaenaceae	Herb	Blue
Crinum jagus	Amaryllidaceae	Herb	Blue
Cussonia bancoensis	Araliaceae	Tree	Gold
Schumaniophyton problematicum	Rubiaceae	Tree	Gold
Antiaris toxicaria	Moraceae	Tree	Pink
Distemonanthus benthamianus	Fabaceae	Tree	Pink
Piptadeniastrum africanum	Fabaceae	Tree	Pink
Pycnanthus angolensis	Myristicaceae	Tree	Pink
Sterculia rhinopetala	Malvaceae	Tree	Pink
Aframomum melegueta	Zingiberaceae	Herb	Pink
Elaeis guineensis	Arecaceae	Tree	Pink
Terminalia superba	Combretaceae	Tree	Pink
Entandrophragma cylindricum	Meliaceae	Tree	Scarlet
Milicia excelsa	Moraceae	Tree	Scarlet
Triplochiton scleroxylon	Malvaceae	Tree	Scarlet

Species of International Conservation Concern

The floristic analysis shows that about 97% of the species recorded are of no global conservation concern (i.e., Data Deficient, Least Concern or Not Assessed), while 3% are considered to be of international conservation concern (Table 22). The species of national conservation concern are presented in Table 23. Three species are near threatened while two are vulnerable. These species are threatened by the exploitation for timber trade, with the exception of *Cussonia bancoensis* which is threatened as a result of land use change and loss of upland evergreen forest habitat. *Mitragyna ledermannii* and *Mitragyna stipulosa* occur only in the freshwater swamp forests encountered along the pipeline route. A single individual of *Cussonia bancoensis* was encountered on a cocoa farm with isolated trees.

Table 22: IUCN Red list status Composition of the flora

IUCN Red list Status	No.	%
Data Deficient	3	1.9
Least Concern	78	48.4
Not yet Assessed	75	46.6
Near Threatened	3	1.9
Vulnerable	2	1.2
Total	161	100

Table 23: Species of National Conservation Concern

Scientific name	Family	Life Form	Star Rating
Mitragyna ledermannii	Rubiaceae	Tree	Near Threatened
Mitragyna stipulosa	Rubiaceae	Tree	Near Threatened
Milicia excelsa	Moraceae	Tree	Near Threatened
Cussonia bancoensis	Araliaceae	Tree	Vulnerable
Entandrophragma cylindricum	Meliaceae	Tree	Vulnerable

Invasive Species

Four of the species recorded were Invasive Alien Species; *Broussonetia papyrifera* (Paper mulberry), *Chromolaena odorata* (Siam weed), *Imperata cylindrica* (Lalang grass) and *Lantana camara* (wild sage) (APPENDIX C). *C. odorata*, *I. cylindrica* and *L. camara* are listed among the top 100 invasive species of the world by the IUCN Invasive Species Specialist Group. The most widespread of them within the pipeline route was *C. odorata* (occurring in 71.1% of samples) followed by *L. camara* (34.2%). *B. papyrifera* and *I. cylindrica* occurred in 7.9% of the samples respectively. The construction and operation phases of the project should be carried out in such a manner as to prevent the proliferation of these species within the project's area of influence.

4.2.3.1 Ecosystem of Conservation Concern

Protected Areas

The proposed pipeline crosses Anhwiaso East Forest Reserve to the west and is also located adjacent the Afram Headwaters in the same direction. The proposed pipeline is also located adjacent the Lake Bosomtwe towards the northeast direction of the pipeline (Figure 24).

The proposed pipeline will cut across the Anhwiaso East Forest Reserve for about 1.76 km. The forest reserve is highly degraded through extensive food crop farm encroachment and does not currently constitute a significant biodiversity area or an area of high conservation significance. However, although this forest reserve is highly degraded and does not constitute a significant biodiversity area, its legal status as a forest reserve has not been revoked and hence it must be recognised as such.

The Afram Headwaters is located within the Anhwiaso East Forest Reserve and approximately 1 km from the proposed pipeline. Afram headwaters is in the transitional zone of Ghana, and it is known for its potential in conserving timber. However, the forest is highly degraded due to fire, logging and farming (Boakye, 2011).

Lake Bosomtwe is located approximately 500 m from the proposed pipeline. The lake is known to be home of a great diversity of wildlife, being home to some of the species of conservation concern such as the pangolin (*Phataginus tricuspis*) (UNESCO, 2020). The lake is an important national cultural and natural site of relevance for international conservation. According to UNESCO (2020), Lake Bosomtwe is the only natural lake in Ghana and one of six major meteoritic lakes in the world and is thus considered a unique national resource.

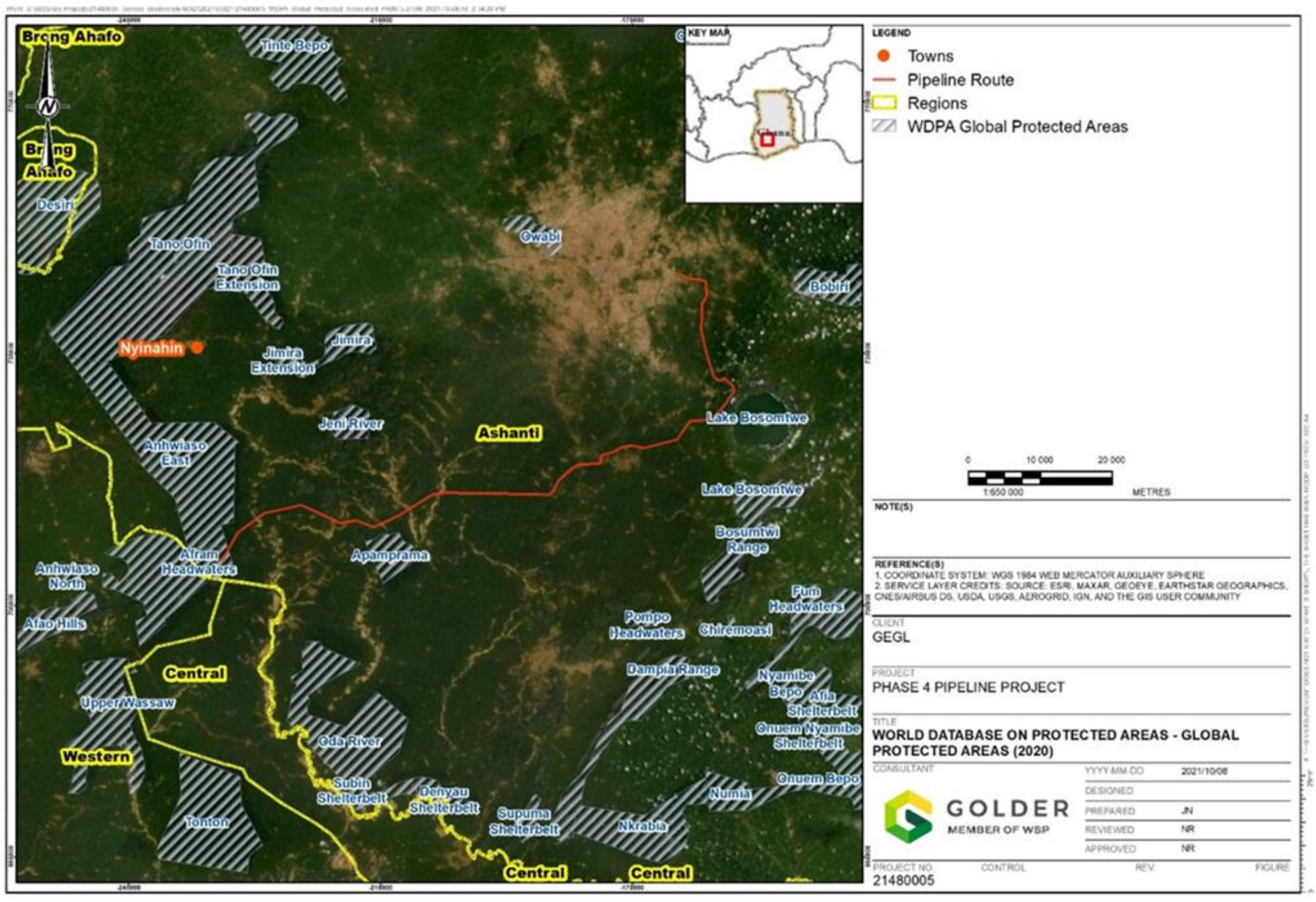

Figure 24: Protected Areas within the pipeline RoW

4.2.4 Fauna

The moist deciduous vegetation zone of Ghana is not only known for its floral diversity but also fauna diversity, with the rich plant community in the characteristic lush vegetation providing safe refuge for a wide range of fauna species. This notwithstanding, a high intensity of human activity has culminated in massive habitat alteration of most of the CHAA and appears to have made the habitats less suitable for many faunal species in the majority of the Study Area. The presence of faunal species in the Study Area was characterised by a few disturbance-tolerant species that are closely associated with open habitats and cultivated areas.

4.2.4.1 Mammals

Large mammals are of key ecological and socio-economic importance in Ghana. Besides their aesthetic values especially in ecotourism, large mammals serve as major source of animal protein in both rural and urban communities in Ghana, a factor that make large mammals the worst victims of the bushmeat trade. Large mammal species richness and diversity in any habitat or area reflects the level of biological richness and the extent and intensity of human pressure on the habitat (Rija, et al. 2020; Abernethy, et al. 2013). Several large mammal species are globally threatened, hence their diversity and richness in an area gives a measure of the conservation value of the habitat. Besides seed dispersal, large mammals are known to facilitate the germination of seeds of some key forest tree species. They are therefore ecologically important in the establishment and regeneration of forests after disturbance.

Species and Richness and Diversity

A total of 11 large and medium-size mammal species were recorded along the proposed pipeline route APPENDIX C. Most large mammal records were obtained through indirect observations, consisting of evidence of faecal pellets, footprints and feeding activities. However, species such as ground squirrel (*Marmotini*), palm squirrels (*Funambulus*) and marsh mongoose (*Atilax paludinosus*) were encountered directly in the vicinity of the proposed pipeline in the course of the field study. Recorded species are mainly common and widespread, being closely associated with cultivated landscape and fallow farm bushes and secondary forest patches and an obvious remnant of the climax population that have persisted through the intense pressure of farming and other habitat degrading activities.

Records of mammal presence were limited to the few patches of uncultivated farm fallows. The highly modified landscape appears to have resulted in severe declines in large mammal community in the proposed pipeline landscape. Massive loss of natural habitats and extensive modification through the different habitat-degrading human activities have also contributed to the severe decline in large mammal species. The paucity in the large mammal species recorded in the survey is consistent with the nature of prevailing habitats and landuse patterns in the Gyegyetreso-Anwomaso landscape. Checklist of the large mammal species recorded is presented in APPENDIX C.

Mammal Species of Conservation Concern

Only one of the eleven (11) large and medium-size species recorded in the survey - Bossman's potto (*Perodicticus potto*) - is of global conservation concern, being listed as Near Threatened on the IUCN Red List of Threatened species. This species was recorded in the forest reserve at the Gyegyetreso end of the proposed pipeline. All the remaining ten species are listed as of least concern on the IUCN Red List of Threatened Species.

At the national level, none of the species recorded are listed on Schedule I of the Wildlife Conservation Regulation (1971), LI 685 as wholly protected species. Overall, the large and medium-sized mammal species along the Gyegyetreso-Anwomaso pipeline landscape did not comprise any rare or species of significant conservation value.

4.2.4.2 Birds

Birds constitute an important component of the fauna resources of Ghana. Birds have been studied in different habitats and ecological settings and their general specific relationship with different ecological settings are well documented. Most birds are generally habitat specific and the general and specific response to environmental and habitat pressures have been well documented. Results of ornithological studies in variety of ecosystems have showed that birds are reliable indicators of general habitat health and condition (Stattersfield, et al. 1998). As with other taxon, the global conservation status of most species of birds are regularly assessed (BirdLife International 2000, Collar et al. 1994, IUCN, 2021). Birds are therefore one of the entities that are regularly used in assessing the biological quality and conservation value of a habitat.

Species of Conservation Concern

Two of the 117 bird species recorded in the landscape of pipeline routes, the hooded vulture and grey parrot are of global conservation concern and listed as Critically Endangered and Endangered respectively in the IUCN Red List of Threatened species (Table 24). At the national level seven (7) of the species recorded are listed in Schedule I of the Wildlife Conservation Regulation as wholly protected species (Table 24). The seven species are in the family Ardeidae, Accipitridae and Falconidae, and are wholly protected by law, (LI, 685), from all forms of hunting and capturing at any time of the year.

Forty-two (42) of the 117 bird species recorded are Biome Restricted species (APPENDIX C). These are bird species whose global populations are limited to the Guinea-Congo Forest Biome of West and Central Africa.

4.2.4.3 Herpetofauna (Amphibians and Reptiles)

Amphibians and reptiles are a prominent and conspicuous component of the West African forest fauna. For biological assessment, amphibians are especially useful for evaluating the health and integrity of the environment (Leache and Caleb, 2009). Amphibians have been well studied in Ghana in different habitat structures and conditions and have been found to respond well to environmental changes and they are also relatively easy to detect in different conditions of complex forest habitats. The wealth of information on the distribution and ecology of amphibians and reptiles throughout Ghana, coupled with the utility of amphibians as good environmental indicator species, makes them a relevant taxonomic group for rapid assessment (Leache and Caleb, 2009). Over one-third of amphibian species are globally threatened, and amphibian populations worldwide are negatively affected by anthropogenic factors such as habitat modification or invasive predators, although many rapid population declines and extinctions have occurred even in habitats lacking obvious anthropogenic disturbances (Whitfield *et al*., 2007).

Species Richness and Diversity

A total of thirty-five (35) herpetofauna observations comprising thirteen (13) species were recorded in the survey. The species recorded comprised (five) 5 amphibians and eight (8) reptiles. The reptiles comprised of five (5) snakes and three (3) lizards. Details of the herpetofauna species recorded in the study are presented in APPENDIX C.

The herpetofauna species recorded are habitat generalists commonly present in cultivated areas within forest landscapes and their occurrence within the pipeline landscape was relatively infrequent.

Being a predominantly cultivated landscape, the general habitat conditions along the pipeline were clearly not suitable for majority of the herpetofauna species, particularly those that are habitat specialist. The land use regime along the pipeline, being mainly cultivated food crop and cash farms, did not appear to support the occurrence of many herpetofauna species. On the whole, the herpetofauna species recorded in the study were common persistent habitat generalist species associated with cultivated areas/remnant bush habitats within the moist forest landscape.

While many reptile and amphibian species thrive in human-disturbed areas, others are restricted to only specific microhabitats conditions and may not thrive when such habitats are compromised. It is apparent that the landuse regime along the Gyegyetreso- Anwomaso pipeline routes may not be suitable to habitat sensitive herpetofauna species. The frequent and persistent use of various agrochemicals in both food crop and cash crop farms poses an obvious challenge to the community of herpetofauna species and this may have accounted for the relatively low number of species encountered along the pipeline.

Species of Conservation Concern

All the herpetofauna species recorded are listed as Least Concern on the IUCN Red List of Threatened species. At the national level one species, the Nile monitor lizard, is listed on Schedule II of the Wildlife Conservation Regulation.

4.2.4.4 Conservation Value of the Pipeline Route

The vertebrate fauna survey along the Gyegyetreso-Anwomaso pipeline recorded a total of 141 vertebrate fauna species, of which only three species, hooded vulture, grey parrot and Bossman's potto are of global conservation significance and listed on the IUCN Red List. About nine other species are listed on Schedule I of the Wildlife Conservation Regulation of Ghana as wholly protected species (Table 24).

The pattern of landuse in the Gyegyetreso-Anwomaso landscapes, particularly the widespread intense cultivation coupled with the reduced availability of significant cover of natural habitats and forests, limits the importance of the LSA for fauna species of concern. This notwithstanding, the 141 vertebrate fauna species recorded constitute an important component of the biodiversity of Ghana and highlight the importance of conservation of remaining areas of natural habitat in the cultivated landscape to ensure these species' persistence.

Table 24: Fauna species of concern confirmed along the pipeline route

Species		Taxon	Conservation Status	
Scientific Name	**Common Name**		**IUCN**	**WCR**
Bosman's potto	Perodicticus potto	Mammal	Near Threatened	Wholly Protected
Accipiter melanoleucus	Black Goshawk	Bird	Least Concern	Wholly Protected
Buteo auguralis	Red-necked Buzzard	Bird	Least Concern	Wholly Protected
Necrosyrtes monachus	Hooded Vulture	Bird	Critically Endangered	Wholly Protected
Kaupifalco monogrammicus	Lizard Buzzard	Bird	Least Concern	Wholly Protected
Falco ardosiaceus	Grey Kestrel	Bird	Least Concern	Wholly Protected
Falco cuvierii	African Hobby	Bird	Least Concern	Wholly Protected
Bubulcus ibis	Cattle Egret	Bird	Least Concern	Wholly Protected
Butorides striatus	Green-backed Heron	Bird	Least Concern	Wholly Protected
Psittacus Erithacus	Grey Parrot	Bird	Endangered	

4.3 Socio-Economic Environment

The baseline evaluation of the socio-economic characteristics of the project area was undertaken through the collection of data from socio-economic survey. The survey was undertaken from 7th August 2021 to 21st August

2021. The primary objective of the socio-economic baseline study was to ascertain data on various aspects of potentially affected communities within and near the project area. The baseline report describing the existing socio-economic conditions is attached in APPENDIX C.

The study area for the socio-economic studies targeted 81 communities. The project affected communities (PACs) have the potential of being affected by the project developments and operations.

To understand the socio-economic conditions of the project host communities and to achieve the study objectives, a multi-dimensional methodology, combining both qualitative and quantitative approaches to primary and secondary data collection and analysis were employed. Primary data collection involved site and community reconnaissance, interviews, focus group discussions and household questionnaire administration. A total of 1166 household respondents were sampled from 48 communities across the five districts in the study area whiles over 30 interviews and focus group discussions were also conducted.

4.3.1 National and Regional Profiles

The Ashanti region is in the middle portion of Ghana. The region occupies a total land surface of 24,389 km^2 (9,417 sq. mi), or 10.2% of the total land area of Ghana. The region has 43 metropolitan, municipal, and district assemblies, which are divided into Metropolitan (1), Municipal (18), and District Assemblies (24). The proposed pipeline project would affect 2 municipal assemblies and 3 district assemblies in the Ashanti region.

The region's population is projected to reach 5,924, 498 in 2021, representing over 25% growth over the past 10 years. While the population of the region is concentrated in few districts, the age distribution of the population in the region shows that nearly 60% of the population are adults within the active labour force, with 37.8% being children (GSS, 2014).

Agriculture and forestry are the region's most profitable economic activities, accounting for 30.5%, followed by wholesale and retail trade (25.4%), manufacturing (10.5%), and lodging and food services (6.1%). Cocoa is the most significant crop grown in the region. The region has the largest mining site in the country at Obuasi.

4.3.2 Project Area Characteristics

4.3.2.1 Demography

More than 60% of total household respondents are males, which is characteristic in all the districts except in Amansie West, where the female proportion is approximately 55%. The youth (aged between 18 and 40) dominated the household respondents. A third of the population is between the ages of 40 and 60, with about 15% over the age of 60.

The ethnic background of the area depicts the dominance of Asantes accounting for over 80% of the population. Minority ethnic groups including Fantes, Ewes, Dagombas and Wassas, are evenly distributed The cocoa cottages, however, are home to the majority of the northerners. Due to the area's growing cosmopolitan nature, Ejisu is the only place with a significant non-Asante population (over 15%). While Christians make up about 90% of the households, Muslims account for 4.4%, Traditionalists and other religious groups account for 3.2%.

The average household size in the area is 5.26. In comparison to other district in the region, household sizes, Ejisu, Bosomtwe, and Bekwai districts have small household size with ~5.3 people. The average number of female household members is 3.74, while the average number of children is 2.28. This means that children account for roughly half of all household members, while female household members account for roughly 20% more than children. This means a typical household in the PAC is dominated by women and children.

4.3.2.2 Household assets

While about 15% of households do not own land, about three-quarters of those who do own land use or own it primarily for farming purposes. Only 10% of landowners develop their land primarily for residential purposes.

The only assets found in almost every household in the study area are cell phones, cutlasses, and hoes. Other common household assets include radio and sleeping mattresses. Electric appliances such as televisions, refrigerators, and cars are not widely available. Motorcycle ownership, however, is more prevalent in the Amansie area and the western part of Bekwai.

4.3.2.3 Housing conditions

Nearly 70% of households owns the homes which they are dwelling in. Those who rent, however, are significant (20%), and this proportion of households are quite dominant in Amansie West (33.3%), Amansie South (24%), and Ejisu (21.2%). The majority of the homes in the area are compound and semi-detached houses.

The dominant material used for building houses or dwelling units is cement block (about 60%). However, the proportion of houses in which the outer walls are built with traditional materials such as mud and landcrete bricks contribute to a total of about 40%. The use of traditional materials is common mostly in the rural areas.

More than 90% of dwelling units are roofed with aluminium roofing sheets, though about 20% of structures in Amansie West are roofed with thatch. 40% of household kitchens are located outside the main dwelling unit. Also, a vast majority (more than 70%) of household kitchen structures are roofed and almost 20% of the households prepare food in the open space.

Mobility of people, and animals through the communities' structures is relatively easy and simple. Furthermore, while it is simple to commute through many of the inner community roads on a motorcycle or tricycle, it is difficult to do so in a car due to high levels of erosion and gravels adorning the streets, although there are few exceptions in communities such as Homabenase, Kwaso Deduako and Esumanjia.

4.3.2.4 Water and sanitation

There are widely observed conditions of plastic and polythene bags scattered on the streets, inner community corridors, and immediate backyards. About 80% of the household members dispose of their waste at the public dumping site. The rest resort to waste burning, burying, and indiscriminate dumping. Within the urban communities such as high tension and Awomaso in the Bekawi area, there are no dumping sites. Community members therefore rely on the services of private waste companies such as Zoomlion and Assando for waste disposal.

While about half of the people in a household use a public toilet, which is mostly in the form of dug pits and KVIPs (Kumasi ventilated-improved pits), 30% of household members have either constructed their private KVIPs or resort to the use nearby toilet facilities owned by neighbouring households and/or private, commercial facilities for which they pay. Most of the toilets and dumping sites are in poor sanitary conditions.

There are several water bodies located within the study area. Most of these water resources are streams and stagnant water. Some of the water resources identified are Bankro, Atuoso, Asuoabena, Akofiankofi, Subri and Subin. Community members harvest either fish or other food products from some of these water bodies. The commonest source of drinking water in the study area is pipe borne water (54.3%) and sachet water (30%). However, reliance on sachet water is more prevalent in semi-urban communities than in rural communities.

4.3.2.5 Agriculture and Economic Activities

The main source of livelihood in the study area is farming. Other sources of livelihood for the inhabitants of the communities in the study area include hunting, forestry, and artisanal mining. As a result, most of the community members are classified as part of the informal private sector.

The activities of the farmers are skewed in favour of food crop production due to subsistence reasons, but cash crops are widely produced for commercial purposes. Common food crops produced are plantain (52.4%), cassava (28%) and yam (10.3%).

Major cash crops produced in the study area are cocoa and oil palm, but the latter is more prevalent in the Amansie area. Oil palm is also increasingly becoming a booming option in the Bosomotwe-Ejisu area.

Due to the prevalence of artisanal mining, industrial activities, and residential developments, farmers face a major shortfall in accessing farmlands for cultivation, especially farmers in the eastern portion of the site. Furthermore, poor farming practices is also a challenging phenomenon in the area due to its negative impacts on soil fertility.

4.3.2.6 Local Market and Inflation

Prices of selected goods, and services are quite moderate and normal as compared to prices of non-PACs in the districts, nearby districts and even Kumasi, the regional capital.

The prices of common goods and services in the domestic or local markets within the study area are displayed in Table 25.

