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SIENNA SERVICES

SCOPING REPORT

Environmental and Social Impact Assessment for the Accra Plains BOST Terminal - Kumasi BOST Terminal Multifuel Pipeline Project

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FOR
Bulk Oil Storage and Transportation Co. Ltd.

BULK OIL STORAGE & TRANSPORTATION COMPANY LIMITED	Front End Engineering Design (FEED) of the Accra to Kumasi Multi Liquid Fuel Pipeline Project		SIENNA SERVICES SMEC Member of the Surbana Jurong Group
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SCOPING REPORT

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Glossary of Terms & Definitions

Ambient sound: A description of the all encompassing sound at a given location and time. This includes sounds from many sources near and far.

Baseline: A reference level of existing environmental conditions against which the project is measured.

Bedrock geology: Solid rock formations underlying superficial depositis.

Biodiversity: The variety of life in the world or in a particular habitat or ecosystem.

Cathodic Protection (CP): Cathodic protection prevents or mitigates corrosion by converting all of the anodic (active) sites on the metal surface to cathodic (passive) sites. It does this by supplying sufficient electrical current from an external source. CP is commonly used to protect steel pipelines and other metallic infrastructure from corrosion.

Construction Environmental Management Plan (CEMP): A plan prepared by a contractor before the start of construction work for a project, detailing 'environmental aspects' that may be affected by the construction work and the measures to be used to prevent or control such effects. A CEMP would be expected to include methods and site management practices to be applied to prevent generation of nuisance dust, potential sources of unintentional damage to the environment, and response and reporting procedures to minimise damage in the event of a pollution incident.

Corridor: A corridor is an area where one or more pipeline routes could be designed.

Decibel (s): Between the quietest audible sound and the loudest tolerable sound there is a million to one ratio in sound pressure (measured in Pascal (Pa). Because of this wide range, a level scale called the decibel (dB) scale, based on a logarithmic ratio, is used in sound measurement. Audibility of sound covers a range of approximately 0-140 dB.

Ecosystem: Biological community of interacting organisms (e.g. plants and animals) and their environment.

Economically active: People who are either in employment or unemployed but available for employment.

Environmental Impact Assessment (EIA): An assessment of the likely effects of a development project on the environment, which is reported in an Environmental Impact Statement that is publicised and consulted on and taken into account in the decision on whether a project should proceed.

Environmental Management System (EMS): A set of processes and practices that enable an organisation to reduce its environmental impacts and increase its operating efficiency.

Greenhouse gases: Atmospheric gases such as carbon dioxide, methane, chlorofluorocarbons, nitrous oxide, ozone, and water vapour that absorb and emit infrared radiation emitted by the Earth's surface, the atmosphere and clouds.
Hazardous waste: Waste which contains substances or has properties that might make it harmful to human health or the environment.

Monitoring: A program of repetitive observation, measurement and recording of environmental variables and operational parameters over a period of time for a defined purpose. Monitoring is important to EIA, both to assess adherence to standards and commitments, and the accuracy of predictions and assumptions in the ES, and to check and to support management options.

Particulate matter: Discrete particles in ambient air, with diameters ranging between nanometers (billionths of a metre) to micrometres (millionths of a metre).

PM_{10}: PM_{10} is any particulate matter with an aerodynamic diameter equal to or less than 10 micrometres.

$PM_{2.5}$: $PM_{2.5}$ is any particulate matter with an aerodynamic diameter equal to or less than 2.5 micrometres.

Receptor: A component of the natural or built environment (such as a human being, water, air, a building or a plant) affected by an impact of the construction and/or operation of a proposed development.

Scoping: An initial stage in the environmental impact assessment process to determine the nature and potential scale of environmental effects arising as a result of a proposed development, and an assessment of what further studies are required to establish the significant environmental effects.

Soil structure: The combination or aggregation of soil particles into larger compound units (or peds) with pore spaces and channels between that allow the flow of air and water and the penetration of roots. The secondary units are characterised and classified on the basis of size, shape and degree of development.

Stakeholder: Organisations and individuals who could affect or are affected by the project, or who otherwise have an interest in the project.

Surface water: Waters including rivers, lakes, loughs, reservoirs, streams, coastal waters and estuaries.

Top soil: Upper layer of a soil profile, usually darker in colour (because of its higher organic matter content) and more fertile than subsoil, and which is a product of natural biological and environmental processes.

Acronyms

APD	Accra Plain Depot
BOST	Bulk Oil Storage and Transport Company Limited
BOD	Biochemical Oxygen Demand
BRV	Bulk Road Vehicles
CBD	Convention on Biological Diversity
CEMP	Construction Environmental Management Plan
COD	Chemical Oygen Demand
dB	Decibel(s)
EC	Energy Commission
EHS	Environmental Health and Safety
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
ESIA	Environmental and Social Impact Assessment
EIS	Environmental Impact Statement
GNPC	Ghana National Petroleun Corporation
GNFS	Ghana National Fire Service
GPS	Global Position System
GS	Ghana Standards
IEMA	Institute of Environmental Management and Assessment
IFC	International Feder
KMA	Kumasi Metropolitan Assembly
MS	Monitoring Station
NADMO	National Disaster Management Organization
NPA	National Petroleum Authority
Nox	Nitrogen Oxide
RoW	Right of Way
TDS	Total Dissolved Solids
TMA	Tema Metropolitan Assembly
TSS	Total Suspended Solids
WRC	Water Resource Commission

WHO	World Health Organization
UNFCCC	United Nations Framework Convention on Climate Change

1. Introduction

1.1 Project Background

Bulk Oil Storage and Transportation Company (BOST) is looking to construct a 265km multifuel pipeline that runs from the Accra Plains Depot at Kpone to the Terminal storage facility in Kumasi.

There is currently a network of liquid fuel storage distribution and transportation systems comprising multiple depots, pipelines (some for single fuel pumping and some for multifuel), Bulk Road Vehicle (BRV) routes and river barge routes.

Due to Ghana's prime location and political and economic stability, the country can export fuel to its neighbouring countries, such as Mali and Burkina Faso. In 2019, petroleum product export from Ghana to Mali and Burkina Faso via BRV was 292,614mt of refined products.

The current barging operations are fraught with challenges. The existing marine infrastructure and vessels are in a poor state and require maintenance to be fully and optimally operational. In addition, lake water levels fluctuate throughout the year depending on rainfall and duration of the dry seasons, leading to increased dependence on the BRVs. The Government of Ghana aims to regulate the transportation of liquid multifuel more closely, primarily by improving the integrity and reliability of the existing pipelines and depots, increasing the extent of the current pipeline network, and reducing reliance on BRVs and barges.

The Bulk Oil Storage and Transportation Company Limited (BOST) was established with the mandate of developing a network of storage tanks, pipelines, and other bulk transportation infrastructure throughout the country. It rents/leases out part of the storage facilities to generate income.

This Project entails the first step in improving the BOST pipeline network by constructing an 18-inch multifuel pipeline to the BOST terminal in Kumasi. There are currently no pipelines feeding the Kumasi terminal, and BRV's are used to transport all fuels to Kumasi. Several corridor options for the pipeline route were identified in the design planning stage. A team of engineering, environmental, and planning experts with significant stakeholders assessed these against the project objectives and guiding principles. A single preferred

corridor was selected within which the pipeline route has been identified (Figure 1). The route referred to within the scoping report is a proposed selected corridor running from Accra to Kumasi. The Project falls within the Environmental Assessment Regulation (LI 1652) and in the category of undertakings (Regulation 3) for which an Environmental Impact Assessment (EIA) is required. In line with regulation 11 of LI 1652, this scoping report is generated to guide the EIA Study.

1.2 Purpose of the Report

The Scoping Report has been prepared in accordance with Environmental Assessment Regulation (LI 1652). Scoping is an essential aspect of the environmental assessment process. It provides information on the Project and identifies where the Project may give rise to significant environmental effects. It sets out to generate the relevant terms of reference to guide the environmental impact assessment study of the Project.

The Scoping Report seeks to identify existing features along the pipeline route such as agricultural areas, cultural heritage areas, ecological protected areas and designations, climate conditions, surface and groundwater. These are term the baseline conditions. It is assumed that the future baseline prior to construction would be the same as the existing conditions.

The baseline forms the basis to assess whether there are likely to be any significant effects on those identified aspects. If any significant impact is identified, these aspects and impacts would be assessed in detail and reported in the EIA. The pipeline's route has been influenced by the desire to reduce potentially significant effects during the design development process. The route was influenced by population density and high activity human settlements, seeking to avoid buildings, active agricultural lands, forest reserves. The selection process is described in detail in the Route Study Report.

The scoping process takes into consideration design features and measures to scope out certain aspects from the environmental impact assessment (EIA). The aspects scoped out would be unlikely to experience or cause significant environmental effects related to the project. In this way, the EIA will be focussed on those areas where there could be a significant effect and mitigation measures will be presented to reduce those effects.

1.3 Project Justification

BOST currently has a network of liquid fuel storage distribution and transportation systems comprising multiple depots, pipelines (some for single fuel pumping and some for multifuel), Bulk Road Vehicle (BRV) routes and river barge routes. These routes supply Ghana's immediate fuel demands and have to meet the export needs of neighbouring countries.

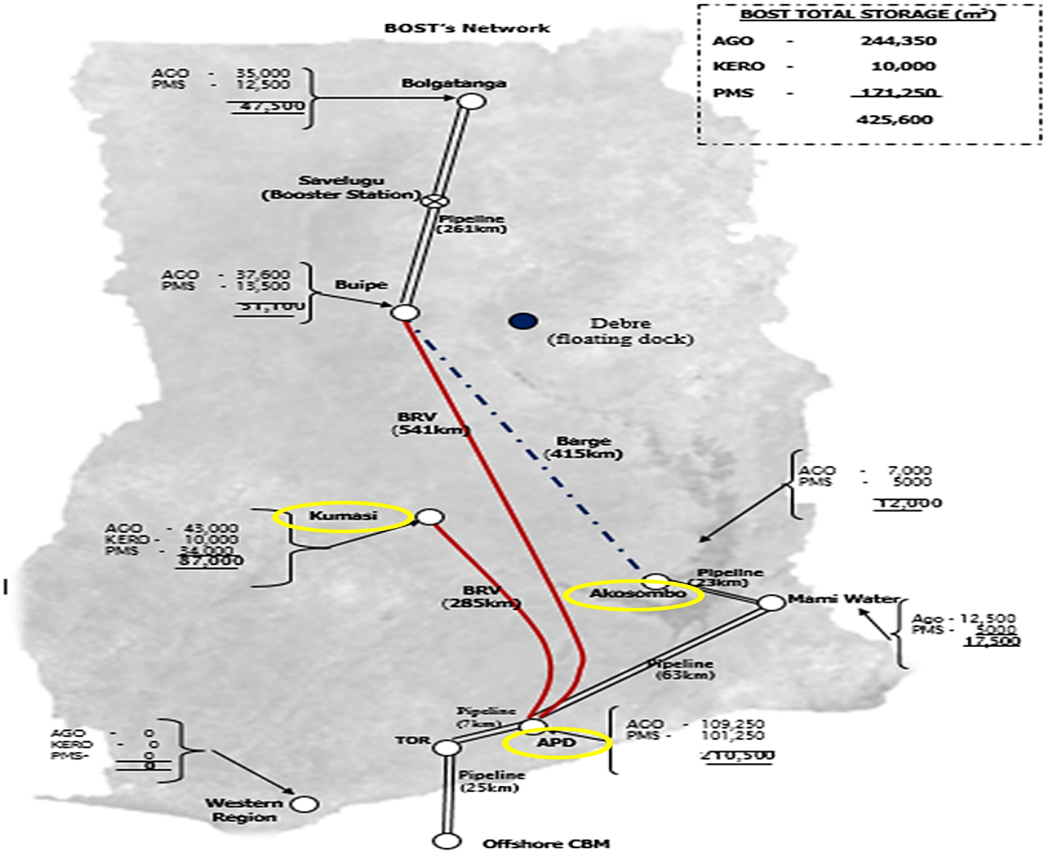


Figure 1 liquid fuel storage distribution and transportation systems

There is no extensive pipeline network that links the main supply depot in Accra to other depots within the country. As a result, BRV's are mainly used for transporting fuel to the North East parts of the country. The use of BRVs to transport petroleum products is accepted worldly as the most expensive means, which also places extensive stress on public maintained roads.

In contrast to BRVs, pipelines offer a safer, reliable and efficient transporting system over long distances from their sources to end-users or consumers. Pipelines have been identified as representing a much safer means of transporting oil and gas products as compared to

other modes of transportation, even though pipelines have the potential to cause harm to public health and the environment because of the hazardous materials they carry and the proximity of some pipelines to highly populated areas (Parfomak, 2019). Through advanced technologies, pipeline operations have harnessed new capabilities such as data analytics and remote monitoring to stay on top of pipeline leaks, thefts and third-party damages, thereby increasing operational efficiency and reliability.

The purpose of this project will eliminate the use of BRVs to supply the Kumasi Depot and take advantage of pipeline systems for a safe, environmentally friendly and cost-effective supply of petroleum products. This will keep over 100 road tankers off the road every day and significantly reduce air emissions to the atmosphere from their operations.

1.4 Approach to Environmental Impact Assessment

The EIA process is laid down in the Environmental Assessment Regulation (LI 1652). The EIA process involves a series of steps, as illustrated in Figure 2. BOST intends to undertake an Environmental Impact Assessment study leading to an Environmental Impact Statement (EIS) preparation. This report is concerned with the process up to the delivery of the Scoping Report.

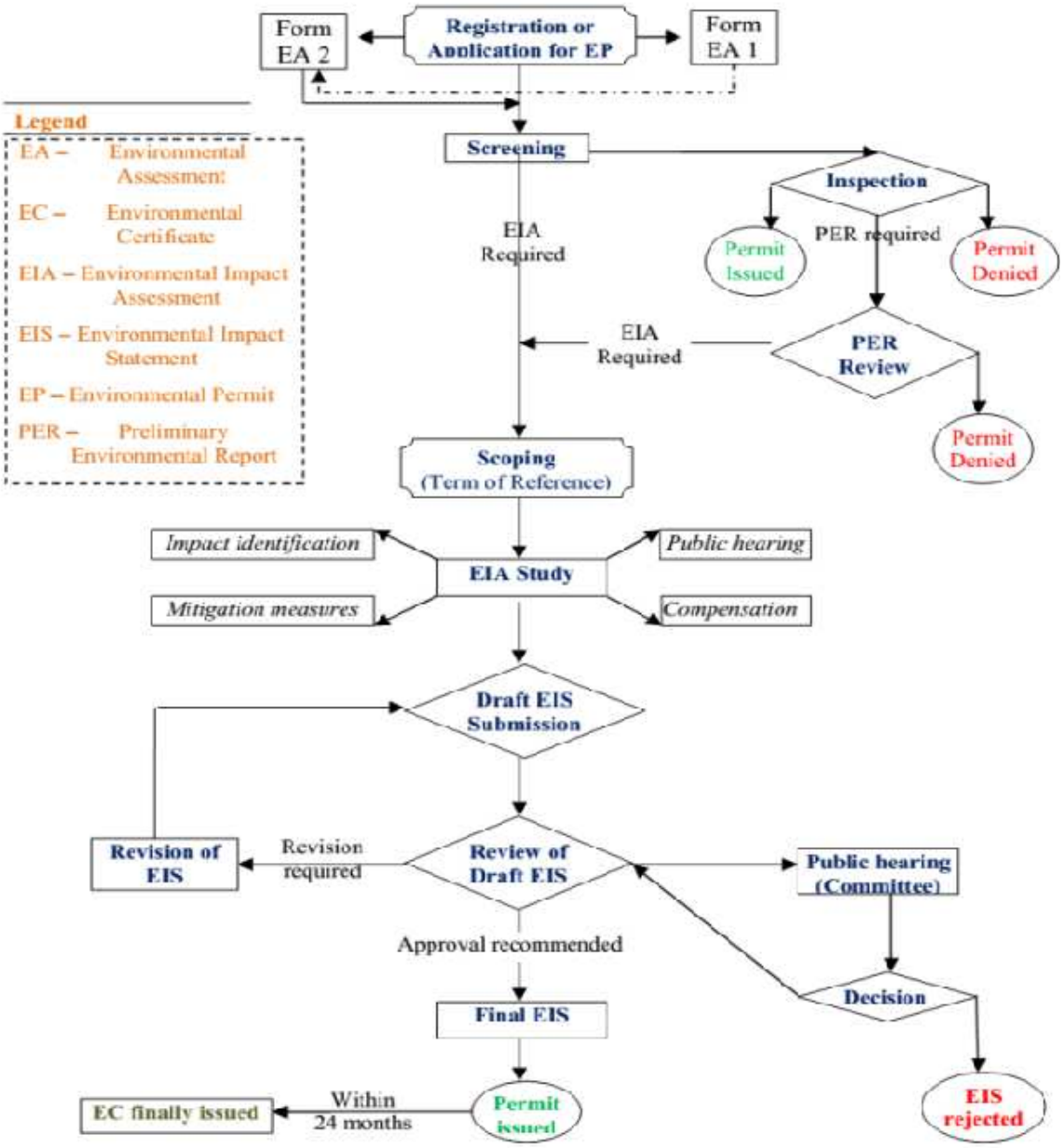


Figure 2 The EIA process

1.4.1 Project Registration/ Notification

Under the EPA Regulations, any undertaking with potentially significant impacts on the environment falls under Schedule 2 of the Environmental Assessment Regulation by virtue of its nature, scale and location; and requires that the undertaking be registered with the EPA and an environmental permit obtained prior to construction and operation.

The proposed Project was duly submitted for registration with the EPA on the 15th of June, 2021.

1.4.2 Project Screening

In Compliance with the Environmental Assessment Regulations, within twenty-five (25) days from the time of taking delivery of the registration form (screening), the EPA will place the project/undertaking at the appropriate level of assessment.

The proposed Project has been categorised under Regulation 3, for which an Environmental Impact Assessment (EIA) is required. This requires that BOST undertake scoping and develop terms of reference to the EPA for approval. This will inform the next steps in the EIA processes.

1.4.3 Scoping Phase

Scoping is a critical, early step in the preparation of an EIA. The scoping process identifies the issues likely to be of most importance during the EIA and eliminates those of little concern. In this way, EIA studies are focused on the significant effects and time and money are not wasted on unnecessary investigations.

The scoping stage is critical for the key issues to be identified through the engagement of key stakeholders and review of the baseline information, among others. Scoping of the project forms a basis for assessing the project impacts and proposed mitigations to address them. This process concludes with the establishment of the Terms of Reference for the preparation of the EIA. Hence, a scoping report is prepared and submitted to the EPA for review and approval before the proponent proceeds with the rest of the EIA process.

1.4.4 Approach to Scoping

The scoping should be proportionate to scope aspects that are likely to result in significant effects. A scoping process has been undertaken to identify the issues to be included in the EIA. The results are presented in this Scoping Report.

An extensive baseline has been constructed for each aspect as described in the individual chapters. Publicly available information has been used in conjunction with consultation and engagement with statutory and non-statutory bodies as outlined in each topic chapter.

In addition, the corridor consultation held has informed the process and allowed for feedback from the local communities along the corridor options.

The scoping process will include an over of the project, the environment and community that is likely to be affected, the possible project alternatives, the range of potential impacts, and how these may be mitigated. In addition, the following will be addressed:

- Geographical area and time-frames for impact analysis
- The policies and institutional frameworks under which the EIA will be conducted
- Existing information sources, gaps and constraints on methodology
- The scheduling of the EIA study, and the allocation of resources and responsibilities and
- The decision-making process of the final pipeline project route and design modifications.

The scoping process has been developed on a receptor-based approach. This means that the topic chapters are based on receptors that may be affected by the project. The following questions will be used as a guide to justify scoping in or out of an aspect;

- Is there an impact pathway from the proposed evelopment to the aspect/matter?
- Is the aspect/matter sensitive to the impact concerned?
- Is the impact likely to be on a scale that may significantly affect the aspect/matter?
- Could the impact contribute cumulatively with other impacts to result in significant effects to the aspect/ matter?
- Is there a method of avoidance or mitigation that would reduce the impact on the aspect/matter to a level where significant effects would not occur?
- Is there sufficient confidence in the avoidance or mitigation method regarding deliverability and efficacy to support the request?
- Is there empirical evidence available to support the request?
- Do relevant statutory consultees agree with the request?

The project spans 269km from the Greater Accra Region, through the Eastern Region to the Ashanti Region. For ease of identification and studying, it has been split into three sections. These are lettered A to C. Within the topic chapters, these sections have been referenced where possible.

1.5 Impact Assessment Methodology

The environmental impact assessment will define the scenarios against which the environmental effects will be assessed. These will include the following scenarios:

- the baseline (2021) as it is today (i.e. the existing conditions along the route). In the event other developments commence before this project, these developments will be considered in future baseline scenarios;
- ·the construction assessment will assess the construction period and the peak year of construction where appropriate.
- the completed and operational phase of the project
- decommission of the project.

1.5.1 Assessment of Significance

This chapter describes the methodology which would be used to assess the potential significance of effects on the natural, human, and built environment because of the project. The environmental impact assessment (EIA) is the receptor-based assessment. Receptors are those aspects of the environment that are sensitive to change because of sources such as dust, noise, and construction activities.

The assessment of significance will be based on a three (3) stage process. These are elaborated below;

- **First Stage**

The first stage assigns sensitivity to a receptor. Sensitivity is how easily the receptor is affected by the change, and value measures its inherent worth. The table provides broad definitions of sensitivity or value.

Table 1 Sensitivity and value criteria

Value/sensitivity	General criteria
High	Of value, importance, or rarity on an international or national scale, and with minimal potential for substitution; and/or very sensitive to change, or has little capacity to accommodate a change

Medium	Of value, importance, or rarity on a regional scale, and with limited potential for substitution; and/or Moderate sensitivity to change, or moderate capacity to accommodate a change
Low	Of value, importance, or rarity on a local scale; and/or not particularly sensitive to change or has considerable capacity to accommodate a change.
Negligible	Of value, importance, or rarity on a very local scale; and/or not sensitive to change or has very considerable capacity to accommodate a change.

- **Second Step**

The second stage of the assessment will determine the likely magnitude of the potential impact. This is the scale of the change caused to the baseline conditions. The magnitude of assessment takes into consideration all embedded mitigation, good practice, and measures to be included in the construction environmental management plan (CEMP), the likely duration of the impact and how easily or quickly the change would be reversed.

Table 2 Magnitude criteria

Magnitude	General criteria
Large	Adverse: Loss of resource or quality resource; severe damage to key characteristics; or Beneficial: Large scale or a major improvement of resources quality; extensive restoration; Long or permanent duration of impact. Irreversible change
Medium	Adverse: Loss of resource, but not adversely affecting its integrity; partial loss of or damage to key characteristics; or Beneficial: Benefit to key characteristics; improvements of attribute quality. Medium-term duration of impact, not beyond the construction period. Change largely reversible

Small	Adverse: Some measurable change in attributes, quality, or vulnerability; minor loss of, or alteration to, one or more key characteristics; or Beneficial: Minor benefit to some key characteristic; some beneficial effect on an attribute or a reduced risk of the negative impact occurring. Short term duration of impact. Easily reversible
Negligible	Adverse: Minor loss or detrimental alteration to one or more characteristic; or Beneficial: Very minor benefit to, or positive addition of, one or more characteristic;

- **Third Stage**

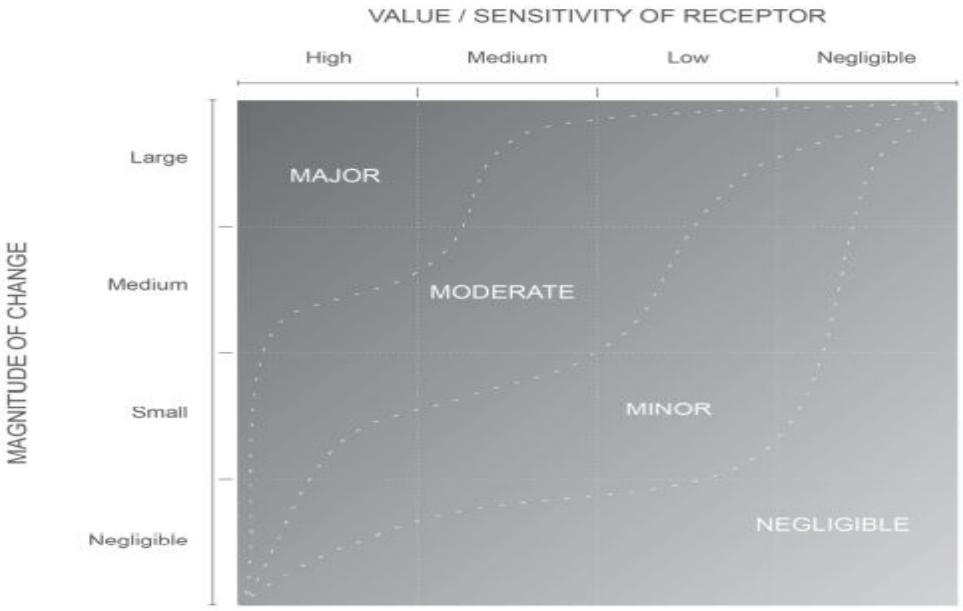
The third stage of the assessment allocates significance to an effect. There is no regulatory definition of significance, so this would be based on expert judgement and literature review.

The sensitivity or value of the receptor will be considered in relation to the magnitude of the potential impact. A highly sensitive receptor subject to a large magnitude of change would suffer a significant alteration. A low sensitivity receptor with a small magnitude of change would not suffer a significant change.

The table shown in Figure 6.1 is used as the basis for assigning significance to an effect. It uses merging bands to reflect the role of professional judgement when allocating significance. This is of relevance for the project, where most of the effects are likely to be short term and during construction.

The matrix allows appropriate consideration to be given to the influence of impact duration on the overall significance of the effect.

Table 3 Significance Matrix



1.5.3 Mitigation & Monitoring

After potential significant impacts arising from the project have been identified and assessed, consideration will be given as to how those effects could be avoided, reduced, or remedied. This is known as mitigation. There are three types of mitigation: primary, secondary, and tertiary, as defined in IEMA's 2015 'EIA Guide to Shaping Quality Development'.

Primary mitigation measures: These are measures that are a fundamental part of design evolution (i.e., alignment of the pipeline route to avoid high population zones). This is detailed within the Project description and design development chapters and is referred to as Mitigation measures.

Secondary mitigation measures: are further activities or measures required to be put in place to reduce the potential significant adverse effects of the Project. These will be detailed within the topic chapters of the Environmental Impact Assessment Statement. An example of secondary mitigation would be habitat replacement after construction.

Tertiary mitigation measures: are measures that may be adopted, regardless of the EIA findings, because of standard sector practices. These measures are generally referred to as Good Practice Mitigation.

1.5.4 Monitoring

A plan to monitor the effectiveness of the mitigation measures implemented will be developed to align with the EIA Regulations.

The monitoring will be detailed within the Environmental Impact Assessment Statement with clear and proportionate objectives outlined for the monitoring. This will be accompanied by an action plan and action owners of the implementation.

1.6 Description of the Project

1.6.1 Overview

The project involves the installation of a pipeline with an internal diameter of about 18inch between the Accra Plain Depot and Kumasi Depot. The proposed pipeline is 269km long and spans from Greater Accra Region through the Eastern Region to the Ashanti Region. The design and development carried out in selecting the route are described in Chapter 6 (Alternatives Evaluation). Following the extended list of corridor options, sifting of the corridor options was performed to create a shortlist of favoured corridors aligned with stakeholder consultations. The preferred corridor largely follows the existing Right of Way (ROW) except for locations where constraints require the corridor to be diverted or widened.

1.6.2 Project Scope

Design, Procure, Install/Commission

- Engineering and construction of an 18'' x 269km pipeline per ASME B31.4 and API 5L.
- Installation of tie-in station
- Installation of Pumping and Pigging stations.

1.6.3 Project Location

The Accra – Kumasi Multifuel Pipeline Project falls with the following co-ordinates 5°42'52.56"N, 0° 0'32.82"E and 6°37'52.58"N, 1°36'16.52"W. A google map extract (Figure 3-3) showing the conceptual pipeline route is provided below.



Figure 3 Pipeline Route

The pipeline route transverses the Greater Accra Region, Eastern Region to the Ashanti Region. The major settlements through which it passes are Kpone, Somanya, Koforidua, New Tafo Akyem, Nkawkaw, Konongo and Kumasi. The route stretch is mainly open scatter trees and forest areas. Its pipeline follows along and crosses some river bodies, including the River Birim and some tributaries of River Pra. Most of the other smaller tributaries dry up during the dry season. The terrain is undulating with occasional high elevations areas.

To aid design development and EIA, the route and corridor is broken down into three separate sections (Sections A to C) as follows

Table 4 The route and corridor sections

Section Name	Name	Section Length (approx.)	General description & characteristics	Outline Construction Scenario
Section A	Kpone to Koforidua	90km	This section of the corridor is between two major cities, Tema and Koforidua, mainly rural settlements. The major towns within this section of the corridor are Afienya, Somanya and Asokore. The route is mainly rural, running through secondary forest and small scale agricultural lands.	Open cut trenching: 95% Street works: 30% Construction Compounds: 1
			This section follows mainly the existing ROWs of BOST, roads and railways lines to minimise risk. The route crosses the N1 Highway at Afienya and some urban roads at Kwamante and Asamang. This section diverts the densely populated towns within Koforidua to join the existing railway line where it ends.	

Section B	Koforidua to Breku	100km	This section of the corridor is mainly rural in character, running through closed forest, open forest areas and small scale agricultural lands. The rural communities that this section of the route transverses have populations of less than 2500 people. Some of the notable communities are Bososo, Osino, Anyinasi Krofofrom, Atawase, Kwaku Besease and Breku, where it ends.	
			This section avoids the densely populated Ayinam and Nkawkaw to minimise risk. The route primarily follows the existing railway line to Kumasi. This section interacts with some major river bodies and tributaries of others. It crosses and runs along the Birim River for about 11km, with some areas over 500m away from the pipeline. It also crosses the River Nwi and River Pra. The route crosses a few	

			urban roads around Bososo, Anyinasin-krofofrom, Denkyira and Adansua.	
Section C	Breku to Sokoban (Kumasi)	80km	This section of the corridor is mainly rural, and a few semi-urban areas in character, running through open scatter trees and shrubs. The population density of this section increases from 9000 to 20,000 when approaching Sokoban in Kumasi. The major towns within this section of the corridor are Juaso, Bonkorkor, Edwinese, Kuntanase, Asaago and Sokoban.	
			This section avoids the densely populated Juaso, Konongo, Kokofu, Oyoko and the N6 Highway to minimise risk. The route primarily follows the existing railway line and road network utilizing the RoW. This section crosses some major river bodies; River Kume, River Anum,	

			River Banke and River Offin. The route ends at the Sokoban industrial area of Kumasi.	