Table 25: Prices of selected common market products/services, units of sales, and prices

Product	Unit	Price (Ghc)
Food items		
Tin of milk (Carnation)	160g	2.80
Tin of Milk (Ideal)	160 g	3.00
Egg	I crate	18.00-22 (depending on the sizes)
Perfume Rice (Locally measured)	1kg	13.00-15.00
Local Rice (Locally measured)	1kg	11.00-13.00
Sugar	1 kg	15.00
Canned Tomato Paste	210g	2.5
Beer (Club)	600 ml	7.00
Sachet water	300ml	0.20
Sardine	125 grams	3.00
Live Chicken	Small size	30
Live Chicken	Large size	50
Fruit Drink (Fruitelli)	1 litre	8.00
Roasted Sausage	1 stick (medium)	2.50
Other non-Food Items		
Exercise book	Note 1	1.00
MTN airtime	Ghc 5,00 card	Ghc 5.00

Source: Field data (2020)

4.3.2.7 Road, and Transportation

Community members rely mainly on vehicles for transportation, but due to poor state of the roads in these communities especially in the Amansie area, motor bicycles are widely used. However, the road network in the eastern section of the PACs (Bekwai, Bosomtwe, and Ejisu) is significantly better. The major challenges with transportation for the community members are poor road infrastructure, and road safety challenges.

4.3.2.8 Education

About 60% of the respondents have completed basic education while 12.4% have never attended school. The rest are either Senior High School or tertiary graduates. Almost every community has at least a basic school in. However, in communities where there are no basic schools (auch as Manso Manhyia), pupils commute about 5km tonearby communities to access education. There are also dozens of senior high schools and few tertiary institutions in the study area.

The yearly average performance of candidates in the area at the Basic Education Certificate Examination shows a percentage pass of about 45%, except for Ashanti Bekwai and Ejisu, which record higher pass rates (average of 70%). Inadequate infrastructure and logistics, pupil truancy and dropouts are the main educational challenges in the PACs.

4.3.2.9 Energy

While the main source of energy for lighting is electricity, less than 10% the households in the study area rely on other sources such as torches, and lamps powered by either dry batteries or kerosine. Majority of households (about 65%) use firewood as the main source of energy for cooking. Households who rely on charcoal and liquified petroleum are about 25% and 15% respectively. Firewood is mostly gathered from the farms, and nearby forests. Similarly, the logs which are used for burning charcoals are mostly sourced from nearby forests and acacia plantations.

Proximity and access to local LPG retail facility is not a big issue in the eastern section of the PACs due to the presence of a few gas filling stations. However, residents in the Amansie area must travel a relatively long-distance to access LPG for domestic use.

There are also a few downstream fuel filling (distribution) stations that serve motorists, motorcyclists, artisanal mining operators and other clients. All the fuel stations in these communities are privately owned as there are no state-owned stations such as Goil. There are also very few informal vendors who sell petroleum products to underserved customers along the road or in communities. The main challenge that residents of these communities' face in terms of electricity is the fluctuation in supply, which is caused by an energy deficit caused by the lack of power generation facilities in the middle belt of Ghana.

4.3.2.10 Traditional values and customs

The entire study area is under the supremacy of the Ashanti Kingdom headed by the Asantehene, Otumfour Osei Tutu II. The Asante Kingdom is structured hierarchically and is made up of traditional chiefs, paramount chiefs, community chiefs as well as diverse sub-authorities, roles, and functions. Community members and local traditional authorities pay great allegiance and respect to the authority of the Asantehene (Ashanti King).

In each community, there are designated cemeteries. Most cemeteries, particularly those in the project area's eastern section (along Bekwai-Kuntenase-Ejisu), are closer to their communities while also being close to forest resources and deep vegetations. Further to this, the majority of cemeteries in these areas are located along roads, where they are visible to road users. Cemeteries closer to communities are well protected and preserved without any signs of residential developments and intrusion of structures. Traditional ceremonies such as funerals, weddings and other gatherings are well patronised with rich decorations, rituals, rites, and ceremonies.

4.3.2.11 Public Health

There are dozens of health care facilities located near or along the project affected communities. However, most of the well-equipped facilities are located around the Ejisu, Bosomtwe, and Bekwai areas. On the contrary, most of the health facilities in the Amansie area are Community-Based Health Planning Services (CHIPS) compounds and health centres. The only major public health facility within the Amansie West district is a health centre

located at Antoakrom. The Amansie West and South districts are without a single medical doctor due to the absence of a major (public) hospital.

Approximately 70% of residents prefer to seek medical care from orthodox facilities rather than traditional medicine because the former offers better or higher quality services. The most prevalent or common disease or illness in the area is malaria. Public attitude towards the Covid-19 pandemic is negative as most of residents do not adhere to protocols. On average, one out of 10 persons on the streets is without a face mask.

4.3.2.12 Financial system and household spending

The main source of income in the project area is household's economic activities including farming, trading, artisan, craft and professional services and small-scale mining activities. The main incidence of household expenditure is food. The main source of credit/loans for the households is from family, and friends. Residents who resort to banks and other financial institutions are account for about 30% of the population.

About one third of the households do not have an active bank account. The commonest form of savings among the households are through cooperative groups (33.9%), mobile money (32.1%) and bank accounts (20%). There are about 15% of households who also keep their earnings or savings at home.

There are dozens of financial institutions across the study area. However, these institutions are widely located in the urban and semi-urban communities. Additionally, the institutions are lower-tier categories such as rural banks, and savings and loans companies.

4.3.2.13 Women, Gender and Vulnerability

Gender-based discrimination and inequity is not a major issue in the PACs. Both genders have equal access to basic livelihood sources such as farmlands. Also, households believe there are equal opportunities when it comes to family decision making and household responsibilities. However, patriarchal values and recognition of males as household heads are seriously upheld and recognised especially in the Amansie area. In one out of every four households, there is at least a household member who is having some level or kind of ability challenges. These challenges may either be minor (10.5%) or major (8.9%).

4.3.2.14 Community conditions

On a typical weekday, most of the household dwellings are left vacant because members of the households go to their farms early in the morning and return late in the evening. As a result, getting in touch with most of the residents in these communities during the day is difficult. The few residents who are mostly accessible during such times are children, petty traders, and street vendors, the aged, people with disabilities and some few non-farm working class.

An average of 8 out of 10 households' members have lived in the area as long-term residents and intend to stay in the community for the coming the years. Such households have no intention to migrate away from their current communities or area. The remaining 20% on the other hand, are residents who have only lived in the area for a short time, and or do not intend to stay in the area permanently.

4.3.2.15 Opportunities and threats of community survival

The proximity of household members to their farmlands and other livelihood sources is the single most important reason for members' long-lasting living, adaption, and immobility from their communities. However, factors which may compel them to migrate from the areas include lack of job opportunities (37.7%), poor social amenities (such as toilet, and water facilities) (23.4%), poor road network (16.2%), and crime, and insecurity. Water pollution and deforestation because of artisanal activities are major concerns especially for the communities in the Amansie area.

Robbery and theft form the major security concerns in the area. Major theft items include gold resources, domestic animals (such as fowls, sheep and goats), motorcycles, and other household assets such as televisions, mobile phones, and laptop computers.

4.3.3 Customary Rites for Sacred Areas

Customary rites are often performed in our host communities at sacred and religious places, such as groves and sanctuaries in which gods or spirits of their ancestors are believed to live and manifest. Sacred places are also sites of natural and historical significance to communities: springs, rivers, forests and mountains - which once served as safe havens from enemies.

In addition, there exist specific days reserved for traditional worship and prayer rituals to the gods and ancestors of some communities. There are also days termed as ‘taboo days’, in which communities are prohibited from farm work, and such sacrosanct days vary from one ethnic group, tribe, or community to the other. In the Ashanti Region for instance, ‘Yawoada’ and ‘Fiada’, (representing Thursday and Friday), are the two ‘taboo days’ observed by the Akan people.

There are also two ‘Adae’ festivals; ‘Awukudae’ and ‘Akwasidae’. The ‘Awukudae’ is a festival celebrated on Wednesday (‘Wukuda’). According to the Akan calendar, the ‘Adae’ is counted nine times every six weeks or a 40-day period. The ‘Awukudae’ occurs every 40 days or in some cases 42 days, and this 40th day is supposed to fall on a Wednesday (‘Wukuda’). Since these days have deep cultural and religious significance to chiefs and traditional leaders in the Ashanti Region, scheduled meetings which happen to coincide with these special days are often times postponed.

Prior to the traditional stakeholder engagements for pipeline projects, customary rites were performed at all major paramount and divisional councils to seek the guidance and blessing of the gods and ancestors of the host community. It was during these events that the history and cultural sites and PACs are shared. So far, 11 of such major sites have been identified; comprising two sacred groves, eight water bodies, and one forest reserve. They are the Ankam and Kokodie sacred groove, Oda and Offin River, Nwini, Sukyem, Asuadia, Dankran, Sugyata and Adankragya streams, and Asenayo Forest

4.4 Traffic

The roadway network in the study area varies, with predominantly sparsely spaced unpaved and poorly maintained roads in the rural western portion of the study area. The road network in the eastern section of the study area and some of the larger communities such as Bekwai, Bosomtwe, and Ejisu are better developed due to the larger population and associated commercial activity. Existing conditions information on roadways proximate to or crossed by the pipeline route was identified through a combination of field observation and use of satellite imagery.

Given the layout of the roadway network in relation to the pipeline route, roads to be used for access are considered arterial roads that connect larger municipalities to each other or connector roads that convey traffic from smaller communities to the arterial roads.

Baseline traffic volumes was collected at ten locations along the pipeline route. These locations were selected as these roads that would provide access to the pipeline route for site preparation, material delivery, and construction workers. Traffic counts were taken from Wednesday October 13, 2021, through Saturday, October 16, 2021. At each location, staff recorded the number of road users in 15-minutes intervals between on the hours of 0600 and 1800 to determine the level of roadway use over time. This baseline data was used to determine whether adverse impacts to the roads level of service would occur from construction and operation activities. Figure 25 depicts the locations of the traffic count stations, with coordinates provided in Table 26. Table 26 again identifies the predominant users of the roads and indicates that motorcycles were the prevalent mode of transportation in the rural areas and taxis and busses were more prevalent in the more developed

areas along the route. APPENDIX C provides the findings of the traffic studies at each of the 10 traffic count stations.

Table 26: Traffic Road Count Survey

Traffic ID	Location (Coordinates)	Road Description and width	Vehicle Predominance
1	N 06°20.180' W 002°04.964'	7m wide, tarred road (bitumen)	Motorcycles
2	N 06°22.835' W 001°56.589'	8.7m wide laterite road (dusty)	Motorcycles and motorized tricycles
3	N 06°24.241' W 001°51.327'	8.9m wide laterite road	Motorcycles and motorized tricycles
4	N 06°27.239' W 001°38.125'	15m wide laterite road	Pick-ups (4*4) and medium buses
5	N 06°27.404' W 001°36.518'	10m wide tarred road (bitumen)	Taxis and Pick-ups (4*4)
6	N 06°28.401' W 001°33.643'	9.6m wide tarred road (bitumen)	Taxis
7	N 06°32.547' W 001°26.999'	9.7m wide tarred road (bitumen) with portions of laterite	Taxis
8	N 06°33.597' W 001°27.848'	8m wide tarred road with portions of laterite	Taxis
9	N 06°38.350' W 001°29.083'	6.7m wide tarred road (bitumen)	Medium buses and taxis
10	N 06°40.942' W 001°29.254'	9.1m wide tarred road (bitumen)	Taxis

Traffic Count data and trends can be summarized as follows:

- Road traffic in the western part of the study area (Traffic Count location (T1)) consisted of 86% bicycle and motorcycles, followed by 4% each other vehicles (tricycles commonly referred to as pragyia and aboboya) and medium duty trucks.
- Peak hour traffic generally occurred from 1100 to 1400 hours and 1500 to 1700 hours. Hourly volumes recorded from early morning and evenings ranged from about 10 vehicles to 20+/- vehicles.
- Directional flow did not vary significantly, about +/- 5% in the rural areas
- Road traffic in the eastern portion of the study area was greatest on N8 (T4) and was more broadly used in relation to vehicle type. Medium-sized buses represented the most common vehicle (18%), followed by taxis (16%) and private saloons (15%). Trucks and trailers represented almost 18%of the traffic volume.

- Except for vehicles traveling to and from Kumasi, peak hour traffic occurred between 1100 and 1500 hours. The morning peak hour was between 0600 and 0700 hours, and the evening peak hour was between 1600 and 1700 hours. Peak hours represented 10%t of the daily average daytime traffic on N8 where the pipeline will cross. This volume is generally consistent with more urbanized traffic patterns.
- Directional flow did not vary significantly, less than 5% on N8 where the pipeline will cross.
- Daily variation ranged from 6% below the average daytime (0600 to 1800 hours) traffic volume taken during the field investigation (Wednesday, 13 October) to 9% above the average daytime traffic volume (Saturday, 16 October).

The current level of service provided by these roads is deemed acceptable. Many of the unimproved roads' do not have the capacity to support high traffic volumes due to their poor conditions. Many of these roads, however, are infrequently used. Paved roads have higher background traffic volumes due to their design and function. While some intersections in larger municipalities experience traffic congestion (an unacceptable level of service), these areas are not near the pipeline route.

The pipeline route with one exception traverses open land and is not parallel to existing public road right-of-way. This aspect of the pipeline route typically results in less impacts during construction. The pipeline route also crosses approximately 40 roads which can have an impact on construction and will be assessed in Chapter 6.0.

No other forms of transportation, such as vessels and related port traffic, rail, and aviation are not a material part of the study area baseline conditions.

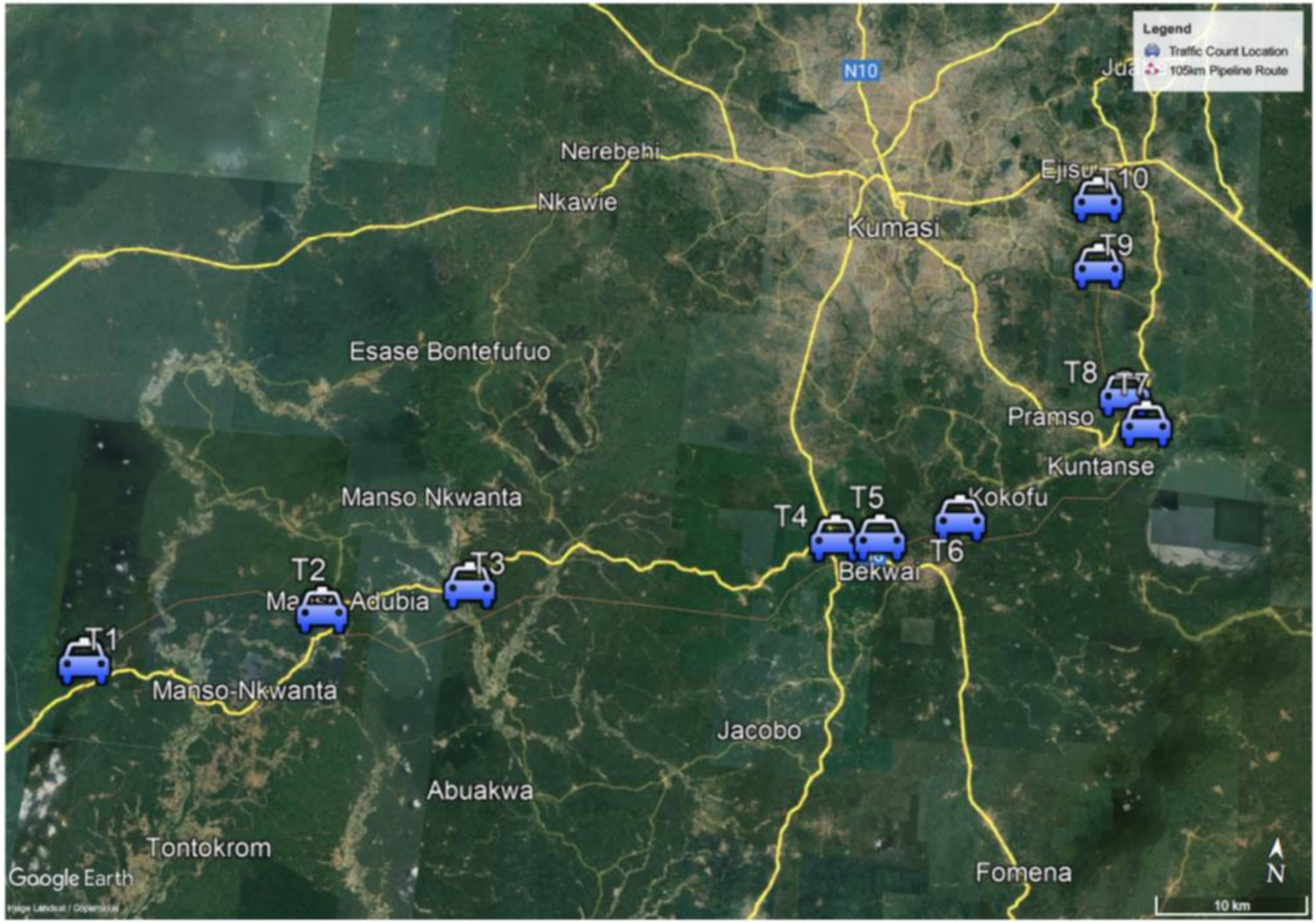

Figure 25: Traffic Count Locations

5.0 PUBLIC PARTICIPATION

Stakeholder consultation is a major component of the EIA process and is generally completed to direct impact assessments on issues of most concern and inform project planners and decision-makers. Effective stakeholder consultation helps build trust and credibility, provides a platform for effective information management, and facilitates the development of positive, long-term relationships with the project proponent, its neighbours, and other stakeholders in the quest for sustainable project development and implementation.

As part of the EIA process, stakeholder engagements were conducted in the project area between 16th July 2021 and 23rd February 2022. The various stakeholders engaged for the project are provided in Table 27.

The meeting minutes and notes from the engagements were used in the preparation of comments and responses report (CRR) presented in APPENDIX E.

5.1 Objectives

The objectives of the stakeholder consultations were to share project information with identified stakeholders and solicit their views, inputs, and concerns regarding the project. Specific objectives of the consultations included:

- Provide adequate and accessible information to enable stakeholders:
  - Understand the context of the EIA process.
  - Be informed and educated on the project and its potential impacts.
  - Identify issues of concern, make suggestions for improved benefits and comment on project alternatives.
- Provide opportunities for stakeholders to comment and provide input/feedback (local knowledge and experiences) to be documented for consideration as part of the EIA process.
- Build community understanding and support for the EIA process and the project in general and incorporate stakeholders' comments and vies into project planning and decision-making, including development of mitigation measures.

5.2 Approach and Methodology

The approach and methodology applied to the public consultation process were influenced by the need to ensure broader stakeholder participation, reliability and validity of data collected. GEGL is committed to engaging stakeholders in decision-making processes, improving communication, sharing information, as well as obtaining views and feedback to enhance the consultation and decision-making process.

The methodology employed during the public consultation process included the following:

- All the engagements were in the form of key informant (face-to-face) and focus group discussions.
- The meetings were conducted in Twi and English and were documented (photos, completion of attendance registers and note-taking).
- Meetings were held at venues easily accessible to stakeholders.
- The project was introduced to stakeholders using a map displaying the pipeline route and the surrounding communities.
- Comments and issues raised were captured and minutes recorded. The minutes of the stakeholder meetings were used to develop the CRR.

5.2.1 Development of a Stakeholder Database

A stakeholder database which comprised of a list of stakeholders from various sectors of society,including those who live in proximity to the project area and are directly affected by it. The participation of the following clusters or organisations in the stakeholder engagement process was considered of key importance:

- Traditional and religious authorities.
- Women, farmers, and youth groups.
- Local communities likely to be directly affected by the project.

5.2.2 Methods of Engagement

5.2.2.1 Notification

The most effect method used by GEGL in engaging the communities was face-to-face interactions. Upon arrival in a community, the community relations team from GEGL first meet with the local assembly or the unit committee chairperson of the assembly and with their assistance, notify the community information centre. The scheduled date for the community engagement is then announced by the information centre a day or two in advance.

5.2.2.2 Invitations and presentation

Invitations were extended through the regional government and community representatives. The invitation request was done through letters which were then followed up on by phone calls. Mobilisation requests were made progressively as the meetings were conducted from one area to the next. Mobilisation took place one week before the engagement date.

5.2.3 Outcomes of the Consultation

A total of 115 meetings were held, with approximately 3,497 people in attendance. The participants included representatives of the traditional authorities, religious leaders, committee members, non-governmental organisations (NGOs), youth and the media. Table 27 shows the details of the stakeholder meetings that were held as part of the pipeline project. Please refer to APPENDIX E for the minutes of the meetings and attendance registers.

Table 27: Details of Stakeholders Engaged for the Project

Date	Stakeholder Group Engaged	Venue	No of Participants
16th July 2021	Bosomtwe District Assembly	Conference Room, Bosomtwe District Assembly	42
19th July 2021	Dess FM – Asante Bekwai	Dress FM Station	9
	Nkomo FM – Anhwia Nkwanta	Nkomo FM Station (Anhwia Nkwata)	8
20th July 2021	NGOs – Bosomtwe District	Bosomtwe District Assembly	12
21st July 2021	Manso Nkwanta Palace	Manso Nkwanta Palace	8
	Bekwai Municipal Assembly	Conference Hall, Bekwai Municipal Assembly	32
	MCE, Ejisu Municipal	MCE Office	2
	Departments of the Ejisu Municipal Assembly	Conference Room, Ejisu Health Directorate	34

Date	Stakeholder Group Engaged	Venue	No of Participants
22nd July 2021	Asaman Traditional Council	Palace	12
	Bekwai Traditional Council	Asante Bekwai Chiefs Palace, Asante Bekwai	10
	Denyase Traditional Council	Denyase Chiefs Palace, Denyase	14
	Essumeja Traditional Council	Essumeja Palace	12
	Kokofu Traditional Council	Kokofu Chiefs Palace, Kokofu	20
	Kuntenase Traditional Council Durbar	Kuntunase Palace	116
23rd July 2021	Abrankese Community	Community Centre, Swedru-Abrankese-Abodiase	58
	Swedru-Abodiase Traditional Council	Swedru-Abodiase Chiefs Palace	11
	Akokofe Community	Community Center, Akokofe	3
	Kokodie Community	Kokodei Community Centre	40
	Petrensa Community	Patrensa Community Centre	30
	Piase Community	Piase Community Centre	91
	Tuamfom Community	Toamfom Community Centre	69
26th July 2021	Amansie South District	Conference Hall, Amansie South District	23
	Onwe Community	Onwe Community Centre, Onwe	73
	Dess FM Marketing Manager	Hotel De Pat Palace, Anwia-Nkwanta	2
	Woarakese Community	Woarakese Community Centre	48
27th July 2021	Adwafu Community	Krom-Adwafo community center, Krom-Adwafo	65
	Akyeremade Community	Community Centre, Akyeremade	29
	Amansie West District	Conference Room, Amansie West District Assembly	29
	Asamang Community	Asamang Community Centre	67
	Bedominase Community	Bedominase Community Centre	50
	Edwenase Community	Community Centre, Edwenase	21
	Japandu Community	Community Centre, Japandu	39
	Kyekyiam Community	Community centre, Kyekyiam	33

Date	Stakeholder Group Engaged	Venue	No of Participants
	Yaasi Community	Chief Palace	36
28th July 2021	Anhwia nkwanta Traditional Council	Anhwia-Nkwanta Palace	10
	Ejisu Traditional Council	Ejisu Palace	13
29th July 2021	Adankragya Traditional Council	Chief Palace	17
	Denyase Community	Denyanase Community Centre	47
	Essumeja Community	Community Centre	35
	Ejisu Traditional Council	Ejisu Palace	13
	Kyekyere Betenanko Community	Community Centre	52
30th July 2021	Asanso Community	Asanso Palace	34
	Boaman Community	Boaman Community Centre	32
2nd August 2021	Afransie Community	Afransie Community Centre	82
	Huntado Community	Huntado Community Centre	53
	Ntinako Community	Community centre, Ntinanko	43
	Poano Community	Community centre, Poano	69
3rd August 2021	Abono Community	Lake Side Grounds	36
	Boni Community	Community Grounds, Boni	103
	Miawano Community	Palace, Miawano	11
	Nyameani Community	Community centre, Nyameani	28
	Sunkyerekrom Community	Community centre, Sunkyerekrom	28
4th August 2021	Amanhyia Community	Community centre, Amanhyia	31
	Fahiakobo Community	Chief's House	9
	Kwabenakrom Community	Community Grounds, Kwabenakrom	44
	Marfokrom Community	Community centre, Marfokrom	21
	Sarfokrom Community	Sarfokrom Market Centre	62
	Yawpongkorkrom Community	Yawpongkorkrom Community Centre	9
5th August 2021	Manso Abodom Community	Palace, Manso Abodom	40
	Domi Community	Community Centre, Domi	48
	Kwakukrom Community	Assembly Grounds, Kwakukrom	32
	Omandware Community	Community Center, Omandware	42
	Oseikokokrom Community	Assembly Grounds, Oseikokokrom	47
	Siabotre Community	Community Center, Siabotre	17

Date	Stakeholder Group Engaged	Venue	No of Participants
	Yawhemenekrom Community	Community Grounds, Yawhemenekrom	23
9th August 2021	Ankam Community	Community Centre	28
	Aponapon Community	Community Grounds	77
	Kumpese Community	Community centre, Kumpese	13
	Miawano Community	Palace, Miawano	28
	Mpatasie Community	Community centre, Mpatasie	53
	Nwineso	Assembly Grounds, Nweneso	3
	Wahaso Community	Community centre, Wahaso	19
10th August 2021	Ebiram Community	Palace, Ebiram	71
	Manso Nkran Council	Community Centre, Manso Nkran	24
	Subinso Community	Subinso Community Centre	24
	Wirempe Traditional Council	Wirempe Palace	25
11th August 2021	Assienimpong Community	Community Centre	45
	Humebenase Community	Catholic Church	35
	Kwaaso Deduako Community	Community Centre, Kwaaso-Deduako	75
	Sarpe Community	Community Centre	45
12th August 2021	Apromase Elders	Chiefs House, Apromase	7
	Domeabra Community	Domeabra Catholic Church	21
13th August 2021	Achinakrom Community	Community Centre, Achinakrom	12
	Krapa No 1 Community	Community Centre, Krapa No 1	31
17th August 2021	Apromase	Community Center, Apromase	63
	Donaso	Community centre, Donaso	18
	Donyina	Funeral grounds	120
	Kwaaso	Assembly Grounds, Kwaaso	42
	Sarpe Traditional Elders	Catholic Church	8
18th August 2021	Adubiaso	Adubiaso Community Grounds	21
	Akwasiso	Community Center, Akwasiso	28
	Keniago	Pentecost Church	49
	Mmoho	Community Centre, Mmoho	65
	Odumase	Community Centre, Odumase	32
	Yankomase	Yankomase Community Centre	41

Date	Stakeholder Group Engaged	Venue	No of Participants
19th August 2021	Abenkyim	Community Centre, Abenkyim	20
	Anwian Nkwanta	Community centre, Awian Nkwanta	24
	Kurase	Palace, Kurase	14
	Sawaba Adankragya	Palace	42
	Sebedie	Community centre, Sebedie	16
31st August 2021	Daa Community	Community Grounds	45
23rd February 2022	Ghana National Gas Company	Virtual Meeting (Microsoft Teams)	9
TOTAL No. of Stakeholders			**3,497**

5.2.3.1 Summary of key issues raised

The issues and concerns raised at the various meetings were noted and have been included in the Comments and Response Report attached as (APPENDIX E). A key issue that emerged was calling the site of the proposed BPS as Dawusaso BPS. The Gyegyetreso community had indicated that the site for the proposed BPS was on Gyegyetreso land and were against it being called Dawusaso BPS. Upon verification, GEGL changed the name to Gyegyetreso BPS. The key issues were grouped in the following themes:

- **Safety and security:** stakeholders expressed concerns about the safety the pipeline which will be in close proximity to their homes or workstations. Others also inquired about the pipeline insurance coverage and how buried pipeline leaks could be detected.
- **Crop and land compensation:** stakeholders wanted to know if compensations would be paid directly to affected farmers or middlemen. They also wanted to know why crops within the 12m RoW were being compensated and not the entire 25m corridor.
- **Resettlement:** stakeholders wanted to know if their homes would be relocated if the pipeline route passed through their residence.
- **Benefit of gas pipeline to the community:** stakeholders enquired about the benefits that the pipeline would bring to their communities.
- **Environmental effects (soil and water):** communities asked about the impacts of thepipeline on soil fertility and water resources.
- **Environmental impact assessment**: there were queries about the general impacts of the pipeline on the environment.
- **Employment:** several communities asked if locals would be employed when the project commenced, and what types of jobs would be available.
- **General issues:** general issues included questions about the continuation of farming after the pipeline had been constructed, the depth of the pipeline below the surface and the size of the pipeline.

6.0 IMPACT IDENTIFICATION AND PREDICTION

In this chapter, potential impacts that could occur as a result of the implementation of the project have been described and evaluated in terms of significance, both prior to and following implementation of mitigations. The various impacts (both positive and negative) identified on the physical, biological and the socio-economic environment of the project area and beyond are discussed according to the project construction and operational phases. Impacts are quantified whenever possible by comparing the predicted effect to established standards or criteria, or by comparing to baseline conditions.

Impacts were initially identified by evaluating the various activities to be undertaken during each phase of the project and reviewing the comments from the various stakeholders involved in the project. Details on the engagements and feedback received from the stakeholders are provided in Chapter 5.0. These impacts were augmented by those identified by specialists, who reviewed the various aspects of the proposed project including the construction and operational aspects while taking into account their areas of expertise.

A summary of the project impacts is provided in the subsequent sections. In addition, an evaluation of cumulative impacts is provided taking into account ongoing or reasonably foreseeable activities within the project area.

6.1 Impact Identification Methodology

Each of the impacts identified through stakeholder engagements and specialists' studies were assessed to establish the significance of the effects on a particular resource area and/or local or regional residents. These effects were evaluated relative to their magnitude, extent, duration and ultimately their significance during the construction and operation phases of project development. The findings from these analyses were compared to quantitative criteria, where possible, to assist in determining the significance of the impact. For resource areas where such numeric impacts could not be established (e.g., impact to socio-economic), the specialists either described the impact or applied their professional judgment in establishing, qualitatively, the degree of impact.

However, this impact assessment is presented in a narrative form, as required by the EPA, in presenting the results of the analyses (based on their magnitude, duration, and scale) of the specific impacts occurring during each of the project phases.

6.1.1 Impact Assessment

In assessing impacts, the specialists also evaluated the potential effects on the social values of the communities with 2km of the pipeline. As a result, stakeholder contributions were important because stakeholder feedback was used to assess the impact and, where appropriate, influence execution plans and mitigations. In some cases, the specialists determined that it was vital to assess worst-case scenarios and use the outcome to develop appropriate mitigations measures.

The general objective of the impact assessment was to describe impacts and, where possible, predict the significance of the impacts associated with the project to inform the mitigation measures that would need to be implemented to avoid, minimise, or reduce negative impacts while enhancing positive impacts associated with the project. The specific objectives were as follows:

- Apply discipline-specific impact analysis methods (including predictive modelling, where warranted) to evaluate each of the potential impacts identified to determine their magnitude, extent, duration and, ultimately, significance.
- Formulate mitigation measures to reduce the significance of the impact to acceptable risk levels (including regulatory requirements and baseline values).
- Discuss and assess the significance of cumulative effects for each impact, where applicable.

- Assess the significance of residual impacts and where possible to inform compensation.

This impact assessment is presented in narrative form, as required by the EPA, presenting the results of analyses (as based on their magnitude, duration, and scale) of the specific impacts occurring during each of the project phases.

6.1.2 Air Quality

A dispersion model for determining pollutant concentration estimates based on screening-level procedures was completed using SCREEN3. SCREEN3 is a Gaussian plume model which provides maximum ground-level concentrations for point, area, flare, and volume sources (US EPA 1992). The model is a single source model, and the impacts from multiple SCREEN3 model runs can be summed to conservatively estimate the impact from several sources. SCREEN3 calculates 1-hour concentration estimates in simple terrain areas. These modelled estimates must be converted to the averaging period of each applicable national ambient air quality standards. SCREEN3 incorporates source related factors and meteorological factors to estimate pollutant concentration from continuous sources. The model assumed that the pollutant does not undergo any chemical reactions, and that no other removal processes (wet or dry deposition) act on the plume during its transportation. SCREEN3 examines a range of stability classes and wind speeds to identify the combination of wind speed and stability that results in the maximum ground level concentrations, the “worst case” meteorological conditions. The maximum ground level concentration predicted using a screening dataset is normally regarded as conservative, often termed 'worst-case scenario' impacts.

Scenarios

Only one scenario has been considered:

- Impacts from the construction phase activities.

Note: Impacts from the operational phase are considered to be minimal and does not need to be screened further.

The model output figures and tables that follow show concentrations that would be experienced at 1.5 m above the ground (considered representative of average human breathing height). The following statistical outputs were calculated:

- Peak 24-hour and annual averages were calculated using the equation below. The dispersion model’s lowest temporal resolution is one hour. The equation was used to convert P100 1-hour average concentrations over the modelled period to peak 24-hour and annual average concentrations. Values can be compared with the relevant 24-hour and annual average NAAQSs to assess likely air quality impacts across the model domain.

$$C_p = C_M \times \left(\frac{T_M}{T_P}\right)^P$$

Where:

C_P = Peak concentration, expressed on the new averaging time [µ/m^3]

C_M = Mean concentration on one hour averaging time [µ/m^3]

T_M = Averaging time for mean hour [60 minutes]

T_P = New averaging time [minutes]

P = Decay value = 0.2 [non-dimensional]

It must be noted that ambient air quality objectives are applied to areas beyond the facility boundary but within the facility boundary, occupational health and safety criteria need to be applied.

Construction Phase Assessment

Increase in dust and particulates:

The results if the atmospheric dispersion modelling conducted for the construction phase are as follows and the Figure 26 to Figure 31 show the dispersion over distance graphs for the predicted concentrations for the construction phase:

- **TSP Concentrations:**
  - Beyond approximately 4.5 km from the construction phase pipeline operations, 24-hour TSP concentrations will drop below the 24-hour TSP GSA Standard of 150 µg/m^3 (Figure 26)
  - From approximately 3 km from the construction phase pipeline operations, annual TSP concentrations will drop below the annual TSP GSA Standard of 80 µg/m^3 (Figure 27)
- **PM_{10} Concentrations:**
  - Beyond approximately 4 km and 5 km from the construction phase pipeline operations, 24-hour PM_{10} concentrations will drop below the 24-hour PM_{10} GSA Standard of 70 µg/m^3 and 24-hour PM_{10} IFC Standard of 50 µg/m^3, respectively (Figure 28)
  - From approximately 1.6 km from the construction phase pipeline operations, annual PM_{10} concentrations will drop below the annual PM_{10} GSA Standard of 70 µg/m^3 and annual PM_{10} IFC Standard of 20 µg/m^3 (Figure 29)
- **$PM_{2.5}$ Concentrations:**
  - Beyond approximately 1.6 km and 2 km from the construction phase pipeline operations, 24-hour $PM_{2.5}$ concentrations will drop below the 24-hour $PM_{2.5}$ GSA Standard of 35 µg/m^3 and 24-hour $PM_{2.5}$ IFC Standard of 25 µg/m^3 (Figure 30)
  - From approximately 1.7 km from the construction phase pipeline operations, annual $PM_{2.5}$ concentrations will drop below the annual $PM_{2.5}$ IFC Standard of 10 µg/m^3 (Figure 31)

Based on the predicted concentrations from the model it is evident that that the construction activities will result in particulate emissions from the site clearance and earthworks. Although such activities will be for a short-term, they are likely to reach a local level even with mitigation measures in place, resulting in an overall medium impact on the key surrounding receptors.

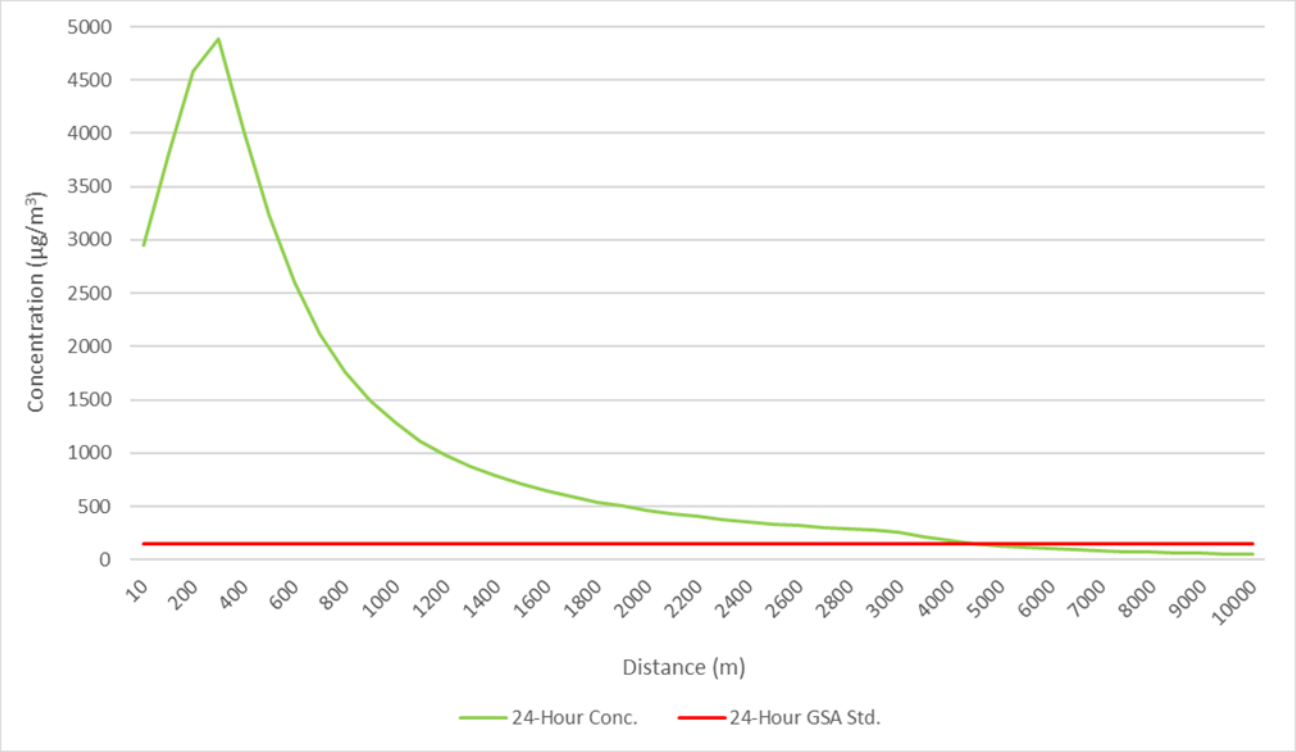

Figure 26: Predicted 24-hour TSP concentrations during the construction phase (µg/m³)

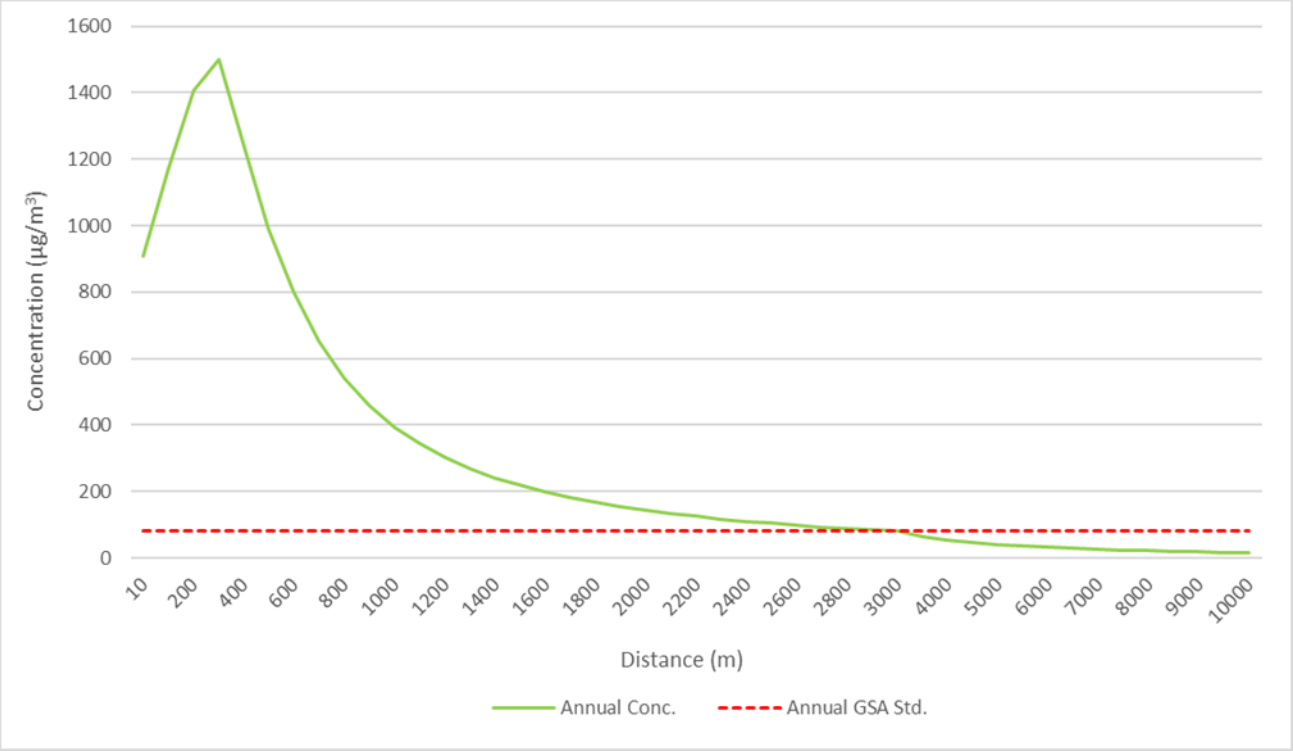

Figure 27: Predicted 24-hour TSP concentrations during the construction phase (µg/m³)

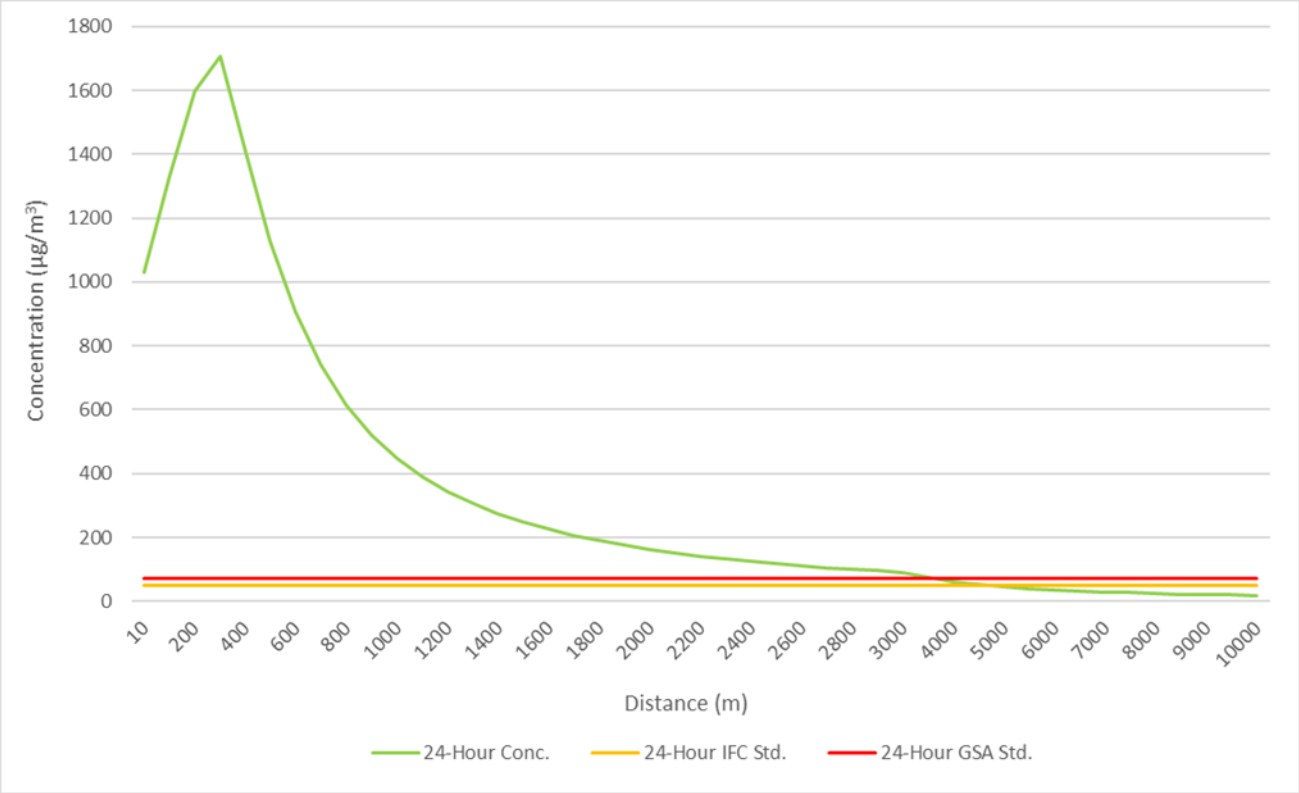

Figure 28: Predicted 24-hour PM_{10} concentrations during the construction phase (µg/m³)

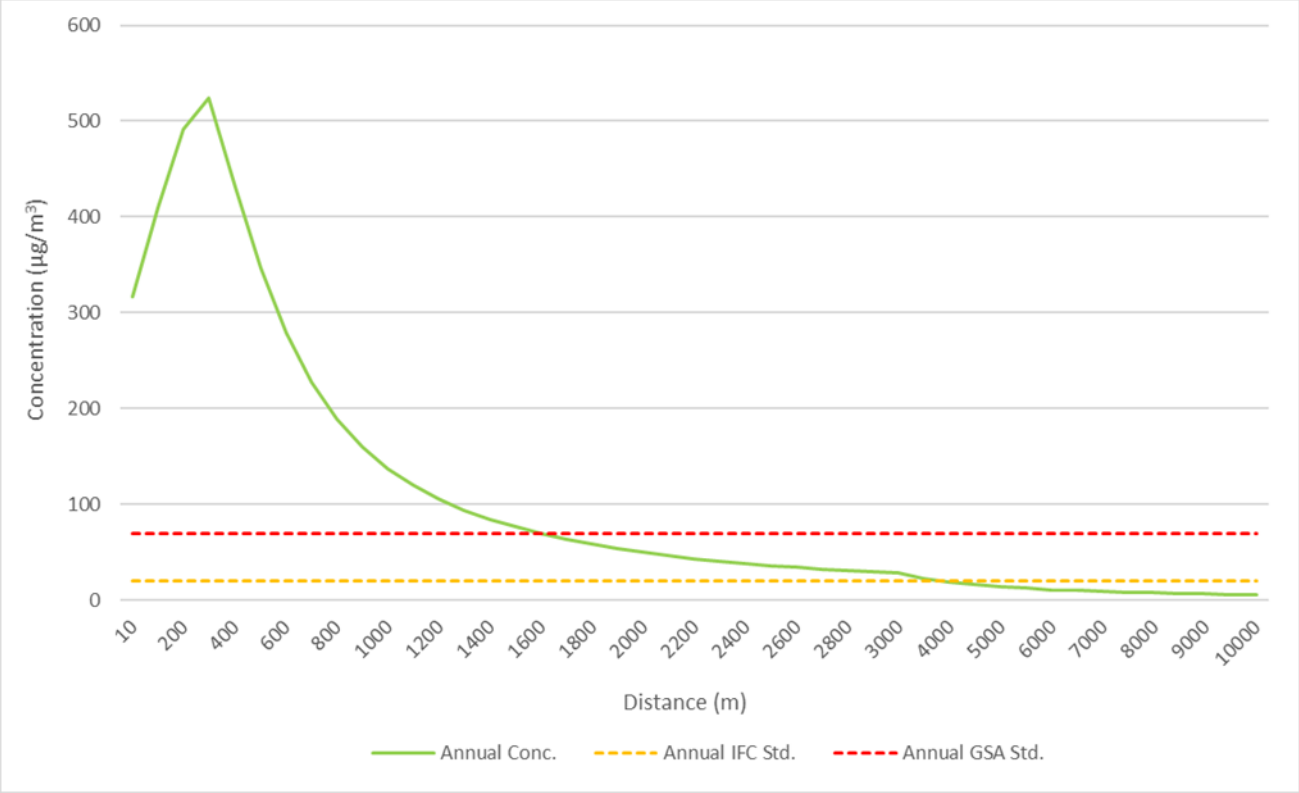

Figure 29: Predicted annual PM_{10} concentrations during the construction phase (µg/m³)