2. REGULATION & REGULATORY FRAMEWORK

It is required to provide an overview of all national legislation and international conventions and guidelines that the proposed project aligns with to inform the EIA Process. The institutional and administrative framework of the energy sector in Ghana and relevant national policies and legislative requirements must be considered with regard to the project. The ESIA aims to provide the relevant information to enable EPA and other relevant stakeholders to set appropriate level(s) of assessment for the proposed undertaking regarding its impact on the environment for the critical review and permitting and facilitate the decision-making process for sustainable project development.

The relevant national and sector policies and plans, national legal and institutional frameworks, international conventions and national environmental quality guidelines to guide the implementation of the Multifuel Pipeline Project are described in this chapter.

2.1 National and Sector Policies and Plans

The national and sector policies and plans identified to be relevant to the proposed Multifuel Pipeline Project include the following:

- National Energy Policy, 2010;
- Health, Safety and Environmental Policy for the Energy Sector, 2016;
- National Land Policy, 1999;
- National Environmental Policy, 2012;
- National Climate Change Policy, 2013

The essential compliance requirements for the policies listed above are summarised in

Table 5 Essential compliance requirements

Policy Framework	Summary of the core requirement	Relationship to the proposed project
National Energy Policy, 2010	This National Energy Policy of February 2010 is intended to guide the development and management of Ghana's energy sector, especially the emerging oil and gas sector, following the discovery in commercial quantities of petroleum resources in 2007. It outlines the energy sector goals, challenges and actions. Within the context of the energy sector vision, the goal of the energy sector is to make energy services universally accessible and readily available in an environmentally sustainable manner.	The proposed project aligns with the Policy's objective to make energy services universally accessible and readily available in an environmentally sustainable manner.
Health, Safety and Environmental Policy for the Energy Sector, 2016	The Policy describes the elements necessary to develop, implement and maintain a high level of safety in all energy sector activities. The Policy develops relevant regulations and standards, which will ensure that operators consider relevant information about hazards, environmental effects, safety and security threats to their operations. To achieve this outcome, regulators are to ensure that energy sector activities are carried out in an efficient manner that strives for continuous improvement of HSSE performance	The proposed project aligns with the Policy's objective to ensure minimal harm to property, the environment and national reputation.

National Land Policy, 1990	The National Land Policy protects water bodies and the environment in the long-term national interest under any form of land usage, be for human settlements, industry and commerce, agriculture, forestry and mining. Key aspects of Section 4.4 (Ensuring Sustainable Land Use) of the Policy relevant to the Project are provided below: (a) The use of any land in Ghana for sustainable development, the protection of water bodies and the environment and any other socio-economic activity will be determined through national land-use planning guidelines based on sustainable principles in the long term national interest. (b) Land categories outside Ghana's permanent forest and wildlife estates are available for such uses as agriculture, timber, mining and other extractive industries, and human settlement within the context of a national land-use plan. (i) Unless approved by the appropriate public authority, no land-use change of any kind will be countenanced. All land and water resources development activities must conform to the country's environmental laws, and where the Environmental Impact Assessment report is	The RoW of the proposed project meets the land use planning requirements for the affected land.

	required, this must be provided. Environmental protection within the 'polluter pays principle will be enforced.	
National Environmental Policy, 2012	The Ghana National Environmental Policy was launched in November 2012 with the vision to manage the environment sustainably to benefit Ghanaian society. This Policy aims to promote healthy lifestyles and reduce risk factors that arise from environmental, economic, social and behavioural causes, thereby promoting healthy lifestyles in a healthy environment. The Policy notes that proper management of Ghana's resources requires that efforts be redirected to more environmentally sustainable programmes and practices. Such programmes should protect and preserve the resource base for use by present and future generations. Assessment of the potential environmental impacts of development projects and planning in advance to mitigate or eliminate these impacts will decrease environmental costs to the economy and make more cost-effective use of the country's resources.	The proposed project promotes sustainable development by including economic, social and environmental considerations.

	The ultimate aim of the National Environmental Policy of Ghana is to improve the surroundings, living conditions and quality of life of the entire citizenry, both present and future. It seeks to promote sustainable development by ensuring a balance between economic growth and natural resource conservation. The Policy thus makes a high-quality environment a key element supporting the country's economic and social development. Specifically, the Policy seeks to: • Maintain ecosystem and ecological processes essential for the functioning of the biosphere; • Ensure sound management of natural resources and the environment; • Adequately protect humans, animals and plants, their biological communities and habitats against harmful impacts and destructive practices, and preserve biological diversity; • Guide development per quality requirements to prevent, reduce, and as far as possible, eliminate pollution nuisances;	

	• Integrate environmental considerations in sectoral structural and socio-economic planning at the national, regional, district and grassroots levels; • Seek standard solutions to environmental problems in West Africa, Africa and the world at large. • Principles of the National Environmental Policy In order not to deviate from the Policy in the National Environmental Action Plan, 1991, by the then Environmental Protection Council (EPC), this strategic plan takes into consideration the following principles that are consistent with the above policy: • Optimum sustainable yield in the use of resources and ecosystems; • Use of most cost-effective means to achieve environmental objectives; • Use of incentives in addition to regulatory measures; • Delegation of decision-making and action to the most appropriate level of government; • Polluter pays for the cost of preventing and eliminating pollution and nuisances caused by them; • Public participation in environmental decision-making;	

	• International co-operation; • Citizens have the right to a safe, healthy environment • All sectors of society are responsible for ensuring a sustainable environment, viz. government, business, industry and the citizenry.	
National 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 thematic areas have been prioritised. These are energy and infrastructure, natural resources management, agriculture and food security, disaster preparedness and response and equitable social development.	The project is aimed at reducing the use of BRVs reducing the carbon footprint from transportation.

2.2 National Legal Framework

The relevant environmental laws and regulations to guide BOST through the conceptualisation stage of the project to implementation, monitoring and decommissioning are summarised in Table 2-2 below.

Table 2-2: Summary of National and Sector Legal Frameworks

Legal Framework	Summary of core requirements	Relationship to the proposed project
Sector Regulation		

National Petroleum Authority (NPA) Act 2005, Act 691	The NPA Act 2005, Act 691 empowers the authority to regulate, oversee and monitor activities in the downstream petroleum community; To establish a unified petroleum price fund taking cognisance of the prescribed petroleum pricing formula, and provide for related purposes.	BOST will obtain the relevant licence from NPA and operate under the conditions of the permit.
Natural Gas Pipeline Safety (Construction, Operation Maintenance) Regulations, 2012, LI 2189	The LI 2189 provides consistent, uniform standards and procedures for the safe construction, operation and maintenance of natural gas facilities throughout the country. The Regulations prescribe the minimum safety standard requirements for: • the construction, operation and maintenance of pipeline facilities for the transportation of natural gas, including transportation within the territorial waters and exclusive economic zone of the Republic; • the selection and qualification of pipes and components of the pipeline; • the design of pipelines; • the welding of steel materials in pipelines; • the joining of materials in pipelines other than by welding and outside the course of the manufacture of pipes or pipeline components;	The proposed pipeline will incorporate the standards and procedures in the project implementation.

	• the installation of customer meters, service regulators, service lines, service line valves and service line connections to the mains; • the protection of metallic pipelines from external, internal and atmospheric corrosion; • testing of pipelines; • uprating of pipelines; • persons qualified to perform tasks on a pipeline facility; • integrity management programmes on pipelines, and the abandonment or decommissioning of pipeline facilities.	
Environmental Assessment		
Environmental Protection Agency (EPA) Act 1994, Act 490	The EPA was established under the Environmental Protection Agency Act (Act 490 of 1994) as the leading public body responsible for protecting and improving the environment in Ghana. It is responsible for enforcing environmental policy and legislation, prescribing standards and guidelines, inspecting and regulating businesses and responding to emergency incidents. It is responsible for issuing environmental permits and pollution abatement notices for controlling waste discharges, emissions, deposits	The proposed project is being developed per Environmental Assessment (EA) procedures for approval by the EPA.

	or other sources of pollutants and issuing directives, procedures or warnings to control noise. The EPA has the authority to require an EIA and is responsible for ensuring compliance with EIA procedures.	
Environmental Assessment Regulations 1999, LI 1652	The Environmental Assessment Regulations 1999 (LI 1652) enjoins any proponent or person to register an undertaking with the Agency and obtain an Environmental Permit prior to the commencement of the project. The regulations require that "No environmental permit shall be issued by the Agency for any of the undertakings mentioned in Schedule 2 to these Regulations unless there is submitted by the responsible person to the Agency, an environmental impact assessment per these Regulations in respect of the undertaking". Application for an environmental permit 4. (1) A person required under regulation 1 or 2 to register an undertaking and obtain an environmental permit shall submit to the Agency an application in such form as the Agency shall determine. 2. There shall be paid for the application such fee, as the Agency shall determine.	The proposed project falls in Schedule 2, and therefore an EIA is mandatory, as per the regulations.

Fees and Charges (Amendment) Instrument 2015 (L.I. 2228)	The Fees and Charges (Amendment) Instrument 2015 (L.I. 2228) provides comprehensive rates, fees and charges collectable by Ministries, Department and Agencies (MDAs) for goods and services delivered to the public. The LI 2228, therefore, repeals the Environmental Assessment Regulations (Amendment) 2002 (LI 1703), which originally stipulated the fees and charges to be paid by proponents concerning Environmental Permits and Certificates.	All stipulated fees and charges shall be paid in order to obtain a permit from the EPA.
Environmental Protection		
Ghana Investment Promotion Centre Act 1994, Act 478	The Ghana Investment Promotion Centre Act 1994 (Act 478) requires that every investor wishing to invest in the country must, in its appraisal of proposed investment projects or enterprises, "...have regard to any effect the enterprise is likely to have on the environment and measures proposed for the prevention and control of any harmful effects to the environment...".	The project has environmental impacts, and mitigation measures have been proposed in the ESIA to address the impacts.
Water Resources Commission Act 1996 (Act 522)	The Water Resources Commission Act 1996 (Act 522) establishes and mandates the Water Resources Commission as the sole agent responsible for the regulation and management and the utilisation of water resources and the coordination of any policy concerning them.	If water abstraction is necessary or diversion of a river is necessary during the crossing, a permit will be obtained from the WRC.

	Section 13 prohibits the use of water (divert, dam, store, abstract or use water resources or construct or maintain any works for the use of water resources) without authority. Section 16 empowers the Commission to grant Water Rights (water use permits) to prospective users. The Act states under Section 24 that, except per this Act or with the approval of the Environmental Protection Agency, any person who pollutes or fouls a water resource beyond the level that the EPA may prescribe an offence and is liable on conviction to a fine or a term of imprisonment or both.	
Water Use Regulation (WUR) 2001, LI 1692	The Water Use Regulations, 2001 (LI 1692) lists activities for which a water use permit is required, including domestic, commercial, municipal, and industrial water use, among others. The Regulations also prescribe the raw water charges and processing fees to be paid by prospective water users with respect to the water use permits. The Water Use Regulations 2001, LI 1692 prohibits water resources use without authorization from the Water Resources Commission. The Act provides under section 16 for any person to apply to the Commission in writing for the grant of water rights. The Regulations also prescribe the raw water charges and	Any utilization of raw water resources for the proposed project will require a water use permit

	processing fees to be paid by prospective water users with respect to the water use permits. The Commission is also mandated to request evidence that the EPA has approved an environmental impact assessment or an environmental management plan before issuing the Water Use Permit.	
Ghana Meteorological Agency Act 2004, Act 687	This ACT establishes the Ghana Meteorological Agency, which replaces the Meteorological Services Department. The Agency is to provide meteorological information, advice, and warnings for the benefit of agriculture, civil and military aviation among others, to mitigate the effects of natural disasters such as floods, storms and droughts on socio-economic development and projects. The Agency is to provide accurate climatic data, which are relevant for establishing climate change trends.	Climate information will be obtained from the Agency to guide project implementation.
Hazardous and Electronic Waste Control and Management Act 2016 (Act 917) and Hazardous, Electronic and other waste (Classification), Control and Management Regulations 2016, LI2250	The hazardous and Electronic waste and control ACT 2016 (ACT 917) provides a list of hazardous and other waste. It also provides control, management and disposal of electrical and electronic waste. Hazardous waste generally refers to waste with properties that make it potentially dangerous or harmful to human health or the environment. They include liquids, solids, or gases that common means cannot be treated or disposed of. The Act will also ensure that harmful	The ACT will guide the project on hazardous and electronic waste management and disposal during project implementation.

	elements associated with hazardous and other waste products are captured and processed safely to preserve critical ecological components such as the soil, groundwater, flora and fauna	
Labour & Safety		
Factories, Offices and Shops Act 1970, Act 328	The Factories, Offices and Shops Act of 1970 (Act 328), as amended by the Factories Offices and Shops (Amendment) Law 1983 PNDCL 66, the Factories Offices and Shops (Amendment) Law 1991 PNDCL 275 s.1 (a), and the Ghana National Fire Service Act, 1997 (Act 537) requires all proponents to register every factory/workplace with the Chief Inspector of Factories Inspectorate Department. The Act requires all factories, offices and shops to notify the Chief Inspector of accidents, dangerous occurrences and industrial diseases, post in a prominent position in every factory the prescribed abstract of the act and other notices and documentation, as well as outline the regulations to safeguard the health and safety of workers. The Act complements the provisions made in the Factories (Dock Safety) Regulations 1960, LI 86.	The project will be registered with the Factories Inspectorate Division, and any accident will be reported as per Act 328, 1970.
The Labour Act 2003, Act 651	Section 118(1) of the Labour Act 2003 (Act 651) stipulates that an employer must ensure that every worker employed	Proactive measures will be instituted to ensure the safety

	works under satisfactory, safe and healthy conditions. Act 651 contains some specific provisions relating to an employer's duty of care to its workers. These include providing and maintaining "at the workplace, plant and system of work that is safe and without health risk" and taking "steps to prevent contamination of the workplaces and protect the workers from toxic gases, noxious substances, vapours, dust, fumes, mists and other substances or materials likely to cause risk to safety or health". A worker is required to report situations that he believes may pose "an imminent and serious danger to his or her life, safety or health".	well-being of its workers per the act and best international practices.
Workmen's Compensation Law 1987	It is to provide compensation to workers for personal injuries caused by accidents arising out and in the course of their employment. The tenets of the law place a large share of the burden of supporting workers injured at the workplace on the shoulders of the employers.	
Ghana National Fire Service Act 1997	The Act re-establishes the National Fire Service to provide for the management of undesired fires and related matters. The objective of the service is to prevent and manage undesired fires. To achieve its objective; the service is to organize public fire education programmes to create and	The project will institute measures to prevent fires. A fire permit will be obtained during the operational phase of the project.

	sustain awareness of the hazards of fire, heighten the role of the individual in the prevention of fire and provide technical advice for building plans in respect of machinery and structural layouts to facilitate escape from fire, rescue operations and fire management. The GNFS has a rural fire department responsible for the control and management of bushfires.	
Land Use, Development & Planning		
Local Governance Act 2016, Act 936.	This Act establishes and regulates the local government system and gives the RCC and the District Assembly authority to exercise political and administrative power in the regions and districts, provide guidance, give direction, and supervise all other administrative authorities in the regions and districts, respectively. The Assembly is mandated to initiate programmes for the development of basic infrastructure, provide municipal works and services, and be responsible for the development, improvement, and management of human settlements and the environment in the district.	All Assemblies that the proposed project route passes shall be fully engaged during the planning and implementation of the project.
Land Use and Spatial Planning Authority (LUPSA) Act 2016, Act 925	The LUPSA Act 2016, Act 925 seeks to ensure the orderly and progressive development of the land, town, and other areas, whether urban or rural, to conserve and develop	The project is zoned under industrial.

	resources, preserve and improve amenities, and related matters. It is the new legislation in force regulating the general planning and development of human settlements. It seeks to promote sustainable human settlements developments based on efficiency, orderliness, safety and healthy growth of communities.	
Lands Commission (LC) Act 2008, Act 767	This act provides for the management of public lands and other lands and related matters. The Commission manages public lands and any other lands vested in the President by the Constitution or by other enactments of the lands vested in the Commission. The act advises the Government, local authorities, and traditional authorities on the policy framework for developing particular areas to ensure that individual pieces of land are coordinated with the relevant development plan for the area concerned. The commission formulates and submits to Government recommendations on national policy with respect to land use and capability; advise on, and assist in the execution of a comprehensive programme for the registration of title to land throughout the Republic in consultation with the Title Registration Advisory Board established under section 10 of the Land Title Registration Act, 1986;	The proposed project requires land acquisition and registration and falls under the lands commission. The Project will be implemented in line with the objectives of the Commission for sustainable development of land.

	The Minister may, with the approval of the President, give general directions in writing to the Commission on matters of policy in respect of the management of public lands. The commission has the following divisions: • Survey and Mapping; • Land Registration; • Land Valuation; • Public and Vested Lands Management; and • Any other Division the Commission may determine.	
Office of the Administrator of Stool Lands Act 1994, Act 481	The OASL Act 1994, Act 481 establishes the Office of the Administrator of Stool Lands as enshrined in Article 267 (2) of the 1992 Constitution. It is responsible for the establishment of stool land account for each stool, collection of rents and the disbursement of such revenues. The Administrator is charged with the management of stool lands as per the provisions in the 1992 Constitution. 10% of the gross revenue goes to the Administrator of Stool Lands for administrative expenses whilst the remainder is disbursed as follows: • 25% to the stool through the traditional authority for the maintenance of the stool; • 20% to the traditional authority; and	The appropriate traditional and stool landowners will be consulted for land acquisition.

	• 55% to the District Assembly, within the area of authority of which the stool lands are situated.	

2.3 International Conventions

Ghana is a signatory to several international conventions that have been established by the United Nations or its specialized agencies to manage and protect the environment sustainably. The ones that should be considered for the Project are:

- United Nations (UN) Convention on Biological Diversity 1994;
- United Nations Framework Convention on Climate Change (UNFCCC);

- **United Nations (UN) Convention on Biological Diversity, 1994**

The Convention on Biological Diversity (CBD) is an international legally binding treaty. The Convention has three main goals:

- conservation of biological diversity (or biodiversity);
- sustainable use of its components; and
- fair and equitable sharing of benefits arising from genetic resources

In other words, its objective is to develop national strategies for the conservation and sustainable use of biological diversity. It is often seen as the key document regarding sustainable development.

- **United Nations Framework Convention on Climate Change (UNFCCC)**

The United Nations Framework Convention on Climate Change (UNFCCC) provides the basis for global action to protect the climate system for present and future generations. The convention on climate change sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognizes that the climate system is a shared resource whose stability can be affected by industrial and other carbon dioxide emissions and other greenhouse gases. The convention enjoys near-universal membership, with 189 countries having ratified.

The ultimate objective of this convention and any related legal instruments that the conference of the Parties may adopt is to achieve, per the relevant provisions of the convention, stabilization of greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, ensure that food production is not threatened, and enable economic development to proceed sustainably. Under the convention, governments:.`

- Gather and share information on greenhouse gas emissions, national policies and best practices.
- Launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries; and
- Cooperate in preparing for adaptation to the impacts of climate change.

2.4 National Environmental Guidelines

In addition to national and sector policies and plans described above, the environmental guidelines and standards relevant to the Project are presented below.

- **Environmental Impact Assessment Guidelines for the Energy Sector (2010), Volume 1** has been prepared to ensure the sustainable use of energy resources and contribute to sound environmental management in the energy sector. Volume 2 of the Guidelines provides systematic procedures on EIS/EMP preparations for the energy sector as well as guidelines on common potential impacts and mitigation measures;
- **Environmental Impact Assessment Guidelines for the General Construction and Services Sector (2011)** have been prepared to ensure the sustainable development of the general construction and services sector and also contribute towards sound environmental management in the general construction and services sector;
- **Environmental Assessment in Ghana, A Guide (1996)** produced by the EPA provides detailed guidance on the procedures to be adhered to when undertaking an EIA;
- **Ghana's Standard for Environment & Health Protection – Requirements for Ambient Air Quality & Point Source Emission (GS1236:2019)** provides advice on maximum permissible levels of a variety of air pollutants;
- **Ghana's Standard for Health Protection – Requirement for Ambient Noise Control (GS1222: 2018)** provides advice on the maximum permissible noise levels; and
- **Ghana's Standard for Environmental Protection – Requirement for Effluent Discharge (GS:1212: 2019)** provide maximum permissible concentrations for a number of effluent quality parameters.

2.5 International Guidelines

For purposes of total regulation of the industrial environment, the EPA accepts a number of internationally acceptable standards and guidelines where there are no such local guidelines in the country. These include:

- World Bank Guidelines

The World Bank Group EHS Guidelines are reference documents on environmental, health, and safety issues applicable to all industry sectors. They cover general and industry-specific examples of Good International Industry Practice, as defined in IFC's Performance Standard 3 on Pollution Prevention and Abatement.

The General EHS Guidelines (April 2007) contain the performance levels and measures that are generally acceptable to the IFC and are considered to be achievable in new facilities at reasonable costs by existing technology. When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures are appropriate given specific project circumstances, a complete and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment. Specific industry EHS Sector guidelines relevant to the project are:

- Environmental, Health, and Safety Guidelines for IFC Environmental, Health, and Safety Guidelines for Oil and Gas Sector (April 2007);
- Environmental, Health, and Safety Guidelines for Waste Management Facilities (December 2007)
- Environmental, Health, and Safety Guidelines for Water and Sanitation, (December 2007)

The EHS Guidelines for Oil and Gas include information relevant to oil and gas facilities' environmental, health, and safety aspects. Construction activities for oil and gas projects typically include land clearing for site preparation and access routes; excavation, piling and filling; transportation of supply materials and fuels; construction of foundations involving excavations and casting of concrete; operating cranes for unloading and installation of

equipment, and commissioning of new equipment. Decommissioning activities may include the removal of project infrastructure and site rehabilitation. Environmental issues specific to the operation of oil and gas projects and facilities include the following:

- Air pollution
- Noise
- Habitat alteration
- Species disturbance, injury or mortality
- Vehicular and transportation impacts
- Habitat alteration
- Water quality
- Public health and safety
- Socioeconomic impacts, i.e., the influx of job seekers

The General EHS Guidelines for the oil and gas include information on:

- Construction site waste generation and management;
- Soil erosion and sediment control from materials sourcing areas and site preparation activities;
- Fugitive dust and other emissions (e.g., from vehicle traffic, land clearing activities, and materials stockpiles);
- Noise from heavy equipment and truck traffic;
- Potential for hazardous materials and oil spills associated with heavy equipment operation and fueling activities.

3. CONSULTATION AND ENGAGEMENT

3.1 INTRODUCTION

This chapter set out the approach to consultation and engagement with the public, communities, statutory and non-statutory organisations. It includes a summary of the consultation and engagements that have been undertaken to date in relation to the pipeline project.

Engagement is a continual process of ongoing dialogue with individuals, communities and organisations about the Project. It is used to ensure an ongoing exchange of information and continual sharing of knowledge and insight between the project team and relevant stakeholders.

Consultation is a more defined process, which includes presenting proposals, holding exhibitions and having two-way interactions with individuals, communities and organisations at specific times during the project's development on a specific proposal or options. The consultation aims to achieve a fair dialogue based upon an exchange of views and enables stakeholders to formally comment on the project design and development.

The community/ public engagement has been led and facilitated by BOST with the collaboration of Sienna Service Limited. The BOST/ Sienna stakeholder engagement considers good international industry practices concerning information disclosure. It also outlines the general engagement principles that BOST/ Sienna adopts and those used for the project.

3.2 Legislation

BOST operations are based on the principles of environmental sustainability. In addition to BOST own principles and environmental and social safeguard standards, the stakeholder engagement process was executed in compliance with the national legislation and regulations related to public consultation as outlined in the following subsections.

Environmental Protection Agency Act, 1994 (Act 490)

The Environmental Protection Agency Act, 1994 (Act 490), amongst other aspects, established the EPA and provided for the powers and functions of the EPA. A key function of the EPA is to oversee EIAs in Ghana.

Environmental Assessment Regulations, 1999 (LI 1652)

LI 1652 regulates listed undertakings by requiring that the EPA must register any such undertaking(s) and that the Agency must issue an environmental permit for that

undertaking to continue. The following Stakeholder Engagement Plan (SEP) considerations per the above requirements were followed:

- Section 5 (1) emphasizes the importance of the stakeholder in the decision-making process: "The Agency shall on receipt of an application and any other relevant information required, as an initial assessment, screen the application taking into consideration (c) the concerns of the public, if any, and in particular concerns of immediate residents, if any".
- Section 12 indicates that an EIA for an undertaking must deal with matters including "Consultation with members of the public likely to be affected by the operation of the undertaking".
- Section 15 (1) emphasizes the public involvement in the review of an Environmental Impact Statement (EIS).

3.3 Stakeholder Identification

Stakeholder identification was based on proximity to the project area, interest in the project, influence on and/or being affected by the project activities. The main stakeholder groups were selected from the following clusters:

i. Groups in the communities along the pipeline corridor (45 communities)
   a. Traditional authorities.
   b. Farmers and landowners
   c. Local communities which are likely to be directly affected by the project.
ii. Local government authorities (District Assemblies and Coordinating Directorates).
iii. Other government institutions which may be involved or have direct interest (EPA, Ghana National Fire Service, Ghana Railways Authority)

3.4 Approach and Methodology

BOST has a commitment to engage stakeholders in decision-making processes, improve communication, share information, and obtain views and feedback to enhance the process. The participation of the BOST team afforded a mutual exchange of information and immediate communication feedback between the project proponent, the consultant, and stakeholders, which is an ongoing process. The engagement with the various groups of stakeholders helped to:

i. Provide the alternatives being considered.
ii. Highlight commitments to key guiding principles.
iii. Address stakeholder questions and issues relating to the proposed project.

The methodology employed for the stakeholder engagements:

i. The Project was introduced to stakeholders in the form of oral presentations and other electronic media depending on the nature and characteristics of the stakeholder group.
ii. After every presentation, stakeholders were given the opportunity to comment, provide suggestions and raise any concerns or issues regarding the Project. All comments, suggestions, concerns, and issues raised were documented and compiled into a Comment and Report. Stakeholders felt very comfortable during the consultation process.
iii. Some of the engagements were in the form of a face-to-face key informant, group interviews and Focus Group Discussions.
iv. The meetings were conducted in Twi and English and were documented (photos, completion of attendance registers and note-taking).

3.5 Engagements to date

The stakeholder engagement began on March 15, 2021, and will continue throughout the project span. A total of 45 meetings and 115 participants were organized. These included key community leadership bodies such as traditional authorities, farmers, landowners, assembly members, committee members, youth representatives as well as people/businesses near the project site.

The issues and concerns raised during the various meetings were grouped into the following themes;

- Employment
- Livelihood and Compensations
- Safety and Security
- Environmental Impact
- Road Usage and Infrastructure
- General Issues

The comments received so far from engagement with the community, and other stakeholders are summarized below in Table 3.5

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Engagement is a continual process of ongoing dialogue with individuals, communities and organisations about the Project. It is used to ensure an ongoing exchange of information and continual sharing of knowledge and insight between the project team and relevant stakeholders.

Consultation is a more defined process, which includes presenting proposals, holding exhibitions and having two-way interactions with individuals, communities and organisations at specific times during the project's development on a specific proposal or options. The consultation aims to achieve a fair dialogue based upon an exchange of views and enables stakeholders to formally comment on the project design and development.

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BOST operations are based on the principles of environmental sustainability. In addition to BOST own principles and environmental and social safeguard standards, the stakeholder engagement process was executed in compliance with the national legislation and regulations related to public consultation as outlined in the following subsections.

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- Section 5 (1) emphasizes the importance of the stakeholder in the decision-making process: "The Agency shall on receipt of an application and any other relevant information required, as an initial assessment, screen the application taking into consideration (c) the concerns of the public, if any, and in particular concerns of immediate residents, if any".
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Stakeholder identification was based on proximity to the project area, interest in the project, influence on and/or being affected by the project activities. The main stakeholder groups were selected from the following clusters:

iv. Groups in the communities along the pipeline corridor (45 communities)
   d. Traditional authorities.
   e. Farmers and landowners
   f. Local communities which are likely to be directly affected by the project.
v. Local government authorities (District Assemblies and Coordinating Directorates).
vi. Other government institutions which may be involved or have direct interest (EPA, Ghana National Fire Service, Ghana Railways Authority)

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BOST has a commitment to engage stakeholders in decision-making processes, improve communication, share information, and obtain views and feedback to enhance the process. The participation of the BOST team afforded a mutual exchange of information and immediate communication feedback between the project proponent, the consultant, and

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viii. The meetings were conducted in Twi and English and were documented (photos, completion of attendance registers and note-taking).

3.5 Engagements to date

The stakeholder engagement began on March 15, 2021, and will continue throughout the project span. A total of 45 meetings and 115 participants were organized. These included key community leadership bodies such as traditional authorities, farmers, landowners, assembly members, committee members, youth representatives as well as people/businesses near the project site.

The issues and concerns raised during the various meetings were grouped into the following themes;

- Employment
- Livelihood and Compensations
- Safety and Security
- Environmental Impact

- Road Usage and Infrastructure
- General Issues

The comments received so far from engagement with the community, and other stakeholders are summarized below in Table 3.5

4.0 Environmental Baselines Conditions

This chapter describes the physical, biological and ecological characteristics (the baseline) of the pipeline route. The existing characteristics of the route have also been mapped so that any sensitive issues, or constraints, can be visualised in relation to the potential locations affected by the Project.

4.1 Climate Conditions and Climate Change

4.1.1 Introduction

The climate change impact assessment determines how the development is likely to interact with a changing climate and whether any significant effects could arise. This section sets out the proposed approach that will be taken in the assessment, together with a summary of information that is currently available.

The Institute of Environmental Management and Assessment (IEMA) published the Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation. Consideration has been given to two aspects of climate change assessment:

- Assessment of the project's effects on climate change
- Assessment of the project's resilience in the context of climate change

Recent climate projections have identified the following relevant climatic trends as a result of climate change:

- Increased temperature;
- Changes in the frequency, intensity and distribution of rainfall events
- Increased intensity of harmattan (dry season); and
- Sea level rise.