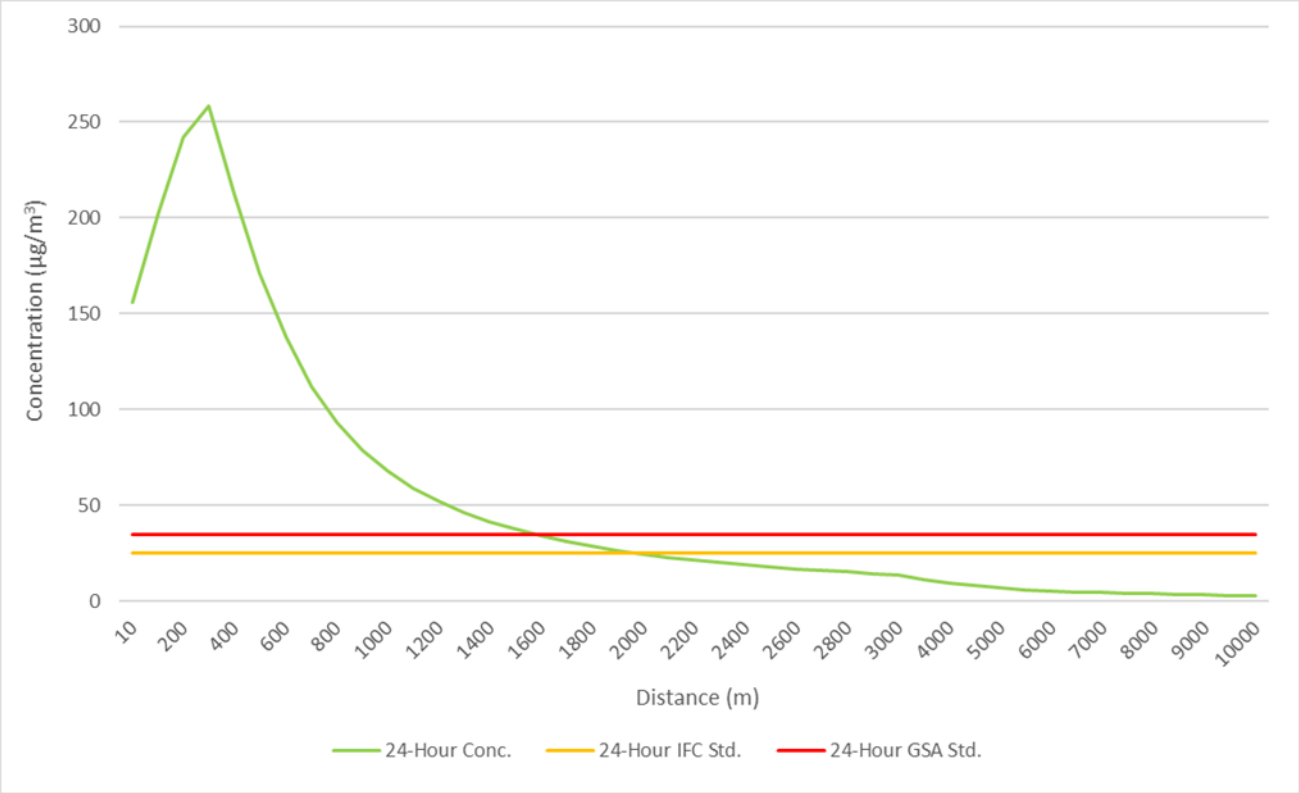

Figure 30: Predicted 24-hour $PM_{2.5}$ concentrations during the construction phase (µg/m³)

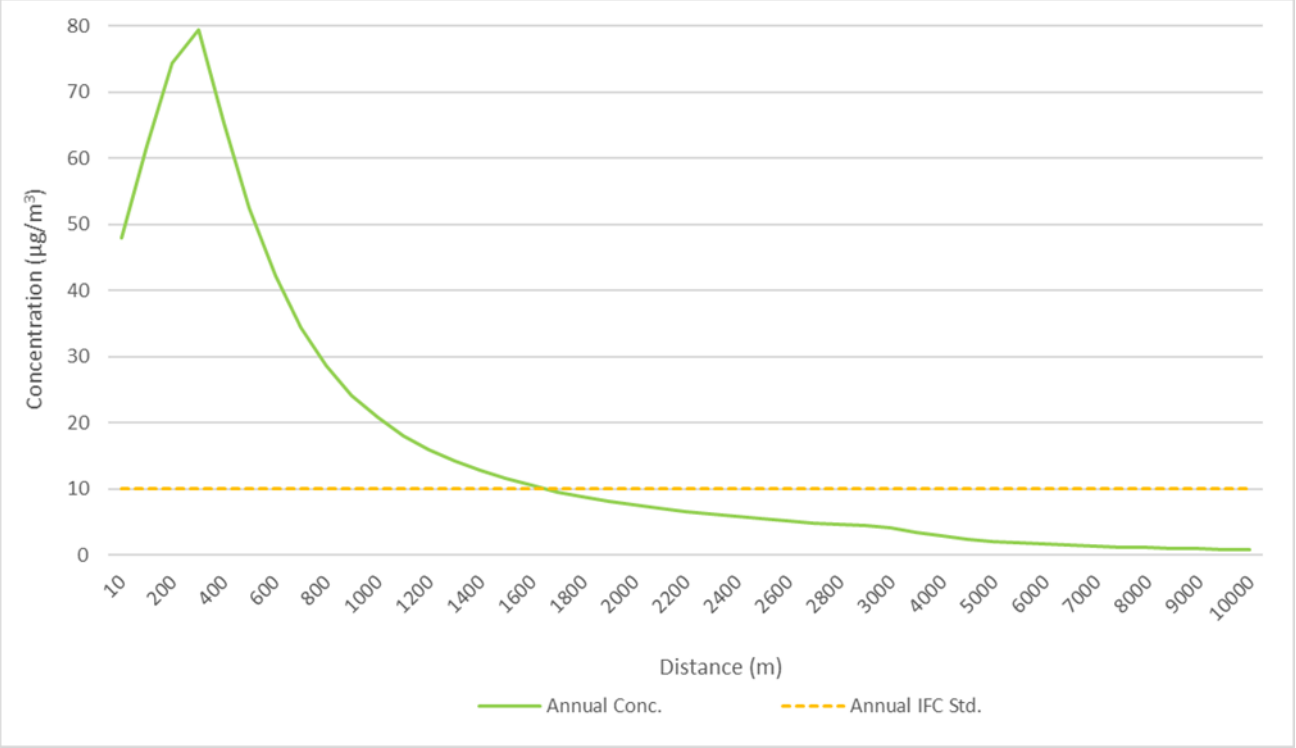

Figure 31: Predicted annual $PM_{2.5}$ concentrations during the construction phase (µg/m³)

Operational Phase Assessment

Operational activities will result in VOCs being emitted into the atmosphere however this will be minimal and as such the overall impact is anticipated to be low on the key surrounding receptors.

6.1.3 Noise

The standards considered in the assessment are the Ghana Health Protection Requirements for Ambient Noise Control (GS 1222:2018) and the IFC Environmental, Health, and Safety Guidelines for noise management (IFC, 2007). However, when the host country regulations differ from the levels and measures presented in the IFC Guidelines, projects are required to achieve whichever is more stringent. If less stringent levels or measures than those provided in the IFC Guidelines are appropriate in view of specific project circumstances, a full and detailed justification must be provided for any proposed alternatives through the environmental and social risks and impacts identification and assessment process. As such, the most stringent standards for this assessment have been used, being the IFC Residential Noise Regulations.

A semi-qualitative assessment was undertaken to assess the impacts from the construction and operational phases. This included attenuation-over-distance acoustic calculations (the equation below) to calculate the resulting sound power level (PWL), using the sound pressure level (SPL) data sourced from the British Standards Code of Practice for Noise and Vibration Control on Construction and Open Sites (BS5228-1:2009)) and the distance (r) from the source.

$$PWL = SPL - 10\,log\frac{2}{4\pi r^2}$$

Construction Phase Assessment

Increase in noise levels at sensitive receptors:

As a conservative approach the cumulative PWL of 122 dB(A) (Table 28) from all construction equipment operating concurrently was used to determine the resultant noise levels at various distances from the source (Figure 32). Noise levels below 100 m are predicted to be significantly higher. From 920 m from the source (i.e., the construction activities associated with the proposed pipeline route), noise levels will drop to below the IFC residential daytime guideline rating levels of 55 dB(A).

Predicted impacts and resultant noise levels during the daytime at the noise receivers are presented in Table 29. Results indicate that increases in noise levels (i.e., from baseline noise levels) as a result of the construction activities are above the 3 dB(A) threshold for annoyance as per the IFC Noise Regulations at receptors SR4 to SR6, SR9, SR11, SR12, SR22, SR24, SR27, SR29, SR30 and SR32 to SR37 during the day. The largest change was predicted at SR37, located approximately 140 m away from the proposed construction activities.

As such, increase in noise levels are likely to result in sporadic complaints at these receptor locations, given the proximity of these locations in relation to the proposed construction activities. The remaining noise receivers are likely to experience noise levels that will be absorbed into the existing environment.

The magnitude of the impact is moderate and although the construction activities are for a short-term, they are likely to reach a local level. The impact remains medium even with the implementation of mitigation measures.

Table 28: Construction Phase Equipment and Sound Power Level Ratings from the proposed Project

Equipment	No. in Operation (Simultaneously)	Sound Power Level (dB(A))
Excavators	1	105
Bulldozers	1	111
Graders	1	105
Compactors	1	110
Backhoe	1	95

Equipment	No. in Operation (Simultaneously)	Sound Power Level (dB(A))
Grinding and Cutting Machines	1	108
Welding Machines	1	101
Power Tools	1	105
Shovels	1	108
Spades	1	113
Wheelbarrows	1	116
Hammers	1	115
Saws	1	115
Logarithmic Total		122

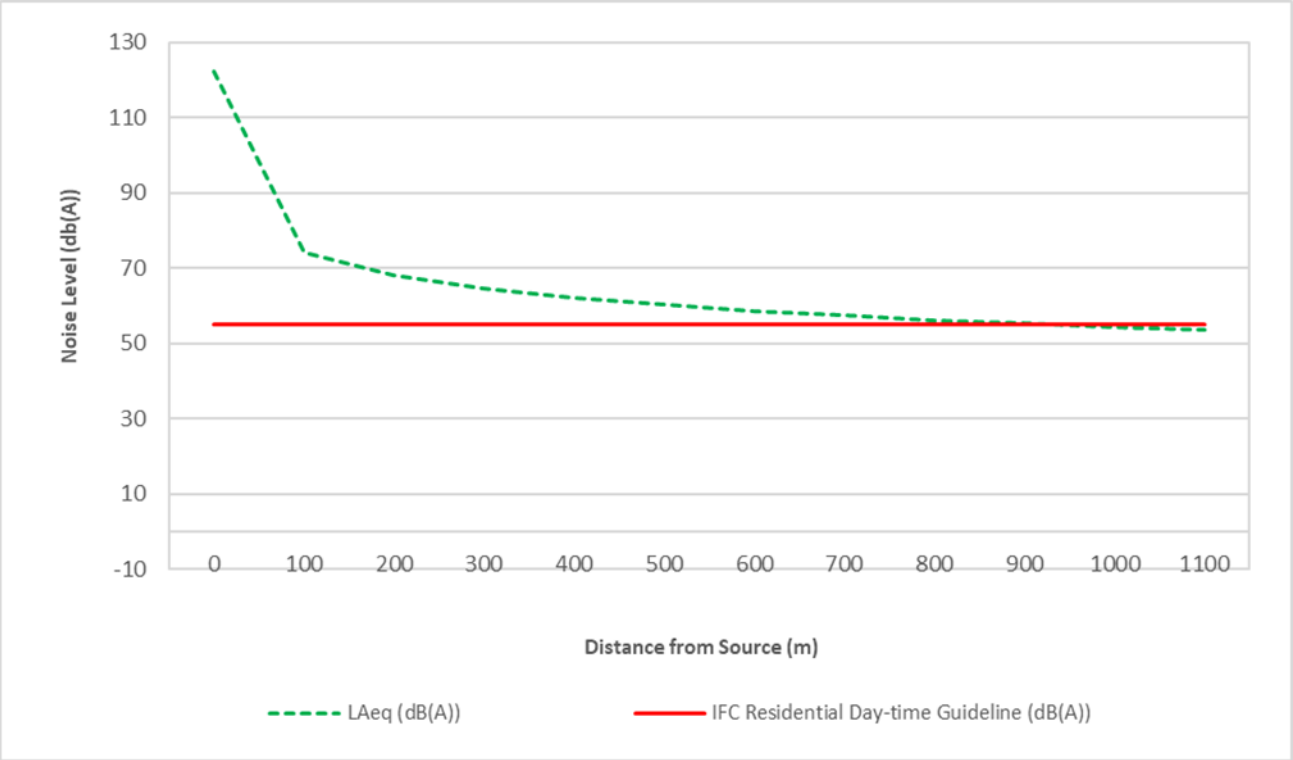

Figure 32: Predicted day-time noise levels with distance during the construction phase

Table 29: Predicted day-time noise levels at the receptors during the construction phase

Receptor ID	Distance from Pipeline Route (km)	Predicted Noise Level (dB(A))	Baseline Day-time Noise Level (dB(A))	Cumulative Noise Level (dB(A))	Change (dB(A))	Above or Below 3 db(A) Change
SR1	2.76	45.5	55.0	55.5	0.5	Below
SR2	1.84	49.0	55.0	56.0	1.0	Below
SR3	4.60	41.0	55.0	55.2	0.2	Below

Receptor ID	Distance from Pipeline Route (km)	Predicted Noise Level (dB(A))	Baseline Day-time Noise Level (dB(A))	Cumulative Noise Level (dB(A))	Change (dB(A))	Above or Below 3 db(A) Change
SR4	0.59	58.9	55.0	60.4	**5.4**	Above
SR5	0.45	61.2	55.0	62.2	**7.2**	Above
SR6	0.41	62.0	55.0	62.8	**7.8**	Above
SR7	0.97	54.6	55.0	57.8	2.8	Below
SR8	5.38	39.7	55.0	55.1	0.1	Below
SR9	0.84	55.8	55.0	58.4	**3.4**	Above
SR10	3.29	43.9	55.0	55.3	0.3	Below
SR11	0.37	62.9	55.0	63.6	**8.6**	Above
SR12	0.72	57.1	55.0	59.2	**4.2**	Above
SR13	2.69	45.7	55.0	55.5	0.5	Below
SR14	2.68	45.7	55.0	55.5	0.5	Below
SR15	1.52	50.6	55.0	56.4	1.4	Below
SR16	1.95	48.5	55.0	55.9	0.9	Below
SR17	2.42	46.6	55.0	55.6	0.6	Below
SR18	2.92	45.0	55.0	55.4	0.4	Below
SR19	1.79	49.2	55.0	56.0	1.0	Below
SR20	2.32	47.0	55.0	55.6	0.6	Below
SR21	2.13	47.7	55.0	55.7	0.7	Below
SR22	0.92	55.0	55.0	58.0	**3.0**	Above
SR23	0.95	54.7	55.0	57.9	2.9	Below
SR24	0.71	57.3	55.0	59.3	**4.3**	Above
SR25	1.13	53.2	55.0	57.2	2.2	Below
SR26	1.53	50.6	55.0	56.3	1.3	Below
SR27	0.23	67.1	55.0	67.3	**12.3**	Above
SR28	1.11	53.4	55.0	57.3	2.3	Below
SR29	0.15	70.8	55.0	70.9	**15.9**	Above
SR30	0.42	61.8	55.0	62.6	**7.6**	Above
SR31	0.94	54.8	55.0	57.9	2.9	Below

Receptor ID	Distance from Pipeline Route (km)	Predicted Noise Level (dB(A))	Baseline Day-time Noise Level (dB(A))	Cumulative Noise Level (dB(A))	Change (dB(A))	Above or Below 3 db(A) Change
SR32	0.50	60.3	55.0	61.4	**6.4**	Above
SR33	0.67	57.8	55.0	59.6	**4.6**	Above
SR34	0.74	56.9	55.0	59.1	**4.1**	Above
SR35	0.49	60.5	55.0	61.6	**6.6**	Above
SR36	0.31	64.5	55.0	64.9	**9.9**	Above
SR37	0.14	71.4	55.0	71.5	**16.5**	Above
SR38	3.09	44.5	55.0	55.4	0.4	Below
SR39	2.86	45.2	55.0	55.4	0.4	Below

Operational Phase Assessment

Increase in noise levels at sensitive receptors:

As a conservative approach the PWL of 108 dB(A) (Table 30) from each gas station was used to determine the resultant noise levels at various distances from the source (Figure 33). Noise levels below 50 m are predicted to be significantly higher. Beyond 180 m during the daytime and 560 m during the night-time from the source, noise levels will drop to below the IFC residential daytime and night-time guideline rating levels of 55 dB(A) and 45 dB(A), respectively.

Predicted impacts and resultant noise levels during the daytime and night-time at the noise receivers are presented in Table 31 and Table 32. Results during the day indicate that increases in noise levels as a result of the operational activities are well below the 3 dB(A) threshold for annoyance as per the IFC Noise Regulations, with the largest change predicted at SR11, located approximately 390 m away from the source (i.e., from the Ejisu BMS). During the night, increases in noise levels due to the operational activities are below the 3 dB(A) threshold for annoyance as per the IFC Noise Regulations, with the exception of SR11 (i.e., a change of 4.9 dB(A). This is expected, given the proximity of the receptor to the Ejisu BMS source.

As such, increase in noise levels are likely to result in sporadic complaints at the SR11 location during the night. The remaining noise receivers are likely to experience noise levels that will be absorbed into the existing environment. Overall, the impact is assessed to be low with mitigation measures implemented.

Table 30: Operational phase equipment and sound power level ratings from the proposed Project

Equipment	Distance from Pipeline Route (km)	Predicted Noise Level (dB(A))
Pipeline	1	N/A
Gas Stations	4	108
Logarithmic Total		108

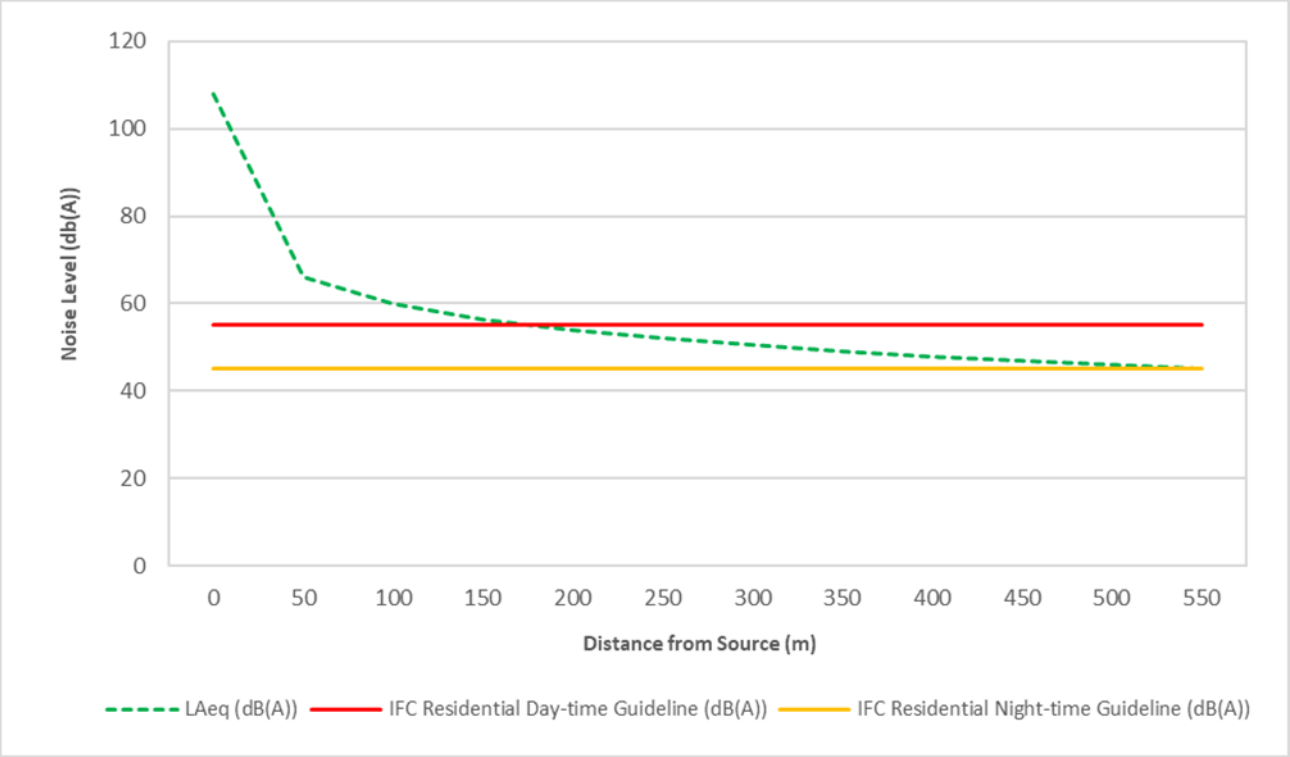

Figure 33: Predicted noise levels with distance during the operational phase

Table 31: Predicted day-time noise levels at the receptors during the operational phase

Receptor ID	Distance from BVS/BMS (km)	Predicted Noise Level (dB(A))	Baseline Day-time Noise Level (dB(A))	Cumulative Noise Level (dB(A))	Change (dB(A))	Above or Below 3 db(A) Change
Miawano BVS						
SR1	4.91	26.2	55.0	55.0	0.0	Below
SR2	3.85	28.3	55.0	55.0	0.0	Below
SR8	5.84	24.7	55.0	55.0	0.0	Below
SR21	2.70	31.4	55.0	55.0	0.0	Below
Ntinako BVS						
SR3	5.51	25.2	55.0	55.0	0.0	Below
SR15	3.21	29.9	55.0	55.0	0.0	Below
SR18	4.88	26.2	55.0	55.0	0.0	Below
SR23	2.06	33.7	55.0	55.0	0.0	Below
Adwafo BVS						
SR9	0.76	42.4	55.0	55.2	0.2	Below
SR17	3.25	29.8	55.0	55.0	0.0	Below

Receptor ID	Distance from BVS/BMS (km)	Predicted Noise Level (dB(A))	Baseline Day-time Noise Level (dB(A))	Cumulative Noise Level (dB(A))	Change (dB(A))	Above or Below 3 db(A) Change
Ejisu BMS						
SR11	0.39	48.2	55.0	55.8	0.8	Below
SR36	2.72	31.3	55.0	55.0	0.0	Below
SR37	1.96	34.2	55.0	55.0	0.0	Below

Table 32: Predicted night-time noise levels at the receptors during the operational phase

Receptor ID	Distance from BVS/BMS (km)	Predicted Noise Level (dB(A))	Baseline Day-time Noise Level (dB(A))	Cumulative Noise Level (dB(A))	Change (dB(A))	Above or Below 3 db(A) Change
Miawano BVS						
SR1	4.91	26.2	45.0	45.1	0.1	Below
SR2	3.85	28.3	45.0	45.1	0.1	Below
SR8	5.84	24.7	45.0	45.0	0.0	Below
SR21	2.70	31.4	45.0	45.2	0.2	Below
Ntinako BVS						
SR3	5.51	25.2	45.0	45.0	0.0	Below
SR15	3.21	29.9	45.0	45.1	0.1	Below
SR18	4.88	26.2	45.0	45.1	0.1	Below
SR23	2.06	33.7	45.0	45.3	0.3	Below
Adwafo BVS						
SR9	0.76	42.4	45.0	46.9	1.9	Below
SR17	3.25	29.8	45.0	45.1	0.1	Below
Ejisu BMS						
SR11	0.39	48.2	45.0	49.9	**4.9**	Above
SR36	2.72	31.3	45.0	45.2	0.2	Below
SR37	1.96	34.2	45.0	45.3	0.3	Below

6.1.4 Soil and land use

The key soil aspects that will be affected due to the project activities for the project phases are as described below.

Degradation of soil quality:

Soil is degraded when it partially or totally loses its capacity to support vegetation productivity. Land degradation means that the soil has lost the capacity to function within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water quality, and support human health and habitation. The vegetation removal and soil disturbance expected during the construction phase could result in the disruption of the nutrient cycling process in the soil, i.e., the source of organic matter (vegetation, debris) is removed with a subsequent reduction in soil biodiversity and distortion in soil aggregate stability. The magnitude of this impact is high. However, due to the localised construction activities, concurrent rehabilitation and the activities being for a short-term, could be quicker restoration of soil aggregate stability, the overall impact is anticipated to be medium.

Loss of soil as a resource:

The pipeline project will involve the excavation of soil material to enable the laying of the pipeline. It will also entail the clearance of vegetation for the construction of the BVS, BMS and camps, and these could result in the loss of soil, particularly topsoil. The geotechnical pits dug along the pipeline route show that the topsoil depths vary significantly and are between 10cm and 80cm deep. Although topsoil will be lost from the site during the construction phase, as this is a pipeline project this will be limited, and the topsoil can potentially be transferred to an alternative area and stockpiled for reuse. Therefore, during the construction phase, the significance of the impact on soil as a resource and land use is medium since the soil excavated from the pipeline trench could be reused. No further impact on the soil and land use is anticipated during the operational phase.

Land use change:

The proposed development activities will result in a change in current land use from natural forests and farmlands during the construction and operational phases. This impact is assessed to be high since operations could be for a period of over 50 years.

Soil contamination from hydrocarbon and other chemical spills and improper disposal of waste:

The contamination of soil from hydrocarbon spillages associated with machinery used for construction activities will likely occur since the machinery used rely on fuels. Contamination is anticipated to occur along the pipeline route and the areas for the BVS and BMS. Improper disposal of waste could also result in the contamination of soil. Overall, the impact is assessed to be low as it is anticipated to be limited to the site only.

Soil loss through erosion:

The soil which was initially covered with vegetation would be exposed resulting in the increased potential for soil erosion. Erosion will be more pronounced when the vegetation is removed, and the soil is left bare during the wet season. Non-vegetated soil stockpiles will be prone to wind and water erosion. Due to earthwork activities, it is anticipated that the soil characteristics controlling soil erodibility (i.e., soil organic matter content, structure, and permeability) are likely to be altered. The impact is assessed to be medium during construction phase, however, it is anticipated that the implementation of appropriate mitigation measures could minimize the effect of the impact.

Soil Compaction:

Some soil compaction is anticipated to occur across the pipeline site during the construction. Compaction of further areas of the site will occur during the operational phase when pipeline maintenance and monitoring is undertaken. Although compacted soils could be ripped after decommissioning of the site, the soils will never regain their original structure. This impact is therefore assessed to be high during the construction phase, however, it is anticipated that the implementation of appropriate mitigation measures could minimise the effect of the impact.

6.1.5 Surface Water

Construction Phase Assessment

The main construction phase activities that would impact the water resources will be the clearing of the RoW to excavate the trench for installation of the pipeline, where the pipeline crosses water courses, the diversion, and the compaction and rehabilitation thereafter. If inadequately done, erosion will occur, and sediments will be washed into water courses increasing the turbidity of the water for downstream users.

In addition, the banks and the bed of the river will be impacted due to the diversion of the streams and removal of vegetation, and instream habitat.

Diversion of the water course:

The process of diverting the water course where flowing water is present will reduce the flow for a short time where the interception method is used (Section 3.5 and Figure 4) and where the two-cofferdam method is used, the reduction of flow will be limited. Without mitigation, the magnitude of the impact may be moderate. However, the duration is expected to be short-term, and the reduced flow will be local. By implementing the interception method, the degree of the impact from the construction activities will likely be minor.

Disturbance of the surface drainage system – bed and banks of the water courses crossed:

Disturbance of the banks and beds of water courses from trench construction, laying of the pipeline, backfilling and compaction. Poor rehabilitation could lead to erosion and associated downstream sedimentation and loss of riparian habitats. The magnitude of this impact is moderate because of the area to be impacted, the impact is short-term and local. Overall, the impact is anticipated to be medium.

Contamination due to hydrocarbon spills from mechanical equipment:

The use of machines and equipment for excavation could result in the contamination of the soil and this has the potential to be washed downstream into water bodies from runoff. The magnitude of the impact is low with the duration being short term and limited to only the site. Therefore, the overall impact is low.

Operational Phase Assessment

During the operation of the pipeline, it is not expected that there could be further impacts. However, any maintenance on the pipelines could require excavation and should this be necessary, the identified impacts for the construction phase are anticipated, and the mitigation measures recommended could be relevant.

6.1.6 Biodiversity

Construction Phase Assessment

Loss/disturbance of ecosystems of concern:

The clearing of vegetation during the construction of the pipeline will result in a reduction in extent of remaining natural habitats in the LSA, including freshwater swamp of the Anhwiaso East Forest Reserve, as well as indirect impacts on the nearby protected areas such as Afram Headwaters Forest Reserve, Apamprama Forest Reserve

and Lake Basomtwe. Although these habitats may be slightly-moderately degraded, they support several flora species of conservation concern, and have potential to support fauna species such as Grey Parrot, Hooded Vulture, Bosman's Potto.

The impact of the development on vegetation would be of local extent, with a moderate magnitude given the high sensitivity of the Anhwiaso East Forest Reserve as well as nearby protected areas, and Freshwater Swamp sites (presence of species of global and national conservation concern such as *Cussonia bancoensis and Schumaniophyton problematicum*). The impact prior to implementation of mitigation measures will be low both before and after the implementation of recommended mitigation measures.

Loss of flora of Species of Conservation Concern:

The clearing of vegetation for roads and pipeline construction will lead to disturbance of the area and loss of biological diversity, including the potential loss of globally/locally rare species. Increased human presence can lead to poaching, illegal plant harvesting and other forms of disturbance such as fire. The impact of the development on vegetation/flora SoCC would however be of a local extent, with a moderate magnitude given the presence of species of global and national conservation concern such as *C. bancoensis* and *S. problematicum*.

The impact is assessed to be long-term as most cleared areas are required for the pipeline and other infrastructure and some areas expected to be rehabilitated. Hence, the loss of vegetation and flora Species of Conservation Concern (SoCC) due to the clearing of vegetation, is anticipated to be of moderate without mitigation measures as the loss of vegetation is definite during construction. However, with the successful implementation of the required mitigation measures the impact to flora SoCC can be reduced.

Disturbance/contamination of aquatic ecosystems during pipeline construction:

Buried pipelines crossing rivers and wetlands could obstruct surface water flow during construction if trench and/or temporary river/stream diversions are necessary. The impact to these systems is mainly due to the disruption of vegetation and soils by heavy machinery, particularly when tracked vehicles are used that have greater impact on soil structure and from earthworks. Disruption of flows and ecosystem composition may also occur if backfill material imported into the rivers or wetland areas being crossed, to provide stability for excavators and pipe layers, are not completely removed and replaced with the natural soils after construction.

The geographical extent of the impact will be local, and the impact duration will be short-term, because impacts are expected to last as long as it takes the pipeline crossing to be constructed. The magnitude of the impact will be low because, although temporary changes to riparian habitat structure in areas crossed by the pipeline are likely, which could result in edge effects, changed flow regimes, and erosion and sedimentation of affected wetlands, the extent of the area affected will be relatively small. Therefore, a moderate impact on aquatic ecosystems is expected, pre-mitigation.

Erosion due to vegetation clearance:

Vegetation clearing and soil disturbance will lead to an increase in exposed soils, which may leave the disturbed areas vulnerable to erosion. This may impact downstream wetland and riparian habitats if a lot of fine particulate matter or sediment enter the environment. In addition, the construction of many hard surface areas for roads, laydowns, etc. will generate runoffs which could also increase erosion potential of surrounding areas. Although most parts of the site contain a high proportion of grass within the vegetation and grasses which should in most instances help to prevent erosion in areas receiving runoff, the impact of erosion, particularly during heavy rains, remains.

Given the above, impacts associated with erosion will be of local extent, short term duration and of a medium magnitude. The overall impact is anticipated to be low before and after the implementation of recommended mitigation measures. Although the impact is low without mitigation, it is still highly recommended that mitigation measures are implemented successfully as construction of the pipeline could have indirect and cumulative impacts on the surrounding environment.

Increased dust deposition into the receiving environment:

The clearing of vegetation for roads and pipeline construction during the construction phase could result in the release of fine particulate matter which is likely to settle on plant surfaces as dust. The particles could impair respiration by blocking the stomata through which gaseous exchange occur. Furthermore, the particles reduce the surface area available for chlorophyll to trap solar energy for photosynthesis. Although inefficiencies in respiration and photosynthesis can result in weakening and death of plants, the impact intensity of this impact is considered low. Moreover, microorganisms and fauna that survive on such plant leaves will be displaced. There is also the likelihood of changing the visual morphology of plants in the project footprint.

However, this is a temporal impact which could be reversed by rainfall if excavation activities cease, therefore, the impact is assessed to have a short-term duration, with local extent and moderate magnitude. The overall impact is low before and after the implementation of mitigation measures.

Introduction of alien and invasive species:

During the construction phase, the introduction of exotic vegetation or the invasion of disturbed areas by exotic vegetation through either a physical vector (e.g., machinery, vehicles etc.) or dispersion vectors (e.g., wind, birds) could occur.

For ecosystems of concern and associated flora SoCC, the impact magnitude could be moderate prior to mitigation, potentially extending beyond the site into the local extent and would likely persist for the duration of the construction and operation activities. The impact is anticipated to be high prior to the implementation of mitigation measures. With the application of recommended mitigation measures, the magnitude of the potential impacts could be reduced, ensuring a residual impact of low environmental significance.

Loss and disturbance of fauna of SoCC:

Vegetation clearance for construction of the project infrastructure could result in the loss of habitat for species of conservation concern and could cause fatalities to individual species of concern, particularly mammals and herpetofauna; injuries or mortalities of fauna species could also be sustained from collisions with vehicles travelling in the construction area. In addition, indirect effects due to the presence of people and heavy machinery, associated noise and vibration, and site lighting at night, could impact faunal SoCC in unaffected habitats adjacent to the LSA. The direct construction activities as well as the indirect disturbance by people and machinery could create a barrier to movement and dispersal of faunal SoCC, particularly (ground-dwelling) mammals and herpetofauna.

The magnitude of the loss and disturbance of SoCC could be moderate. Although there is a significant fauna biodiversity along the pipeline landscape, the conservation significance was rather low, as the fauna species recorded were primarily species of least concern on the IUCN Red List with just two species making the IUCN Red list. However, care should still be taken during construction as any loss or disturbance of the few SoCC could result in impacts of moderate magnitude that would be at least long-term.

The overall impact is high given the extent of loss of species of national and international SoCC is assessed on a regional scale prior to mitigation, and the potential losses would be at least long-term. With the application of the recommended mitigation measures for employee management and prevention of hunting, the duration of

the impact could be confined to the construction phase, or short-term only, and the magnitude reduced to a medium due to the regional extent of the impact.

Habitat fragmentation and barriers to movement:

The construction of the pipeline with its RoW could potentially affect biodiversity through fragmentation during the construction phase. The pipeline habitat is already fragmented and degraded but construction of pipeline could cause further degradation. Although the pipeline and the RoW may not directly affect fauna biodiversity, consequential impacts such as edge effect could potentially affect vertebrate fauna as well as flora.

Loss of ecological connectivity is one of the likely impacts of the pipeline construction and maintenance. Disruption of ecological connectivity may adversely affect ground-moving herpetofauna species. Reptiles and amphibians are the species likely to be affected. The presence of the pipeline route may also cause some ground-moving species to change their movement patterns, which may increase their vulnerability to predation (Laurance, *et al*., 2000, Laurance, *et al*., 2006).

The construction of the pipeline and maintenance of the RoW could also affect the microclimatic conditions at some sections of the pipeline route, particularly the sections passing through relatively good conditions of the forest reserves. Adverse alteration in microclimatic conditions could affect vertebrate fauna species that are sensitive to changes in microclimatic conditions, especially amphibians (Hillers *et al.,* 2008, Laurance, *et al*., 2006).

The magnitude of this impact on fauna SoCC during construction is assessed as being moderate, as potential changes in their natural movement patterns as a result avoidance of the pipeline RoW during construction activities is considered likely. The extent of impacts would be regional, and short-term, persisting for the construction phase of the project. With the application of the recommended mitigation measures, the magnitude and extent of the impact may be reduced, resulting in a low residual impact.

Operational Phase Assessment

Increased human presence and activity:

Indirect effects due to the increased presence of people and increased access to forested areas for bush meat hunting along the RoW and access tracks are expected to affect faunal species of conservation concern occurring in the area, particularly mammal SoCC which may be targets for hunting, and SoCC that are targeted for trade, for example the Endangered African Grey Parrot (*Psittacus erithacus*). There is also a potential for increased human encroachment into the ecosystems of concern (Forest Reserves) being traversed by the pipeline, as a factor of ease of access via the cleared RoW.

The magnitude of loss and disturbance of species of conservation concern is assessed as being moderate as the current and future intensity at which bush meat hunting takes place is unknown. The extent of impacts during operation could be reginal, extending beyond the LSA and into adjacent forested areas – potentially in to the Anhwiaso East Forest Reserve. Impacts may be long-term, particularly increased human presence associated with population influx, which could persist beyond decommissioning. The impact prior to mitigation is therefore considered to be of high. Implementation of the required mitigation measures may reduce the intensity of the impact to moderate; however, the impact would still occur at a regional extent, and at best the duration of the impact could be limited to the operation phase only (medium-term), resulting in a medium impact after the implementation of mitigation measures.

Presence of the pipeline and barriers to movement:

The presence of the pipeline and the associated transformation of intact vegetation, particularly in forest reserves, is not considered likely to pose a threat to the connectivity of the landscape and the ability of fauna

and flora to respond to environmental change, since the pipeline will be buried. Assuming that the pipeline RoW will not be fenced to prevent human/faunal access, the magnitude of potential effects on species of conservation concern during operation is assessed as being low. The extent of impacts would be local, and impact will be long-term, persisting for the operational lifetime of the project. The impact is therefore considered to be low before and after mitigation.

Impact on flora during maintenance activities:

Maintenance activities such as vegetation clearing will impact the biodiversity of the site if not conducted in a sensitive manner. This is a site-specific impact with long-term duration and a moderate magnitude. The intensity is rated as medium before mitigation since it involves the possible loss of species and habitats. The impact can be reduced to a low given that the mitigation measures are implemented and the fact that the lost species can be replaced through replanting.

6.1.7 Socio-economic

The socio-economic impacts anticipated for the project phases are as described below.

Change in land use:

The proposed pipeline will lead to a change in land-use within the local area. Land-use changes refer to actual or perceived changes in land-use, whether temporary or permanent. The assessment of a land-use change process from a social perspective considers how the proposed pipeline might affect the behaviour or livelihood of landowners and or land users.

Change in land use has the potential to affect access to environmental resources such as wood, water, medicinal plants, and forest resources. This impact is high as it expected to be for the entire duration of the project life.

There is also the issue of food insecurity because livelihood assets will be reduced through the reduction in access to lands, food production by the farmers will reduced and this is likely to threaten the food system in the project area. The impact will be short-lived if the appropriate livelihood interventions are implemented.

The project will also result in limited access to farm-based activities. Land resources that could have been used to undertake other developmental projects may be limited. Community members may also be denied the right their lands. This impact is expected to be high as it is permanent loss and will persist for the entire project lite. It is anticipated that all compensation processes would be completed by GEGL prior to project implementation.

Demographic changes:

Already, there is pressure on the available infrastructure, public facilities, housing stock, and other amenities in the project area. Additionally, construction activities of the pipeline project could lead to a change in the number, and composition of the population within the affected local area, which in turn could lead to economic, land-use, and socio-cultural change processes. The anticipated population growth may be influenced by the following:

- Speculative migration of labour by job seekers
- GEGL camps to be established along the pipeline route
- Some temporary construction workers may opt to stay in the communities after the expiry of their contracts with GEGL

Land Acquisition and Compensation:

The immediate geographical area of influence of the project is about 105km long and 12m wide of land area. The minimum working belt required for construction activities is 12m. As a result, the pipeline will be built using

a 12m working belt. Accordingly, only crops within a 12m belt will be destroyed and compensated for. However, we are engaging farmers with farmlands beyond the 12m working belt up to 25m to ensure that only shallow-rooted crops are cultivated in order to avoid future interference of these crops with the buried pipeline. Thus, the RoW width for the pipeline will be 12m.

- The most likely impact of acquiring the proposed RoW width is an agreement on the compensation amount for the demarcated areas for pipeline installation because some farmers will be deprived of farming on part of their agricultural lands, thereby deprived of livelihoods from the crops to be destroyed. The project is expected to pay special attention to issues of livelihood. In light of this, GEGL, with the assistance of the Land Valuation Board, would ensure that the appropriate people are identified and adequately engaged in the process in order to ensure that compensation is paid to the appropriate people. As part of this EIS, GEGL's Compensation Plan and details of Project Affected Persons are provided as APPENDIX E.

Economic impacts:

Economic change processes relate to the changes brought about through employment, local businesses and general economic profiling of the area. For example, job opportunities might be created because of the construction and operation of the proposed development. Employment creates a source of income, increase household assets, help boost the local economy, and reduce the rate of social vices. Details of the economic impacts are outlined in Table 33.

Table 33: Economic impacts of the project

Key issue	Impact details	Significance
Increase in employment opportunities	Unskilled labour may be needed during preconstruction and construction related activities such as bush clearance, trenching, road flagging and traffic assessment. These human efforts may be sourced from the local communities.	These are short term positive impacts and are not likely to be sustainable in the medium to long term. However, the income generated increase purchasing power and may have spill-over impact on the local economy in the long term.
	Most of the employment opportunities would be restricted to the construction phase. However, the operational phase may also generate a few employment opportunities in areas such as security, and even other supervisory, and managerial positions	These are positive impacts and are likely to be sustainable in the medium to long term.
Cost of living and local inflation	There may be a high cost of living and local inflation due to the in-migration of job seekers and workers. Local inflation may also be increased through the reduction in food baskets because of the reduction in farm-produced due to the land taken. Additionally, increase in disposable income may create a demand-pull inflation.	This impact may be severe in the short term, especially during the construction phase
Change in the commercial/ industrial focus of the community	In areas where the pipeline facilities such as BMS, BVS, and worker camps are located, community members who may have the required skills, life experiences, and contextual understanding of the project may benefit from the project. Also, some community members may be exposed to non-farm-based opportunities which can change their focus.	Impacts are expected to be long term, and positive

Key issue	Impact details	Significance
Change in access to resources that sustain livelihoods	The project will result in limited access to farm-based activities. Also, land resources that could have been used to undertake other developmental projects may be limited. Community members may also be denied the right to their lands	This impact is expected to be significant, and permanent across the entire project life

Access to basic social services:

- Increase in social amenities and other development opportunities through GEGL's corporate social responsibility interventions
- The development would create economic growth through the availability of services such as electricity
- The construction and operation will enhance more equal opportunities to resources because additional services will be provided in the energy sector. Also, opportunities will become available, and these will create the platform for diversified and equitable opportunities.

Socio-cultural impacts:

Socio-cultural change processes that are associated with the construction and operation of the proposed project include the following.

- Culture dilution by "external community members or in-migrants" due to differences in social and cultural practices.
- Impacts on social and cultural history, especially in communities with a deep sense of traditional values and customs which are interlinked with forest, and water resources, cemeteries, and other sacred places where the pipeline route and auxiliary infrastructure is likely to interfere.
- There could be conflict between community members, community members, and in-migrants, and even community members, and GEGL because of conflicting interests and developments.
- Changes in psychological, health, and safety aspects and sense of place can be a source of mental and social health.
- Incidence of accidents, crime, and insecurity. Criminal opportunists are also likely to move into the pipeline areas. This is because, considering the location of the proposed project in farmlands, it is likely that theft cases in the farmlands (such as stealing of cocoa beans and plantain) may increase.
- The proposed development route can easily facilitate access due to the unique demarcation and identification of the pipeline route. It will also ease the access to protected farmlands, forests, and natural resources which may not have been originally accessed.
- These changes can occur in relation to health and safety because of the presence of construction workers and job seekers during construction. However, they are likely to be minimal in the medium to long term, especially during the operational phase.

During construction, many trucks, cars, and equipment such as forklifts, cranes, and excavators will be in use along the pipeline route. Because the pipeline will cross major roads, construction activities may result in road diversion. This can result in increased travelling time and other traffic challenges for road users. An increase in

the movement of heavy trucks may also worsen these traffic conditions in the area. Other impacts include the following:

- Decreased safety of pedestrians and other road users
- Increase in dusty and noisy conditions

Health and social wellbeing:

- Any development which causes the migration of people has the potential to result in the spread of diseases such as HIV and AIDS, and Covid 19.
- The presence of migrant construction workers may lead to an increase in activities such as prostitution and promiscuous behaviour.
- There will be pressure on the available health facilities, especially during the construction stage, due to the likelihood of injuries and other diseases. This may worsen the already deteriorating health care delivery system, especially in the underserved communities.

Socio-environmental impacts:

- Fire and explosions - During the construction process, there could be uncontrolled fires, particularly when construction activities are undertaken in the dry season. Such fire explosions may be because of the following:
  - Poor management of highly inflammable liquids and other materials along the pipeline route. This could result in situations where for instance, bush burning is undertaken at farms closer to the pipeline route or a construction worker or even a nearby farmer smoking cigarette recklessly without much regard to fire outbreak. Other activities such as rat chasing, and alcohol breweries can also result in fire outbreaks if not well regulated and monitored.
  - Construction and digging activities can result in situations where frictional contacts of metallic objects with rocks and other materials can spark a fire, and this could explode with nearby explosives if they are available.
- Waste management - The project could result in a relatively high generation of waste discharges which may affect public health. Various types and quantities of wastes are expected to be generated during pipeline construction and operations. Solid waste generation at the project site is expected to consist mainly of office waste, domestic waste, and other waste such as plastic packaging. Leftover refuse has the potential to attract rodents, flies, and vermin, which are vectors of diseases. If not well managed, waste generated could have serious health and safety implications for the populace. This impact without the implementation of mitigation measures is high as the magnitude is moderate and will occur throughout the life of the project. It is anticipated that appropriate waste management strategies will be instituted during project implementation.

6.1.8 Traffic

Construction traffic impacts were assessed in two contexts:

- The affect the construction traffic would have on the existing public road network and
- The affect pipeline road crossings would have on traffic using the road when road traverses the road right-of-way

Traffic impacts during construction will result from the delivery and use of the by construction equipment to prepare the pipeline right-of-way, delivery of material and the commuting of construction employees to the active

construction zone. Four camps are proposed as staging areas for the project during construction. These camps are generally located about 25 km apart. Use of the camps facilitate the use of buses and larger vehicles will reduce the number of trips. At the peak of construction, approximately 300 workers will need to access the constriction zoned from the camps. Trip generation is estimated at 20 vehicle trips, including ten buses (30 workers for bus assumed) and ten construction related trucks (equipment and materials) during the start and end of the construction day. Additional trips are anticipated, including deliveries of equipment and materials during the day.

While the capacity of the roads is limited due to the number of lanes and surface conditions, the number of trips can be accommodated on the roads that provide access to the site due to the number of background trips that currently use the road network. Road use and resulting level of service will be limited due to the potential for construction workers and equipment to be coming from multiple camps and the fac that the use of roads will be temporary since construction activity and related trip generation will migrate onto other roads as the construction activity moves along the 105 km route over a ten-month timeframe.

Limited degradation of the road surface may occur due to increased use. Assuming grading occurs prior to and during construction if needed, the surface conditions can be maintained for both project and construction use.

Access to the pipeline right-of-way and back to the public right-of way has the potential to cause vehicle and pedestrian accidents due to turning movements. The construction zone signage placed in both directions along the road will reduce the potential for accidents. Similarly, the use of signage along the approaches to the camps will warn the public right-of-way users of additional traffic and turning movements into and out of the camps.