4.1.2 Present Climate Conditions

The project is located in different climatic zones comprising the tropical rainforest, the coastal savannah, the moist semi-deciduous forest and the transitional zone and is characterized by bimodal precipitation creating a major and a minor rainy season.

The data on temperature, precipitation, wind and humidity is available from weather stations of Tema, Koforidua and Kumasi, which are located at sections along the pipeline route (Figure 4)

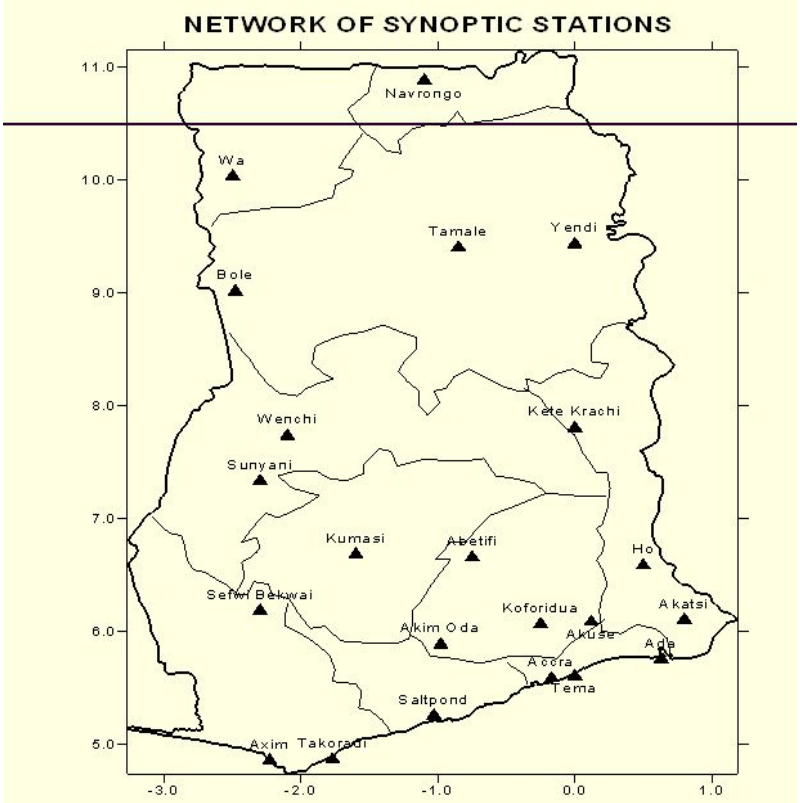


Figure 4 Map of weather monitoring station in Ghana

Ghana generally has a tropical climate with an average mean annual temperature of 28.2°C in the north sector and 27.3°C in the south sector where the project is located. The mean annual precipitation ranges from 900mm in the north to an average of 1500mm in the south. A detailed overview of the present climate will be provided in the ESIA using meteorological datasets obtained from the weather stations mentioned in Figure 4.1.2.

4.1.3 Projected Climatic Conditions

- **Temperature**

In response to increasing greenhouse gas (GHG) concentrations, air temperature over Ghana is projected to rise by 1.7°C to 3.7°C (very likely range) by 2080 relative to 1876.

Compared to preindustrial levels, median climate model temperature increases over Ghana amount to approximately 1.8°C in 2030, 2.2 °C in 2080, and 1.2 °C in 2080 under the low emissions scenario. Under the medium/high emissions scenario, the median climate model temperature increases to 2.0°C in 2030, 2.5°C in 2050, and 3.3 °C in 2080.

- **Rainfall (Precipitation)**

Future projections of precipitation are substantially more uncertain than projections of temperature or sea-level rise. Detecting annual mean precipitation projections trends is complicated by large natural variability at multi-decadal time scales and considerable modelling uncertainty. Based on four emissions scenario climate models, one project a decline in annual mean precipitation while the other three project that there will be no change. The best estimate suggests that there will be almost no change in total precipitation per year until 2080, irrespective of the emissions scenario, yet this result is highly uncertain.

4.1.4 Assessment of the project's effects on climate change

The development is inherently designed to reduce adverse climate change effects by offsetting the carbon dioxide produced by burning fossil fuels through the use of BRVs for the transportation of fuels. The current baseline with respect to greenhouse gas emissions will be identified using existing data from the government, operational sites, and experience of other similar developments. This information will provide the baseline information against which to assess the contribution of the project to reducing greenhouse gas emissions and identifying any potential for significant effects to arise.

4.2 AIR QUALITY

4.2.1 Introduction

The term 'air quality refers to levels of air pollutants that could potentially affect health, such as emissions of air pollutants from car exhausts and other sources such as generators. It also refers to dust, which could affect health or give rise to annoyance due to the soiling of surfaces through deposition. Both air pollution and dust could also affect fauna and flora. This scoping report considers the potential emission sources of air pollutants and dust associated with the project, as set out below:

- dust emissions generated by construction activities including earthworks, trench excavation and material storage;
- emissions of pollutants to air from construction plant and machinery.

There are no significant sources of air quality or dust effects associated with the operation of the pipeline.

The Ghana Standard Environment & Health, Requirements for Ambient Air Quality and Point Source Emissions (GS1236:2019) aim to improve air quality by reducing the impact of air pollution on human health and the environment.

The requirements for ambient concentrations of air pollutants are shown in Table 4.2.1 below:

Table 6 Ghana Standard Requirement for Ambient Air Quality & Point Source Emission

No.	Substance	Maximum Limit	Averaging Time
1.	Sulphur Dioxide (SO_2), µg/m^3	520	1 hour
		50	24 hours
2.	Nitrogen Oxides (NOx), µg/m^3	250	1 hour
		150	24 hours
3.	Particulate Matter 10 (PM_{10}), µg/m^3	70	24 hours
		70	1 year
4.	Particulate Matter 2.5 ($PM_{2.5}$), µg/m^3	35	24 hours

4.2.2 Baseline Conditions

The air quality survey aims to collect a representative dataset to inform an understanding of air quality within the study area. The route passes through various sensitive receptors (high population density areas, natural areas, tourist sites), which lie within a 500m radius of the pipeline. These sensitive receptor areas identified are shown in the figure below:



Figure 5 Identified air quality receptor areas selected for air quality monitoring stations

Air quality parameters such as sulphur dioxide (SO_2), Oxides of Nitrogen (NOx) and Particulate Matter (PM_{10} & $PM_{2.5}$) will be monitored at selected sensitive receptors along the pipeline route. Ambient air concentration will be monitored over 24-hour periods based on GS1236:2019 Standards.

Elevated levels of particulate matter (dust) are expected to be observed in areas where road constructions are ongoing. The primary sources of atmospheric emissions expected include open burning around communities, vehicular traffic emissions and combustion of wood for domestic purposes.

4.3 Ambient Noise

4.3.1 Introduction

Noise generation is expected to arise from the following project activities:

- Construction activities within the pipeline corridor, construction compounds and site haul route.

- The operation of the pipeline, involving pumping operations, maintenance and inspections.

The Ghana Standard Health Protection, Requirements for Ambient Noise (GS1222:2018) specifies the requirements for acceptable ambient noise levels. The objective of this requirement is to reduce noise pollution to levels that minimize harmful effects on human health.

The requirements for construction activities are to ensure that the minimum noise level near the construction site does not exceed;

- 75 dB (A) Leq (5min.) in an industrial area and
- 66 dB (A) Leq (5min.) in other areas.

4.3.2 Baseline Conditions

Baseline noise levels are likely to vary along the pipeline route as it passes through various settlement types (rural and urban settings) and vegetation zones. The main factors that affect baseline noise levels are expected to be as follows:

- Higher noise levels would be expected at locations closer to transport infrastructure and industrial activity;
- Diurnal patterns - higher noise levels would be expected at times of peak economic activity and lowest at night in settlement areas;
- Meteorological conditions – noise levels would be at their lowest in the absence of wind and rain.

The baseline noise levels at specific locations where project activities have the potential to create noise nuisance to sensitive receptors will be assessed in detail in the ESIA. Noise monitoring will be performed concurrently with ambient air quality monitoring locations. Monitoring will be performed for 24 hours to monitor and record noise contributors during the day and night.

4.4 Surface Water

4.4.1 Introduction

This chapter describes the current environmental baseline for surface water that the pipeline route interacts with. It identifies the potentially significant effects associated with the construction and operation of the project on key receptors. The chapter then provides

the proposed methods for assessing the likely significant effects and reporting on these within the ESIA.

4.4.2 Baseline Condition

Water quantity and quality have an essential role in supporting flora and fauna in rivers, lakes and wetlands. Fresh surface water can be abstracted for water supply. Flooding from surface water features can have an adverse effect on structures and communities.

Some of the water bodies (rivers and streams) along the pipeline route are seasonal in nature; they do not flow throughout the year. A number of major river bodies are located along the pipeline route at various locations. Notable among them are the Niene, Birim, Nwi, Pra and Anum rivers.

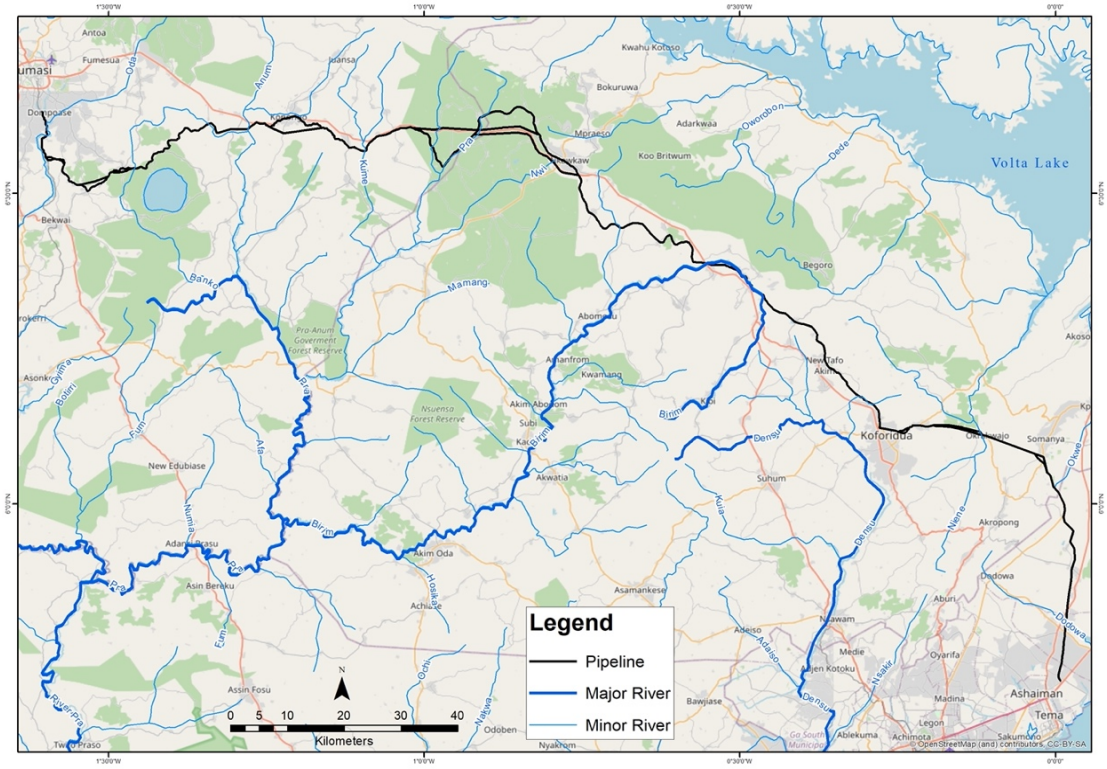


Figure 6 Showing water bodies along the pipeline route.

Drinking water guidelines provide the recommendations of the World Health Organization (WHO) for managing the risk from hazards that may compromise the safety of drinking water (WHO, 2011). The water quality parameters to be measured include; pH, temperature, conductivity, turbidity, chemical oxygen demand (COD), biochemical

oxygen demand (BOD), total dissolved solids (TDS), total suspended solids (TSS), oil and grease, nitrate, ammonia, lead, zinc, iron and cadmium.

4.5 Geology & Soil

4.5.1 Introduction

Soils and geology are key factors in determining the environmental character and quality of any given location or area. The rocks and superficial deposits beneath the ground's surface have a major influence on the landform – i.e. the topography and other geographical features of an area. The physical and chemical properties of the rocks and the overlying soils influence the type and variety of vegetation that will grow, agricultural quality, drainage and water storage capacity. They also influence the transfer and distribution of contaminants arising from current and previous land use.

4.5.2 Baseline Conditions

Based on the geological map of Ghana and information obtained from published geological records, the pipeline alignment will generally cross the following geological units between Accra Plain Depot (APD) and Kumasi BOST Depot; the Dahomeyan system, the voltaian system, Birimian supergroup, Tarkwaian system and intrusive rocks.

The Dahomeyan system is of the precambrian age and consists of acid and basic gneisses and schists with occasional bands of quartzose. The schists and gneisses in their fresh state are competent with high bearing strength. In their decomposed states, they form lateritic soils in high elevations, while clay soils form in flat and depressed areas.

The Birimian Supergroup is sub-divided into upper and lower series. The lower series is predominantly metasedimentary rocks. The main rock types consist of slates, phyllites, schists, meta greywackes and tuffs. The upper birimian series, on the other hand, is primarily a metavolcanic series made of metamorphosed lavas and pyroclastics referred to as greenstones, metamorphosed tholeiitic basalts, volcaniclastics, minor andesite and felsic flow rocks - rhyolites.

The Tarkwaian system trends in a northeast-southwest direction and consists of an alternating sequence of low-grade metasedimentary rocks: phyllites, sandstones, meta-conglomerates, breccias, quartzites. Minor basic rocks of gabbroic composition intruded into this system.

The Voltaian Supergroup is of neoproterozoic age and consists of the Kwahu Morago group, Oti and Obussum groups. The areas traversed fall within the Kwahu Morago group. The rock types are primarily fine sandstones and medium-grained quartzose. Current investigation revealed the presence of fine sandstones.

The Intrusive Rocks

Intruded into the Birimian rocks are large masses of granitoid related to the late stages of the eburnean orogeny at or after the birimian deposition. These granitoids are divided into three groups, namely; sedimentary basin granitoids with common rock types, muscovite-biotite granite, granodiorite, porphyroblastic biotite gneiss, aplites and pegmatites.

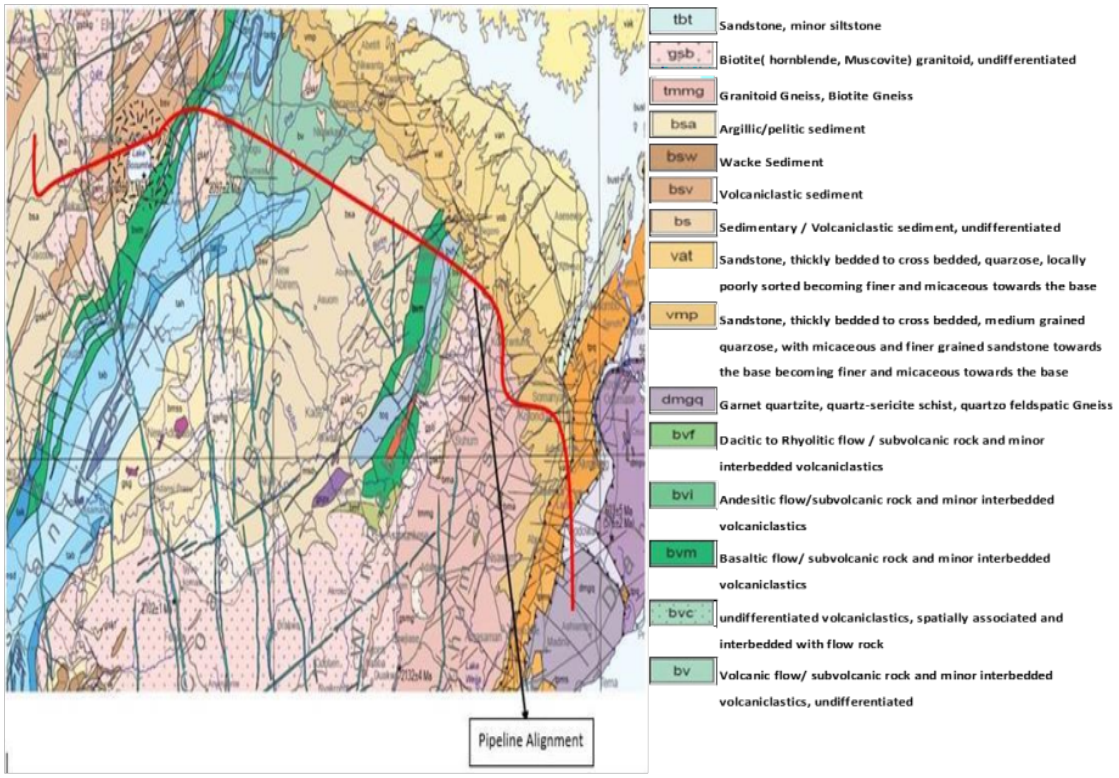


Figure 7 Geological information along the pipeline route

4.6 Biodiversity & Vegetation

4.6.1 Introduction

This chapter on biodiversity and vegetation considers habitats and species along the pipeline route. The project can potentially affect habitats and species of biodiversity value within the project's zone of influence.

4.6.2 Baseline Condition

Pipeline construction generally produces temporary and localised impacts. A desk study involving the collection of existing records within a 500m radius from the corridor has been undertaken to reflect this.

The results of the desk study have informed the requirement for field surveys. The area subject to field surveys has been defined by professional judgement (e.g. based on the habitat preferences of the target species), consultation and engagement responses, appropriate good practice guidelines, and the extent of the Project's anticipated zones of influence.

The vegetation cover profile along the pipeline route from the desk study are shown in the images below:

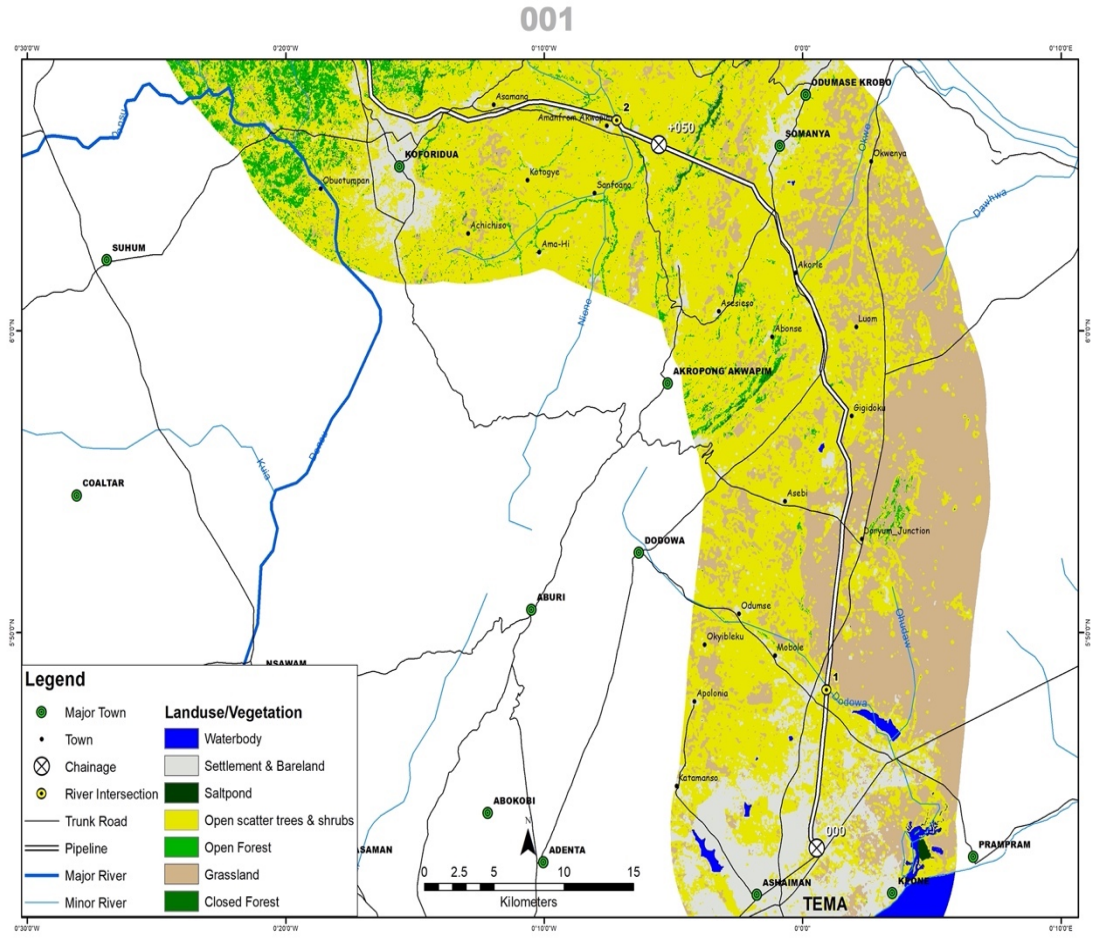
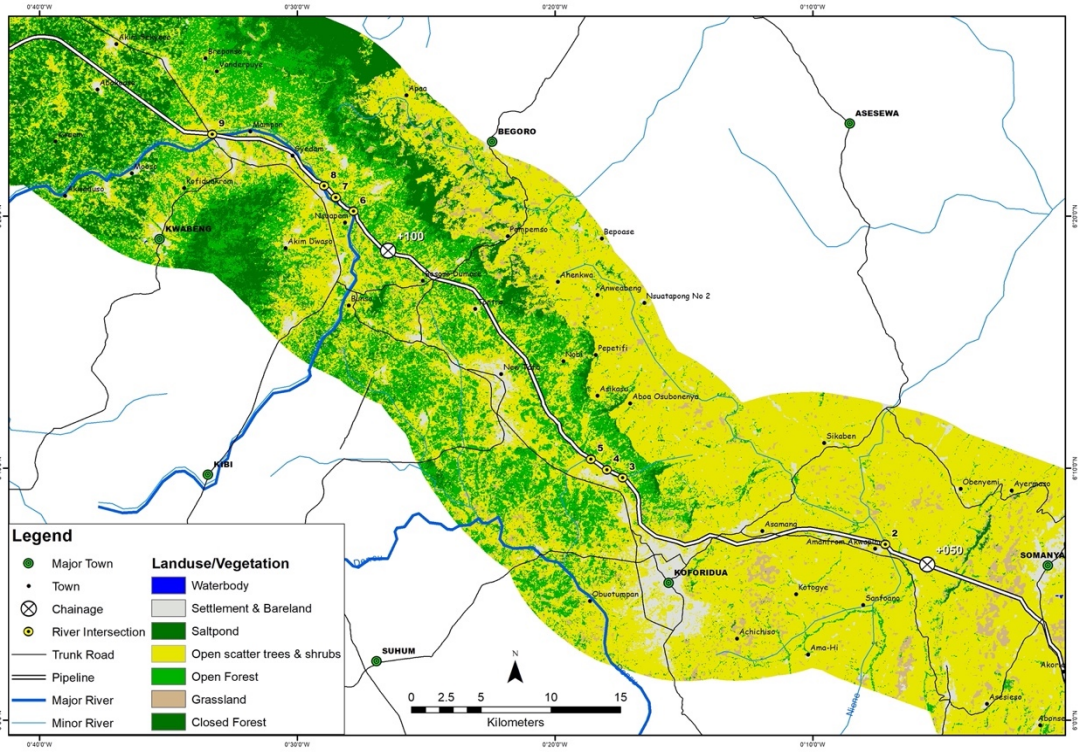
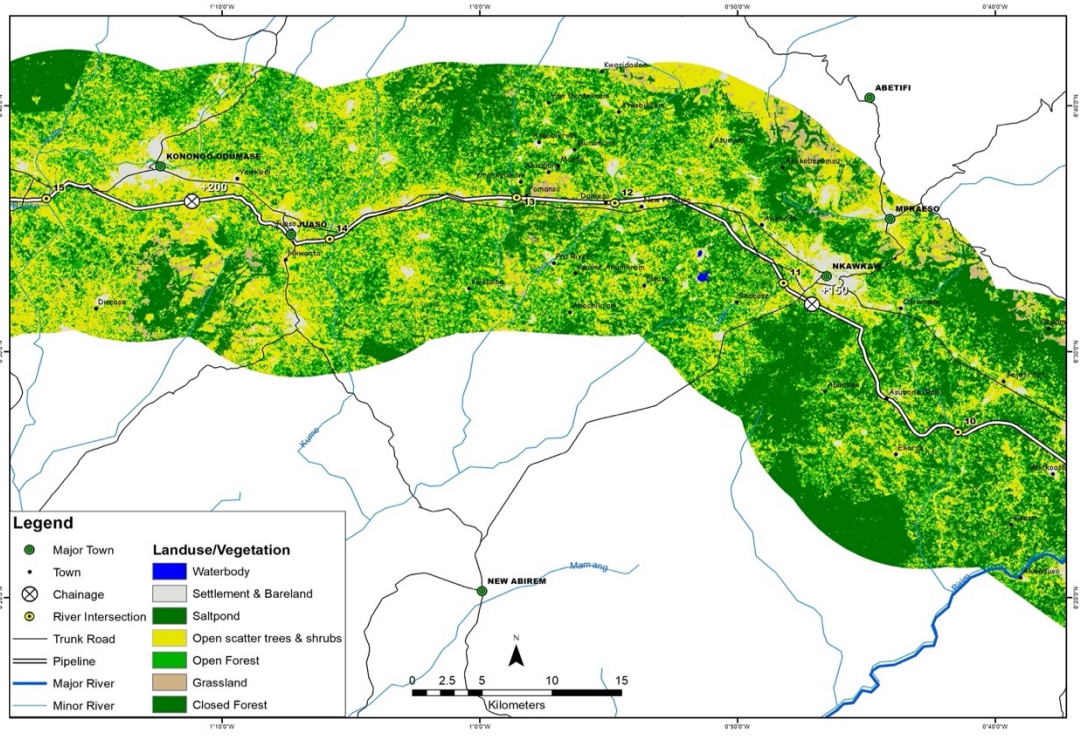


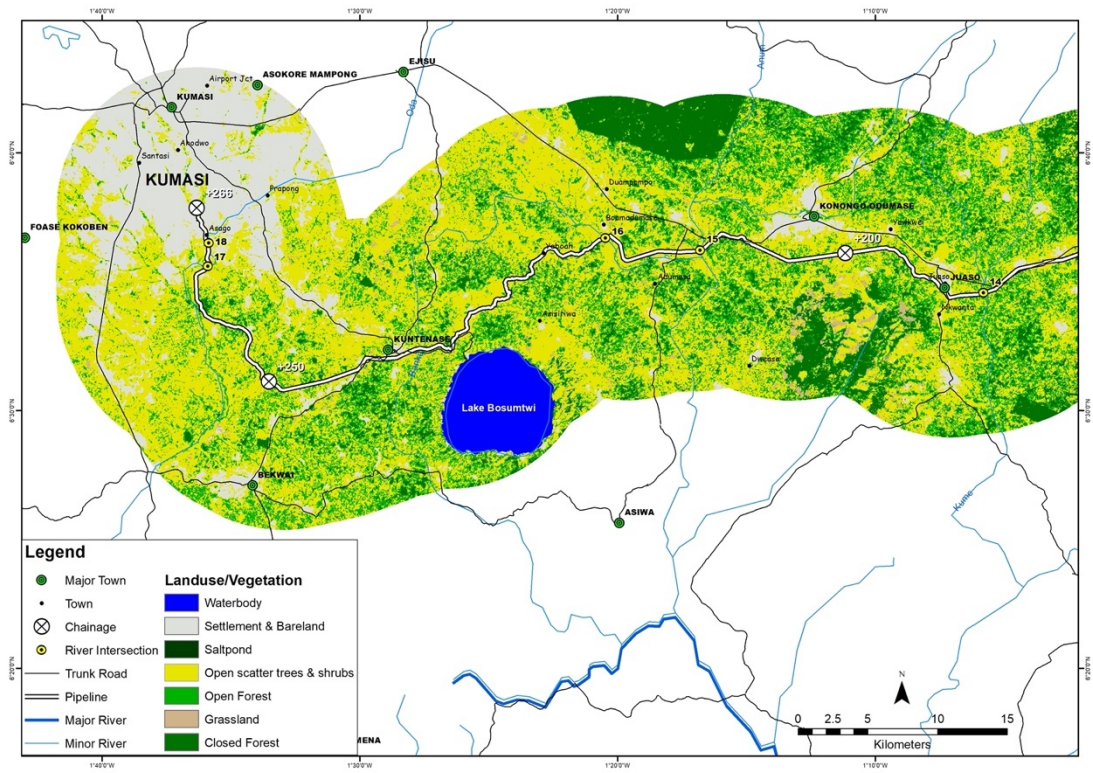
Figure 8 Vegetation cover profile along the pipeline route

002


BEGORO
ASESEWA
KWABENG
KYBI
SUHUM
KOFORIDUA
SOMANYA
+100
+050
Legend
Major Town
Town
Chainage
River Intersection
Trunk Road
Pipeline
Major River
Minor River
Landuse/Vegetation
Waterbody
Settlement & Bareland
Saltpond
Open scatter trees & shrubs
Open Forest
Grassland
Closed Forest
0 2.5 5 10 15
Kilometers

003


ABETIFI
KONONGO-ODUMASE
JUASO
MPRAESO
NKAWKAW
NEW ABIREM
+200
+150
Legend
Major Town
Town
Chainage
River Intersection
Trunk Road
Pipeline
Major River
Minor River
Landuse/Vegetation
Waterbody
Settlement & Bareland
Saltpond
Open scatter trees & shrubs
Open Forest
Grassland
Closed Forest
0 2.5 5 10 15
Kilometers



The field study has been sectioned (Section A, B & C) as described in Chapter 1 of this scoping report.

4.7 Population size, structure and composition

The pipeline transverses several settlements between the Greater Accra, Eastern and Ashanti regions. The major municipalities along which the pipeline route transverses are described below:

4.7.1 Section A

The major towns within the Section A of the route are Tema and Somanya.

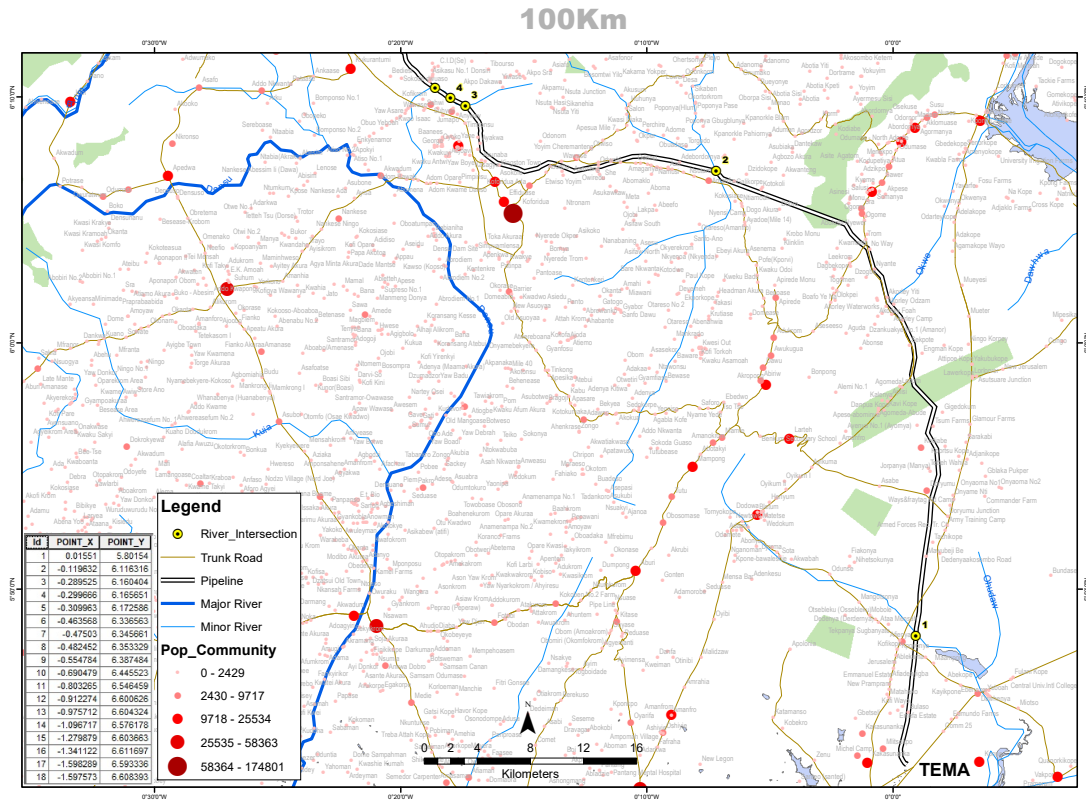


Figure 9 Map of Tema

Tema is a metropolis with a population of 292,773, representing 7.3% of the Greater Accra region's total population. Males constitute 47.8%, and females represent 52.2%. Also, 100% of the population live in urban localities.

Household: The Tema metropolis has a household population of 285,139 with a total number of 70,797 households. The average household size in the Metropolis is 4.1 persons per household. Children constitute the largest proportion of the household composition accounting for 34.1%. Spouses form about 10.6%, while other relatives constitute 11.2%. Nuclear (head, spouse(s), children) constitute 22.4 % of the total number of households in the Metropolis, and this is followed by Extended households (head, spouse(s), children and head's relative) (19.4%).

Literacy and education: Of the population 11 years and above, 91.1 % are literate, and 8.9 % are nonliterate. The proportion of literate males is higher (94.8 %) than that of females (87.8%). About five out of ten people (48.8%) indicated they could speak and write both English and Ghanaian languages. Of the population aged three years and above

(272,880) in the Metropolis, 8.5 % has never attended school, 33.8 % are currently attending, and 57.7 % have attended in the past.

Economic activity status: About 72.0 % of the populations aged 15 years and older are economically active, while 28.0 per cent are economically not active. Of the economically active population, 90.4 % are employed, while 9.6 % are unemployed. For the economically not active, a larger percentage of them are students (50.2%), and 20.2 % perform household duties. Again, about 53.5 % of the unemployed seek work for the first and are available for work.

Occupation: Of the employed population, about 31.5 % are engaged as service and sales workers, 20.2 % in craft and related trade and 10.4 % in elementary occupations. About 22.5 % are engaged as managers, professionals, and technicians.

Agriculture: In the metropolis, 3.6% of households are engaged in agriculture. Most agricultural households in the metropolis (about 74.7%) are involved in crop farming, with chicken (being 47.5%) as the dominant animal reared.

- **Yilo Krobo Municipal - Somanya**

The population of Yilo Krobo Municipal, according to the 2010 Population and Housing Census, is 87,847 representing 3.3% of the region's total population. Males constitute 48.2%, and females represent 51.8%. About seventy of the population is rural. The Municipal has a sex ratio of 93.2. The population of the municipal is youthful (47.4 %), depicting a broad base population pyramid that tapers off with a small number of elderly persons (8.7 %)

Household: The municipal has a household population of 86,567 with a total number of 20,613 households. The average household size in the municipality is 4.2 persons per household. Children constitute the largest proportion of the household structure, accounting for 39.4%. Spouses form about 10.5%. Nuclear households (head, spouse(s) and children) constitute 26.3% of the total number of households in the district.

Literacy & Education: Of the population 11 years and above, 79.0% are literate (50,012) and 21.0% are non-literate (13,290). The proportion of literate males is higher (87.9 %) than that of females (71.0 %). About six out of ten people (57.0 %) indicated they could read and write both English and Ghanaian languages. Of the population aged three years

and above (110,282) in the municipality, 19.0% has never attended school, 38.6% are currently attending, and 42.4% have attended in the past.

Economic Activity Status: About 72.1% of the population aged 15 years and older are economically active, while 27.9% are economically not active. Of the economically active population, 94.1% are employed, while 5.9% are unemployed. For those who are economically not active, a larger percentage are students (50.2 %), 18.2 % perform household duties,s and 14.3% are too old or young to work. Seven out of ten unemployed are seeking work for the first time.

Occupation: Of the employed population, about 41.9% are engaged as skilled agricultural, forestry and fishery workers, 21.7% in service and sales, 18.1% in craft and related trade, and 7.1% as managers, professionals, and technicians.

Employment status and sector: Of the population 15 years and older, 73.2% are self-employed without employees, 14.1% are employees, 5.3% are contributing family workers, 1.1% are casual workers, and 0.4% are domestic employees (house helps). Overall, men constitute the highest proportion in each employment category except the contributing family workers and apprentices. The private informal sector is the largest employer in the municipal, employing 89.6% of the population, followed by the public sector with 5.7%.

Agriculture: As high as 57.3% of households in the district are engaged in agriculture. In the rural localities, seven out of ten households (72.2 %) are agricultural households, while 29.7% of households are into agriculture in the urban localities. Most households in the district (93.9 %) are involved in crop farming. Poultry (chicken) is the dominant animal reared.

4.7.2 Section B

The major towns within the Section A of the route are Koforidua and Nkawkaw.

- **Nkawkaw**

Nkawkaw is the administrative Municipal Capital of Kwaku West Municipality, the second-largest town in the Eastern Region and ranked 20th in the country in terms of population (MLGRD, Habitat Survey Report, 2009).

The population of Kwahu West Municipal is 93,584, representing 3.6% of the region's total population. Females constitute 52.0% and males represent 48.0%. Forty-nine percent of the population is in rural areas. The municipality has a sex ratio of 92 males per 100 females. The population of the municipality is youthful (37.8%), depicting a broad base population pyramid.

Household: There are a total of 23,296 households in the municipality. The average household size in the municipality is 3.9 persons per household. Children constitute the largest proportion of the household structure, accounting for 40.3%. Spouses form about 10.7%. Nuclear households (head, spouse(s) and children) constitute 29.6% of the household population in the municipality.

Literacy and education: Of the population 11 years and older, 87.0% are literate, and 13.0% are not literate. The proportion of literate males is higher (92.0 %) than females (82.5%). Sixty niSixty-nine indicated they could read and write both English and Ghanaian languages. Of the population three years and older (36,254) in the municipality, 11.5% have never attended school, 42.1% are currently attending school, and 46.4% had attended in the past.

Economic activity status: About 70.4of the population aged 15 years and older are economically active, while 29.6%are economically not active. Of the economically active population, 95.3% are employed, while 4.7% are unemployed.

Occupation: Of the employed population, about 29.6% are engaged as skilled agricultural, forestry and fishery workers, 26.8% in service and sales, 16.8% in craft and related trade, and 2.4% are engaged as managers.

Employment status and sector Of the population 15 years and older, 66.6% are self-employed without employees, 3.7% are contributing family workers, 2.1% are casual workers, and 0.4% are domestic employees (house helps). The private informal sector is the largest employer in the municipality, employing 88.6% of the population, followed by the public sector with 6.0%.

Agriculture: The proportion of agricultural households in the municipality constitutes 43.8% of the total households. In the rural localities, 68.6% of households are engaged in agriculture, while 22.4% of households are into agriculture in the urban localities. Most

households in the municipality (96.0%) are engaged in crop farming. Poultry (chicken) is the most dominant livestock farming activity in the municipality.

- **New Juaben Municipal - Koforidua**

The population of New Juaben Municipality, according to the 2010 Population and Housing Census, is 183,727 representing 6.9% of the Eastern region's total population. Males constitute 48.3%, and females represent 51.7%. More than 93.3% of the population in the Municipality live in urban localities. The Municipality has a youthful population with about one third (30.8%) of the population below 15 years. This age structure results in a broad base population pyramid which tapers off with a small number of elderly persons (7.3%).

Household: The Municipality has a household population of 120,320 with a total number of 26,930 households. The average household size in the Municipality is 4.5 persons per household. Children constitute the largest proportion of the household structure, accounting for 45.5%.

Literacy and education: More than 90% of the population aged 11 years and older in the Municipality are literate. Females have a higher proportion of the not literate population than males. Close to three quarters (72.0%) of the literate population are literate in English and a Ghanaian language(s). Less than one percent are literate in English and French. The majority (54.9%) of the population currently in school are in basic schools, i.e., primary and JSS/JHS. Persons in senior secondary schools constitute 12% of the population currently in school. The proportion (57.0%) of females in basic schools is higher than that of males (52.8%), but the reverse is the case for those in tertiary education (9.7 % for females and 15.3% for males).

Economic Activity Status: About 66.4% of the population aged 15 years and older are economically active, while 33.6% are economically not active. Of the economically active population, 92.7% are employed, while 7.3% are unemployed. For those who are economically not active, a larger percentage of them are students (62.1%), 12.4% perform household duties, and 3.9% are disabled or too sick to work. About 63% (62.8%) of the unemployed are seeking work for the first time.

Occupation and industry: Majority (51.2%) of the working population are into service and sales, followed by craft and related works. A higher percentage of females (35.7%) are into service and sales than males (20.1%). The majority of male workers (27%) are rather into craft and related works. Wholesale and retail is the predominant industry for both male (19.6%) and female (42.5%) workers in the Municipality.

Employment status: More than half (53.1%) of the employed population are self-employed without employees. Females (64.0%) are more likely to be self-employed without employees than males (40.9%). About one third (31.3%) of the working population are employees. Three quarters (75%) of the employed population are in the private informal sector.

Agriculture: Agricultural households constitute 19.7% of the total households in the Municipality, with the majority of the households engaged in crop farming (87.6 %). Rural households tend to be more involved in agriculture (53.2%) than their urban counterparts (17.6%).

4.7.3 Section C

- **Ashanti Akim Central Municipality - Konongo**

According to the 2010 Population and Housing Census, the population of Ashanti Akim Central Municipality is 71,508. Males constitute 47.5%, and females represent 52.5%. A higher proportion of the population (67.8%) is urban. The municipality has a sex ratio of 90.4. The municipality's population is youthful (39.2 %), depicting a broad base population pyramid that tapers off with a small number of elderly persons (5.2 %).

Household: The municipality has a household population of 70,584 with a total number of 16,919 households. The average household size in the municipality is 4.2 persons per household. Children constitute the largest proportion of the household members accounting for 40.5%. Spouses form about 9.5%. Nuclear households (head, spouse(s) and children) constitute 25.7% of the total number of households in the municipality.

Literacy and education: Of the population 11 years and older, 85.9% are literate, and 14.1% are nonliterate. The proportion of literate males is higher (90.8%) than that of females (85.9 %). Of the population aged three years older in the municipality, 12.3% has never attended school, 42.0% are currently attending, and 45.7% have attended in the past.

Economic activity: About 68.0% of the population aged 15 years and older are economically active, while 32.0% are economically not active. Of the economically active population, 92.7% are employed, while 7.3% are unemployed. For those who are economically not active, a larger percentage of them are students (46.5 %), 25.6% perform household duties, and 5.4% are disabled or too sick to work.

Occupation: Of the employed population, about 33.0% are engaged as skilled agricultural, forestry and fishery workers, 23.9% in service and sales, 15.7% into craft and related trade, and 2.1% are engaged as managers.

Employment status: Of the population 15 years and older, 62.6% are self-employed without employees, 7.8% are contributing family workers, 2.5% are casual workers, and 0.4% are domestic employees (house helps). The private informal sector is the largest employer in the municipality, employing 85.9% of the population, followed by the public sector with 7.6%.

Agriculture: Half of the households (50.0%) in the municipality are engaged in agriculture. In the rural localities, seven out of ten households (75.1 %) are agricultural households, while 39.3% of households are into agriculture in the urban localities. Most households in the municipality (95.7 %) are involved in crop farming. Poultry (chicken) is the dominant animal reared in the municipality.

- **Kumasi Metropolitan**

The population of Kumasi Metropolis is 1,730,249, representing 36.2% of the total population of Ashanti Region, from the 2010 Population and Housing Census. The Metropolis has a sex ratio of 91.4. The population of the Metropolis depicts a broad base population pyramid that tapers off with a small number of elderly persons (60 years and older).

Household: The Metropolis has 440,283 households with an average household size of about four persons. Children constitute the largest proportion of the household members accounting for 39.7%, and spouses 9.9%. Nuclear households (head, spouse(s) and children) constitute 26.9%, and single-parent nuclear also form 12.9% of the household structure in the Metropolis.

Literacy and education: The percentage of the population aged 11 years and older who are literate is 89.5%, while 10.5% are not literate. About 9.1% of the population three years and older have never attended school, while 40.5% are currently in school and 50.4% have attended school in the past.

Economic activity: About 66.5% of the population aged 15 years and older is economically active, while 33.5% is economically not active. Of the economically active population, 91.4% is employed, while 8.6% is unemployed. For those who are economically not active, a larger percentage of them are students (56.4%), 19.5% perform home duties, and 2.9% are disabled or too sick to work. Of the employed population, 38.9% are in the service and sales work, 22.8% are in craft and related trades, 10.3% are into elementary occupation, and only 2.6% are skilled agricultural forestry and fishery workers. About 49.2% of the workforce is self-employed.

Agriculture: Less than 10% (8.5%) of households in the Metropolis are engaged in agriculture. Of those in Agriculture, 91.6% are into crop farming, and 10.7% are livestock rearing. Poultry (chicken), goat, sheep, and pigs are mostly reared in the Metropolis.

5. IDENTIFICATION OF POTENTIAL IMPACTS

5.1 INTRODUCTION

The process of identifying potential impacts was sterned from consultation with key stakeholders and desktop study. The engagement with communities, regulatory bodies and authorities provided information that may cause a significant impact. Desktop and field studies of the pipeline route provided the needed information for the basis of stakeholder engagement.

During the scoping phase, environmental and social receptors likely to be impacted by the project were identified. Physical environmental receptors as air quality and noise levels, surface water quality, sedimentation generated from construction activities. Natural environmental receptors such as flora and fauna, habitats and human environment (settlements, economic activities, culture and heritage and the need for job opportunities) were identified.

These potential and significant issues and impacts identified have been assessed to develop mitigation measures to address them.

5.2 Ambient Air Quality Impacts

5.2.1 Operational Phase

There are no significant sources of air quality or dust effects associated with the operation of the pipeline. Therefore, these are not considered further.

5.2.1 Constructional Phase

- **Emissions of Dust**

Construction activities associated with the Project have the potential to generate fugitive dust emissions. These may give rise to annoyance due to the soiling of surfaces, risk of health effects due to the increase in exposure to fine particulates such as PM_{10} and $PM_{2.5}$ and damage to vegetation and ecosystems (where very high levels of dust soiling occur).

The main construction activities associated with the project that could generate dust include earthworks, trench excavation and material storage. Vehicle movements may also generate dust.

There are not currently expected to be any demolition activities associated with the Project. Along the route, there are sensitive human receptors within 500m. In addition, the route

pass within some ecological receptors. Therefore, there would be a risk of dust impacts on human and ecological receptors.

Based on the limited construction activities associated with the construction of the pipeline and the short duration that each receptor would be potentially exposed to the construction works, it is considered that there would be a low potential for risk of significant dust impacts.

The risk of dust impacts from these activities can be controlled by adopting standard good practice dust mitigation measures and controls. The relevant good practice mitigation measures for the construction phase will be detailed in the contractor's Construction Environmental Management Plan (CEMP).

Therefore, with the implementation of the dust mitigation measures and controls, the likely effect of dust emissions on human health and ecological receptors during construction is concluded to be minimal and not significant.

- **Emissions from Construction Plant and Machinery**

The type and numbers of construction plants and machinery would vary over the construction period. The construction plant and machinery are anticipated to consist of a mixture of the following types:

- tracked machines
- dumper trucks
- trench rollers
- excavators
- small diesel generators

The construction areas would generally be long and narrow, with the works spread out across different parts of a Section at any one time. Where there would be an overlap in construction activities, these would typically be undertaking different elements of the works rather than all plants operating at the exact location simultaneously. For example, machinery associated with the excavation of the pipeline trench would operate in one area initially, followed further behind by the plant laying the pipe, and then the plant required to refill the excavated material and the levelling of the new surface.

Construction plant and machinery would be in operation at any one location for only a short duration. There would also be a relatively low number and size of plant and machinery items operating during construction simultaneously on each work front. Therefore, the potential effect on local air quality at human receptors and ecological receptors in the vicinity of the construction works would be negligible. On this basis, the effect on air quality from construction plant and machinery emissions in rural and urban areas is considered to be not significant.

5.3 Ambient Noise Levels Impacts

5.3.1 Operational Phase

During the operation of the pipeline, the noise generation will be from pump stations situated along the route. The noise levels from the operational phase are low and will have little impact on the background noise levels.

5.3.2 Construction Phase

Noise will be generated mainly during the construction phase of the project within the pipeline corridor. The following construction activities will contribute to background noise levels:

- Movement of trucks in rural areas
- Fencing;
- Topsoil Strip in rural areas;
- Breaking of hard surfaces;
- Compound preparation;
- Pipe Stringing;
- Pipe Welding;
- Excavation;
- Pipe Laying;
- Backfill;
- Compaction; and
- Reinstatement.

The construction activities would not occur at the exact location simultaneously. Equipment associated with the excavation of the pipeline trench would operate in one area initially. These would be followed behind by the plant laying the pipe, and then the plant needed to refill the excavated material and level the new surface. Within the overall construction period, there would be days when no construction activities would be audible. Similarly, any receptor would only experience the highest construction noise levels for a limited duration within the construction period.

In the event that noise from construction activities at two simultaneous work fronts occur during the same day or night at a particular receptor, the short term construction noise level could be temporarily elevated.

Some control measures to mitigate noise impacts to be included in the CEMP would be:

- avoidance of simultaneous working close to places of gatherings (schools, churches, etc.);
- provision of construction site hoarding around a construction compound; and
- Set limits to the duration and nature of simultaneous activities

For daytime, noise generated from construction activities would have a large magnitude of change. For nighttime construction noise, the magnitude of change would be based on the noisiest night during the construction works. All settlements where the pipeline passes through would be considered to have medium sensitivity.

5.4 Surface Water Quality Impacts

5.4.1 Operational Phase

It is considered that the vast majority of the project does not present the potential for significant effects on surface waters due to inherent design considerations to detect leaks and the pipeline being located below ground. The project does not present the potential for significant effects on surface waters except at pigging stations. However, the management of waste at pigging stations has the potential to impact local receptors. Draining down fuel from the isolated pipeline at pigging stations and waste emerging from the pipeline during pigging operations will require effective management. Mitigation measures include the design of systems to contain fuel and wastes drained from the pipeline during inspections (prior to removal from the site for treatment and disposal).

5.4.2 Construction Phase

Some construction activities would interact directly with surface water bodies and their potential to impact water quality. Such instances could arise from construction activities within watercourses and their catchments or where dewatering activities discharge to a surface water receptor. Impacts could arise from; the introduction of contaminants such as chemicals and/or suspended sediment.

Compaction of ground and installation of temporary haul roads, accesses and lifting platforms also has the potential to increase runoff and suspended sediment, as does direct runoff from construction areas. Mitigation measures to address these risks would include establishing pollution prevention guidelines which will be included in the CEMP. These would include the appropriate storage and handling of substances hazardous to the environment and reinforcement of river banks or crossings.

The assessment of the construction effects of the project on surface water quality is considered significant.

5.5 Ecological (Flora & Fauna) Impacts

5.5.1 Operational Phase

There is no significant impact associated with the ecosystem with the operation of the pipeline. Therefore, these are not considered further.

5.5.2 Construction Phase

The assessed degree of significance of the effect is a function of a receptor's value and the potential magnitude of change caused by a given effect. To determine this, the guidance given in Impact Assessment Methodology would be used, together with professional judgement. Only those effects considered likely to result in a 'moderate' or 'major' magnitude of change would be considered as significant. Those assessed as 'negligible' and 'minor' would be considered as non-significant effects. Where significant effects are predicted, additional mitigation would be applied to reduce the magnitude of the effects, where practicable.

Continued engagement with statutory bodies and key stakeholders would be undertaken throughout the assessment process to identify and address important constraints and enhancement opportunities.

5.6 Geological Impacts

A geotechnical study is undertaken to determine the geology, soil type, underground water availability, and existence of any faults and seismic activity along the pipeline. A detailed geotechnical study is being carried out with the topographical survey and percussion drilling in non-rock formations to determine the site suitability with regard to the soil quality (type, acidity, resistivity), as well as the geology to determine the depth of any rock formations to be embedded in the design development of the pipeline. From the desk study, no designated sites of geological importance have been identified. The pipeline route during the desktop study was designed to avoid geological places of interest such as mineral reserves and protected areas. The ESIA will analyze data from the geotechnical study in order to advise design parameters.

5.6.1 Operational

The presence of the pipeline would restrict access to the ground throughout the period of operation. Contamination requiring remediation may be identified during the operational phase. However, existing ground conditions would be assessed, and the area at any one location that might be affected in this manner would be relatively small. Land contamination aspects related to the pipeline itself acting as a potential contaminant source are not considered significant because of the project design and operating practices.

5.6.2 Construction Phase

During the construction phase, the impact on soils may include:

- Loss of topsoil;
- Deterioration of soil properties through handling and storage;
- Degradation of soil quality through the transfer of soil-borne invasive weeds;
- Contamination of soil from spills arising from construction machinery and equipment.

The impacts to soil would be localized within the route corridor.

5.7 Social Impacts

The project's potential effects on employment, economy, tourism, effect on the community and public safety are outlined below. These effects may occur during the construction and/or operation of the project.

5.7.1 Employment

Operation Phase

Employment opportunities during the operational phase of the project are expected to be very limited as maintenance and general operations of the project would be undertaken by a few highly skilled workforce. It is anticipated that there would be no potential significant effects during the operation of the pipeline in rural and urban areas with respect to employment.

Construction Phase

Construction works in rural and urban areas would require construction workers based in that locality. The total person employed in construction will increase employment and boost job opportunities for communities along the pipeline route temporarily during the construction with their locality.

5.7.2 Economy

Operation Phase

The pipeline is particularly important to the national economy. The operation of the pipeline looks to provide and maintain a constant supply of fuels for economic activities throughout the country. However, the pipeline would not provide communities with direct service, therefore no potential for significant effects on the local economy of the communities in which it passes.

Construction Phase

It is anticipated that economic activities would temporarily increase during the construction phase at the point of construction due to the influx of construction workers in an area. Indirect economic boost for these communities will not be significant as construction works will not be stationary. However, designated areas where construction camps are to

be placed will experience economic growth for the entire duration of the project's construction phase.

5.7.3 Land Use and Compensation

The project scoping visit indicated the presence of commercial and subsistence farms along the pipeline route. In the course of further consultation, additional checks will be carried out to ensure that owners of any crops or farms or trees of commercial value that the pipeline will impact are adequately compensated for before the commencement of construction activities.

6. EVALUATION OF ALTERNATIVES

6.1 Introduction

This chapter summarizes the main alternatives considered, the scheme's development and the good practice mitigation relied upon for the scoping process. The importance of sustainability in consideration of development projects is paramount. Therefore, project alternatives in terms of route selection must consider sustainability issues, including environmental, social, social health and safety, in evaluating route alternatives to arrive at the best option.

6.2 Consideration of Alternatives

This section provides a summary of the main alternatives considered and the decisions made to date. The consideration of the environmental, social, economic and technical feasibility of the project was studied.

6.2.1 Do Nothing Scenario

A ‘do nothing’ scenario would not take forward any development proposals associated with the project. To be a viable alternative to the project, BRVs will continue to be the primary mode of transport of multifuel to the BOST Terminal in Kumasi. This has been rejected as unsustainable and not environmentally friendly. The main issues of a ‘do nothing’ scenario are:

- The use of BRVs contribute for transportation contributes significantly to air emission into the environment.
- The use of BRVs places extensive stress on the road network, thereby damaging the roads and regularly necessitating repairs of the roads. BRVs poses a safety risk with frequent collisions and delays during transport. BRVs accidents may lead to fire/ explosion causing loss of lives and damages to the environment.
- The use of BRVs reduces the potential economic development opportunity to expand fuel supply and export to neighbouring countries.

6.2.2 Alternatives To The Project

- ***Transporting By Road***

The primary and existing mode of transporting fuel by road is the alternative consideration for the project. The project would keep around 50 road tankers off the road every day. Transporting large quantities of fuel by road on a daily basis would be unreliable, uneconomic and have long term environmental and social consequences. The Project has therefore rejected the alternative option of transporting fuel by road.

- ***Transporting By Rail***

Another alternative considered by the Project is the use of rail to transport fuel. This process would involve the expansion and rehabilitation of existing railway lines. This option was rejected as unfeasible due to the poor infrastructure of the rail network in the country. Also, the short-term environmental impact of the pipeline construction and the operational environmental impact is much lesser. This alternative would offer no environmental benefit.

For the above reasons, BOST/ Sienna has decided there is no feasible alternative other than constructing a pipeline between the Accra Plain Depot and the Kumasi Depot. Therefore, the remainder of this chapter describes the development of the proposal for the pipeline and the alternatives considered within this process.

6.3 Development of Pipeline Corridor Alternatives

Several alternatives were considered in relation to the selection of the pipeline route; the pipeline's design and construction are discussed in the subsections below.

6.3.1 Evaluation Criteria for alternatives

The following criteria were considered during the route selection process:

• Construction requirements:

- Accessibility;
- Proximity to existing power supplies;
- Proximity to existing towns (to facilitate access to supplies);
- Utilisation of existing rights of way to minimise societal impact;
- Terrain profiles, topography, elevation, and slopes.

- Operating & Maintenance requirements:
  - Accessibility;
  - Pig station requirements and locations.
- Pipeline Integrity requirements:
  - Interaction with railway lines and power lines (parallel and perpendicular).
- Construction safety:
  - Security risks;
  - Political or civil unrest;
  - High-tension areas;
  - Interaction with railway lines and power lines (parallel and perpendicular).
- Environmental requirements & impacts:
  - Nature reserves;
  - Forests, lakes and mountain ranges;
  - Seismic activity potential;
  - Mineral fields.
- Social & community requirements & impacts:
  - Population density analysis.
- Pipeline cost.
- Hydraulic analysis:

- The ability of the new pipeline to support export flowrate requirements;
- The ability of existing pipelines and terminals to support export flowrate
- requirements;
- Dependence on barging and road vehicle infrastructure to achieve export flowrates;

These criteria have been utilised to compare the possible route options using a scoring process quantitatively and qualitatively.

6.4 Pipeline Route Study

The following routes are considered for the route study and comparison:

Route Option 1:

- Accra Plains Depot to Kumasi Depot directly via land.

Route Option 2:

- Akosombo Depot to Kumasi Depot via land.

Route Option 3:

- Akosombo Depot to Kumasi Depot via Lake Volta

6.5 Pipeline Route Development

- **Straight line**

The first step in the approach to the route study is to utilise a straight line between the selected starting and endpoints for each route option and identify the key challenges, risks, concerns and benefits of the selected routing using the information available on the spatial database and the identified route selection criteria. The straight-line routing is used as the starting point as this is the shortest possible route with the lowest associated cost for material and installation, and therefore probably the shortest execution timeline.

- **Optimize route**

After that, the straight line route is optimised by deviating away from key problem areas where possible and selecting an appropriate routing for exiting the main cities (i.e. selecting a routing that does not traverse through homes, churches, schools, golf courses and other buildings or yards, but instead keeps to road reserves and open fields).

- **Routing parallel to roads**

The second route assessed under each option typically follows main roads or highways as far as possible. This route is typically longer than the direct line (and will require additional

material and installation timelines). However, it may be far easier to access, therefore decreasing the logistics costs associated with deliveries of diesel, materials, consumables, food, water and other sites requirements.

- **Alternative routes**

The outcomes of the analysis of the first two routes and field review feedback assisted in identifying alternative routes following railway and power line rights of way.

- **Route detailing**

Once all high-level route options had been agreed upon and edited with the larger team, each route was detailed to avoid key obstructions and follow logical elevation and right of way routes. This exercise increases the overall length of each route but assists in distinguishing the routes such that they can be critically compared based on a set of specified criteria.

6.6 Pipeline Corridor Selection

6.6.1 Route Corridor 1

The first route corridor is directly from Accra Plains Depot to Kumasi Terminal via land. Four different route permutations were identified within this corridor based on avoiding key risks (namely the Bauxite and diamond fields) and high elevation points whilst maximising utilisation of existing rights of way.

6.6.1.1 Route Corridor 1A

Route Option 1 A, which started as a straight line between APD and Kumasi Terminal, has been updated and detailed to follow main roads wherever possible. The route exits Accra along the existing pipeline RoW and joins the railway RoW to enter BOST from the southern direction. This route is the shortest possible route for option 1.