Pipeline construction across public road right-of-way crossings also has the potential to adversely affect public right-of-way users as they approach the construction zone. Many of the non-paved roads have numerous curves that prohibit the road user from seeing a significant distance down the road while traveling. These line-of-sight limitations can result in an increase in accident potential if a vehicle approaches a bend in the road with construction just beyond the line of sight. The approaches to road crossings were evaluated to determine whether limited line of sight could impose a risk to public roadway users as they approach the construction zone. The findings are summarized below:

- Crossing 1 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (300 ft+/-) NB and SB
- Crossing 2 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (300 ft+/-) NB and SB
- Crossing 3 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (<300 ft+/-) NB, poor line of site SB
- Crossing 4 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB
- Crossing 5 crosses single lane unpaved road. Single vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB
- Crossing 6 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) SB, fair line of sight NB
- Crossing 7 crosses two lane unpaved collector road. No vehicle traffic noted. Good line of sight (<300 ft+/) NB and SB
- Crossing 8 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB.

- Crossing 9 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB.
- Crossing 10 crosses two lane unpaved minor arterial road. No vehicle traffic noted. Good line of sight (<300 ft+/-) EB and WB
- Crossing 11 crosses single lane unpaved road (mine access). No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB.
- Crossing 12 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) EB and WB. Pipeline RoW parallels road RoW 500 ft +/- but does not impede development or driveways.
- Crossing 13 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Pin 9
- Crossing 14 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Pin 10
- Crossing 15 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Pin 11
- Crossing 16 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Pin 12
- Crossing 17 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (<300 ft+/-) NB and poor SB. Note crossing correlates with Pin 13
- Crossing 18 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (<300 ft+/-) NB and poor SB. Note crossing correlates with Pin 14
- Crossing 19 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Pin 15
- Crossing 20 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Pin 16
- Crossing 21 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (300 ft+/-) NB and poor SB. Note crossing correlates with Pin 17
- Crossing 22 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Pin 18
- Crossing 23 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) EB and WB.
- Crossing 24 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB.
- Crossing 25 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) EB and WB.
- Crossing 26 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Pin 21
- Crossing 27 crosses two lane paved minor arterial road. Little vehicle traffic noted. Good line of sight (>300 ft+/-) NB and fair line of sight SB. Note crossing correlates with Pin 22

- Crossing 28 crosses two lane paved minor arterial road. Some vehicle traffic noted. Poor line of sight (<300 ft+/-) EB and WB. Note crossing correlates with Pin 23 and Traffic County Station T5.
- Crossing 29 crosses single lane unpaved road. No vehicle traffic noted. Good line of sight (>300 ft+/-) NB fair line of sight SB. Note crossing correlates with Pin 24
- Crossing 30 crosses two lane paved minor arterial road. Some vehicle traffic noted. Good line of sight (>300 ft+/-) NB and SB. Note crossing correlates with Pin 25 and Traffic County Station T6
- Crossing 31 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) EB good line of sight WB.
- Crossing 32 crosses two lane paved minor arterial road. Some vehicle traffic noted. Poor line of sight (>300 ft+/-) EB and WB.
- Crossing 33 crosses two lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) EB and WB.
- Crossing 34 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (<300 ft+/-) NB, poor line of sight SB
- Crossing 35 crosses two lane paved minor arterial road. Some vehicle traffic noted. Good line of sight (>300 ft+/-) NB, poor line of sight SB. Note crossing correlates with Traffic County Station T7
- Crossing 36 crosses two lane improved minor arterial road. Some vehicle traffic noted. Fair line of sight (300 ft+/-) NB, poor line of sight SB. Note crossing correlates with Traffic County Station T8
- Crossing 37 crosses two lane unpaved minor arterial road. Some vehicle traffic noted. Good line of sight (>300 ft+/-) NB and SB. Note crossing correlates with Pin 31 and Traffic County Station T8
- Crossing 38 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) EB and WB
- Crossing 39 crosses two lane improved minor arterial road. No vehicle traffic noted. Good line of sight (>300 ft+/-) EB and WB. Note crossing correlates with Pin 35 and Traffic County Station T9
- Crossing 40 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) EB and WB
- Crossing 41 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB
- Crossing 42 crosses two lane paved minor arterial road. Little vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Traffic County Station T10

Most of the proposed pipeline crossings do not have good line of sight as the construction zone is approached, meaning vehicles that traverse the area will not see construction until close to the activity. Construction zone road postings will be required to reduce accident potential. Due to the slow speeds anticipated by vehicles that use unpaved roads, vehicle speed should not be significant. However, maintenance of traffic to include road postings at several intervals prior to the constriction activity is needed. Flagmen can be considered if traffic volume warrants. In addition, compliance with right-of-way use permits and related adopted codes and guidelines will be necessary.

It should be noted that with one 200m long exception, the pipeline right-of-way does not parallel public road right-of-way. The cross-country route proposed by GEGL inherently reduces traffic impact potential by removing construction activity from areas immediately adjacent to public right-of-way.

6.2 Impacts from Operations

It is expected that the impacts will be minor during the operation of the proposed pipeline to Kumasi. This 105km pipeline, which is buried underground, is the most efficient way to deliver natural gas to the Ameri Plant in Kumasi in an environmentally friendly manner.

Because pipelines deteriorate over time, it is expected that proper maintenance activities on the pipeline and gas stations will be carried out to ensure the complete elimination of the risk of leakage, cracking, splitting, or rapturing, which will eliminate the risk of explosion and disruption in power supply from the Ameri Plant. Measurable impacts, on the other hand, may be recorded in cases where the ground where buried pipes must be accessed in order to repair a leak or raptured section of the pipe.

Sections of the pipeline that remain above ground may be vulnerable to vandalism and accidents, raising community health and safety concerns. Furthermore, areas of the pipeline, particularly those near mining communities, may be degraded as a result of illegal mining known colloquially as galamsey. In light of this, emergency measures to address pipeline safety concerns and illegal mining encroachment will be completed and implemented to ensure adequate preparedness for all such emergency situations.

Decommissioning and closure will have little impact on the study area roadways. Construction-type equipment and trucks to haul decommissioned material will be required. Regulating and metering stations and block vales do not comprise a lot of equipment, so the numbers of construction equipment and trucks are considered minimal. The same precautions and mitigation recommended during construction are also recommended during decommissioning within and adjacent to public road right-of-way. Decommissioning of the pipeline will not incur significant impacts since almost all of the pipeline is located on an independent right-of-way and not parallel and adjacent to public road right-of-way. Decommissioning vehicles will need to exercise care when entering and exiting the pipeline-public road right-of-way intersections. Construction camps are likely to repurposed.

6.3 Cumulative Impacts

Cumulative impacts are those that will occur due to a combination of the project and other projects and activities that may result in the total impacts being greater than with the project alone. For each impact identified for the project, an analysis was performed to consider if other projects or activities ongoing in the region will contribute to the same effects present within the spatial and temporal extent associated with the project itself.

Surface water determined to potentially be subjected to cumulative impacts (currently or in the future).

6.3.1 Surface Water

The cumulative impacts to the water resources where crossings will take place, are related to increased sedimentation if erosion occurs. However, the water resources are mostly within extensively developed areas and the cumulative impacts are unlikely to be significant.

7.0 IMPACT MITIGATION

GEGL has developed several internal standards that address the measures the company intends to take to promote and manage environmental stewardship and social well-being. These standards, along with a variety of mitigation measures described herein, will guide GEGL's efforts to minimise, control, and where practicable, avoid adverse impacts during the construction, and operational phases of the project. The mitigation measures will also be implemented to maximise, where possible, the benefits associated with the project implementation. For each phase of the project, several factors were considered by GEGL in developing mitigation measures:

- What design techniques can be used to avoid the impact (e.g., interception method for river crossings)?
- What alternative methods can be used to avoid the impact?
- What methods can be used to minimise the impact (e.g., use dust suppression during construction during drier days)?
- What methods can be used to rehabilitate/repair an impact (e.g., reclaim an area after disturbance)?
- What actions can be undertaken to compensate for unavoidable impacts?
- What actions can be undertaken to ensure a positive, lasting long-term effect is realised?
- What can be done to ensure sustainable development occurs (e.g., while GEGL benefits from the project, measures will be put in place to ensure continued environmental stewardship and community well-being)?

The mitigation measures developed for the identified impacts in Chapter 5.0

7.1 Air Quality

Dust and particulate emissions to the atmosphere will be mitigated during the construction phase by the application of the following:

- Wet suppression (wet misting during material handling activities):
  - Covering or keeping construction material / stockpile heights as low as practicable to reduce their exposure to wind erosion and thus dust generation
  - Progressive rehabilitation and re-vegetation of areas when available
  - Reduction in unnecessary traffic volumes
- There will be routine inspections to identify areas of unpaved roads that are increasingly dusty. Maintenance work to be undertaken on these areas including watering, application of dust suppressants, compaction, dust removal and/or utilisation of soil aggregate
- Rigorous speed control and the institution of traffic calming measures to reduce vehicle entrainment of dust. A maximum speed limit will be set on all unpaved roads
- All equipment will be well maintained and in good working order to ensure that emissions are kept to a minimum
- The area to be disturbed will be minimised

During the operational phase, VOC emissions will be managed by:

- The pipeline and all associated fixtures will be well maintained to ensure that emissions are kept to a minimum

- A fiber optic cable will be provided beside the underground pipeline to detect leakage and rupture should they occur

No additional mitigation is proposed during the operational phase other than GIIP, which may include the mitigation measures provided for the construction phase impact.

7.2 Noise

To minimise potential noise impacts arising from the construction and operational phases of the project, the following mitigation measures will be implemented:

- The number of simultaneous activities will be minimised to as far as possible when working near a potential sensitive receptor
- Communication channels will be established between GEGL management and potential sensitive receptors, including the following information but not limited to:
  - Proposed working times
  - How long the activity is anticipated to take place
  - What is being done, or why the activity is taking place
  - Contact details of a responsible person where any complaints can be lodged should there be an issue of concern.
- A drop height policy will be implemented onsite to reduce the level of noise generation when handling materials. All equipment operators will be trained in the policy
- A maximum speed limit will be set on all unpaved roads
- A traffic management plan will be developed to optimize vehicle usage and movement
- The receipt of materials will occur during non-peak traffic hours to avoid traffic build-up and associated noise
- Equipment with the lowest possible sound power levels will be selected for the project
- Equipment will be is well maintained and fitted with the correct and appropriate noise abatement measures
- All vehicles and other equipment will be maintained and serviced regularly to ensure that the noise levels are reduced
- Vehicles will not be allowed to idle for more than 5 minutes when not in use
- A berm and/or tree screens will be provided by SR11 to minimize noise at SR11 from the source

7.3 Soil and Land Use

Degradation of soil quality and loss of soil as resource and land use change will be mitigated as follows:

- The project footprint will be minimised and areas to be disturbed will be clearly marked.
- The surface footprints will be minimised to the extent possible and heavy machinery and heavy truck access to sensitive soil areas will be restricted. Lighter machinery will be used during soil handling. Here, lighter machinery refers to machinery typically used in the agricultural industry for soil handling.
- Soil conservation measures will be implemented (e.g., segregation, proper placement and stockpiling of clean soils and overburden material for site remediation

- Disturbed areas (other than permanent disturbances such as the pipeline trench) will be restored where possible to original contours and drainage lines.
- Inform relevant personnel regarding the handling of soils and consider demarcating and indicating areas intended for stockpiling of topsoil with signage or noticeboard.
- Stockpile side slopes will be limited to 1 in 4 (or gentler where practically possible), and the top edges will be rounded.
- A runoff containment berm will be placed down-gradient of the stockpile to capture runoff, the transported soil will be allowed to settle and subsequently recovered.
- Topsoil stripped from the site will be managed as follows:
  - Stockpiled for rehabilitation
  - Irrespective of where topsoil is stockpiled, it will be reused or kept moist and vegetated as soon as possible.
  - Topsoil stockpiles will be kept low (between 3 and 5 meters tall). It is recommended that the top 50cm of soil be stripped, where the soils are deep enough, and relocated by truck along set removal paths.
  - Stripping will not occur in wet conditions.

Soil contamination by hydrocarbons and other chemical spills and improper waste disposal will be mitigated as follows:

- GEGL will observe proper handling and storage of hazardous chemicals and materials (e.g., fuel, oil, cement, concrete, etc.) as per their corresponding Safety Data Sheets.
- Vehicles and equipment will be maintained regularly, and maintenance activities will be carried out in designated facilities fitted with spillage containment, floors, and sumps to capture any fugitive oils and greases.
- Regular site inspections will be carried out for materials handling and storage.
- Detailed procedures for spills containment and soils clean-up will be developed for implementation on-site.
- Environmental inspections and auditing will be carried out.
- Wastes will be classified into streams to enable appropriate segregation, handling, transport, disposal and recycling/ reused in a manner appropriate to the waste.

Soil erosion mitigation measures include:

- Land clearance activities will be stopped during heavy rainfall.
- Access road gradients will be limited to reduce run-off-induced erosion.
- Vegetation cover will be increased upwind of cleared and exposed areas such as the RoW area.
- Closed areas such as access roads and lay down areas will be ripped, replaced with soil, and revegetated following completion of construction works.

While all development involves some soil compaction, moist soils have less resistance to compaction than dry soils do. The best approach to prevention of soil compaction is thus the avoidance of all unnecessary pressure-

inducing operations, limiting the areas of necessary pressure-inducing operations and undertaking these actions when the soil is dry.

The soil compaction mitigation measures include:

- Essential road routes will be pre-defined and clearly demarcated and adhered-to during all phases of the project to restrict soil compaction.
- Vehicles will not drive on soil when it is wet to avoid further soil compaction.
- Soils will not be stripped when they are wet.

7.4 Surface Water

Reduced flow diversion of the water courses will be mitigated by the following:

- Downstream users will be informed that river flow may be limited/changed for a short time
- Diversion of water resources will be done only once relevant authorisations have been received, climatic conditions for the proposed construction period are known, and construction materials and the pipe are at the site and ready for installation.
- The diversion will be undertaken outside of a rain event, and this will involve assessing the climatic conditions for the period of construction

Sedimentation of surface water bodies will be mitigated by the following:

- Construction will be undertaken outside a rain event as far as possible to limit erosion
- Riverbanks and bed will be rehabilitated as soon as the trench is backfilled and compacted by introducing the natural vegetation on the banks, or including gabions as needed, and replace instream habitat such as rocks and vegetation that was removed
- The trench line will be maintained to ensure erosion is limited until vegetation is re-established

Changes to the water chemistry will be mitigated by the implementation of the following measures:

- Machinery will be maintained in good working order
- Good housekeeping will be maintained at the site to ensure that any hydrocarbon spills are dealt with adequately to ensure that run-off or river flow is not contaminated, and if necessary, contaminated soil is removed for disposal at an authorised disposal site or remediated to regulatory requirement

7.5 Biodiversity

Loss/disturbance of ecosystems of concern will be mitigated by the following:

- Micro-routing of the final pipeline alignment will be undertaken to minimise its footprint as it traverses across areas of Freshwater Swamp and protected areas i.e., forest reserves; and avoid mature specimens of tree species of conservation concern.
- Protected plant species search, and rescue surveys will be done in advance of clearance of the final pipeline footprint. Where possible, protected plant specimens will be dug out and maintained in a nursery, for use in rehabilitation activities, particularly in protected areas. In addition, seeds or propagules will be harvested from indigenous species for generation of new plants in the nursery for rehabilitation activities. The nursery will be established in proximity to the construction camp to avail of water resources for the duration of plant maintenance prior to rehabilitation.

- Areas to be cleared will be demarcated prior to the commencement of vegetation clearing and keep cleared areas to a minimum.
- All construction staff will be provided with environmental awareness training to ensure that basic environmental principles are adhered to.
- The construction campsites, lay-down and other temporary storage areas will be in already disturbed habitats, such as cultivated or fallow fields and these will be clearly demarcated.
- The construction of new vehicle access tracks will be kept to the barest minimum and the use of existing roads/tracks will be encouraged. Track routes will be selected in such a way as to minimize any damage to natural habitats.
- Vegetation clearance will be done via mechanical means and the use of herbicides will be restricted.
- Removal of stream bank vegetation will be avoided as much as possible.
- Cutting of trees will be done by a certified timber contractor, and strictly in line with the prescribed safety guidelines. The landing area of falling trees will be carefully selected to minimize damage to farms. Adequate warning will be given to ensure that public safety is not compromised.
- Active revegetation of freshwater swamp areas and other areas of natural habitat will be undertaken to rehabilitate the vegetation cover in areas where construction activity have taken place (i.e., pipeline footprint, laydown aeras, temporary access routes).
- Direct and indirect losses of natural and critical habitats will be quantified once the final pipeline alignment is determined, and offsetting via compensation or other conservation actions that ensure that no net loss is sustained, in accordance with lender's requirements.
- Rehabilitation of affected vegetation communities/bare areas following completion of construction work will be implemented.
- A Biodiversity Management Plan will be developed for project implementation.

Loss of flora of SoCC will be mitigated by the following:

- Wherever possible, micro-routing of the final pipeline alignment will be undertaken to minimise impact on SoCC.
- A pre-construction walk-down of planned clearing/development footprints will be undertaken to identify species of concern that can be translocated if necessary.
- Flora SoCC within the development footprint that require relocation will be demarcated and labelled .
- No flora SoCC will be translocated or disturbed without the permission of the Environmental Manager, and appropriate permits in place.
- Collection of propagules including seeds, cuttings and seedlings of species identified for specific conservation actions will be conducted to preserve genetic diversity of SoCC. These will be cultivated in a nursery and replanted in areas of the Study Area that are proposed for rehabilitation
- The nursery will be established in proximity to the construction camp to avail of water resources for the duration of plant maintenance prior to rehabilitation. It will include suitable shaded areas for growth of seedling plants and will be built and run under the supervision of an appropriately experienced horticulturalist.

- Rehabilitation of affected vegetation communities/bare areas following completion of construction work will be implemented.
- A Biodiversity Management Plan will be developed for project implementation

Disturbance/contamination of aquatic ecosystems during pipeline construction will be mitigated by the following:

- An aquatic ecosystem baseline assessment will be undertaken prior to construction, for use as a baseline to monitor any construction impacts on aquatic communities downstream of the pipeline crossing
- A detailed construction method statement will be developed for river and wetland crossings, defining the requirements to contain construction equipment within the construction footprint, to minimise compaction of wetland soils, to reinstate any clay layers and replace soils in the correct order and to return the wetland to the same profile that existed before construction
- The construction footprint across aquatic ecosystems will be demarcated to prevent inadvertent damage outside of this footprint
- Riparian/wetland vegetation clearance will be minimised for the pipeline crossing to the smallest possible footprint
- If possible, directional drilling will be used beneath aquatic ecosystems for the construction of pipelines
- Access to personnel outside of the defined project work sites and access roads will be prohibited. Personnel will be trained to understand the sensitivity of the local environment in induction and during toolbox meetings
- Erosion protection measures will be in place during construction to minimise runoff from disturbed areas into aquatic ecosystems
- Ensure that All vehicles and machinery will be maintained in sound mechanical order, do not have any oil leaks and are fitted with appropriate mufflers to minimise nuisance affecting wildlife
- Pumps, generators, or other equipment containing oil used to manage water at the aquatic ecosystem crossings will be located on impervious plastic sheeting or drip trays
- Refueling of equipment within 100 m of an aquatic ecosystem will be prohibited
- The use of backfill intended to provide firm footing for vehicles in wetlands will be minimized. Measures to ensure that diffuse flow of water in aquatic ecosystem being crossed is maintained will be implemented.
- Mechanical weed control will be used instead of chemical weed control wherever possible
- The use of chemicals in the control of pests, rodents, snakes etc. around the project site and settlement areas will be avoided
- In situations where chemical control is inevitable, spot application strategy in chemical application will be adopted instead of the broadcast method in other to minimize exposure to non-targeted plants and animals.
- A Biodiversity Management Plan will be developed for project implementation

Erosion due to vegetation clearance will be mitigated by the following:

- A rehabilitation and re-vegetation plan will be developed prior to construction, and will include provision for monitoring for and managing incidences of erosion
- Regular monitoring of the site during construction for issues with erosion will be undertaken

- Construction activities will be undertaken during the dry season, when the soil moisture is low, and the risk of damaging/compacting soils is lowest
- Topsoil should be removed and stored separately and will be reapplied in the pipeline construction footprint as soon as possible to encourage and facilitate rapid regeneration of the natural vegetation on cleared areas
- Revegetation of exposed areas will be undertaken following completion of construction activities.
- Dust suppression methods such as use of the water bowser should be implemented in and around the construction site regularly, particularly during the dry season

Introduction of alien and invasive species will be mitigated by the following measures:

- A project-specific alien invasive management plan will be developed and implemented on-site during all phases of the project. The plan will include provision for:
  - Identification of all alien invasive species observed on-site with emphasis on particularly aggressive species
  - Identification of priority areas of alien invasive species control
  - Species specific control methods
  - Alien invasive species monitoring and roll-out of follow-up treatments
- Only plants and seeds collected on-site from locally occurring indigenous flora species will be used for revegetation/rehabilitation of construction-affected areas.

Loss and disturbance of fauna of SoCC will be mitigated by the following:

- Undertaking targeted surveys of the Anhwiaso East Forest Reserve as well as Afram headwaters, Apamprama Forest Reserve and lake Bosomtwe to confirm the presence and abundance of the globally and nationally protected species. Based on these surveys, it will be determined whether these forest reserves will be categorized as critical habitat
- Access to personnel outside of the defined project work sites and access roads will be prohibited. This will reduce disturbance associated with construction activity (presence of people and heavy machinery), to faunal species of conservation concern – particularly in the protected areas
- Personnel will be trained to understand the sensitivity of the local environment in induction and during toolbox meetings. Hunting activity by construction staff will be prohibited
- Targeted searches for less mobile fauna species of conservation concern confirmed or with high probability of occurring within the Project footprint (e.g., Bosman's potto) will be conducted prior to commencement of clearance activities to allow conservation trapping and relocation to take place and avoid mortalities of these species
- Conservation trapping and relocation of fauna will only take place under the guidance of the national nature conservation authority, and with the appropriate permits in place. This process will be initiated timeously to avoid construction schedule delays, should the presence of fauna species requiring conservation/relocation become apparent.
- Measures to minimise impacts arising from sensory disturbance caused by human presence and mechanical noise generated during construction activity will be implemented, particularly for the highway diversion works. These will include restrictions in operating hours for heavy machinery, use of low-pitched

reverse alerts, and restriction of access for road construction workers to areas beyond the road upgrade right of way.

- Speed limit within the construction footprint will be restricted, particularly in areas adjacent or within protected area (i.e., Anhwiaso East Forest Reserve, Afram headwaters Forest Reserve, Apamprama Forest Reserve, and lake Basomtwe).
- An ecological clerk of works should be employed by GEGL to supervise clearance and construction works and stop work where necessary (e.g., a breeding/nesting site of a species of conservation concern is discovered) so that the appropriate conservation measures can be undertaken.
- A Biodiversity Management Plan will be developed for project implementation

Habitat fragmentation and barriers to movement will be mitigated by the following:

- Habitat restoration through active revegetation will be undertaken to restore habitat connectivity
- Reduced impact clearing and construction techniques will be adopted and where possible such areas will be avoided
- Rehabilitation through planting of appropriate plant community will enhance connectivity and prevent potential invasion of pioneer invasive species
- Rehabilitation of such areas will emphasize the use of species of the characteristic flora community
- A Biodiversity Management Plan will be developed for project implementation

Increased human presence and activity will be mitigated as follows:

- GEGL will enforce a complete ban on wildlife harvesting (hunting/trapping/fishing) for all project personnel, including any such activities by any person with access to the pipeline servitude during operation
- Worker and community education programs, which focus on the impacts and risks of bush meat hunting and consumption (e.g., diseases like Ebola and the current novel COVID-19) will be developed to contribute to the alleviation of hunting pressure on fauna species and reduce local people's reliance on consumption of bush meat, and the associated health risks
- An Influx Management Plan for the project will be considered to manage access control, prevent unplanned growth in housing development near the pipeline route, at the same time reducing pressure on ecosystems of concern and associated species for provision of natural resources
- There will be awareness creation and sensitization notices of existing statutory access restrictions for forest reserves
- To restrict use of the servitude as an access corridor into forested areas, a physical barrier (trench or earthen berm) will be placed across the pipeline servitude at the points at which it enters/exits the protected areas.