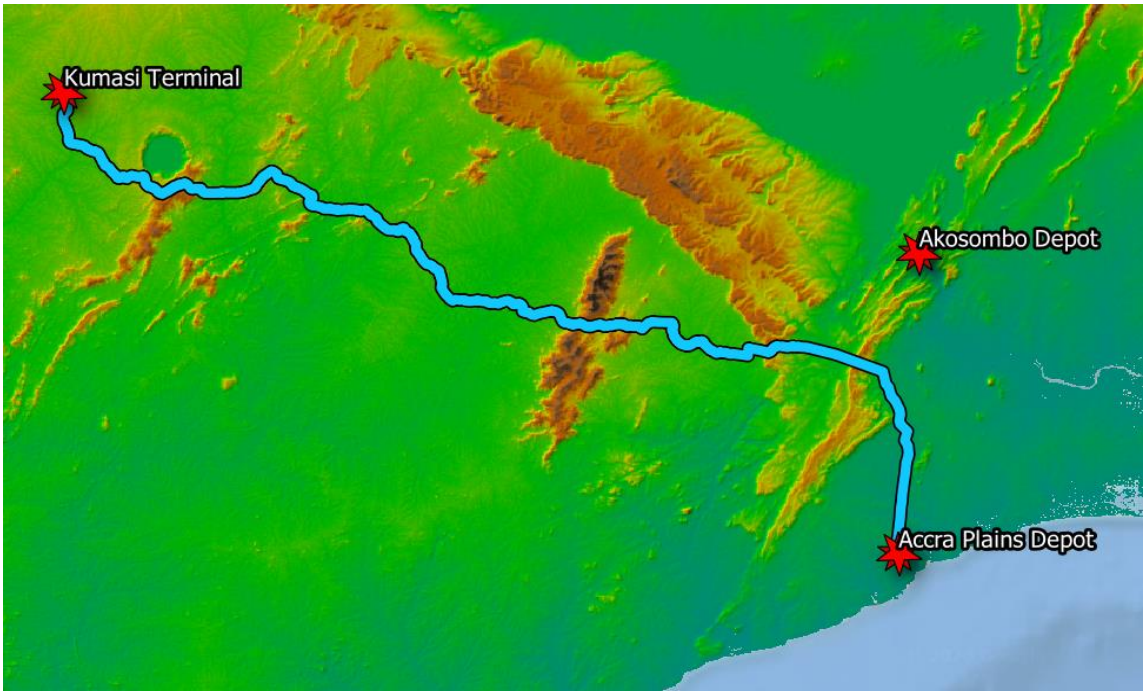


Figure 10 Route Corridor 1A

*6.6.1.2 **Route Corridor** 1B*

Route Option 1B follows the N4 and N6 highways for the majority of the route between APD and Kumasi Terminal. The route exits Accra along the existing pipeline RoW and joins the railway RoW to enter BOST from the southern direction. The key objective of this route is to avoid the Atewa mountain range via the north.

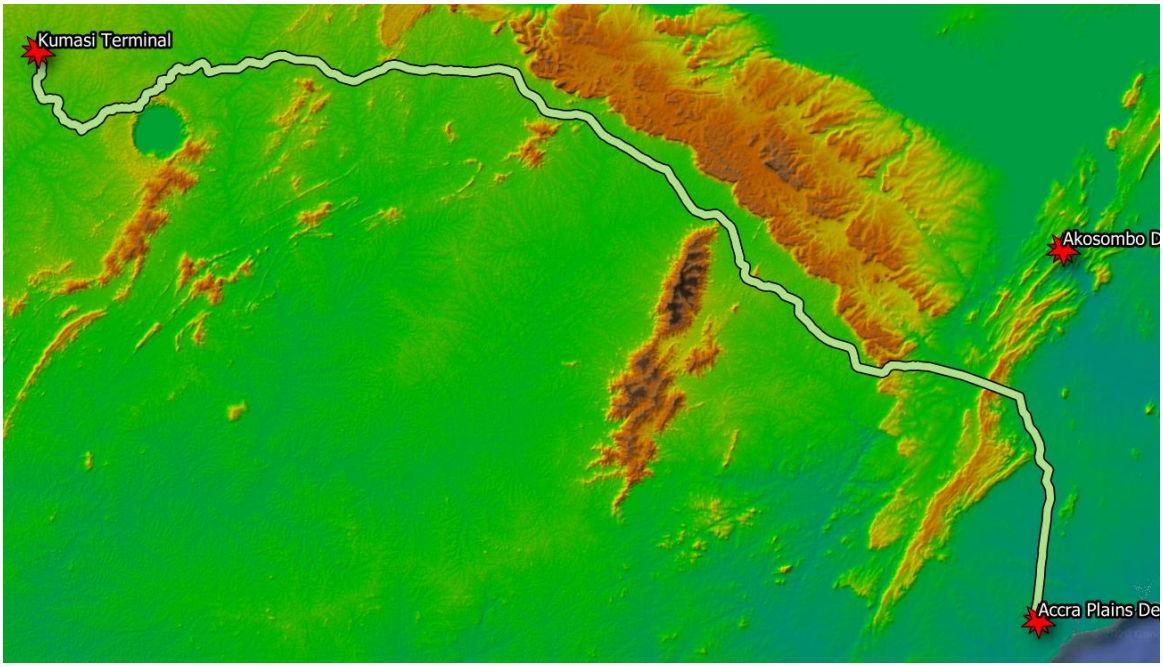


Figure 11 Route Corridor 1B

6.6.1.3 Route Corridor 1C

Route Option 1 C follows roads to exit Accra (i.e. not the pipeline RoW) and follows main roads wherever possible around the southern side of the Atewa mountain range. The route joins the railway RoW to enter BOST from the southern direction. The key objective of this route is to avoid the Atewa mountain range via the south.

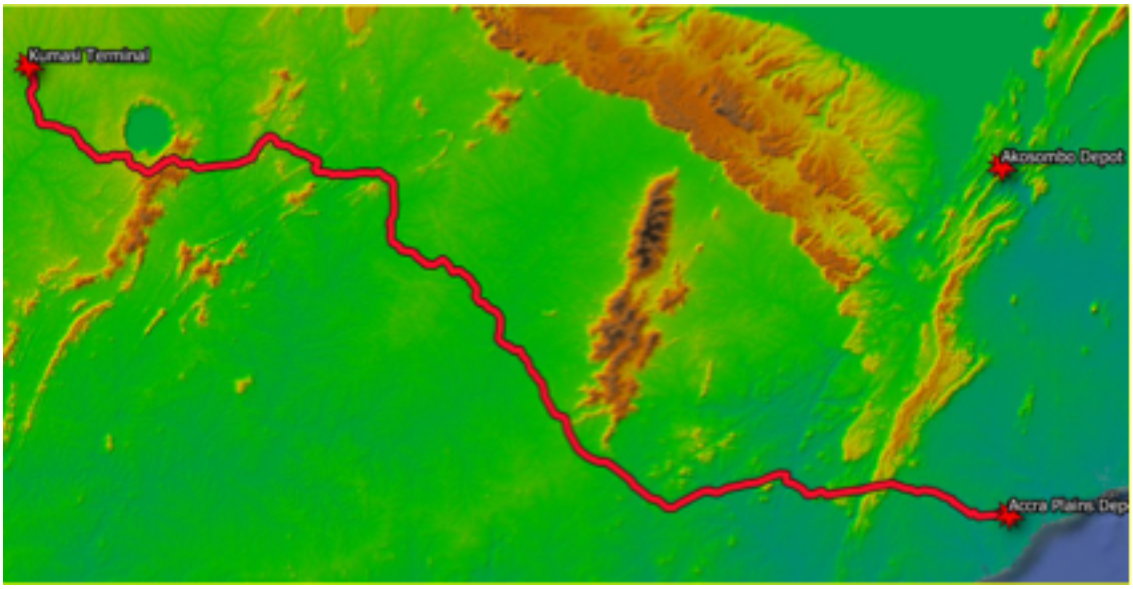


Figure 12 Route Corridor 1C

6.6.1.4 Route Corridor 1D

Route Option 1D is a route option stemmed from the field review studies. The route is detailed as follows:

- Exit APD in Tema following the existing pipeline ROW (between APD and Akosombo) for about 15km;
- Follow roads to approach the railway ROW between APD and Kumasi (avoid Koforidua city centre);
- Follow railway ROW between APD and Kumasi;
- Follow roads to approach the railway ROW between Takoradi and Kumasi;
- Follow railway ROW between Takoradi and Kumasi to enter BOST.

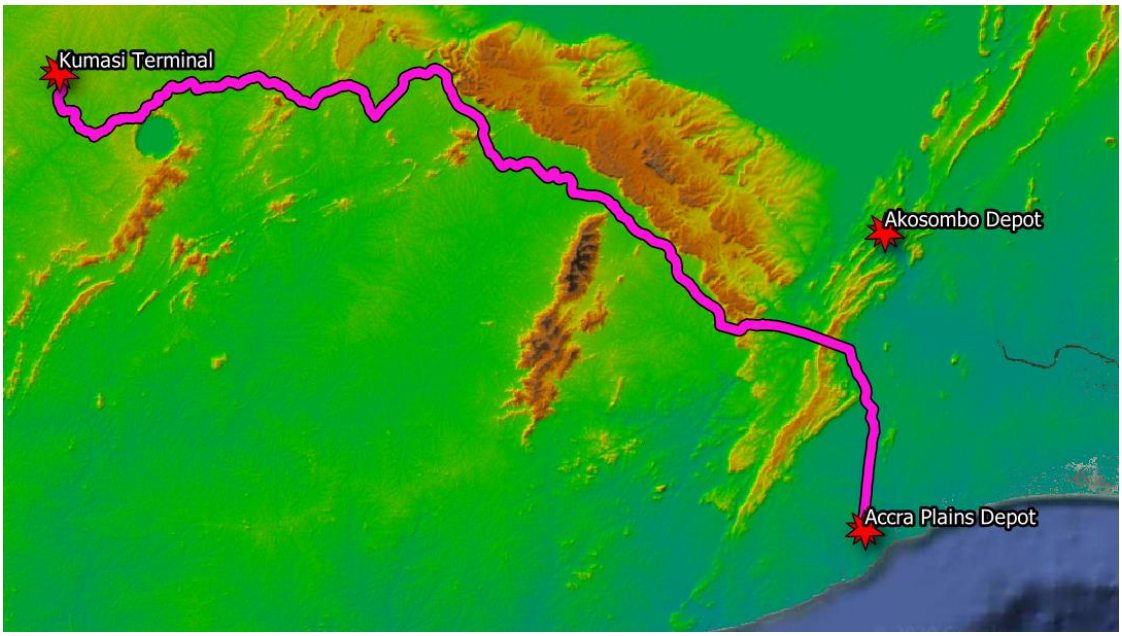


Figure 13 Route Corridor 1D

6.6.2 Route Corridor 2

The second route corridor as part of the route analysis is directly from Akosombo Terminal to Kumasi Terminal on land. 4 different route permutations were identified within this

corridor based on avoiding key risks (namely the Bauxite and diamond fields) and high elevation points whilst maximising utilisation of existing rights of way.

6.6.2.1 Route Corridor 2A

Route 2A primarily avoids the narrow mountain range near Tema, which may pose a few risks during construction, as identified by the field review. The route follows main roads to exit Akosombo before merging with route 1D (via the railway line ROW) to Kumasi.

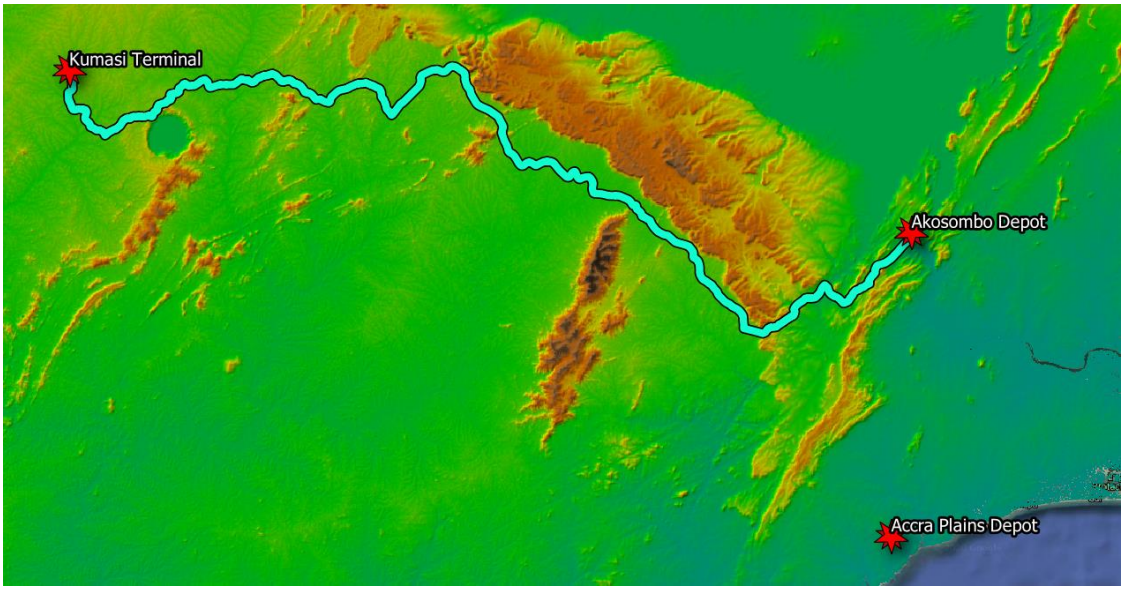


Figure 14 Route Corridor 2A

6.6.2.2 Route Corridor 2B

Route 2B runs around the back of the mountain range near Tema and then crosses it at an identified low elevation point (no existing infrastructure here). The detailed route follows main roads to exit Akosombo and then joins route 1B (via the railway line ROW) to Kumasi.

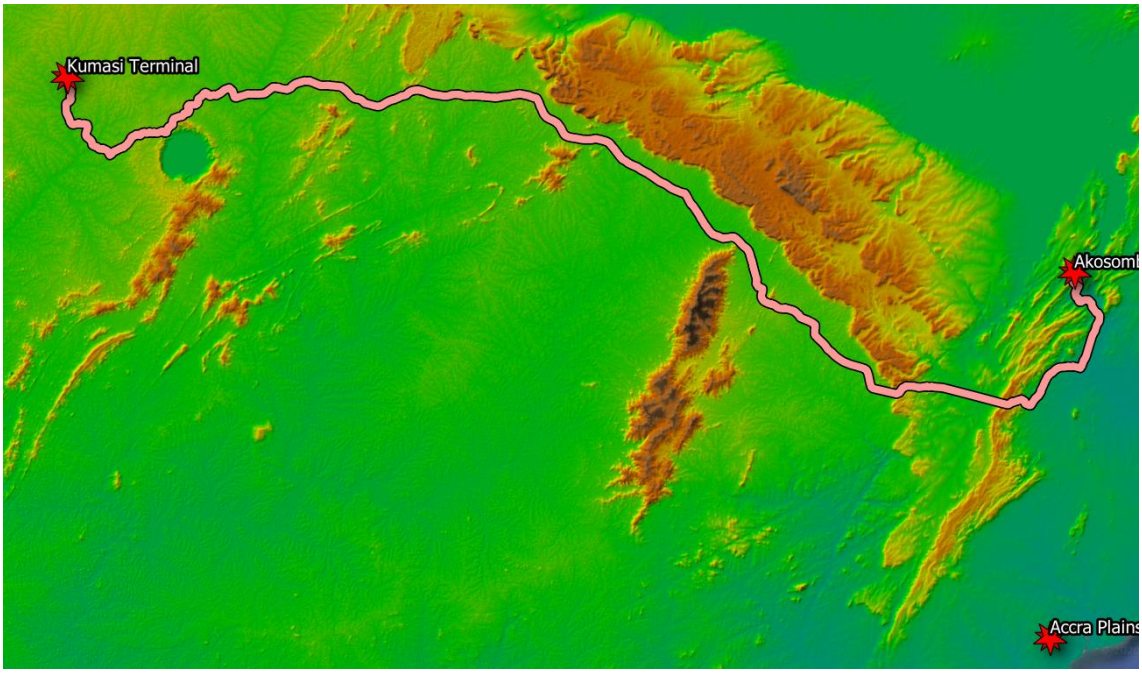


Figure 15 Route Corridor 2B

6.6.2.3 Route Corridor 2C

Route 2C is a new route identified during the field review phase. The proposed route follows the existing pipeline ROW to exit Akosombo and then joins route option 1D (via the railway ROW) to Kumasi.

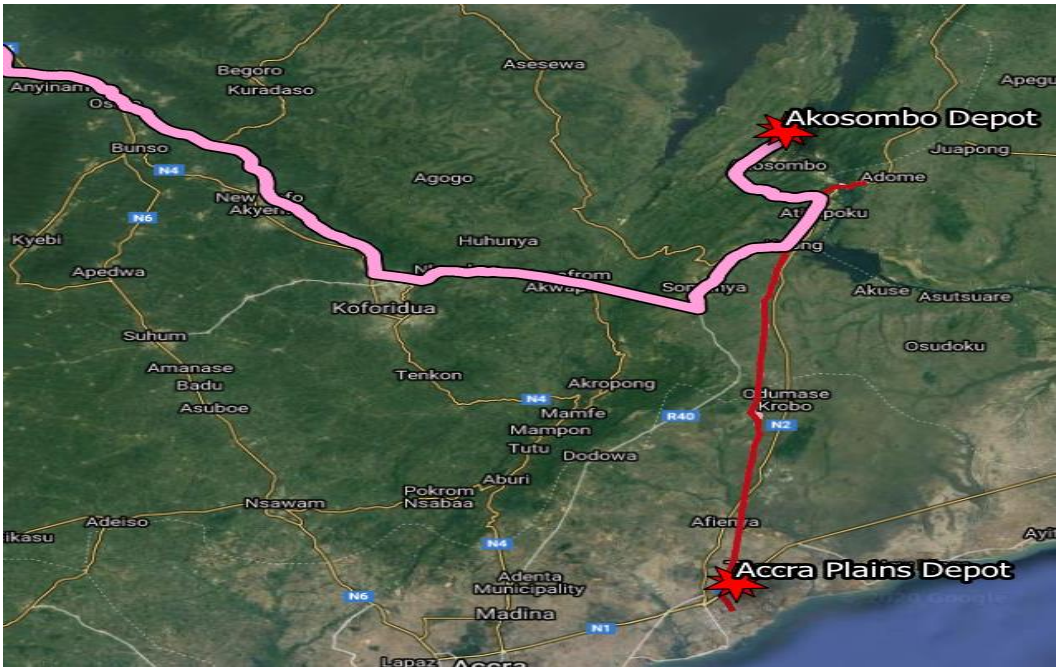


Figure 16 Route Corridor 2C

6.6.3 Route Corridor 3

The final route corridor part of the pipeline routing analysis is to utilise barges via Lake Volta to transport the fuels from Akosombo to an identified jetty point in Adowso before utilising a pipeline from Adowso to Kumasi (on land). This route has been detailed to follow main roads exiting Adowso towards Nkawkaw before joining pipeline route 1D (via the railway ROW) and route 1B (via the power line ROW) to enter Kumasi from the south.

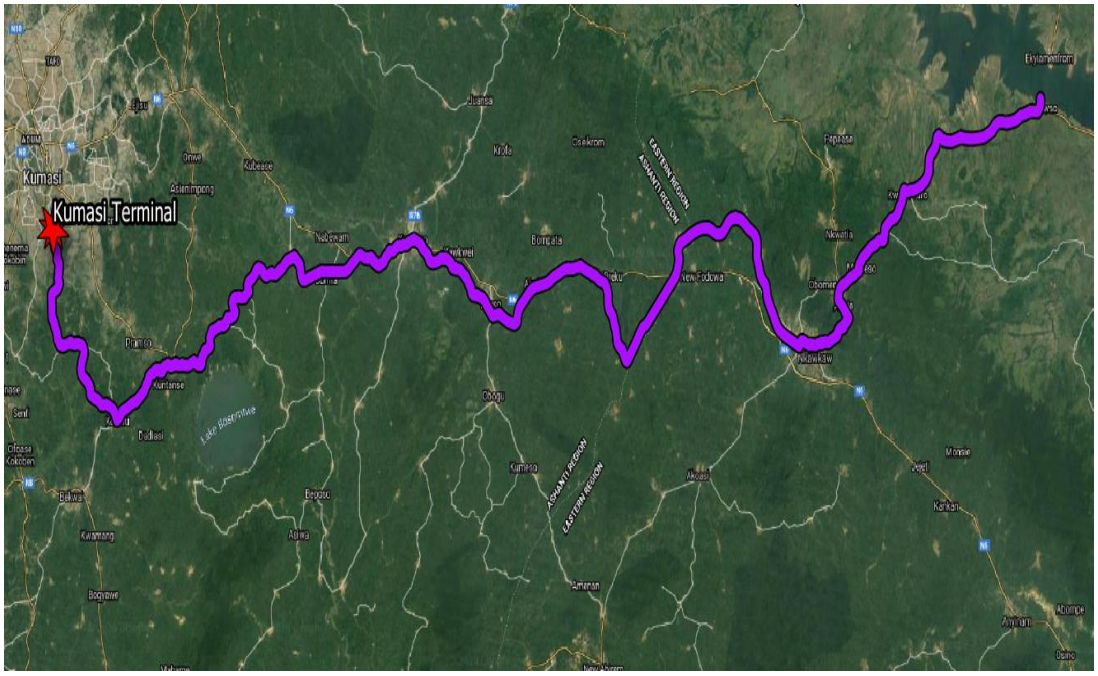


Figure 17 Route Corridor 3

6.7 Route Comparison

The route identified and studied were weighted against the selection criteria and compared to each other. This was conducted in order to identify the optimal route option.

A summary based on the weighted criteria for route selection is shown in Table 6.7 below:

Table 7 Weighted criteria analysis

		Weighting	Option 1								Option 2								Option 3			
			APD to Kumasi Depot on Land								Akosombo Depot to Kumasi Depot on Land								Lake Volta Jettee to Kumasi Depot on Land			
			1A		1B		1C		1D		2A		2B		2C		2D		3A		3B	
			Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score
CON	Constructibility & accessibility	1	3	2	4	2	2	1	4	2	5	3	4	2	4	2	3	2	1	1	2	1
COST	Pipeline capital cost (length)	10	2	20	2	20	2	20	1	10	2	20	2	20	1	10	3	30	3	30	3	30
ENV	Long term environmental impact	7	1	7	2	13	4	27	3	20	4	27	2	13	2	13	1	7	2	13	2	13
PROX	Proximity to potential branch zones	2	2	3	5	8	3	5	4	7	3	5	4	7	3	5	4	7	1	2	1	2
POP	Population density - societal risk	8	4	33	2	17	5	41	2	17	3	25	3	25	3	25	2	17	4	33	4	33
UTI	Access to market & utilities	4	2	8	4	15	1	4	4	15	3	12	3	12	3	12	4	15	2	8	2	8
POW	Proximity to existing power supply	4	2	9	4	18	1	4	4	18	3	13	3	13	3	13	4	18	2	9	2	9
CP	Cathodic protection requirement	3	3	8	2	6	5	14	3	8	4	11	4	11	5	14	1	3	4	11	4	11
REG	Regulatory requirements	1	2	2	2	2	1	1	1	1	4	4	3	3	2	2	4	4	4	4	4	4
ROW	Utilisation of existing right of way	19	3	58	3	58	3	58	5	97	4	77	1	19	4	77	5	97	3	58	3	58
SEI	Seismic activity areas interaction	7	1	7	1	7	1	7	1	7	1	7	1	7	1	7	1	7	3	21	3	21
EFF	Efficiency	8	5	41	5	41	5	41	5	41	3	25	3	25	3	25	3	25	1	8	1	8
EXP	Ability to support exports	16	5	80	5	80	5	80	5	80	1	16	1	16	1	16	1	16	1	16	1	16
HYD	Favourability of hydraulic profile	10	3	31	4	42	4	42	4	42	4	42	4	42	3	31	4	42	5	52	5	52
		100	38	310	45	329	42	346	46	365	44	286	38	215	38	253	40	288	36	266	37	266

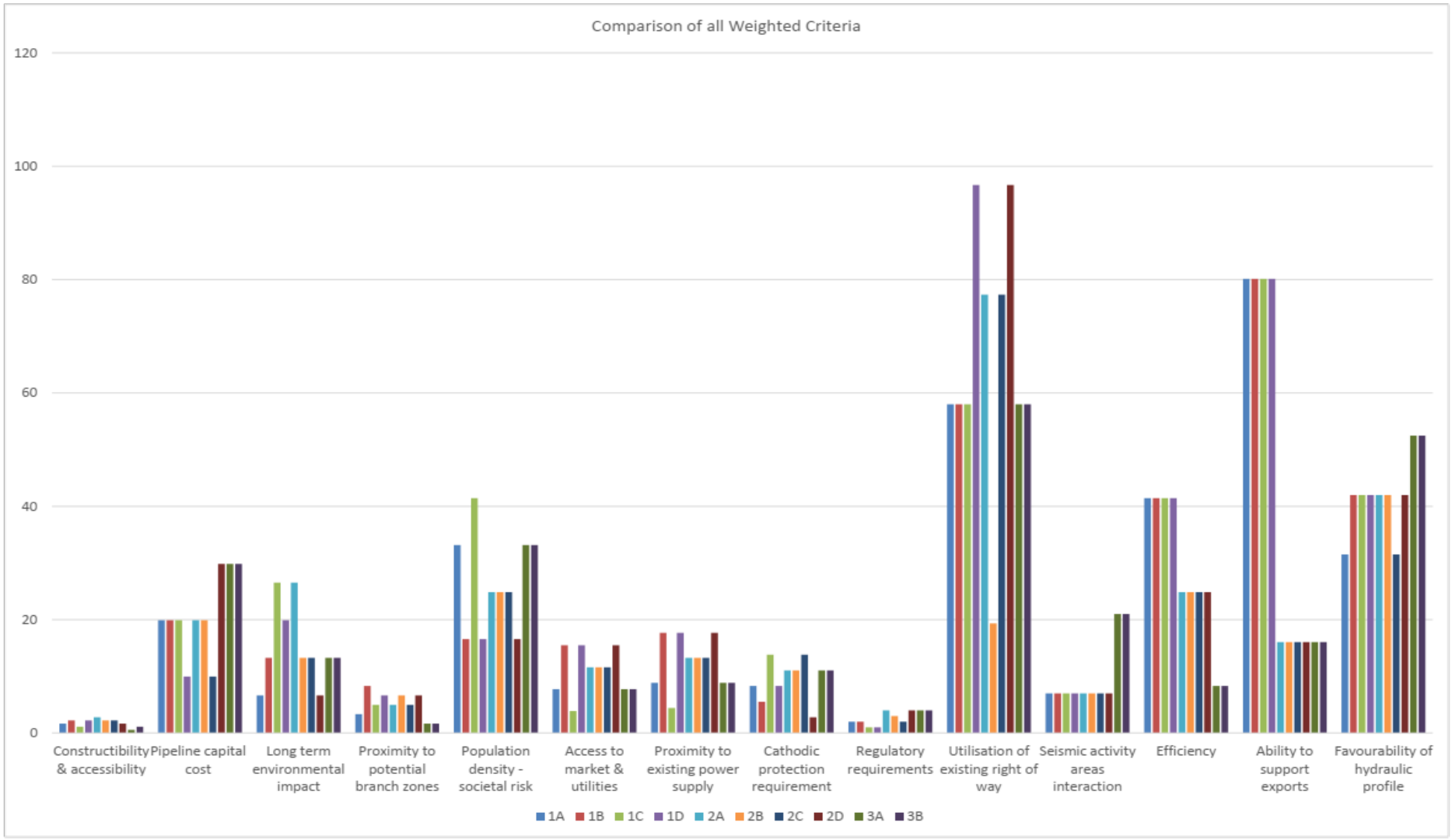


Figure 18 Graph of the comparison of weighted criteria per pipeline option

6.8 Selected Pipeline Route

The selected optimal route option is Route 1D which exits Accra via the existing pipeline ROW and then follows the Kumasi-Accra railway line RoW until near Nabewam. From there, the route follows existing roads for a short distance before joining the Kumasi-Takoradi railway line RoW to enter BOST Kumasi Depot.

This route option is identified as the most favourable due to maximised use of existing rights of way, high pipeline efficiency and ability to accommodate exports, as well as its proximity to existing populated areas, which improves accessibility to food, water, sanitation and day-to-day site requirements, as well as power supplies for required cathodic protection and pumping systems.

7. ESIA Terms of Reference

7.1 Introduction

This Chapter of this ESIA Scoping Report draws upon the findings of the scoping, in more detail, the proposed scope of works for each of the key technical topics covered within the ESIA process.

As part of the main ESIA, each technical discipline lead will be developed detailing the specific methodologies to be employed for the baseline data collection.

7.2 Terms of Reference

The draft terms of reference for the Environmental Impact Statement on the Proposed Accra – Kumasi Multifuel Pipeline Project undertaking will assess the following in detail;

1. a description of the project;
2. an analysis of the need for the project;
3. alternatives to the project, including alternative situations where the project is not proceeded with;
4. matters on route selection, including a statement of the reasons for the choice of the proposed route and whether any other alternative site was considered;
5. identification of existing environmental conditions including social, economic and other aspects of significant environmental concern;
6. information on potential, positive and negative impacts of the proposed undertaking from an environmental, social, economic and cultural aspect in relation to the different phases of development of the undertaking;
7. the potential impact on the health of people;
8. proposals to mitigate any potential negative socio-economic, cultural and public health impacts on the environment;
9. proposals to be developed to monitor predictable environmental impact and proposed mitigating measures;
10. contingency plans existing or to be developed to address any unpredicted negative environmental impact and proposed mitigating measures;
11. consultation with members of the public likely to be affected by the construction and operations of the undertaking;

12. maps, plans, tables, graphs, diagrams and other illustrative material that will assist with comprehension of the contents of the environmental impact statement;
13. an environmental management plan;
14. compensation for possible acquisition/damage to land or property arising from the construction and operation of the undertaking; and

7.3 Format for Presentation of ESIA

The format for the presentation of the ESIA is provided below:

1.0 Executive Summary

This is a non-technical summary that will include the following:

1.1 Description of the project, location, justification etc.

1.2 Potential adverse and positive impacts that may arise from the development.

1.3 Measures aimed at mitigating adverse impacts whilst optimizing positive impacts that have been identified.

1.4 Monitoring and environmental management programme

1.5 The main conclusions from the study and the benefits of the project to the national economy.

2.0 Legal and Regulatory Framework

This section will cover a review of all relevant pieces of Legislation, Policies and Guidelines which are applicable to the sustainable development of the Pipeline Project and include, among others:

- National Environmental Action Plan (NEAP-91),
- Environmental Protection Agency Act, 1994 (Act 490),
- Environmental Assessment Regulations 1999 (LI 1652),
- Environmental Assessment Fees and Charges (AMENDMENT) Instrument 2011
- Energy Commission Act (1997), Act 541,
- Factories, Offices and Shops Act (1970), Act 328,
- Labour Act (2003), Act 651, and
- National Petroleum Authority Act (2005)
- Environmental Legislation

5.0 Identification of Potential Project Impacts

The potential impacts of the project will be considered for the following phases of the project:

- Constructional and
- Operational

In particular, impacts on or due to the following will be identified and discussed.

5.1 Air quality

5.2 Noise

5.3 Surface Water quality

5.4 Impacts on flora and fauna

5.5 Impact on geology and soils

5.6 Visual intrusion

5.7 Waste Management

5.8 Socio-economic/ cultural issues (e.g. local economy. population, land use, compensation, cultural or religious significant places etc.)

5.9 Occupational safety and health

5.9.1 Hazard identification

5.9.2 Fire hazards

5.10 Emergency Preparedness Planning

6.0 Proposed Mitigation Measures

This section address measures to be implemented to prevent or reduce potential adverse impacts. Specific mitigation measures against the significant impacts that will have been identified in the previous section will be outlined here.

7.0 Consideration of Alternatives

Alternatives considered during route selection and the choice which enhances environmental and social integrity will be elaborated.

8.0 Monitoring Plan

In this section, measures to be periodically carried out to find out significant deviations from baseline conditions will be outlined. Compliance monitoring will also be carried out to assess how conditions comply with EPA guidelines, and standard parameters to be monitored will include but not limited to:

- Ambient air quality monitoring
- Ambient noise level assessment
- Surface water quality
- Socio-economic effects (including compensation issues, sacred groves/shrines)
- Occupational safety and health (availability and use of protective clothing)
- Waste generation and management
- Preparedness for Fire hazards and other emergencies
- Occupational and public safety

9.0 Provisional Environmental Management Plan (EMP)

A provisional Environmental Management Plan will be developed. The Environmental Management Plan will include the following:

i. Institutional Arrangements for Environmental Management
ii. Occupational Safety and Health Management
iii. Provisional budget for environmental management
iv. Human and Financial resources for environmental management
v. Monitoring procedures
vi. Environmental record-keeping and reporting systems
vii. Fire and Emergency Preparedness

10.0 Consultations, Interagency & Public/Non-Governmental Involvement

This section will present the findings of all the consultations held in connection with the proposed project with agencies, District Assemblies and local communities, and individuals to be affected by the project etc. The discussions will cover the various issues of concern raised and how they have been addressed in the EIA.

11.0 Decommissioning

Issues relating to work camp decommissioning will be discussed.

12.0 Conclusions

General overview of all conclusions arrived at during the study

REFERENCES

1. Ghana Statistical Services: 2010 Population and Housing Census Report

2. IEMA ‘EIA Guide to Shaping Quality Development’, 2015.

APPENDICES AND ANNEXURES

Appendix 1: Community Engagement Report

Appendix 2: Pipeline Route Selection Report

Appendix 3: ESIA Reference Maps of Proposed Pipeline

Appendix 4: ESIA Team Profile

Appendix 1: Community Engagement Report

MARCH 25, 2021



COMMUNITY SENSITIZATION

BOST FEED

ACHEAMPONG KWARTENG WARREN
ASSISTANT PROJECT ENGINEER
SIENNA SERVICES LTD

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BACKGROUND

A total of forty-five (45) communities were identified on the selected route. The community engagements were carried out by two (2) teams made up of a combined member of BOST's community relations personnel and that of Sienna. Each of the two teams was led by BOST's community relations personnel.

The first four identified communities (yellow coded) already existed in BOST's ROW. Team 1 handled the following 20 communities (turquoise coded) while Team 2 attended to the last 21 communities (green coded).

Due to the COVID-19 pandemic the team limited the engagement to the chiefs, elders, and opinion leaders with the exception of Kwahu Praso #2 where the stakeholders insisted the team addressed the whole community. The team informed the community leaders to share with their respective communities the relayed information regarding the project that was presented to them and the discussions and concerns arising from these engagements. This approach was adopted to guard against larger gatherings and prevent the spread of the corona virus.

The ultimate objective of the community engagement was:

- to educate community/stakeholders on the proposed Accra-Kumasi multifuel pipeline project.
- to officially introduce the Contractor (Sienna) to the communities/key stakeholders
- to seek the community/stakeholders' consent for subsequent FEED activities, obtain the communities' concerns on the environmental, social, public health safety and security issues so that these concerns will be addressed.

IDENTIFIED COMMUNITIES

i. Tema
ii. Afienya
iii. Doryumu
iv. Kordiabe
v. Odumase Krobo
vi. Agameda
vii. Akwali
viii. Somanya
ix. Kamina
x. Amafrom Akwapim
xi. Asamang
xii. Nkurakan
xiii. Asokore
xiv. Oyoko

xv. Jumapo, Koforidua
xvi. New Tafo Akyem
xvii. Tontro
xviii. Adjeikrom
xix. Osino
xx. Anyinam Ankaase
xxi. Akyem Mampong
xxii. Atiwa
xxiii. Awosoase
xxiv. Nkawkaw
xxv. Asubone Station/Rails
xxvi. Akwaseho
xxvii. Kwahu Praso #1
xxviii. Kwahu Praso #2
xxix. Pra River
xxx. Breku
xxxi. Adansi
xxxii. Asankare
xxxiii. Atwidie
xxxiv. Juaso
xxxv. Yawkwei
xxxvi. Konongo
xxxvii. Bomfa
xxxviii. Ejisu Juaben
xxxix. Yaokwakwakrom
xl. Edwinese
xli. Kuntanse
xlii. Kokofu
xliii. Oyoko
xliv. Aduaben
xlv. Sokoban

*Asante Akyem Praso
**Odumase

Towns with asterisks were not in the initial list but were twin communities to Kwahu Praso and Konongo respectively hence, Team 2 took the initiative to engage them.

Team Members (Team 2)

1. Emmanuel Boavo TWUM (Team Lead) – BOST
2. Kwaku Fosu GYEABOUR (Project Engineer) – BOST
3. Joseph SOMUAH (Transport Officer) – BOST
4. Warren Kwarteng ACHEAMPONG (Asst. Project Engineer) – Sienna

ENGAGEMENTS

Monday, 15 March 2021							
NO.	**COMMUNITY**	**ASSEMBLY MEMBER'S NAME**	**CONTACT NUMBER**	**MCE/DCE NAME**	**MUNICIPALITY DISTRICT NAME**	**CONTACT NUMBER**	**COMMENTS**
1	Asuboni Rails	Agnes Okanta	0246734489	Hon. Yaw Owusu Addo	Kwahu East	0205959541	- Chief has to be paid twice when visited.
Tuesday, 16 March 2021							
NO.	**COMMUNITY**	**ASSEMBLY MEMBER'S NAME**	**CONTACT NUMBER**	**MCE/DCE NAME**	**MUNICIPALITY DISTRICT NAME**	**CONTACT NUMBER**	**COMMENTS**
2	Akwaseho	Bismark Kankam Boadu	0242854011	Hon. Isaac Agyapong	Kwahu East	0247026489	- The community insists on recruiting workers from the township else they will obstruct the progress of the project.
3	Kwahu Praso #1	Owusu Ansah Michael	0243025095	Hon. Emmanuel Atta Ofori	Kwahu South Mpraeso	0244660223	Successful
4	Kwahu Praso #2	Alex Kwarteng	0543456799	Hon. Emmanuel Atta Ofori	Kwahu South Mpraeso	0244660223	- Community has problems with gold-digging so chief insisted the community be met at large which was scheduled and done. - Community insists on being informed about the colour codes and type of markers to be used before commencing survey. Chief: 0244518389
*	Asante Akyem Praso	Hon. Daniel Ntiamoah	0545392498				Adjacent town to Kwahu Praso #2 so was engaged successfully.
Wednesday, 17 March 2021							

NO.	COMMUNITY	ASSEMBLY MEMBER'S NAME	CONTACT NUMBER	MCE/DCE NAME	MUNICIPALITY DISTRICT NAME	CONTACT NUMBER	COMMENTS
5	Pra River	Acheampong Benedicta	0557363170	Hon. Alexander Frimpong	Asante Akim South	0540126555	Successful
6	Breku	Appiah Prince	0244217717	Hon. Alexander Frimpong	Asante Akim South	0244201210	- Community asked to be notified two weeks prior to subsequent visits. - Community stakeholders request for complimentary cards and souvenirs.
7	Adansi	Appiah Prince	0244217717	Hon. Alexander Frimpong	Asante Akim South	0244201210	Same as Breku and Adansi with same leaders.
8	Asankare	Koomson Michael	0556951473	Hon. Alexander Frimpong	Asante Akim South		- Use 'Okofrobour' title when addressing chief. - Traditional council would prefer paying compensation for affected persons in their presence to avoid disputes that could arise after the team's departure. Queenmother: Nana Abena Kyerewaa
Thursday, 18 March 2021							
NO.	**COMMUNITY**	**ASSEMBLY MEMBER'S NAME**	**CONTACT NUMBER**	**MCE/DCE NAME**	**MUNICIPALITY DISTRICT NAME**	**CONTACT NUMBER**	**COMMENTS**
9	Atwidie	Boateng Vasco	0240657041	Hon. Alexander Frimpong	Asante Akim South		Successful
10	Juaso	a. Owusu Boahen-Mills b. Osaborn Ayenim-Boateng c. Victor Owusu	a. 0243631342 b. 0246679993 c. 0244476515 d. 0543273003	Hon. Alexander Frimpong	Asante Akim South		- Four Assembly members. - Successful engagement.

		d. Dominic Sarpong					
11	Yawkwei	Saddique Mohammed	0246942698	Hon. Alexander Frimpong	Asante Akim South		Successful. CSR for BOST: Community has begun building a school and asked for BOST's help to complete since their school system runs morning and afternoon.
Friday, 19 March 2021							
NO.	**COMMUNITY**	**ASSEMBLY MEMBER'S NAME**	**CONTACT NUMBER**	**MCE/DCE NAME**	**MUNICIPALITY DISTRICT NAME**	**CONTACT NUMBER**	**COMMENTS**
12	Bomfa	Ofori Kyei-Wiredu	0243575767	Hon. Kwadwo Anash-Sem	Juaben		- Team asked to consider unemployed graduates in the township for permanent employment. - Chiefs requested for annual royalties aside compensation and expressed the willingness to personally assist in getting people to patrol the ROW.
13	Kuntenase	Paul Owusu	0243214307	Hon. Joseph Asumeng	Bosomtwi	0244232305	- Successful - Chiefs ask for two bottles of schnapps or equivalent money when visited.
14	Konongo	Mr. Gyasi	0242554914				Traditional council meets on Tuesdays so subsequent meetings involving them should be scheduled accordingly. Chief: Nana Acheampong
Monday, 22 March 2021							

NO.	COMMUNITY	ASSEMBLY MEMBER'S NAME	CONTACT NUMBER	MCE/DCE NAME	MUNICIPALITY DISTRICT NAME	CONTACT NUMBER	COMMENTS
15	Edwinese	Fodjour Owusu	0243935657	Hon. Joseph Asumeng	Bosomtwi	0244232305	-Team was notified that there are about four Edwinese's but theirs is on the Ejisu-Bekwai road, around the Kuntenase area. Chief: Nana Akwasi Addae
16	Kokofu	Richard Peprah	0243523305	KI Baffour	Bekwai		- Chiefs indicated that lands in the region are leased for 50yrs from the chief and for commercial purposes, 25yrs. The chiefs therefore take compensations regarding lands and give a stipulated fraction to the land occupants. - For an audience with the paramount chief, two bottles of schnapps with money is required. Chief: Barima Offe Akwasi Okogyeasuo II Contact: 0205888586 / 0242220310
**	Odumase	Samuel Ohemeng	0554108467/ 0265214925				- For valuation stage, chief indicated that drink money (the negotiable price of the land which would be set by the chief) and the lease money for the land would be accepted before crops or properties on the land would be valued. - The traditional council asked that

							Odumase be preferentially considered for the construction of the booster station if it meets the requirements. They indicated that the land for the station would be offered for free. Chief: Nana Kofi Antwi II (Essampong) Ph.D. Contact: 0244786372 / 0507351957
Tuesday, 23 March 2021							
NO.	**COMMUNITY**	**ASSEMBLY MEMBER'S NAME**	**CONTACT NUMBER**	**MCE/DCE NAME**	**MUNICIPALITY DISTRICT NAME**	**CONTACT NUMBER**	**COMMENTS**
17	Oyoko	George Owusu	0543587599	Hon. Comfort Asante	New Juaben North		- Successful. - Chief: Nana Kissi Appiah Queen: Nana Boahemaa
18	Sokoban	Kwadwo Boateng	0548040318	Hon. Osei Asibey	KMA	0202010100	- For an audience with the paramount chief, two bottles of schnapps with money is required. - Team asked to bring copies of identification with affiliated companies along on subsequent visits. - Team asked to give a minimum of 5days prior notice before subsequent visits. - Traditional council insisted on compensation before destructive activities begin.

Wednesday, 24 March 2021							
NO.	**COMMUNITY**	**ASSEMBLY MEMBER'S NAME**	**CONTACT NUMBER**	**MCE/DCE NAME**	**MUNICIPALITY DISTRICT NAME**	**CONTACT NUMBER**	**COMMENTS**
19	Aduaben	Isaac Boakye Aggrey	0542807521	Hon. Joseph Asumeng	Bosomtwi		- Successful engagement - Call Mr. Amoaduah Festus (Assembly Committee Chairman) on 0249471556 when assemblyman is not reachable.
20	Ejisu Juaben	Mr. Boakye	0242271200				- Team entreated by the traditional council to deal mostly with chiefs instead of the assembly committee members when it comes to land matters. - Chief entreats that using the Accra old road will be more feasible. He also advised the team to use the railway ROW in addition to the old road. Chief: Nana Afrane Okese IV, Ejisu Manhene Contact: 0243220612
21	Yaokwakwakrom						- Town can only be identified on GPS as "Yaokwakwakrom". The indigenous call it 'Amangoase'. - Key people found in the community: a. Baaji (024500482) b. Agyemang (0556957888)

***All engagements were successful and no hostility encountered. Also, some communities in close proximity with communities identified were skipped because they were not listed eg: Kantanso (after Breku and Adansi)

APPENDIX



Figure 1: Engagement at Kwahu Praso #2 (entire community met)







Figure 2: Engagement at Bomfa (key stakeholders met)

















Figure 3: Engagement at Edwinese (key stakeholders met)



Figure 4: Engagement at Kokofu (key stakeholders met)



Figure 5: Engagement at Sokoban (key stakeholders met)





Figure 6: Engagement at Ejisu (key stakeholders met)




E.T.C.
19


E.T.C. 10
E.T.C. 29


E.T.C. 10
E.T.C. 29


E.T.C.
19

Appendix 2: Pipeline Route Selection Report

SMEC South Africa
Member of the Surbana Jurong Group

SIENNA SERVICES

BOST Liquid Multifuels Pipeline – Corridor Study

Date 3 November 2020 Ref. JU0107



AUSTRALIA | ASIA | MIDDLE EAST | AFRICA | PACIFIC

DOCUMENT CONTROL

Project Name:	BOST Multifuels Pipeline
Project Number:	JU0107
Report for:	BOST

REVISIONS

Revision #	Date	Change Overview	Prepared by	Reviewed by
0	14 August 2020	Desktop Review	M Hardwick	H Naik / D du Plessis
1	5 October 2020	Field Review Hydraulic Analysis	M Hardwick/ GN Sidinile	H Naik / D du Plessis
2	30 October	Weighted criteria analysis	M Hardwick/ GN Sidinile	H Naik / D du Plessis

APPROVAL

Approver Name:	Prince John Abakah	**Approver Position:**	Project Manager
Approver Signature:		**Date:**	30th October 2020

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1. EXECUTIVE SUMMARY

A long-term view for the development and sustained use of the fuel storage and transportation infrastructure in Ghana is at the forefront of all decisions, recommendations and assumptions made during the route study.

The primary goal of developing the current pipeline and terminal infrastructure in Ghana is not only to improve the reliability of the transport and supply of various fuels locally, but also to secure and regulate long term export agreements with Burkina Faso and Mali.

1.1 Desktop Review

The first issue of the project study report was focused on identifying possible corridors for a proposed new 18-inch multifuel pipeline to supply diesel and gasoline to the Kumasi Terminal. Three (3) route options have been considered and compared considering key constructability, operability, maintainability, and integrity criteria using geospatial data available in a desktop review format. In addition to this, the impact of the pipeline on the environment, community, mineral resources, and topography along each route were considered and critically compared.

Key challenges along the proposed pipeline corridors identified in the desktop study are:

- Population concentrations;
- Bauxite fields and conflicts;
- Diamond fields and conflicts;
- Atewa mountain range environmental impact;
- High population density in Kumasi and Accra;
- Cathodic Protection requirements near power line and railway line crossings.

1.2 Field Review

The second issue of the report built on the desktop study by using a large database of photographs and video footage (including drone footage) collected within Ghana by travelling the identified corridors and identifying any key challenge items along the way which may not have been visible via desktop.

The data collected supported the detailing of the original route options to follow identified roads or existing ROWs wherever possible. In addition, a number of additional routes were identified and added to the study.

1.3 Hydraulic Analysis

A detailed analysis of the potential growth of local and export gasoil (AGO) and gasoline (PMS) consumptions was carried out to ascertain whether the proposed 18-inch line size would be sufficient as well as whether the existing pipeline infrastructure in Ghana would be adequate to support the installation of the new pipeline.

These conclusions have a considerable impact on the optimal route selection.

1.4 Weighted Corridor Comparison

This final issue of the pipeline route study entails a detailed weighted comparison of all the relevant criteria per route. This exercise assists in identifying the optimal route in terms of constructability, accessibility, operability, minimal environmental & social impact, security, minimal additional cathodic protection requirements, optimised cost benefit and optimised hydraulic profile whilst being able to maximise export capacity.

The identified optimal route option is Route 1D which exits Accra via the existing pipeline ROW and then follows the Kumasi-Accra railway line ROW until near to Nabewam. From there, the route follows existing roads for a short distance before joining the Kumasi-Takoradi railway line ROW to enter BOST Kumasi Depot.

This route option is identified as the most favourable due to maximised use of existing rights of way, high pipeline efficiency and ability to accommodate exports, as well as it's proximity to existing populated areas which improves accessibility to food, water, sanitation and day-today site requirements, as well as power supplies for required cathodic protection and pumping systems.

Route 1D is the longest pipeline and will require a diameter of 26-inches to achieve the desired flowrate of 1400 m^3/h. This results in Route 1D having the largest capital outlay when compared to the other routes, but this does not outweigh the multiple other advantages of this optimal route.

This issue of the report provides detailed hydraulic calculations for Route 1D as well as a high level cost estimate, construction schedule and project cash flow specifically for this pipeline route.

2. INTRODUCTION

2.1 Project Background

Ghana currently has a network of liquid fuel storage distribution and transportation systems comprising of multiple depots, pipelines (some for single fuel pumping and some for multifuel), Bulk Road Vehicle (BRV) routes and river barge routes. These routes do not only supply Ghana's direct fuel demands - due to Ghana's prime location as well as political and economic stability, the country has also been in a position to export the required fuel volumes to meet the consumption requirements in Mali and Burkina Faso by BRV.

2.2 Current Infrastructure & Challenges

In 2017, petroleum product export from Ghana to Mali and Burkina Faso via BRV exceeded 2.3 million metric tons, and their volume demands are expected to increase.

The current barging operations are also fraught with challenges. The existing marine infrastructure and vessels are in a poor state and require maintenance to be fully and optimally operational. The barges are operating far slower than they would if they were properly and frequently maintained. In addition, lake water levels fluctuate throughout the year depending on rainfall and duration of the dry seasons, leading to increased dependence on the BRVs.

2.3 Planned Improvements

The Government of Ghana aims to regulate the transportation of liquid multifuel more closely, primarily by improving the integrity and reliability of the existing pipelines and depots, but also by increasing the extent of the current pipeline network and reducing the reliance on BRVs and barges.

The Bulk Oil Storage and Transportation Company Limited (BOST) was established with the mandate of developing a network of storage tanks, pipelines, and other bulk transportation infrastructure throughout the country. It rents/leases out part of the storage facilities to generate income. In addition, it manages the Strategic Reserve Stocks for Ghana as well as the "Zonalization" policy of the National Petroleum Authority (NPA).

2.4 Project Scope

This phase of the project entails the first step in the improvement of Ghana's BOST pipeline network by analysing the route options for a proposed 18-inch multifuel pipeline to the BOST terminal in Kumasi. This pipeline can either commence at Accra Plains Depot or at Akosombo.

It is understood that there is currently a 6-inch pipeline feeding the Akosombo depot from Accra Plains depot via Mami Water, and that there are plans for a new 12-inch multifuel pipeline to be constructed directly between Akosombo and Accra Plains. There are currently no pipelines feeding the Kumasi terminal – all fuels are transported to Kumasi via BRV.

Three main routes have been highlighted as the preferred possibilities and are addressed in this route study.

Route Option 1:

- Accra Plains Depot to Kumasi Depot directly via land.

Route Option 2:

- Akosombo Depot to Kumasi Depot via land.

Route Option 3:

- Akosombo Depot to Kumasi Depot via Lake Volta (proposed best location of port/jetty along Volta lake and link with pipeline via land to Kumasi Depot).

2.5 Approach

Multiple detailed route corridors have been identified under each main route option and each are compared considering a set of specified criteria. An extensive database of geospatial data was used to critically analyse each corridor. This was the basis of the desktop study.

Certain challenges to construction or operation of the pipeline along certain corridors or portions of routes which were discovered during the desktop review were investigated on-site. Additional advantages and disadvantages of each route were identified by driving the multiple routes and taking many photos and videos for analysis.

The conclusions drawn from in-depth analysis of the flowrate and consumption data provided in the RFIs are key to route selection. A theoretical growth profile of local and export fuel demands was developed and used to identify the optimal diameter for the new pipeline, as well as to analyse which portions of the existing pipeline network in Ghana would not be sufficient to transport the required flowrates. This exercise clearly rules out some route options which would depend on existing pipelines with insufficient capacities.

The final step in selecting the optimal pipeline route is to critically compare each using a weighted criteria matrix. The criteria and proposed weighting are based on various discussions with the project team.

The proposed costing of each route option is a critical criterion, and for this reason a high-level cost estimate was compiled. Concepts around the execution methodology for the various activities were assumed to compile the cost estimate, and these are discussed in this report.

Specification of the various pump, valve, metering, pigging and other stations along the route will be finalised during the Front-End Engineering and Design (FEED) Phase of the project.

3. KEY PROJECT DATA

3.1 Abbreviations

AGO	Automotive gas oil (Diesel)
ANSI	American National Standards Institute
APD	Accra Plains Depot
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
BOST	Bulk Oil Storage and Transportation Company
BRVs	Bulk road vehicles
CBM	Conventional Buoy Mooring
FEED	Front End Engineering Design
MOC	Material of construction
MT	Metric tonnes
NACE	National Association of Corrosion Engineers
NDT	Non-destructive testing
PMS	Premium motor spirit (Gasoline, Petrol)
RFI	Request For Information
ROW	Right-Of-Way
TOR	Tema Oil Refinery
VLTC	Volta Lake Transport Company

3.2 Requests for information used

Responses to the following requests for information (RFIs) have been received and some of them utilised in the development of this document as indicated in the table below:

Table 3-1: RFIs received

RFI number	Title	Attached documents	Information used
001	Clarification on pipeline route options	None	Desktop corridor analysis
002	Studies of multi fuel pipeline	None	
003	Proposed route data	None	
004	ROW data	land_ROW memo	
005	Environmental data		
006	Multifuels properties/specifications	GSA_Specifications for Gasoil GSA_Specifications for Motor Gasoline GSA_Specifications for domestic kerosene	Hydraulic simulation & line sizing
007	Product volume information	National Consumption -Sienna Service	Hydraulic simulation & line sizing
008	Flow rate requirements	KUMASI DEPOT RECEIPT & DELIVERY -BOST SYSTEM	Hydraulic simulation & line sizing
009	Design philosophies and specifications	BOST Scada Philosophy manual_B2P3_1_AFC SOP FOR AKOSOMBO SOP FOR BUIPE Transmix Philosophy	Operation & Maintenance criteria
010	Depot details	Depot photos and flow diagrams (Kumasi, Akosombo and Accra Plains)	Hydraulic simulation & line sizing

RFI number	Title	Attached documents	Information used
011	Pumping and valve station requirements	Photos and Savelugu diagrams	
012	Tie-ins for oil market companies	None	
013	Electrical system for pipelines	BOST_IEC_Internal Electrical Spec_01025	Pipeline integrity criteria
014	Interfacing and transmix philosophy	Transmix philosophy	Operation & Maintenance criteria
015	Regulatory requirements and approvals	None	
016	Specifications, philosophies of process, safety, piping/pipeline, mechanical, C&I, civil/structural, SCADA, CP system, etc.	Specifications, philosophies of process, safety, piping/pipeline, mechanical, C&I, civil/structural, SCADA, CP system, etc.	Operation & Maintenance criteria
017	Line size	None	Hydraulic simulation & line sizing
018	Geotechnical information	None	N/A
019	Spatial information	Shapefiles	Desktop corridor analysis
020	18” line size confirmation	None	Hydraulic simulation & line sizing
021	Pipeline project design basis / pigging based pipe	General specification - pipeline material	Cost benefit analysis
022	Battery limits	None	
023	National Strategy on Fuel	Master Plan for Petroleum Products Transportation in Ghana	Hydraulic simulation & line sizing
024	Details of barging operations	RFI_#024 Response (Barging information) SOP for Akosombo	Desktop corridor analysis
025	Studies of multi fuel pipeline (bathymetry) Process Flow Diagrams	RFI_25 memo P&IDs	Hydraulic simulation & line sizing
027	12” BATV pipeline legacy data	-APD-AKOSOMBO PIPELINE - BATV Project – 2 Design Book Binder _TAPP 2_ Design Book Binder TAPP_2_Cover	Desktop corridor analysis Hydraulic simulation & line sizing
028	Zonal volume data & growth of demand	Zonal consumption of petroleum products from 2010 to 2016	Hydraulic simulation & line sizing
029	Clarification on pipeline route options	None	Desktop corridor analysis

The following RFIs are still outstanding without any responses received:

RFI number	Title
026	Allowance for kerosene in pipeline

3.3 Terminals information

3.3.1 Accra Plains Depot

Table 3-2: Accra Plains Depot information

Accra Plains Depot	
Number of tanks (total)	15
Number of gasoline tanks in use	6 (3 not in use)
Number of gasoil tanks in use	6
Gasoil total capacity (m^3) • 4 x 20 000 m^3 tanks • 1 x 14 200 m^3 tank • 1 x 14 300 m^3 tank	108 500
Gasoline total capacity (m^3) • 2 x 10 000 m^3 tanks • 2 x 20 000 m^3 tanks • 1 x 14 400 m^3 tank • 1 x 14 300 m^3 tank	88 700
Total capacity (m^3)	197 200
Loading gantry	Yes
Number of racks	6
Number of loading arms	18
1 x pump house for gasoil 1 x pump house for gasoline	4 pumps in each house: • Static Head = 37.4 m – 43.9 m • Flowrate = 401.7 L/s • Speed = 1470 rpm

(a) Additional points

- Located in Greater Accra Region
- The depot receives fuel from:
  - An 18”, 14 km bi-directional multi-product pipeline from Conventional Buoy Mooring (CBM) to the depot with a 30m servitude (7.5 bar)
  - A dual 6” pipeline from Tema Oil Refinery (TOR) to depot:
    - One pipeline used for transfer of gasoline.
    - One pipeline used for transfer of gasoil.
- The depot transfers fuel to:
  - Mami Water: via a pipeline (6”, 63 km, 30m servitude);
  - Akosombo: via BRVs;
  - Akosombo via Mami Water as a pump station (12”) [TBC];
- Support systems are available at the depot:
  - Firefighting water storage tanks;
  - Interface/slop tanks (For mixed fuels);
  - Backup power generation;
  - Pig launcher/receivers (3-hour travel time from launcher at CBM to receiver at APD; 5 bar);
- Piping protected by impressed current

(b) Location



Figure 3-1: Google Earth image of APD

3.3.2 Akosombo Depot

Table 3-3: Akosombo Depot information

Akosombo Depot	
Number of tanks	5
Gasoil capacity (m^3)	7 000
Gasoline capacity (m^3)	5 000
Total capacity (m^3)	12 000
Number of Gasoil tanks	1 (May potentially become 2) (TBC)
Gasoil tanks capacity per tank (m^3)	TBC
Number of Gasoline tanks	1 (TBC)
Gasoline tanks capacity per tank (m^3)	TBC

(a) Additional points

- Located in Eastern Region
- Transfer occurs from:
  - Accra Depot: via bulk road vehicles (BRVs)
    - Pumps at 5 bar transfer fuel from BRVs to 2 tanks;
    - Gravity feeds the fuel from 2 tanks to the 3 tanks located close to the lake;
  - Mami Water: via a pipeline (6”, 63 k m) (Currently not operational, TBC).
- Transfer occurs to:
  - Buipe via river barges:
    - Gravity feeds the fuel from the 3 lake-side tanks to the barges through three 4” lines.
- Support systems are available at the depot:
  - Firefighting water storage tanks;
  - Interface/slop tanks;
  - Backup power generation.

(b) Location



Figure 3-2: Google Earth image of BOST Akosombo

3.3.3 Kumasi Terminal

Table 3-4: Kumasi Terminal information

Kumasi Terminal	
Number of tanks	9
Number of gasoil tanks	6
Number of gasoline tanks	3
Gasoil capacity (m^3)	53 000
Gasoline capacity (m^3)	34 000
Kerosene capacity (m^3)	10 000
Total capacity (m^3)	87 000
Discharging loading bays	2
Loading: Number of racks	3
Loading: Number of loading arms	11
Gasoil tanks capacity per tank (m^3)	TBC
Gasoline tanks capacity per tank (m^3)	TBC
Pumps	2 – 5 bar Head = 38 m Flowrate = 150 m^3/hr

(a) Additional points

- Located in Ashanti Region
- Product is received via BRVs
- Support systems are available at the depot:
  - Firefighting water storage tanks;
  - Interface/slop tanks;
  - Backup power generation.