The RoW will not be fenced-off during operation to minimize hindrances to the movement of fauna and flora species within the RoW.

Impact on flora during maintenance activities will be mitigated as follows:

- The use of chemical herbicides during vegetation clearance will be avoided
- Invasive alien species will be uprooted and burnt once spotted

- Native rare plants will be replanted in buffer zones to prevent extinction
- All vegetation clearance will be done manually/mechanically

7.6 Socio-Economic

Based on the social impacts which have been identified and assessed, the following measures are proposed to be implemented to mitigate the negative impacts identified and maximise the positive impacts.

- Operations to be limited within the limits of the RoW.
- Community infrastructure and sustainable livelihood will be improved through CSR, and other interventions.
- As much as possible some community members will be employed to build their capacity which will ultimately boost the local economy.
- People from the neighbouring communities will be employed during the construction activities to avoid/minimise influx of external job seeker.
- A mechanism will be put in place to ensure that there is food supply to the construction workers to reduce food shortages in the local markets.
- GEGL will consider non-cash compensation schemes such as negotiating for increased land sizes, especially for food crop farmers who will be affected.
- There will also be prompt payment of compensations schemes.
- GEGL will honour the payment of taxes, royalties, ground rents, and other financial obligations to individuals, traditional councils, and mandated statutory bodies.
- The movement of workers between the site and the camps will be controlled to minimise loitering around the project facility by providing scheduled transportation services.
- Adequate signages will be provided along the roads to warn motorists of the construction activities taking place on site.
- All key stakeholders such as community representatives and leadership will be engaged in the planning and implementation of the project to ensure that all likely concerns, risks, and inputs are factored throughout the project cycle.

Potential fires and explosions will be mitigated by the implementation of the following measures:

- Fire extinguishers will be provided at strategic locations along the pipeline route.
- There will be frequent inspections of the pipeline route and associated facilities.
- Community members, employees, and visitors will be educated and trained on fire hazards, prevention, and use of fire equipment.
- A pipeline leak detection system will be installed on the pipeline to identify gas leaks whiles continuous monitoring will be undertaken in the control rooms.
- There will be clear demarcation, frequent clearing of the RoW and sensitisation of residents on the potential risk of hunting with fire within the RoW.

7.6.1 Customary Rites for Sacred Areas

GEGL's Policy Statement ensures that all customary and religious rites are performed as tradition demands before any activity is carried out by the company or its contractors within an affected community. Rites to pacify the gods will are performed solely by traditional leaders, in the presence of representatives from the company, its contractors, and other community members. Items typically required for the performance of these rituals include crates of eggs, sacrificial animals, schnapps and other drinks, cash, and other items as demanded by the traditional authorities for the ritual. It is believed that non-observance of rituals would thwart any activity in the area, and in some rare cases, cause retribution on workers evoked by the gods.

7.7 Traffic

Traffic impact mitigation is largely comprised of safety-related activities since the pipeline route is almost exclusively located within an independent right-of-way in rural areas. Since trip generation related to construction operations, maintenance, and decommissioning vehicles is modest, mitigation is mostly associated with the locations where the pipeline will cross public right-of-way.

- The condition of unimproved and improved unpaved roads will be assessed prior to construction commencement and grade the roads if required to ensure safe transit of construction workers, equipment, and material deliveries
- A Maintenance of Traffic Plans will be prepared for each public road crossing. Plans will be in accordance with Ghana regulations and guidelines and any other commitments made by project stakeholders
- Once the Plans are approved, a signage will be installed in accordance with the Plans prior to construction
- Flagmen will be used to control traffic where open cut of the road is planned or when line of sight is limited
- Public notice to affected communities will be provided if pipeline constriction across a road is open cut and maintenance of one lane of traffic is not possible
- For open cut crossings, steel plates will be used if construction cannot be completed in one day and flagmen and not present
- Access (ingress and egress) of the pipeline right-of-way will be located where line of sight is sufficient to minimize accident potential between construction vehicles and public right-of-way users
- Access (ingress and egress) to construction camps and construction staging areas will be located where line of sight is sufficient to minimize accident potential between construction vehicles and public right-of-way users
- Signs will be posted along public road right-of-way prior to construction camps and construction staging area access drives to warn the public of project related vehicle movements

7.8 Mitigation for Impacts from Operations

As the proposed pipeline is constructed, operated, and maintained in accordance with its design, it will achieve the goal of zero significant incidents. As a result, the 105km pipeline will be built without posing a significant risk to the public's safety. The proposed pipeline has sufficient strength and wall thickness to withstand the maximum operating pressure specified in the design. This will be confirmed during the Hydrotest phase when the pipeline's strength will be tested.

To ensure that these conditions are not violated, GEGL will implement corrective, preventive, predictive and proactive maintenance practices to troubleshoot and/or repair issues from the operation of the pipeline including leakage or rapture as soon as possible in order to prevent the occurrence of a major incident. In addition, GEGL will only use trained personnel to operate and properly carry out periodic monitoring and inspection on the pipeline RoW.

To prevent accidental damage from encroachment by farmers and galamsey operators, as well as pipeline vandalism, GEGL Operations and Maintenance team stationed in some communities will partner up with community leaders, particularly youth leaders, to patrol the pipeline on a regular basis and report any intrusion detected on the pipeline right of way. The Ghana Police Service will be called in to provide security in areas where galamsey is prevalent.

GEGL will also ensure that no farming is carried out on the pipeline's 12m width RoW and that no deep-rooted crops are planted at least 25m away from the pipeline RoW.

8.0 MONITORING PROGRAMMES

One tool that will be applied by GEGL to determine the effectiveness of its EMP is an Environmental Monitoring Programme that quantifies trends and exceedances and provides basis from which the need for further mitigation actions could be determined. The monitoring programme to be implemented for the project will adhere to sampling processes that are supported by accepted scientific methods and international standards. The programme will be designed to complement GEGL's ongoing environmental monitoring programme currently in place for the various operations.

The general objective is to determine the interaction occurring between the project activity and the environmental receptors. Specifically, the environmental monitoring programme will:

- Assist in detecting the development of impacts and thus provide a basis for determining the need for implementing appropriate mitigation measures and control measures.
- Assess the performance of the control measures implemented by GEGL and the development of appropriate corrective actions.
- Identify situations requiring intervention or additional mitigation measures.
- Provide management with information on the effectiveness of environmental management programmes.
- Demonstrate conformance to regulatory standards and international best practice.

8.1 Monitoring Assessment Criteria

The monitoring programme will establish appropriate levels of environmental protection, identify applicable criteria, establish appropriate monitoring compliance points and apportion responsibilities for implementing the programme. The programme will be assessed in accordance with the following guidelines and standards:

- Ghana Standards Authority Standards for Environment and Health Protection – Requirements for Ambient Air Quality and Point Source/Stack Emissions (GS 1236:2019)
- Ghana Standards Authority Standards for Health Protection – Requirements for Ambient Noise Control (GS 1222:2018)
- The IFC Environmental, Health, and Safety (EHS) Guidelines for noise management (IFC, 2007)
- WHO Guidelines for Community Noise (WHO, 1999)

8.2 Categories of Monitoring

The general monitoring categories include:

- **Surveillance monitoring:** Internal monitoring will be undertaken for early assessment of the performance of mitigation measures.
- **Compliance monitoring:** Environmental parameters (air quality and noise (during construction)) will be monitored to adhere to regulatory requirements.
- **Investigative monitoring:** Monitoring will be undertaken as part of a specific investigation, typically to determine the occurrence, nature and extent of possible impacts following an incident or the lodging of a grievance/complaint.

8.3 Environmental Monitoring Programme

The project monitoring programme will comprise new monitoring elements to complement the existing monitoring activities GEGL has planned for the project. The monitoring programme sets out the monitoring locations, parameters, sampling, or observation frequencies, and reporting requirements for the following aspects and Table 34 outlines the monitoring requirements for the project.

8.3.1 Air Quality Monitoring Programme

Monitoring of air quality will be carried out to ensure that any unacceptable air quality impacts can be readily detected, and timely and appropriate action can be implemented to rectify the situation.

8.3.2 Noise Monitoring Programme

Monitoring of noise levels will be carried out in line with the GS 1222:2018 and IFC Noise Regulations to ensure that any unacceptable noise impacts can be readily detected, and timely and appropriate action be undertaken to rectify the situation.

8.3.3 Surface Water Monitoring Programme

The monitoring programme for the surface water resource aspects will be an audit (photographic) at all surface water crossings of:

- Removal of diversion structures
- Rehabilitation of disturbed vegetation and habitat (on the riverbanks and in the riverbeds)

8.3.4 Biological Monitoring Programme

The first required action of monitoring will be to determine whether the mitigations measures have been implemented, and in the manner prescribed. It is therefore required that the monitoring mechanism is implemented at the commencement of the proposed project. Impact mitigating protocols will be adhered to at all stages of the project, thus, pre-clearing, during clearing and operation/maintenance. This is important as some of the mitigation measures will be implemented during the pre-clearing and clearing stages of the project.

The responsibility of the monitoring rests with GEGL and therefore GEGL will appoint qualified personnel with the requisite knowledge of the ecological and biodiversity dynamics along the pipeline and to make objective assessment of the prevailing conditions and make the appropriate recommendations. Furthermore, GEGL will ensure that all key construction workers and subcontractors receive appropriate training in relation to biodiversity issues, so that the activities do not generate impacts on biodiversity. GEGL will develop a biodiversity training protocol to train supervisors/officers to enable these officers provide support to construction workers.

8.3.5 Socio-Economic Monitoring Programme

GEGL recognises that the most efficient tool for determining the effectiveness of a Social Management Plan is the implementation of an operative Social Monitoring Programme. GEGL will therefore develop an effective system for monitoring its activities. The monitoring will provide a mechanism for checking that all intended actions are strictly implemented. It will also provide the basis to evaluate and review interventions.

GEGL is committed to social performance and compliance issues, and these will be standard items on the agenda of all management actions. In this manner, early warning signs of system failure and/or non-compliance can be recognised, the situation analysed, and the problems addressed.

8.3.6 Traffic Monitoring Programmes

Roadway level of service degradation is not expected due to the location of the project and the limited number of construction, operation and maintenance, and decommissioning vehicles required. However, traffic congestion is possible during peak use of the roads when construction across or under the road impedes traffic. A traffic monitor should be retained to observe traffic when a single lane closure is required, and flagmen cannot oversee the overall flow of traffic in both directions. A daily review of signs associated with the Maintenance of Traffic Plans should be undertaken to ensure that the required signage is in place at the beginning of the construction day.

Table 34: Environmental Monitoring Programme

Aspect	Objective	Detailed Actions	Monitoring Location	Timeframe/ Frequency	Responsibility
Air Quality					
TSP, PM_{10} and $PM_{2.5}$	To monitor air quality levels during the construction and operational phases to ensure emissions are within acceptable limits	Exceedance investigations will be conducted by the Environmental Officer when they occur, potential causes (i.e., sources), weather conditions noted, and reported in the quarterly reports. Monitoring data irregularities will be checked. Potential causes of the irregularities will be identified and recorded in a spreadsheet and such records will include equipment malfunction, human error, and environmental change.	Neighbouring sensitive receptors such as nearby residential areas away from obstructions such as trees, etc.	Quarterly campaign to undertake particulate measurements for one hour at peak times during the day (i.e., at least three one-hour periods over one day) over the construction period.	Construction Manager / Operations Manager / CCCSA / Community Coordinator
VOCs		Exceedance investigations will be conducted by the Environmental Officer when they occur, potential causes (i.e., sources), weather conditions noted, and reported in the bi-annual reports. Monitoring data irregularities will be checked. Potential causes of the irregularities will be identified and recorded in a spreadsheet and such records will include equipment malfunction, human error, and environmental change.		A once off bi-annual (i.e., a campaign during the wet and dry season each) campaign to deploy passives for a two-week period at each location, then to be collected. Should emissions show increasing concentrations, this should be undertaken on a yearly bi-annual	

Aspect	Objective	Detailed Actions	Monitoring Location	Timeframe/ Frequency	Responsibility
				basis for the project duration	
Noise					
Increased noise levels at sensitive receptors	To monitor noise levels during the construction and operational phases.	In the case of an exceedances, monitoring data irregularities will be checked. Potential causes of the irregularities will be identified and recorded in a spreadsheet and such records will include: Equipment malfunction Human error Environmental change Possible economic measures will be investigated to minimise noise (Section 7.2)	Neighbouring sensitive receptors such as nearby residential areas away from obstructions such as trees, etc.	A once off bi-annual (i.e., a campaign during the wet and dry season each) campaign for 24 hours will be conducted at each location during the construction phase During the operational phase should noise complaints arise, an annual campaign (i.e., a campaign during the dry season) for 24 hours at each location will be undertaken	Construction Manager / Operations Manager / CCCSA / Community Coordinator

8.4 Contingency Actions

Where monitoring indicates an exceedance of a criteria, a contingency action or mitigation will be implemented. The actions will depend on the severity of exceedance and will include any of the following:

- Confirming the exceedance by timely repetition of the measurement(s).
- Reviewing the exceedance against baseline data.
- Advising site management and environmental manager.
- Initiating an assessment monitoring programme by increasing monitoring frequency.
- Reporting to the EPA for advice and further action (where necessary).
- Limiting the construction time of open cut road crossings to avoid peak hour lane closures (consider night time closure if warranted in rural areas where sensitive receptors are not impacted).

8.5 Records Management

Monitoring records will be retained electronically by GEGL for the duration of the project. Quality assurance and quality control procedures will be incorporated into data collection, management, and review. Field notebooks will be retained for future reference.

9.0 PROVISIONAL ENVIRONMENTAL MANAGEMENT PLAN

This chapter presents the provisional Environmental Management Plan (EMP) which will guide GEGL's activities to reduce potential impacts on the environment during the implementation of the project. Regulation 24 (1) of LI 1652 stipulates that a person responsible for an undertaking in respect of which a preliminary environmental report or an environmental impact statement has been approved shall submit to the Agency an environmental management plan in respect of his operations within 18 months of commencement of operations and thereafter every three years. The periodic update of the EMP enables GEGL and regulatory agencies to review project activities, strategies, and systems and thereby ensure that appropriate amendments and modifications are made such that intended outcomes are realized.

The objectives of this provisional EMP are to provide management and mitigation measures that will be implemented to control the potential impacts of the project as identified in Chapter 6.0. The provisional EMP will also inform the EMP for the project. Specifically, the provisional EMP:

- Describes the environmental management measures designed to meet environmental objectives and outcomes
- Provides a framework for impact management
- Defines roles and responsibilities for environmental management

9.1 Corporate Commitments and HSE Policies

GEGL has a Mission Vision and Health, Safety and Environmental Policy to guide their operations. The policy statement is as shown in Figure 34.

GENSER ENERGY	GENSER ENERGY - GHANA OCCUPATIONAL HEALTH AND SAFETY PIPELINE PROJECT HSE MANAGEMENT PLAN	Ref. No:	GE-GHA-HSE-PRO-002
		Date	08/10/2020
		Rev.	1

ANNEX A: MISSION, VISION AND HEALTH, SAFETY AND ENVIRONMENTAL POLICY

HSE MISSION

Prevent injuries, ill health and environmental impacts by means of recognized techniques of hazard identification, assessment and control of industrial risks in the Genser Power Plants.

HSE VISION

To be leading sustainable energy solution provider in Africa with best safety, health and Environment records.

HSE POLICY:

We at Genser Energy Africa Incorporated believe that our main responsibility to provide sustainable and cost-effective energy to numerous sectors in Africa is based on the protection of the environment, health and safety of employees, contractors, clients and the community in which we operate.

In this regard, we promote a daily practiced culture in which HSE (Health, Safety and Environment) is recognized as an imperative value that forms the basis of all decision making activities. As such, we aim to fully comply with all applicable laws and relevant industry standards of practice to protect the health and safety of all who are associated with our business activities, while minimizing any adverse impact on the environment.

Baafour Asiamah-Adjei
President / CEO

Figure 34: Mission, Vision and Health, Safety and Environmental Policy

9.2 Environmental Management Structure

This section includes the structure of the team of professionals who will be responsible for the successful implementation of the provisional EMP. The Health, Safety and Environment (HSE) Department of GEGL will be responsible for implementing this plan. The organisational structure of the Pipeline Project Team is presented in Figure 35.

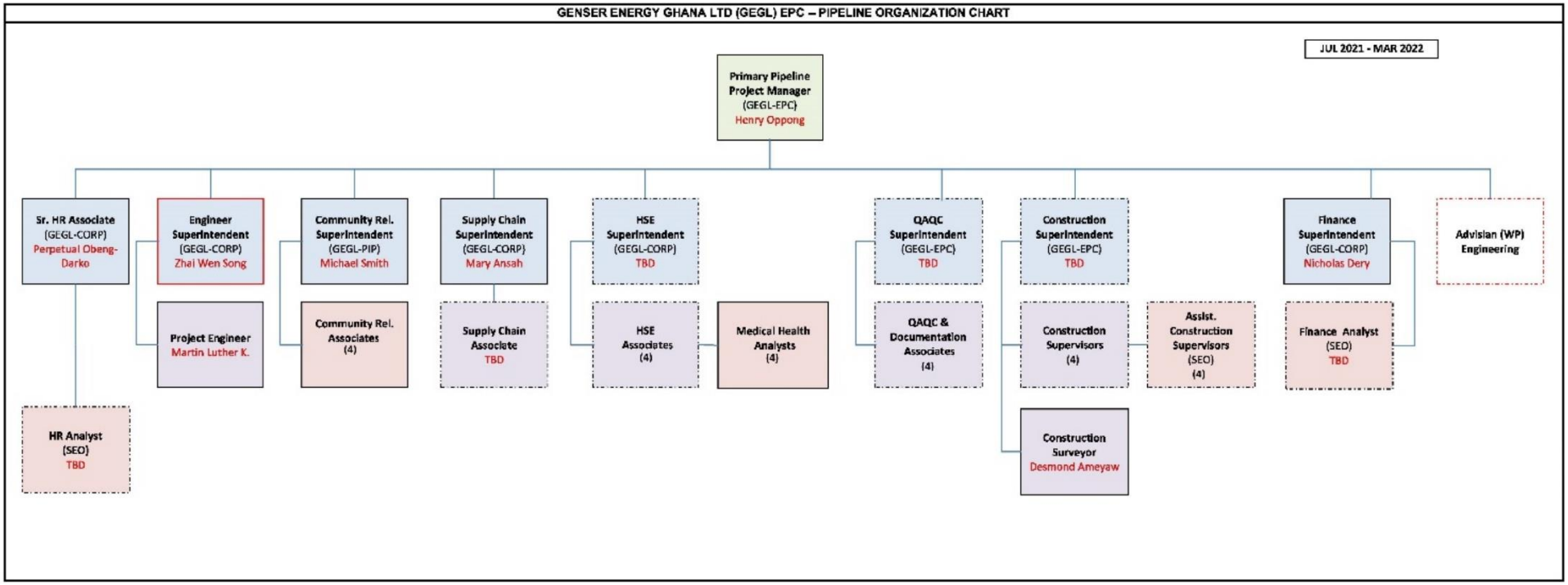

Figure 35: GEGL Pipeline Organisational Structure

9.3 Financial Allocations

GEGL recognises that the successful implementation of the provisional EMP requires the allocation of sufficient and appropriate financial resources. GEGL will ensure that sufficient funds are allocated to support the implementation of this plan as well as potential liabilities the Company may incur associated with planned activities. The resources for the implementation of the provisional EMP will be incorporated into GEGL's annual budget and operating costs for the project.

9.4 Project Overview

Details of the project infrastructure and components are provided in Chapter 3.0 of this report.

9.5 Existing Natural and Socio-Economic Environments

Details on the biophysical and socio-economic environment are provided in Chapter 4.0 of this report.

9.6 Environmental and Social Impacts and Mitigation Measures

Chapter 6.0 of this document presents the list of impacts likely to occur as a result of the proposed project and Chapter 7.0 provides recommended mitigation measures to minimise the impacts and in the case of a positive impact, to enhance the benefits.

9.7 Environmental Action Plans

Based on the potential environmental and socio-economic impacts identified in Chapter 6.0, environmental action plans have been formulated to reduce the impacts and enhance the benefits of the project. A summary of the environmental action plan is presented in Table 35.

Table 36 presents a summary of the social management plan that will be implemented by GEGL for the project.

Table 35: Environmental Management Plan

Impact	Source(s) and Activity	Action Required	Timeframe/ Frequency	Responsibility
Air quality				
Dust fallout and emissions of TSP, PM10 and PM2.5	Site clearance Earthworks Temporary storage of soil Storage of construction aggregates	Dust suppression (wet misting during material handling activities).: Covering or keeping construction material / stockpile heights as low as practicable to reduce their exposure to wind erosion and dust generation, Progressive rehabilitation and re-vegetation, Routine inspections to identify dusty/unpaved roads to inform the required maintenance work. A maximum speed of will be set on all unpaved roads. Equipment maintenance to ensure that emissions are kept to a minimum level possible, Demarcation of disturbed locations to ensure minimum land take,	Throughout the construction phase of the project	Construction Manager / Operations Manager / Community Coordinator – Community and Stakeholder Affairs / Community Coordinator
VOC/H2S	Pipeline leakage	The pipeline and all associated fixtures will be well maintained to ensure that emissions are kept to a minimum level possible, A fiber optic cable will be provided beside the underground pipeline to detect any potential leakage and rupture.	Throughout the operational phase of the project	Operations Manager / Community Coordinator – Community and Stakeholder Affairs / Community Coordinator
Noise				
Increased noise level at sensitive receptors	Earthworks Construction and installation of project infrastructure Operation of the BMS and BVS	The number of simultaneous activities will be minimised as far as possible when working near a potential sensitive receptor. Communication channels will be established between GEGL management and potential sensitive receptors, including the following information: ■ Proposed working times. ■ The anticipated duration of the activity. ■ The reason/purpose of the activity.	Throughout the construction and operational phases	Construction Manager / Operations Manager / Community Coordinator – Community and Stakeholder Affairs / Community Coordinator

Impact	Source(s) and Activity	Action Required	Timeframe/ Frequency	Responsibility
		■ Contact details of a responsible person for potential concern. A drop height policy will be implemented onsite to reduce the level of noise generation when handling materials. All equipment operators will be trained to implement the policy. A maximum speed will be set on all unpaved roads. A traffic management plan will be developed to optimize vehicle usage and movement. The transport and receipt of materials will occur during non-peak traffic hours to avoid traffic build-up and associated noise. Equipment with the lowest possible sound power levels will be selected for the project. Equipment will be is well maintained (serviced regularly) and fitted with the appropriate noise abatement device. Vehicles will not be allowed to idle for more than 5 minutes when not in use. A berm and/or tree screens will be provided at SR11 (the nearest sensitive receptor) to minimize noise at SR11 from the source.		
Soil and land use				
Degradation of soil quality	Soil stripping for pipeline trench	The surface footprints will be demarcated and minimised to the extent possible, Heavy machinery and heavy truck access to sensitive soil areas will be restricted. Soil conservation measures will be implemented (e.g., segregation, proper placement and stockpiling of clean soils and overburden material for site remediation. Disturbed areas (other than permanent disturbances such as the pipeline route) will be restored where possible to original contours and drainage lines. Soil stripping and pipelaying will not occur in wet conditions. Topsoil stripped from the site will be stockpiled for concurrent rehabilitation.	Throughout the construction phase	Construction Manager / Operations Manager / Environmental Officer
Loss of soil as a resource			During the construction phase when soil is stripped	Construction Manager / Operations Manager / Environmental Officer
Soil contamination	Hydrocarbon spillages associated with machinery used for earthworks and vehicles	GEGL will observe proper handling and storage of hazardous chemicals and materials (e.g., fuel, oil, cement, concrete.) as per their corresponding Safety Data Sheets requirement.	Throughout the construction and operational phases	Construction Manager / Operations Manager /