(b) Location



Figure 3-3: Google Earth image of BOST Kumasi terminal

3.4 Existing pipeline and depot capacities in BOST network

BOST has multiple existing pipelines in its network, information for which is shown in the table below:

Table 3-5: BOST existing pipelines information

Existing pipeline description						RFI number and response	Influences Route Corridor
Starting point	Ending point	Diameter	Design flowrate (m^3/h)	Grade	Wall thickness		
TOR	APD	6" (dual)	100 (each)	TBC	TBC	RFI023	1, 2 & 3
CBM	APD	18"	1200	TBC	TBC	RFI023	1, 2 & 3
APD	Mami Water	6"	45	B and X-46	4mm, 4.37mm, 4.8mm, 5.2mm	RFI027	2 & 3
Mami Water	Akosombo	6"	42	B and X-46	4mm, 4.37mm, 4.8mm, 5.2mm	RFI027	2 & 3
APD	Akosombo	12"	250	X-56	5.56mm	RFI027	2 & 3
Buipe	Bolgatanga (via Savelugu)	8"	88.2	X-52	6.35mm	RFI009	None

The existing pipeline grade and wall thickness are according to ASME B31.4 and API Specification 5L.

The following figure shows BOST's network of pipelines and depots with transfer methods between each.

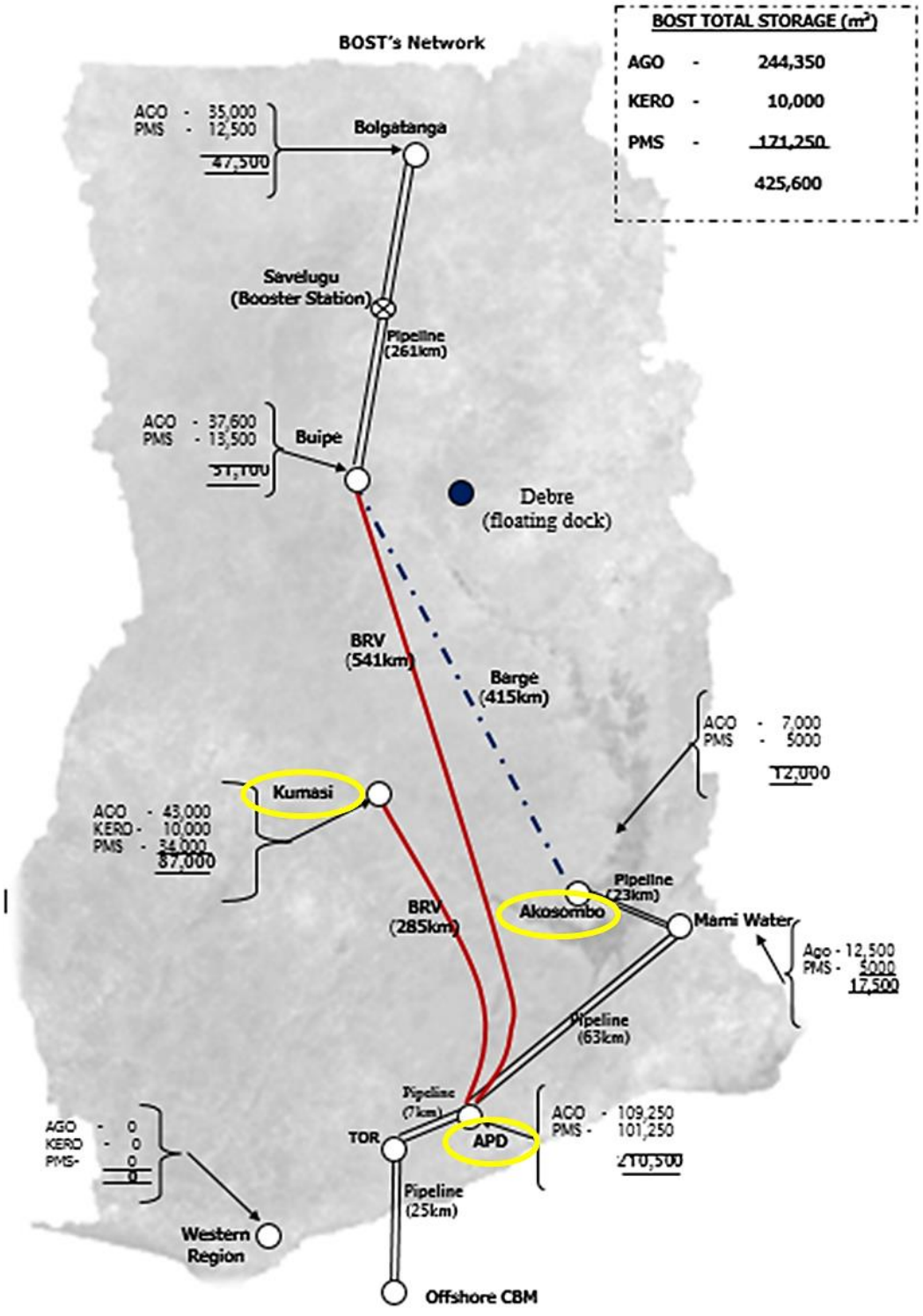


Figure 3-4: BOST pipeline networks and depots information

3.5 Proposed APD to Kumasi Pipeline information

3.5.1 General

Table 3-6: General pipeline specifications

Property	Value
Service	Multi-fuel (Gasoline and Diesel)
Diameter	18" (see Section 8)
Length	Approx. 250km
MOC	Carbon steel
Underground	Yes
Schedule	80 (see Section 8)

3.5.2 Ancillaries

Ancillaries along the pipeline will include:

- Initial tie-in station – Location to be confirmed during FEED.
- Metering stations – Quantity, location, and specification to be confirmed during FEED.
- Terminal station/Final tie-in station – Location to be confirmed during FEED.
- Valve stations – Quantity, location and specification to be confirmed during FEED.
- Pump stations – Quantity, location and specification to be confirmed during FEED.
- Brake stations – Quantity, location and specification to be confirmed during FEED.
- Pigging stations – Quantity, location and specification to be confirmed during FEED.

3.5.3 Codes, Standards and Regulations

The following codes, standards and regulations will be adhered to during the design and construction of the pipeline:

Table 3-7: Pipeline codes, standards and regulations

Title	Description
ASME B31.4	Liquid transportation systems for hydrocarbons, LPG, anhydrous ammonia and alcohols
ASME B31.8	Gas transmission and distribution piping system
ASME VIII	Boiler and pressure vessel code
API Std 1104	Welding of pipelines and related facilities
API RP 5 L1	Recommended practice for railroad transportation of line pipe
API RP 5 L2	Recommended practice for internal coating of line pipe for non-corrosive gas transmission service
API RP 5 L3	Recommended practice for conducting drop-weight tear tests on line pipe
API RP 5 L5	Recommended practice for marine transportation of line pipe
API RP 5 L6	Recommended practice for inland waterway transportation of line pipe
API RP 14 C	Details of protective devices on pipelines connected to platforms
API RP 1102	Recommended practice for liquid petroleum pipelines crossing railroads and highways
API RP 1107	Recommended pipeline maintenance welding practices
API RP 1109	Recommended practice for making liquid petroleum pipeline facilities
API RP 1110	Recommended practice for pressure testing of liquid petroleum pipelines
API RP 1111	Recommended practice for design, construction, operation and maintenance of offshore hydrocarbon pipelines
API Std 1104	Welding of pipelines and related facilities
API PSD 2201	Procedures for welding or hot tapping equipment containing flammables

ANSI B16.34	Steel valves
ANSI B16.10	Boiler and pressure vessels
ANSI B16.11	Forged steel fittings, sockets, welded and threaded
ANSI B16.25	Butt weld ends
ANSI B16.5	Steel pipe flanges, flanged valves and fittings
ANSI B16.9	Factory-made wrought steel buttwelding fittings
NACE RP-01-69	Control of external corrosion on underground or submerged metallic piping systems
NACE RP-02-74	High voltage electrical inspection of pipeline coatings prior to installation
NACE RP-06-75	Control of corrosion on offshore steel pipelines
NACE RP-01-75	Sulphide stress cracking resistant metallic materials for oilfield equipment
API PSD 2201	Procedures for welding or hot tapping equipment containing flammables

3.5.4 Mechanical pipeline specifications

See General Technical Specification No. 17888-2981901 For Piping Material (Provided as response to RFI 21).

The grade and wall thickness of the pipe will be in accordance with ASME B31.4 and API 5L, and will be confirmed during the FEED stage of the project.

4. ROUTE SELECTION CRITERIA SUMMARY

The following criteria were considered during the route selection process:

- Construction requirements:
  - Accessibility;
  - Proximity to existing power supplies;
  - Proximity to existing towns (to facilitate access to supplies);
  - Utilisation of existing rights of way to minimise societal impact;
  - Terrain profiles, topography, elevation, and slopes.
- Operating & Maintenance requirements:
  - Accessibility;
  - Pig station requirements and locations.
- Pipeline Integrity requirements:
  - Interaction with railway lines and power lines (parallel and perpendicular).
- Construction safety:
  - Security risks;
  - Political or civil unrest;
  - High-tension areas;
  - Interaction with railway lines and power lines (parallel and perpendicular).
- Environmental requirements & impacts:
  - Nature reserves;
  - Forests, lakes and mountain ranges;
  - Seismic activity potential;
  - Mineral fields.
- Social & community requirements & impacts:
  - Population density analysis.
- Pipeline cost.
- Hydraulic analysis:
  - Ability of new pipeline to support export flowrate requirements;
  - Ability of existing pipelines and terminals to support export flowrate requirements;
  - Dependence on barging and road vehicle infrastructure to achieve export flowrates;

- Pump requirements (pressure drop and power ratings)

Details around the various considerations are provided in the Appendices and summarised in the table below. These criteria have been utilised to compare the possible route options using a scoring process quantitatively and qualitatively.

Table 4-1: Criteria for route selection

Category	Criterion	Desktop Review Outcomes	Field Review Outcomes
Construction	**Elevation**	Highest and lowest point per route Slope and elevation changes (i.e. cliffs and mountains)	Photos of outlier points (particularly high or low points). Photos of challenging terrain
Construction & Operation	**Working space for temporary and permanent ROW**	High level analysis of space available	Photos of any new developments along proposed routes which are not reflecting on Google Earth Photos of land use i.e. open spaces which have now been occupied by inhabitants (for homes, schools, cemeteries, churches, dumping grounds etc.)
Construction	**Accessibility to site (for deliveries of supplies and material)**	Proximity of highways, urban roads and feeder roads • Furthest point • Closest point Proximity of existing populated towns	State and quality of highways, urban roads and feeder roads • Width • Tar or gravel • Potholes • Water drainage • Kerbs
Integrity	**Power line interaction**	Proximity of power lines • Number and length of crossings • Length of pipeline parallel to power lines • Length of pipeline below power lines	Presence and state of relevant power lines • Still in use? • Transmission vs distribution • General state • Height above ground
Integrity	**Railway line interaction**	Proximity of railway lines • Number and length of crossings • Length of pipeline parallel to railway lines	Presence and state of relevant railway lines • Still in use? • AC/DC current • General state • Confirmation of strange railway line routing depicted on geospatial data
Integrity	**Existing steel pipeline interaction**	No information available	Location, presence and state of relevant existing pipelines • Still in use? • General state • Cathodic protection system

Category	Criterion	Desktop Review Outcomes	Field Review Outcomes
Social	**Political**	• Consider Burkina Faso & Mali export volumes in pipeline sizing and route selection. • Consider current political climate regarding minerals, environmental, etc. considering that 2020 is an election year in Ghana	Any noteworthy political tensions during planning phases. Feedback on current general political climate on key matters.
Social	**Population Density**	High level population density screening. Consider best routes to enter and exit main cities. Identify existing rights of way.	Photos of densely populated areas along selected routes. Photos of land use (i.e. markets and homes)
Environmental	**Nature reserves**	Identify key reserves interacting with pipeline routes. Consider avoiding.	Confirm whether identified reserves are fenced off Regulatory requirements. Photos.
Environmental	**Mineral deposits**	Identify key fields interacting with pipeline routes. Consider avoiding.	Confirm whether identified fields are fenced off & currently in use. Regulatory requirements Photos.

5. ROUTE IDENTIFICATION

5.1 Spatial Database

A spatial database was compiled within a geographic information system (GIS) environment, with a specific GIS application in QGIS being used as the primary desktop route assessment tool. The intent in implementing a spatial database was to gather as much existing applicable geospatial information as possible to serve as an input to an initial route identification study.

Potential routes were then identified via a desktop assessment. Field review verification could then be undertaken with the purpose of ground-truthing the observations made during the desktop assessment as well as gathering other pertinent information not gleanable from the desktop assessment.

The spatial database includes the following types of information:

- Land elevation profile;
- Existing railway line locations;
- Existing power line locations;
    - Transmission vs distribution power not visible on map.
- High way routes;
- Urban road routes;
- Feeder road routes;
- Location and name of nature reserves, forests and mountains;
- Location and name of identified diamond, bauxite and gold fields and prospects;
- Region boundaries and names;
- District boundaries;
- Population density profile.

5.2 Route Identification

The following routes are included in the scope of the route study and comparison:

Route Option 1:

- Accra Plains Depot to Kumasi Depot directly via land.

Route Option 2:

- Akosombo Depot to Kumasi Depot via land.

Route Option 3:

- Akosombo Depot to Kumasi Depot via Lake Volta (proposed best location of port/jetty along Volta lake and link with pipeline via land to Kumasi Depot).

5.3 Desktop Review

5.3.1 Straight line

The first step in the approach to the route study is to utilise a straight line between the selected starting and end points for each route option and identify the key challenges, risks, concerns and benefits of the selected routing using the information available on the spatial database and the identified route selection criteria.

The straight line routing is used as the starting point as this is the shortest possible route with the lowest associated cost for material and installation, and therefore probably the shortest execution timeline.

5.3.2 Optimised route

Thereafter, the straight line route is optimised by deviating away from key problem areas where possible, and selecting an appropriate routing for exiting the main cities (i.e. selecting a routing that does not traverse through homes, churches, schools, golf courses and other buildings or yards, but rather keeps to road reserves and open fields).

5.3.3 Routing parallel to roads

The second route assessed under each option is typically one that follows main roads or highways as far as possible. This route is typically longer in length than the direct line (and will therefore require additional material and installation timelines), but may be far easier to access, therefore decreasing the logistics costs associated with deliveries of diesel, materials, consumables, food, water and other site requirements.

5.3.4 Alternative routes

The outcomes of the analysis of the first two routes as well as field review feedback assisted in identifying alternative routes following railway and power line rights of way.

5.3.5 Route detailing

Once all high level route options had been agreed upon and edited with the larger team, each route was detailed to avoid key obstructions and follow logical elevation and right of way routes. This exercise increases the overall length of each route, but assists in distinguishing the routes such that they can be critically compared based on a set of specified criteria.

5.4 Literature review

During the desktop review, obstacles encountered were researched further by addressing a variety of literature sources and news articles to ascertain the current economic, political, social and environmental climate of the various communities and stakeholders.

6. DESKTOP ROUTE STUDY

The primary purpose of commencing a pipeline route study with a desktop analysis is to identify potential risks or challenges. These are then discussed with the larger team from a political, "bigger-picture" point of view before they are addressed within the field and then ranked.

This section discusses all identified risks from the spatial database. No screenshots of the original routes are included as these have been largely developed and improved throughout the study.

6.1 Bauxite Reserves in Atewa Mountain Range

It is understood that a significant reserve of Bauxite (in excess of 150 million tons) lies beneath the lush forest within the Atewa mountain range – currently a water source to many communities in the Ashanti region. The Atewa mountain range is also home to many plant and animal types including threatened frog and baboon species.

There are currently tensions between the local community and the Government of Ghana as bauxite mining could be critical to economic growth whilst devastating the natural ecology in the area.

From a constructability point of view, the Atewa mountain range is the highest peak along all potential routes (more than 800m in height), which not only poses challenges for accessibility and construction, but will increase the pump size requirements to overcome the elevation.

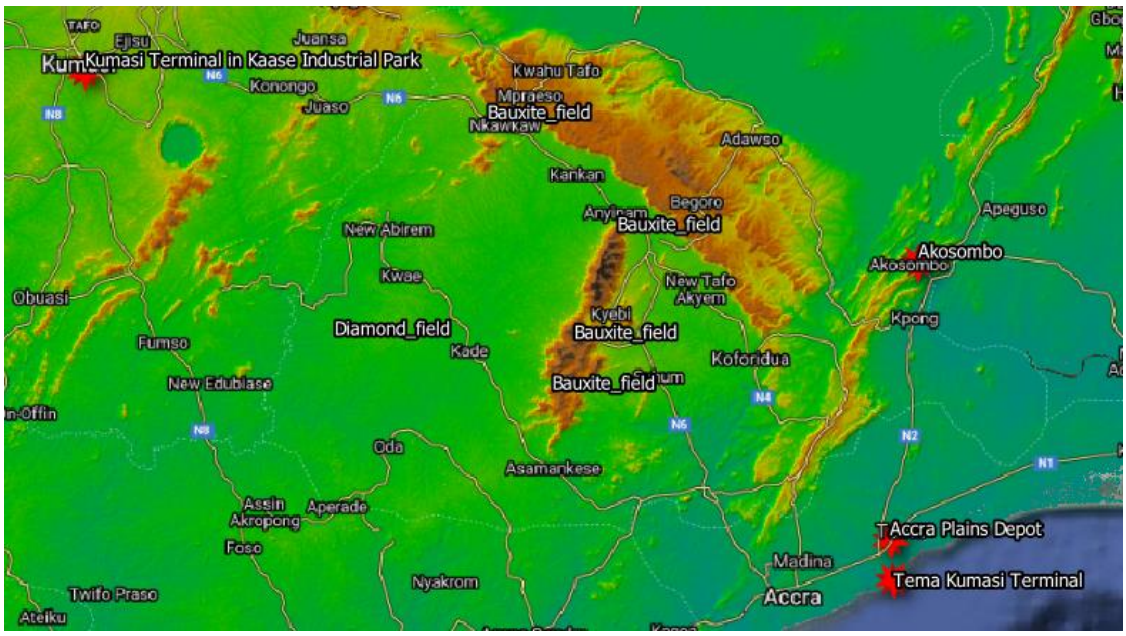


Figure 6-1: Location of Bauxite reserves in Atewa Mountain Range

Key risks to the project should the pipeline route run through or near the Atewa mountain range are:

- **Political unrest** (safety, regulatory delays, strikes);
- **Environmental damage** (dense forest, endangered species, water sources);

- **Potential future damage to pipeline** (surface mining);
- **Increased pump costs** (increased pump pressure requirement);
- **Construction challenges** (typically clay-like soil near bauxite reserves);

The key for the elevation geospatial data used within this report is depicted in the figure below. This shows the spectrum of the colours used.

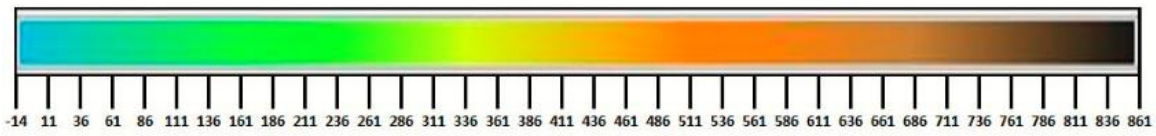


Figure 6-2: Elevation data key

6.2 Diamond Field and Gold Prospects

Another contentious area along the proposed corridors is the presence of a potential extensive diamond field between Accra and Kumasi. The actual locations where diamonds are currently being mined will be confirmed during field review.

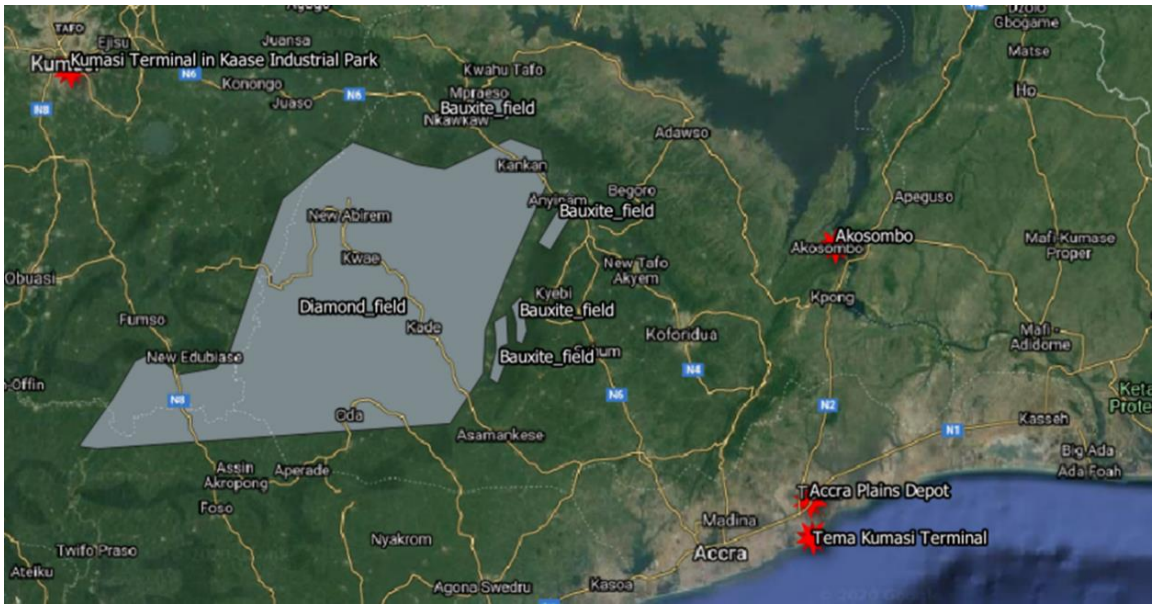


Figure 6-3: Location of Diamond Field between Accra and Kumasi

The area is also dotted with "gold prospect" points as depicted in the figure below.

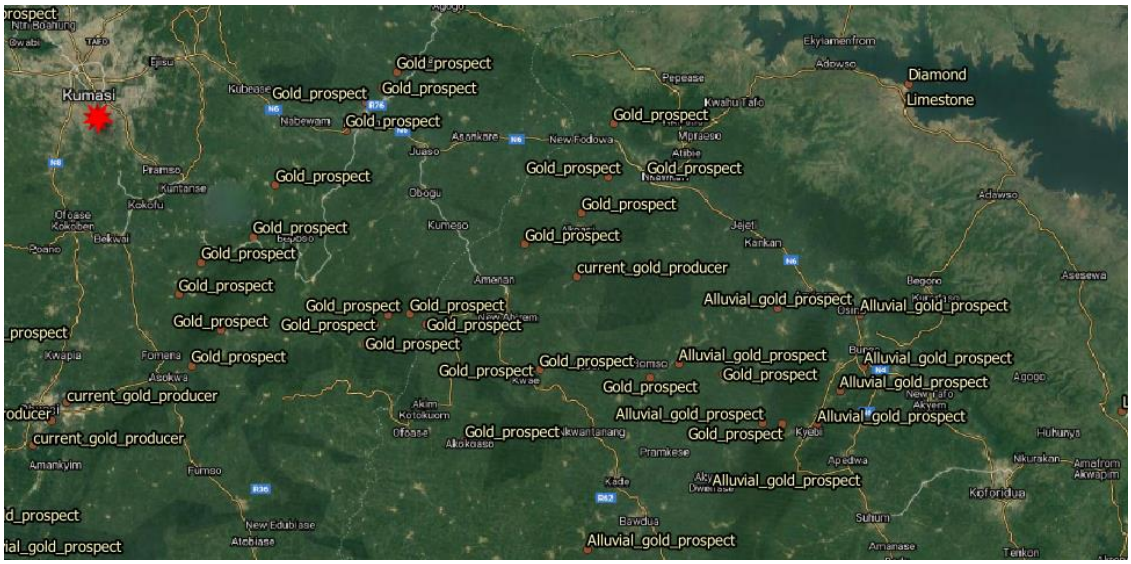


Figure 6-4: Gold prospect points between Accra and Kumasi

It appears that the area is not suitable for mechanised equipment and a large unregulated, illegal trade involving small companies or individuals has developed. It appears that the Government and external parties like the United Nations have been banning and preventing mining in the area in recent years, despite large demands for diamonds in nearby European countries.

Key risks to the project should the pipeline route run through or near the identified diamond field are:

- **Political unrest** (safety, regulatory delays, strikes);
- **Potential future damage to pipeline** (should formal mining be permitted).

6.3 Densely Populated Areas

Kumasi and Accra have highly densely populated areas. Akosombo has a fairly low population density profile.

The key for the elevation geospatial data used within this report is depicted in the table below:

Table 6-1: Population Density data key

Colour	People per hectare
	0.03
	63
	125
	188
	250

The number of people and their proximity to the proposed pipeline is an important consideration to take into account when executing a route study. The construction, operation and maintenance of the pipeline will have an effect on the population that is in close proximity to the pipeline and the major hazardous class location must be established in order to determine the methods for construction, operation and maintenance that will have the lowest impact on the population.



Figure 6-5: Kumasi Population Density

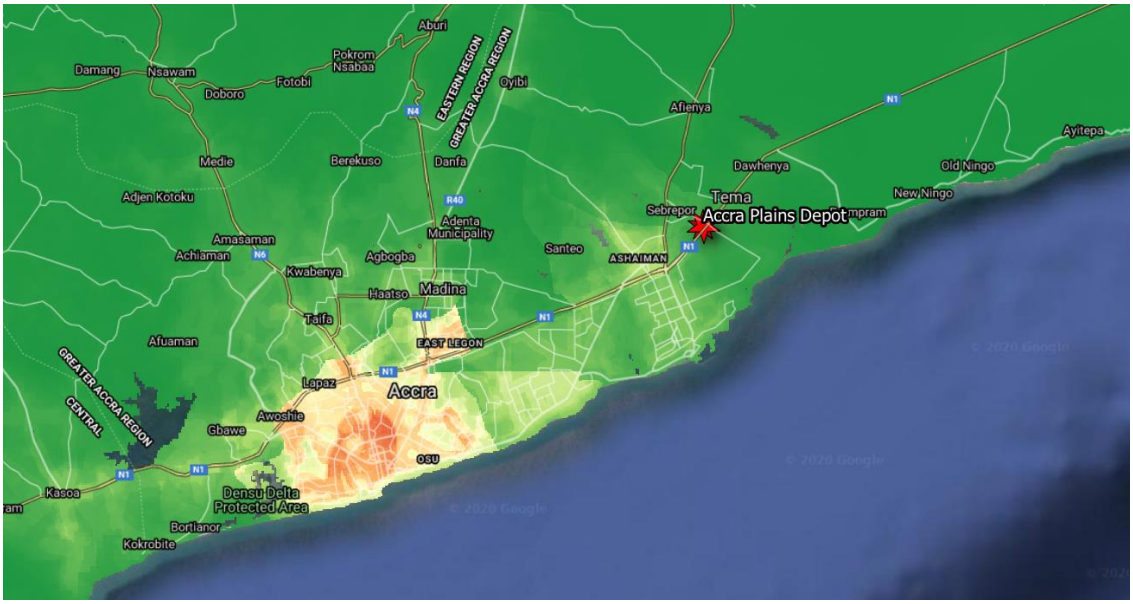


Figure 6-6: Accra Plains Depot population density

Key items to consider when constructing in highly populated zones are:

- Waste management;
- Prevention of air, soil and water pollution (including noise pollution);

- Employment opportunities & skills development;
- Community challenges and strikes;
- Reinstating of construction corridors;
- Traffic management & diversion;
- Pedestrian safety;
- Crime & interference with construction personnel and equipment.

For these reasons, access to Accra Plains Depot and Kumasi Terminal are routed via existing rights of way to minimise risk.

While construction in populated areas is often seen as a risk and a disadvantage, there are certain benefits to routing the pipeline through smaller populated towns and areas along the way. These benefits include:

- Increased and more frequent replenishment of day-to-day supplies including food, water, sanitation supplies;
- Access to market for emergency tools & equipment;
- Material supply points;
- Proximity to labour and housing (i.e. may reduce project housing costs);
- Potential offices and accommodation management and technical support services;
- Proximity to exiting power supplies required for construction of pump and metering stations, potential substations and cathodic protection infrastructure.

6.4 Proximity of Power Lines

Construction of a metallic pipeline in the vicinity of existing live power lines has certain safety risks and cost risks due to coupling between the pipe material and power line which may lead to electric shock and injuries. A temporary AC mitigation system would need to be in place during construction to mitigate these risks.

Once the pipeline is installed within the soil, it continues to interact with electrified structures in the area. This AC and DC interference will be mitigated using a sophisticated cathodic protection system.

Another risk to consider is a potential lightning strike of a transmission power line pylon which may dissipate through several adjacent pylons and directly into the soil which could cause damage to the buried pipeline wrapping system.

One benefit of constructing the pipeline within the transmission powerline ROW is that typical regulatory approvals and certainly environmental impact analyses would have been previously completed for the routing.

Where possible, the pipeline should be routed to not be directly beneath or preferably within 200-300 metres of electrified power lines when running parallel. Crossings of power lines and

railway lines have negligible effect on construction safety but may require drilling and specialized drainage bonds or bunkers to electrically discontinue the pipe.

Sophisticated cathodic protection systems are not complicated to install and have been tried and tested on many pipeline projects globally. The key risks to consider are construction safety and high capital cost should this route be selected.

7. FIELD REVIEW VERIFICATION

7.1 Data Collection & Methodology

The second phase of the project was the field review. The field review was conducted to confirm information obtained during the desktop review and also provide any additional information that may not have been available or easily accessible during the desktop review. The methodology applied in gathering data and confirmation existing information is described in subsequent paragraphs in this section.

The field review was tackled in two phases. The first phase (Phase 1) focused on BOST's assets, the second (Phase 2) focused on the proposed optional routes previously submitted to BOST.

The Phase 1 field review required an inspection of four BOST depots: Accra Plains Depot, Mami Water Depot, Akosombo Depot, and Kumasi depot. Authorization was provided from BOST to gain security clearance. Each Depot provided orientation and safety talk before commencing the team's site walkthrough.

At each Depot, a maintenance manager led a walkthrough of their respective facility while providing answers to the team's inquiries. For each of these depots, the following were inspected:

- Holding capacity;
- Piping;
- Cathodic Protection;
- Potential take-off points;
- Depot environment;
- Pump rating and operating pressure.

The use of flash photography at the depots was limited to a (Nikon D3310) Camera at approved areas of the depots.

Table 7-1: BOST Depot Site Visits

Item No	Location	Date
1	Accra Plains Depot (APD)	05/08/2020
2	Akosombo Depot	05/08/2020
3	Mami Water Depot	05/08/2020
4	Kumasi Depot	07/08/2020

In Phase 2, identified points of concern derived from the preliminary desktop study were inspected along with points of interest, discovered during the exercise. Findings were recorded and documented with:

- DJI Phantom 4 Pro v2 (Drone);
- Samsung Galaxy Tab A (with Q-Field program installed).