Impact	Source(s) and Activity	Action Required	Timeframe/ Frequency	Responsibility
	Improper disposal of waste	Vehicles and equipment will be maintained regularly, and maintenance activities will be carried out in designated facilities fitted with spillage containment, floors, and sumps to capture any fugitive oils and greases. Regular site inspections will be carried out for materials handling and storage. Detailed procedures for spills containment and soils clean-up will be developed for implementation on-site. Environmental inspections and auditing will be carried out. Wastes will be classified into streams to enable appropriate segregation, handling, transport, disposal and recycling/ reused in a manner appropriate to the waste.		Environmental Officer
Soil erosion	Vegetation clearance Temporary soil stockpiles and bare areas (unvegetated)	Land clearance activities will be stopped during heavy rainfall. Access road gradients will be limited to reduce run-off-induced erosion. Vegetation cover will be increased upwind of cleared and exposed areas such as the RoW area. Closed areas such as access roads and lay down areas will be ripped, replaced with soil, and revegetated following completion of construction works.	Throughout the construction phase	Construction Manager / Operations Manager / Environmental Officer
Surface Water				
Reduced flow	Diversion of water courses	Downstream users will be informed of limited/changed of river flow. Diversion of water resources per location will be completed within the shortest possible time and will only be done once relevant authorisations have been received, climatic conditions are known, and construction materials and the pipes are available and ready for installation. The diversion will be undertaken outside of a rain event.	Throughout the construction phase and during operations (if maintenance requires this)	Construction Manager / Operations Manager / Environmental Officer
Sedimentation of surface water bodies	Erosion due to excavation, inadequate backfilling and compaction Inadequate water course bank stabilisation	Construction will be undertaken outside a rain event as far as possible to limit erosion. Riverbanks and bed will be rehabilitated as soon as the trench is backfilled and compacted by introducing the natural vegetation or gabions as needed and replacing instream habitat such as rocks and vegetation that was removed. The trench line will be maintained to ensure erosion is limited until vegetation is re-established.	Throughout the construction. Operational phases if maintenance is required	Construction Manager / Operations Manager / Environmental Officer
Changes to surface water chemistry	Contaminated runoff from the site due to hydrocarbon spills from equipment	Machinery will be maintained in good working order. Good housekeeping will be maintained at the site to ensure hydrocarbon spills are dealt with adequately to avoid run-off and river contaminated, and if necessary,	Throughout the construction and operational phases (if	Construction Manager / Operations Manager /

Impact	Source(s) and Activity	Action Required	Timeframe/ Frequency	Responsibility
		contaminated soil is removed for disposal at an authorised disposal site or remediated to regulatory requirement.	maintenance requires this)	Environmental Officer
Biodiversity				
Loss/disturbance of ecosystems of concern	Vegetation clearance and earthworks during construction Clearing for housekeeping purposes during operations	Areas that will need to be cleared will be demarcated prior to the commencement of vegetation clearing and cleared areas will be kept to a minimum. All construction staff will be provided with environmental awareness training to ensure that basic environmental principles are adhered to. The construction campsites, laydown and other temporary storage areas are in already disturbed habitats such as cultivated or fallow fields and that these are clearly demarcated. The construction of new vehicle access tracks will be kept to the barest minimum and the use of existing roads/tracks will be encouraged. Track routes will be selected in such a way to minimise any damage to natural habitats. Vegetation clearance will be done via mechanical means and the use of the herbicides will be avoided. Direct losses of natural habitats will be quantified once the final pipeline alignment is determined and compensated for via offsetting or other conservation actions that ensure that no net loss is sustained, in accordance with lender's requirements. Affected vegetation communities/bare areas will be rehabilitated following completion of construction work. Micro-routing of the final pipeline alignment will be undertaken to minimise its footprint as it traverses across areas of Freshwater Swamp and protected areas. Removal of stream bank vegetation (e.g., bamboo) will be avoided as much as possible. Active revegetation of freshwater swamp areas and areas of natural habitat in the forest reserves including tree planting will be undertaken to reverse the decline in the vegetation cover of the project footprint. Flora SoCC within the development footprint that require relocation will be demarcated and labelled	Throughout the construction and operational phases of the project	Ecological Clerk of Works (EcoW) / Environmental Officer / Construction Manager
Loss of flora of SoCC	Vegetation clearance and earthworks		Throughout the construction and operational phases of the project	Ecological EcoW / Environmental Officer
Disturbance/contamination of aquatic ecosystems	Runoff from the site being contaminated with hydrocarbons due to spillage from equipment and vehicles	A river crossing plan has been developed for river and wetland crossings, defining the requirements to contain construction equipment within the construction footprint. The construction footprint across aquatic ecosystems will be demarcated to prevent inadvertent damage outside of this footprint. Riparian/wetland vegetation clearance will be minimised for the pipeline crossing to the smallest possible footprint.	Throughout the construction and operational phases of the project	Ecological EcoW / Environmental Officer

Impact	Source(s) and Activity	Action Required	Timeframe/ Frequency	Responsibility
	Improper waste disposal Use of chemical herbicides/ pesticides	If possible, directional drilling will be used beneath aquatic ecosystems for the construction of pipelines. Construction personnel will be trained to understand the sensitivity of the local environment in induction and during toolbox meetings. Actions to mitigate Loss/disturbance of ecosystems of concern will be applicable here.		
Introduction of alien and invasive species	Tyres of equipment and machines for construction	As much as possible only soil excavated with a specific location will be used for revegetation/rehabilitation no soil will be imported to the project site. Only plants and seeds collected on-site from locally occurring indigenous flora species will be used for revegetation/rehabilitation of construction-affected areas.	Throughout the construction and operational phases of the project	EcoW/ Environmental Officer / Construction Manager
Loss and disturbance of fauna of SoCC	Vegetation clearance	Access to project personnel outside of the defined project work sites and access roads will be prohibited. This will reduce disturbance associated with construction activity (presence of people and heavy machinery), to faunal species of conservation concern – particularly in the protected areas. Speed limit within the construction footprint will be restricted, particularly in areas adjacent or within protected area (i.e., Anhwiaso East Forest Reserve, Afram headwaters Forest Reserve, Apamprama Forest Reserve, and lake Basomtwe). Actions to mitigate loss/disturbance of ecosystems of concern, dust fallout (TSP) and increased noise level at sensitive receptors will be applicable here.	Throughout the construction and operational phases of the project	EcoW/ Environmental Officer
Habitat fragmentation and barriers to movement	Vegetation clearance	Habitat restoration through active and concurrent revegetation will be undertaken to restore habitat connectivity. Actions to mitigate loss and disturbance of ecosystems of concern will be applicable here	Throughout the construction and operational phases of the project	EcoW/ Environmental Officer
Increased human presence and activity along the RoW	Construction activity	GEGL will enforce a complete ban on wildlife harvesting (hunting/trapping/fishing) for all project personnel, including any such activities by any person with access to the pipeline servitude during operation. There will be awareness creation and sensitization notices of existing statutory access restrictions for forest reserves. To restrict use of the servitude as an access corridor into forested areas, a physical barrier (reflector tape) will be placed across the pipeline servitude at the points at which it enters/exits the protected areas.	Throughout the construction and operational phases of the project	EcoW/ Environmental Officer / HR Manager / Construction Manager

Table 36: Social Management Plan

Impact	Source(s) and Activity	Action	Timeframe/ Frequency	Responsibility
Socio-Economic				
Change in land use	Project implementation including Construction activities	Operations to be limited within the RoW GEGL will offset for land take via compensation There will also be prompt payment of compensations	During the construction phase	Environmental Officer / Community Coordinator – Community and Stakeholder Affairs / Community Coordinator
Community improvement and Employment Opportunities		As much as possible some community members will be employed to build their capacity which will ultimately boost the local economy. People from the neighbouring communities will be employed during the construction activities to avoid/minimise influx of external job seeker. GEGL will honour the payment of taxes, royalties, ground rents, and other financial obligations to individuals, traditional councils, and mandated statutory bodies. The movement of workers between the site and the camps will be controlled to minimise loitering around the project facility by providing scheduled transportation services Adequate signages will be provided along the roads to warn motorists of the construction activities taking place on site All key stakeholders such as community representatives and leadership will be engaged in the planning and implementation of the project to ensure that all likely concerns, risks, and inputs are factored throughout the project cycle		
Change in livelihoods, food security issues and economic impacts	Project implementation including Construction activities	Community infrastructure and sustainable livelihood will be improved through CSR, and other interventions. A mechanism will be put in place to ensure that there is food supply to the construction workers to reduce food shortages in the local markets		
Population influx	Influx of job seekers, and GEGL workers leading to changes in demographic characterises	GEGL employment plan will be adhered to. Community members will be employed during the construction activities to minimise influx of external job seekers. Stakeholders will be constantly engaged on issues relating to community influx.	Throughout the construction and operational phases	Community Coordinator – Community and Stakeholder Affairs /

Impact	Source(s) and Activity	Action	Timeframe/ Frequency	Responsibility
				Community Coordinator
Health, safety and wellbeing - Spread of diseases such as Covid 19, and HIV, and AIDS. Pressure on the available health facilities leading to a deterioration in the health care delivery system in the project area	Project implementation including Construction	Community members will be educated and sensitised Construction activities will be strategically planned to minimise overcrowding of workers at a particular site or community Multiple activities will be undertaken in different communities simultaneously and within a short period of time	Throughout the construction and operational phases	Community Coordinator – Community and Stakeholder Affairs / Community Coordinator
Increase in social vices such as prostitution, alcoholism, theft, and other social abhorred lifestyles	Project implementation including Construction	Community members will be educated and sensitised Construction activities will be strategically planned to minimise overcrowding of workers at a particular site or community Multiple activities will be undertaken in different communities simultaneously and within a short period of time	Throughout the construction and operational phases	Community Coordinator – Community and Stakeholder Affairs/ Community Coordinator
Potential fires and explosions	Construction and operational activities, hunting, cigarette smoking, etc.	Fire extinguishers will be provided at strategic locations along the pipeline route. There will be frequent inspections of the pipeline route and associated facilities. Community members, employees, and visitors will be educated and trained on fire hazards, prevention, and use of fire equipment A pipeline leak detection system will be installed on the pipeline to identify gas leaks whiles continuous monitoring will be undertaken in the control rooms There will be clear demarcation, frequent clearing of the RoW and sensitisation of residents on the potential risk of hunting with fire within the RoW	Throughout the construction and operational phases	Safety Manager
Traffic				
Traffic delays due to construction in road right-of-way	Pipeline right-of-way clearing, construction, repairs and replacement during operations and decommissioning	The project traffic management plan will include traffic maintenance plans to be executed and requirements will be monitored on a daily basis prior to construction commencement for the duration of construction within and adjacent to the affected right-of-way	During activity within and adjacent to RoW	Safety Manger/ Construction Manager

9.8 Monitoring Programmes

Details of the monitoring programmes to be implemented as part of the provisional EMP are provided in Chapter 8.0.

9.9 Reclamation and Decommissioning

Details of the decommissioning and closure plan to be implemented are provided in Chapter 10.0.

9.10 Contingency Plans

A detailed contingency plan outlining procedure will be employed during the project implementation. The plan will provide the basis for prevention of and response to environmental incidents. The plan includes:

- Identification of emergency situations.
- Understanding the environmental risks presented by these situations.
- Establishing preventive measures.
- Preparation and implementation of effective notification and response systems.

GEGL (2020) has a Health Safety and Management Pan for the Phase II Pipeline project, which provides emergency response directives. The plan will be revised to cater for the Phase III project.

Furthermore, GEGL (2021) has a Security Management Plan, which will be updated to cover the Phase III project.

9.11 Auditing and Review

GEGL will undertake internal and external audits as a means of establishing the effectiveness of the provisional EMP, the accuracy of the predicted impacts and mitigations, and whether the project is compliant with all legal requirements. The audits will provide insight into mitigation measures and programmes which are effective for and those which are not. It will enable the development of appropriate corrective actions and actions to further achieve the objectives of being protective of the environment and social conditions in the project area. Internal audits will be undertaken quarterly, and external audits will be undertaken annually.

10.0 RECLAMATION AND DECOMMISSIONING

Rehabilitation activities will be undertaken concurrently during the construction phase, and will include grading, seeding and planting on disturbed areas. Upon the completion of assembling processes and welding of pipes per each location, the pipe trench will be backfilled with original soil to the riverbed elevation. The cofferdam in the main channel will be removed, and the riverbed and dike outside the main channel will be restored according to the design requirements provided in Section 3.5. Meanwhile, hydraulic protection and water and soil conservation works will be carried out according to the design requirements. GEGL will complete the corresponding hydraulic protection and water and soil conservation works.

The end of the construction phase will result in the demobilization of machines and equipment from site, and rehabilitation of all remaining laydown areas not required for the operational phase.

The pipeline infrastructure has been designed to operate for 50 years and it is anticipated that this could be extended after this period. However, the facility will be decommissioned at the end of the operational phase and as a result, machines, equipment, and other logistics will be demolished from site in a form of rehabilitation. During the rehabilitation, the demolition and removal of construction materials and infrastructure and associated demolition waste from site would effectively reverse the project impacts. This is because the site would essentially be transformed into a pre-project state. Measures that will be implemented at project closure will include:

- Removal of pipeline from trench and separation of pipes
- Dismantling the BMSs and BVSs and demolition of steel stands and concrete bases
- Dismantling/demolition of related support infrastructure including gate house/access controls and fencing for BMS and BVS
- Establishing a salvage yard (expected to be an existing materials laydown area for the GEGL operations) and sorting and screening of demolition waste to recover reusable components and recyclable scrap steel and other high value items such as copper wiring
- Crushing concrete plinths and transport other demolition waste to a suitable land fill or disposal facility
- Collection of hazardous waste elements by a certified contractor for safe disposal or be disposed of at a hazardous waste site

The assumptions and qualifications related to the closure scenario and measures described above are as follows:

- Until a certain make/brand/device is delisted (proven to be non-hazardous), it is generally classified as e-waste, which is hazardous. The waste can either be disposed as hazardous waste at a hazardous waste site or collected by an e-waste company that recovers salvageable components and ensures that the remainder of the hazardous components are appropriately disposed. GEGL should request that a waste manifest and safe disposal certificate be provided by the recycler
- During dismantling and demolition specialist supervision would be required to ensure that the components are safely dismantled and disposed
- Rehabilitation of other areas that may be disturbed as part of the project will be rehabilitated during operations

A Detailed Decommissioning Plan will be developed prior to the end of the service life of the gas pipeline, where all these measures and end uses of all project infrastructure will be firmed up. During decommissioning, GEGL

will develop a programme that will satisfy its obligations and complement EPA's Environment, Health and Safety procedures associated with gas pipeline decommissioning.

In accordance with the Environmental Assessment Regulations, GEGL will submit the Decommissioning Plan to the EPA at least two years before any planned closure of the gas pipeline project as well as any associated components. There will be engagements with key stakeholders for their input into the plan. GEGL will honour all commitments made in the detailed Decommissioning Plan upon receipt of written permission from the EPA.

11.0 CONCLUSION

As part of the expansion works, GEGL is planning to construct and install a 105 km, 24" natural gas pipeline infrastructure from Gyegyetreso to Ejisu-Kumasi in the Ashanti Region of Ghana. The pipeline will connect the existing gas pipeline from the BPS at Gyegyetreso to GEGL's RMS at Ejisu- Kumasi. The pipeline development will include Natural Gas Branch and Metering Station, ~105km 24-inch natural gas pipeline and Block Valve Stations.

In compliance with the requirements of the LI 1652, GEGL is applying for an environmental permit from the EPA for the development of the pipeline and associated facilities. This Draft EIS has been completed in consideration of various technical reports (including a feasibility report), engineering designs, and environmental and social baseline data collected within the project area.

The impact assessment methodology employed subject matter specialist assessment, existing baseline condition reviews, and interpretation of data collected to inform the assessment. The assessment is presented as a narrative and combined magnitude, duration and extent of the specific impact occurring, for the project construction and operational phases. Importance was placed on social values during the impact assessment. The specialist studies focused on air quality, noise, soil and land use, surface water, biodiversity, socio-economic and traffic. The impact assessment showed that the construction and operation of the pipeline and associated facilities will have impacts that are generally site-specific and can be readily addressed through the implementation of the recommended mitigation measures.

The mitigation measures have been incorporated into the project plan to reduce or eliminate negative potential impacts on the physical, biological, and socio-economic environments. Furthermore, an ESMP has been developed for project implementation. A monitoring programme also proposed to be undertaken as part of the existing monitoring programme implemented by GEGL for their operations.

In consideration of the information, data, and analysis presented in this document, GEGL requests that EPA deems this EIS acceptable as one component of the EIA process, ultimately leading to the issuance of an environmental permit for the proposed project.

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Signature Page

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APPENDIX A

EPA letter requesting for an EIA

EIA Project Team

Table 1 - GEGL PIPELINE PROJECT EIA TEAM

Name	Contact Details	Experience	Role
Elizabeth Sarpey	Golder Associates Ghana Limited, Ghana Email: esarpey@golder.com Cell: +233 244 422 483	Environmental and social impact assessment, project management, environmental permitting and compliance	Project Manager / EIA Specialist
Brent Baxter	Golder Associates (Pty) Limited, South Africa Email: bbaxter@golder.co.za Cell:+27 11 254 4861	Environmental impact assessment, environmental management, compliance and due diligence, auditing and lender advice against international standards.	Project Director / Reviewer
Gladys Anaman	Golder Associates Ghana Limited, Ghana Email: ganaman@golder.com Cell: +233 242 279 010	Geo-environmental, planning, field investigations, data collection and interpretations	Project Coordinator / EIA Specialist
Ben Asiedu	Golder Associates Ghana Limited, Ghana Email: basiedu@golder.com Cell: +233266839266	Environmental impact assessments and environmental compliance	Ecologist
Clement Abaidoo	Golder Associates Ghana Limited, Ghana Email: cabaidoo@golder.com Cell: +233 243 001 234 / +233 270 231 000	Social impact assessment, data collection and interpretations, social management, and stakeholder engagement	Social Scientist
Lee Boyd	Golder Associates (Pty) Limited, South Africa Email: lboyd@golder.co.za Cell: +27 828 851 799	Hydrology, hydraulics, and water management systems	Hydrologist
Aisling Dower	Golder Associates (Pty) Limited, South Africa Email: adower@golder.co.za Cell: +27 79 465 0504	Designing, costing and conducting baseline flora and fauna surveys, ecosystem services assessments, and development of mitigation,	Ecologist

		compensation and offsetting measures for projects	
Novania Reddy	Golder Associates (Pty) Limited, South Africa Email: nreddy@golder.co.za Cell: +27 79 497 3460	Data collection, inventory development, compilation of air emission licence and scientific modelling (of air quality and noise) and reporting	Air Quality and Noise Specialist
Karen King	WSP (Africa), South Africa Email: Karen.king@wsp.com Cell: +27 74 129 8488	Soil and land use changes, rainfall patterns, wetlands, soils applications and trans-boundary water.	Pedologist
David de Waal	Golder Associates (Pty) Limited, South Africa Email: ddewaal@golder.co.za Cell: + 27 83 227 8681	Social due diligence for international lenders, implementation and review of social impact assessment and social baseline and related surveys, human rights assessments, integrated environmental governance and institutional conflict management	Socio-economic and stakeholder Specialist
Richard Zwolak	Golder Associates (Inc), USA Email: Richard_zwolak@golder.co.za Cell: +1 813 287 1717	Designing and implementation of traffic surveys, traffic modelling and development of traffic impact assessment and mitigation measures	Traffic Specialist
James Adomako	Independent Consultant, Ghana Email: jadomako@yahoo.com Cell: +233 544 340 346	Floral surveys using the quadrat sample, identification and ecosystem ecology	Flora Ecologist
Augustus Asamoah	Independent Consultant, Ghana Email: aasamoah@mail.com Cell: +233 244 519 719	Biodiversity, environmental conservation and	Fauna Ecologist

		tropical forest ecology and management	

APPENDIX B

BMS layout
Construction Plan for River Crossing,
Detailed PIP

APPENDIX C

Biodiversity Baseline and Impact Assessment Report

Findings of the traffic studies at each of the ten traffic count stations

Route Analysis Report

Traffic count findings are as follows:

- Crossing 1 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (300 ft+/-) NB and SB
- Crossing 2 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (300 ft+/-) NB and SB
- Crossing 3 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (<300 ft+/-) NB,
- Crossing 8 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB
- single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB.
- Crossing 10 crosses two lane unpaved minor arterial road. No vehicle traffic noted. Good line of sight (<300 ft+/-) EB and WB
- Crossing 11 crosses single lane unpaved road (mine access). No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB.
- Crossing 12 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) EB and WB. Pipeline ROW parallels road ROW 500 ft +/- but does not impede development or driveways.
- Crossing 13 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Pin 9
- Crossing 14 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Pin 10
- Crossing 15 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Pin 11
- Crossing 16 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Pin 12
- Crossing 17 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (<300 ft+/-) NB and poor SB. Note crossing correlates with Pin 13
- Crossing 18 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (<300 ft+/-) NB and poor SB. Note crossing correlates with Pin 14
- Crossing 19 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Pin 15
- Crossing 20 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Pin 16
- Crossing 21 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (300 ft+/-) NB and poor SB. Note crossing correlates with Pin 17
- Crossing 22 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Pin 18
- Crossing 23 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) EB and WB.

- Crossing 24 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB.
- Crossing 25 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) EB and WB.
- Crossing 26 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Pin 21
- Crossing 27 crosses two lane paved minor arterial road. Little vehicle traffic noted. Good line of sight (>300 ft+/-) NB and fair line of sight SB. Note crossing correlates with Pin 22
- Crossing 28 crosses two lane paved minor arterial road. Some vehicle traffic noted. Poor line of sight (<300 ft+/-) EB and WB. Note crossing correlates with Pin 23 and Traffic County Station T5.
- Crossing 29 crosses single lane unpaved road. No vehicle traffic noted. Good line of sight (>300 ft+/-) NB fair line of sight SB. Note crossing correlates with Pin 24
- Crossing 30 crosses two lane paved minor arterial road. Some vehicle traffic noted. Good line of sight (>300 ft+/-) NB and SB. Note crossing correlates with Pin 25 and Traffic County Station T6
- Crossing 31 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) EB good line of sight WB.
- Crossing 32 crosses two lane paved minor arterial road. Some vehicle traffic noted. Poor line of sight (>300 ft+/-) EB and WB.
- Crossing 33 crosses two lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) EB and WB.
- Crossing 34 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (<300 ft+/-) NB, poor line of sight SB
- Crossing 35 crosses two lane paved minor arterial road. Some vehicle traffic noted. Good line of sight (>300 ft+/-) NB, poor line of sight SB. Note crossing correlates with Traffic County Station T7
- Crossing 36 crosses two lane improved minor arterial road. Some vehicle traffic noted. Fair line of sight (300 ft+/-) NB, poor line of sight SB. Note crossing correlates with Traffic County Station T8
- Crossing 37 crosses two lane unpaved minor arterial road. Some vehicle traffic noted. Good line of sight (>300 ft+/-) NB and SB. Note crossing correlates with Pin 31 and Traffic County Station T8
- Crossing 38 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) EB and WB
- Crossing 39 crosses two lane improved minor arterial road. No vehicle traffic noted. Good line of sight (>300 ft+/-) EB and WB. Note crossing correlates with Pin 35 and Traffic County Station T9
- Crossing 40 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) EB and WB
- Crossing 41 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB
- Crossing 42 crosses two lane paved minor arterial road. Little vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB. Note crossing correlates with Traffic County Station T10

APPENDIX D

Stakeholder Engagement Report

Traffic count findings are as follows:

- Crossing 1 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (300 ft+/-) NB and SB
- Crossing 2 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (300 ft+/-) NB and SB

- Crossing 3 crosses single lane unpaved road. No vehicle traffic noted. Fair line of sight (<300 ft+/-) NB, poor line of site SB
- Crossing 4 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB
- Crossing 5 crosses single lane unpaved road. Single vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB
- Crossing 6 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) SB, fair line of sight NB
- Crossing 7 crosses two lane unpaved collector road. No vehicle traffic noted. Good line of sight (<300 ft+/-) NB and SB
- Crossing 8 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB.
- Crossing 9 crosses single lane unpaved road. No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB.
- Crossing 10 crosses two lane unpaved minor arterial road. No vehicle traffic noted. Good line of sight (<300 ft+/-) EB and WB
- Crossing 11 crosses single lane unpaved road (mine access). No vehicle traffic noted. Poor line of sight (<300 ft+/-) NB and SB.

APPENDIX E

Compensation Action Plan Compensation Details for Project Affected Persons

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