Exploration of the vast area required that the expedition be carried out in portions as followed.

Table 7-2: Field Review Schedule

Item No	Date	Expedition Description	Objective
1	07/09/2020	Adowso Lake Port	Potential Jetty site inspection
2	09/09/2020	Accra and Akosombo areas	Powerline crossing inspections
3	10/09/2020-11/09/2020	Eastern Region (N6 stretch)	Rail and Powerline crossing inspections
4	12/09/2020	Kumasi	Rail and Powerline crossing inspections
5	13/09/2020	Central/ Eastern region	Minefields, Rail and Powerline crossing inspections
6	24/09/2020	Supplementary info required by desktop team	
7	25/09/2020	Supplementary info required by desktop team	

As seen in the table above, specific areas were targeted, and information was gathered for all route options within the specified area. A combination of drone surveying and geotagged pictures were collated for further review.

It is important to note that the field review was limited to points that were accessible by road and/or footpaths. Areas with overgrown vegetation, steep hills, and valleys were classified as inaccessible and noted.

Field review investigations have commenced for all routes, this section will be finalised when all the data from the remaining investigations is completed.

7.2 Software and Technology

GIS technology was utilised in the field by making use of an Android-based portable tablet computer and a GIS Android application in the form of QField. Relevant components of the spatial database could be transferred over to the tablet device and viewed on QField. These components included geospatial imagery, line shapefiles of the various proposed routes, and point shapefiles outlining various specific areas that needed to be visited. Global Navigation Satellite System (GNSS) technology allows the user's location to be tracked and shown on QField. The user could therefore observe their location relative to the spatial database for the purpose of orientation and also to capture geolocated data mainly in the form of images.

Geotagged photographs were used alongside QField. Geotagging, which is possible with most modern smartphones and tablet computers, is the process of capturing and embedding location metadata within a photograph file. This is achieved by simply ensuring that the geotag function is turned on within the standard camera application of a particular device and then using the standard camera application to capture photographs. The geotagged photographs could then be pulled back into the spatial database using the location metadata, with each photograph being represented by an icon showing the location at which the photograph was captured. When an icon is double-clicked, the corresponding photograph pops up for viewing, allowing for the seamless spatial orientation of the photographs within the spatial database.

7.3 Findings affecting all routes

7.3.1 Railway Network

The field review team reviewed more than 20 locations where the proposed route corridor ran parallel to or crossed the identified railway line data on the spatial database.

It was found that the majority of these railway lines are no longer in use (despite their locations seeming to be quite accurate as per the available spatial data).

In some cases, there was no railway line visible at an identified crossing location which either means that the data is inaccurate in this area or the railway tracks have been removed altogether.



Figure 7-1: Unused railway lines near New Tafo Akyem

7.3.2 Power Line Network

The field review team reviewed more than 50 locations where the proposed route corridor ran parallel to or crossed the power line data on the spatial database.



Figure 7-2: Confirmation of power lines at identified crossing locations

It has now been confirmed that the power line data does not differentiate between distribution and transmission power lines. Important to note is that the different power lines may be governed by different government (national or municipal) bodies and may therefore have different wayleave and ROW legal requirements. They also have different safety requirements to be implemented during construction and possibly different influence on the overall cathodic protection system and design.

In some locations, power lines were identified in areas where they are not shown in the available spatial database which may indicate that they have been erected after the spatial data set was formulated, thus it was not included in the spatial database that collect



Figure 7-3: Transmission power lines physically identified in area not identified on spatial database

7.3.3 Population Density & Space Constraints in Kumasi

The proposed detailed routings in the area entering Kumasi were travelled by the field review team. There have been concerns from project commencement regarding the high population density in Kumasi and the effect this will have on construction durations, costs and safety.

Although communities can be managed effectively by implementing plans to employ and beneficiate the local population, there are key safety concerns regarding this type of construction in congested areas.

Some construction within the road reserve was underway during the field review which provided insight as shown in the images below.



Figure 7-4: Construction within road reserve in Kumasi

A large risk in all construction projects involving excavations with heavy machinery is the potential of damaging services beneath the ground which are not visible above the ground (like buried cables, telephone/fibre lines, water pipes and other product pipes).

During the FEED phase of the project, a detailed topographical and services identification survey will be carried out on the selected route to aid the engineers in planning the required excavation and pipeline installation methods.

The image below shows some underground services which were seriously damaged during construction within Kumasi.



Figure 7-5: Service crossings within road reserve



Figure 7-6: Construction within road reserve in Kumasi

Installation of an 18-inch pipeline will certainly require a great deal of working space to allow for the required pipeline stringing, third party inspections (NDTs and AIA inspections), bedding preparation. For the majority of the proposed corridors, there is plenty of available space for construction.

Within Kumasi, this may prove to be challenging as many homes, shops, power line infrastructure, drainage/storm water infrastructure and business buildings encroach on the road reserve as depicted in the images below.



Figure 7-7: Buildings and markets within road reserve in Kumasi



Figure 7-8: Power line and storm water infrastructure within road reserve in Kumasi



Figure 7-9: Power line infrastructure within road reserve in Kumasi

7.3.4 River Ofin Crossing

A small water body identified about 200m south-east of the Kumasi Terminal is indicated in the images below.

This type of water crossing would typically be crossed using a small pipe bridge should this routing be selected.



Figure 7-10: River Ofin in Kumasi



Figure 7-11: Rocks within River Ofin

8. ROUTE OPTIONS

8.1 Route Corridor 1

The first route corridor as part of the route analysis is directly from Accra Plains Depot to Kumasi Terminal on land. Four different route permutations were identified within this corridor based on avoiding key risks (namely the Bauxite and diamond fields) and high elevation points whilst maximising utilisation of existing rights of way.

8.1.1 1A

Route Option 1 A which started as a straight line between APD and Kumasi Terminal has been updated and detailed to follow main roads wherever possible. The route exits Accra along the existing pipeline ROW and joins the railway ROW to enter BOST from the southern direction. This route is the shortest possible route for option 1.



Figure 8-1: Detailed route option 1A

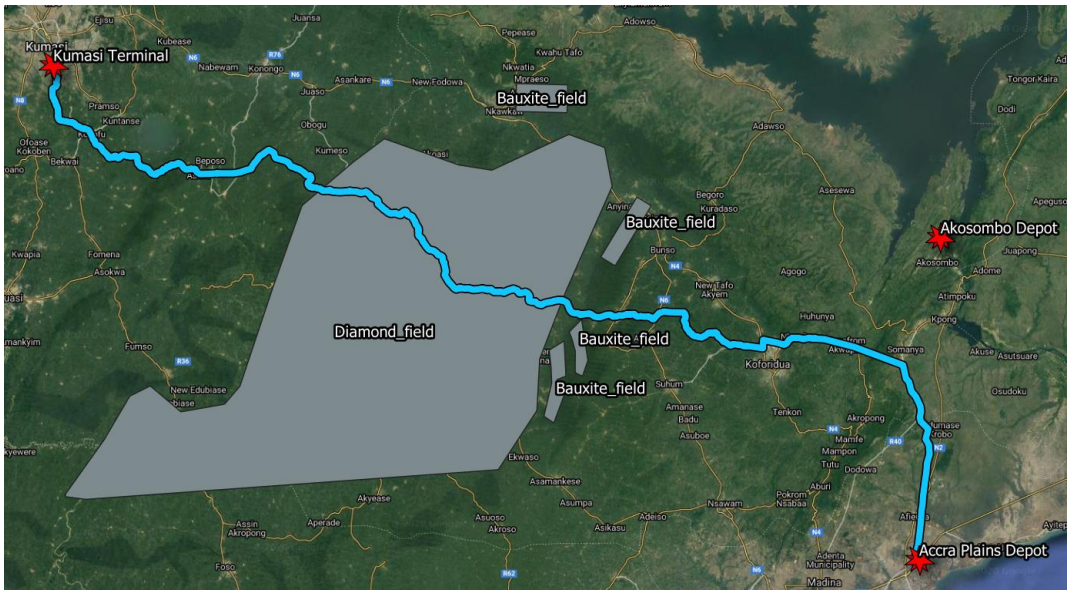


Figure 8-2: Interaction of Route 1A with mineral sources

The images below indicate that there is a lot of open, undeveloped space available within the diamond field, despite several main tar roads (in excellent condition) and some minor developments (i.e. a house being built in image below). Population density appears to be low with minimal security challenges.



Figure 8-3: Image within diamond field



Figure 8-4: Residential area within diamond field

It is clear that there are access roads off of the main tar roads which can be utilised to access the proposed construction routes. Terrain is dense bush, shrubs and trees which would need to be cleared and reinstated. Population density appears low throughout.



Figure 8-5: Area within diamond field

The images below depict the rights of way other than the road ROW which are utilised to form route option 1A.

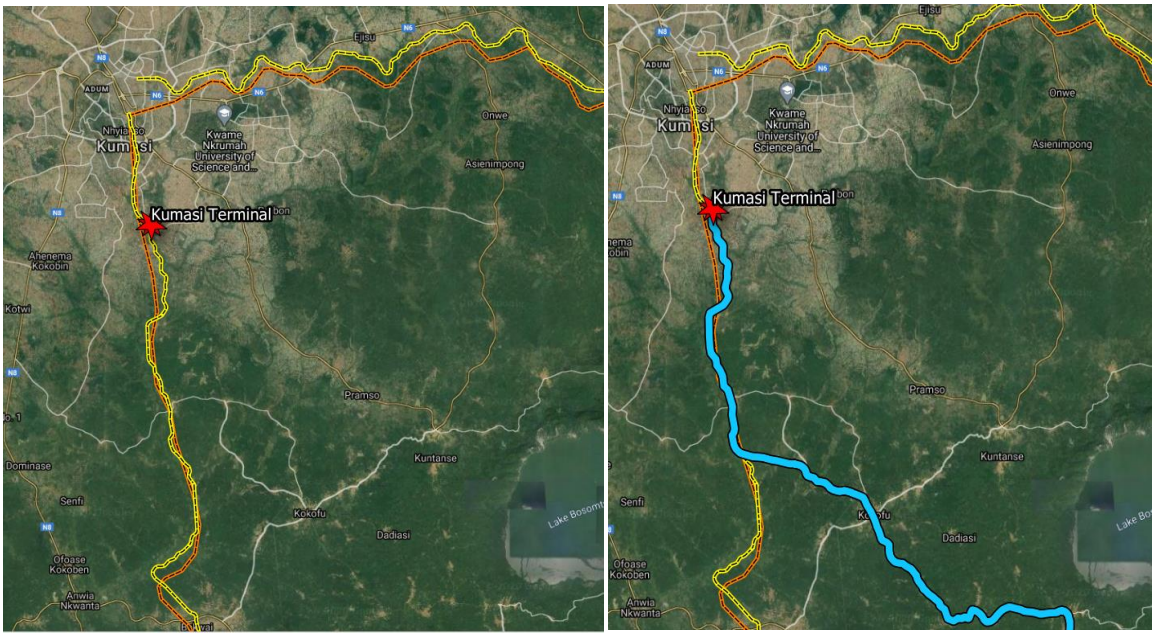


Figure 8-6: Route 1A within railway ROW approaching Kumasi Terminal

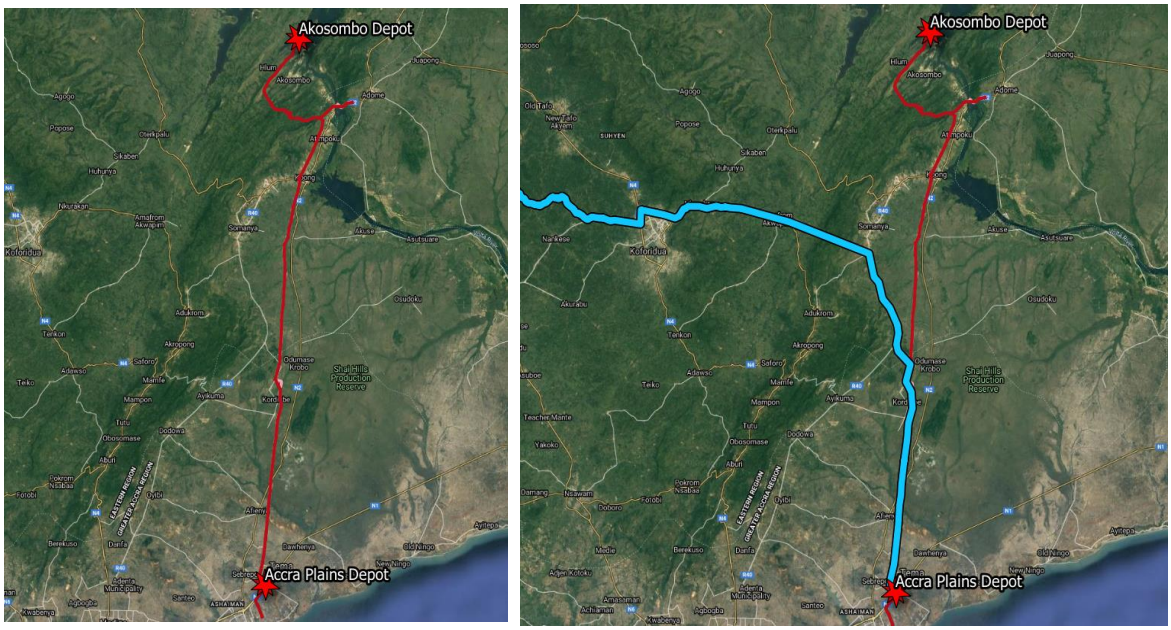


Figure 8-7: Route 1A within pipeline ROW exiting Accra Plains Depot

8.1.2 1B

Route Option 1 B follows the N4 and N6 highways for the majority of the route between APD and Kumasi Terminal. The route exits Accra along the existing pipeline ROW and joins the railway ROW to enter BOST from the southern direction. The key objective of this route is to avoid the Atewa mountain range via the north.

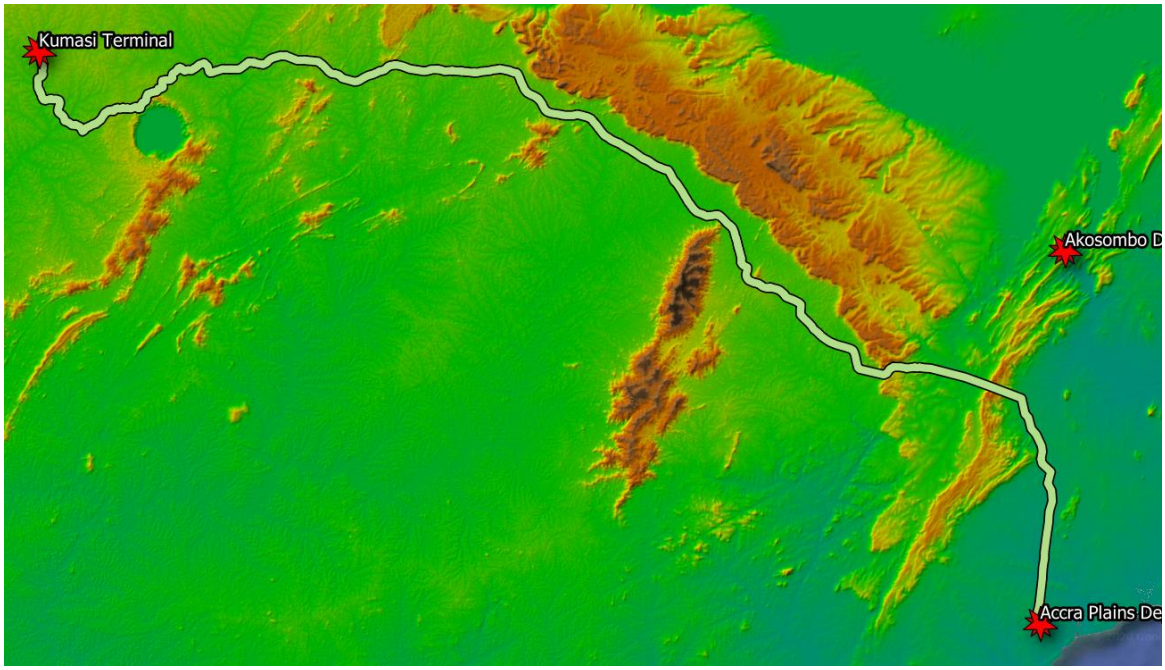


Figure 8-8: Detailed Route Option 1B



Figure 8-9: Route 1B interaction with mineral resources

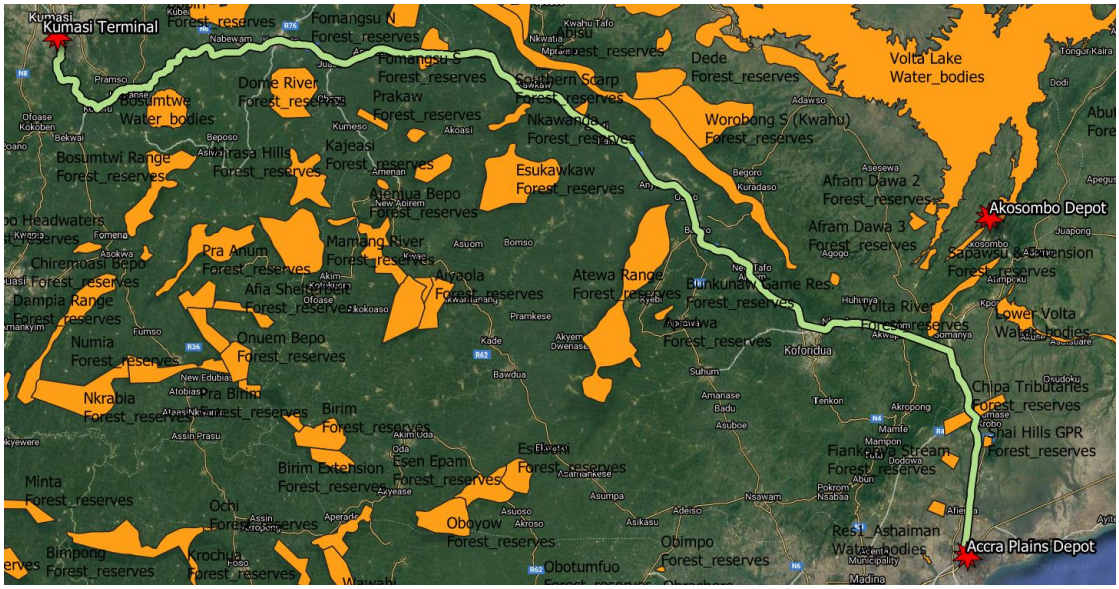


Figure 8-10: Route 1B interaction with nature reserves

Route 1B follows main roads throughout the routing. The image below provides insight into the quality of these main roads:



Figure 8-11: Road along with Route 1B runs

8.1.3 1C

Route Option 1 C follows roads to exit Accra (i.e. not the pipeline ROW) and follows main roads wherever possible around the southern side of the Atewa mountain range. The route joins the railway ROW to enter BOST from the southern direction. The key objective of this route is to avoid the Atewa mountain range via the south.

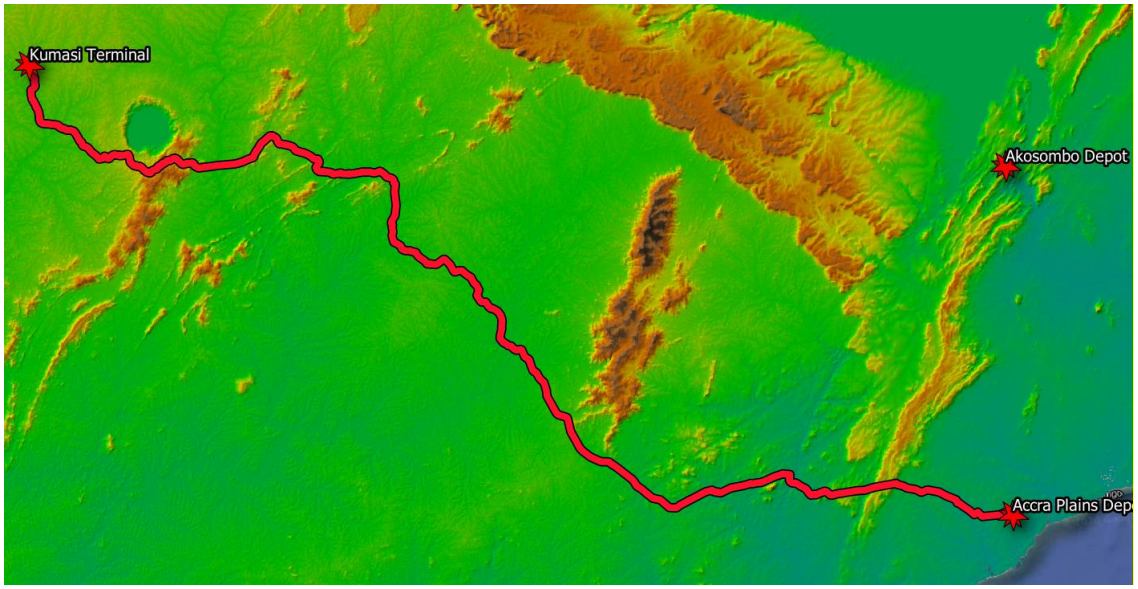


Figure 8-12: Detailed route option 1C



Figure 8-13: Road along which Route 1C runs



Figure 8-14: Road along which Route 1C runs

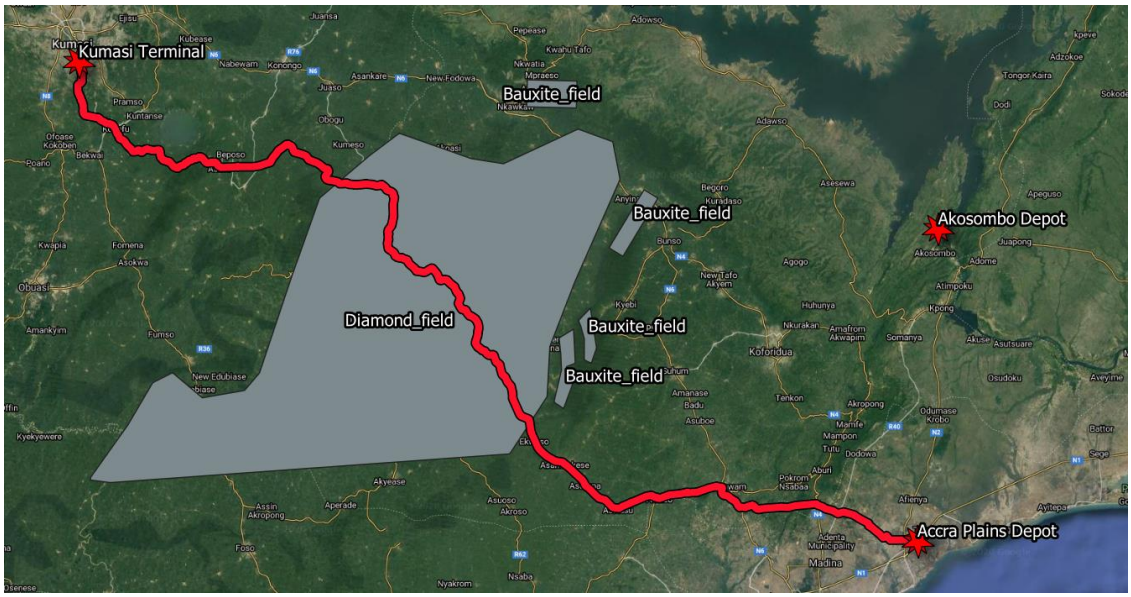


Figure 8-15: Route 1C interaction with mineral sources

Photos from the field review do indicate some degree of exploration or development in the area near the Atewa mountain range as shown in the figures below. It is also clearly visible on Google Earth that there are localised areas where mining is taking place within the identified Bauxite and Diamond fields.



Figure 8-16: Possible exploration near Atewa mountain range (Bauxite reserves)



Figure 8-17: Possible exploration near Atewa Mountain range (Bauxite reserves)



Figure 8-18: Route 1C within road and railway ROW

8.1.4 1D

Route Option 1 D is a new route option which stemmed from the field review. The route has been detailed as follows:

- Exit APD in Tema following the existing pipeline ROW (between APD and Akosombo) for about 15km;
- Follow roads to approach the railway ROW between APD and Kumasi (avoid Koforidua city centre);
- Follow railway ROW between APD and Kumasi;
- Follow roads to approach the railway ROW between Takoradi and Kumasi;
- Follow railway ROW between Takoradi and Kumasi to enter BOST.

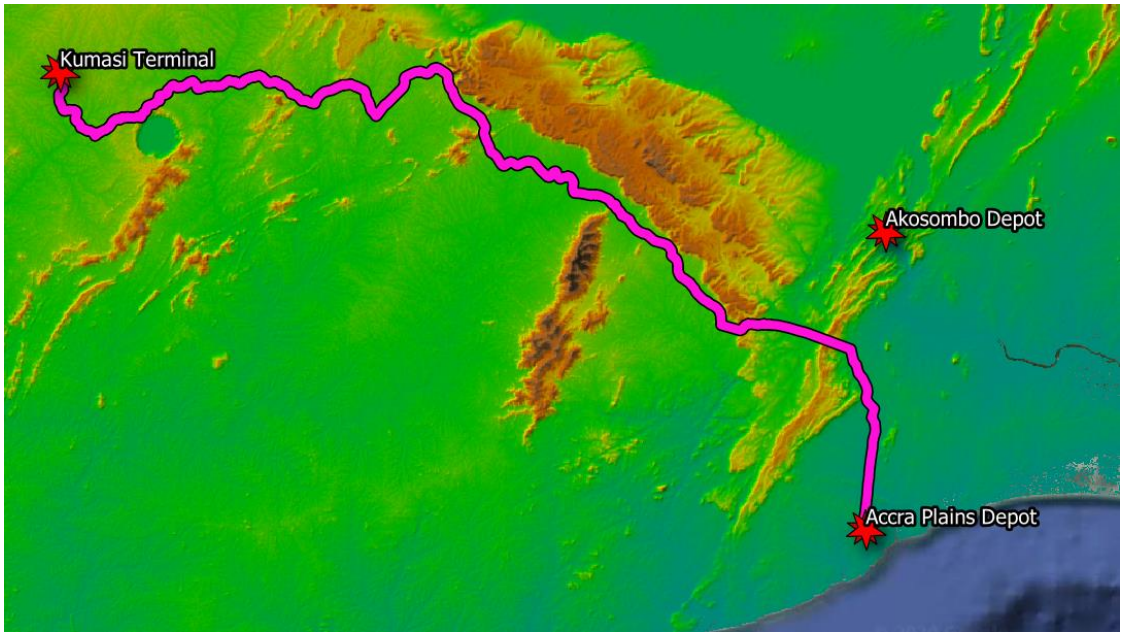


Figure 8-19: Detailed route option 1D

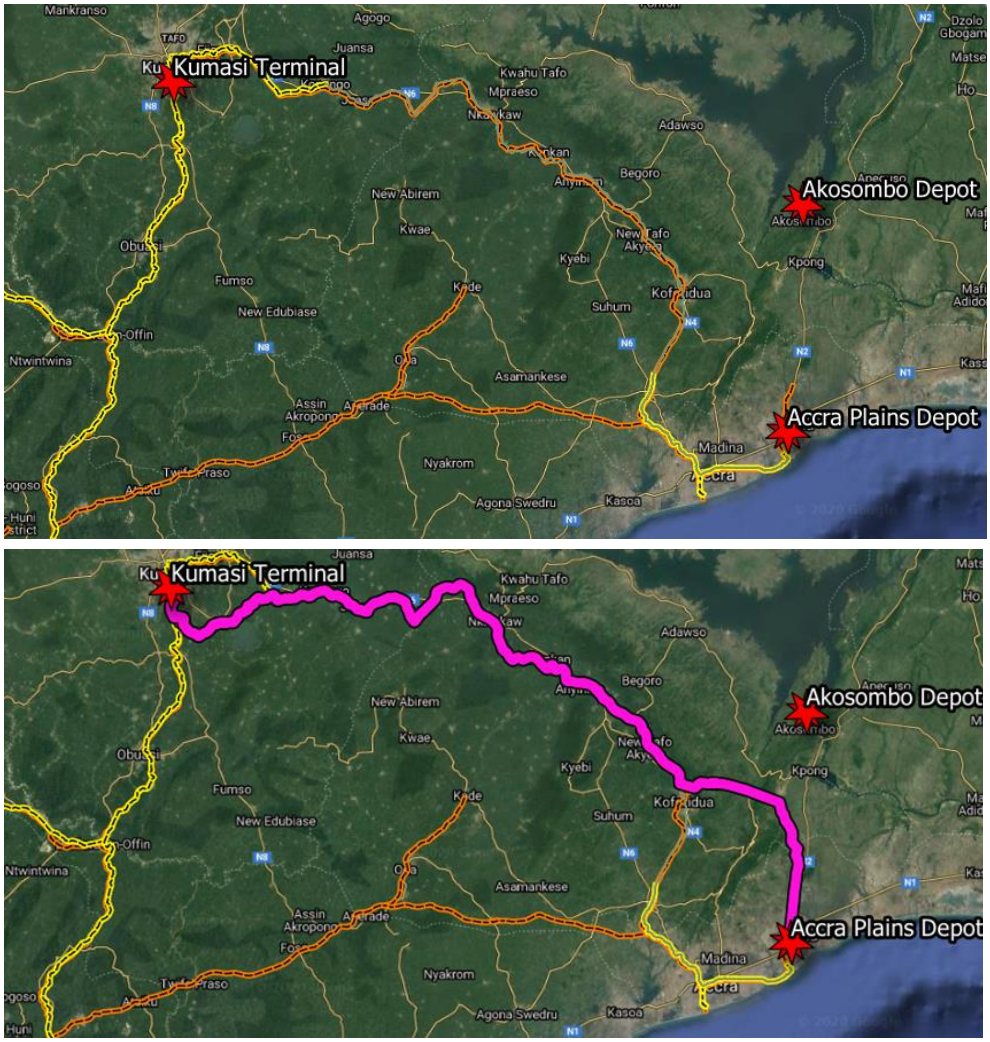


Figure 8-20: Route 1D within railway ROW



Figure 8-21: Drone image of existing railway line ROW

8.2 Route Corridor 2

The second route corridor as part of the route analysis is directly from Akosombo Terminal to Kumasi Terminal on land. 4 different route permutations were identified within this corridor based on avoiding key risks (namely the Bauxite and diamond fields) and high elevation points whilst maximising utilisation of existing rights of way.

8.2.1 2A

Route 2A primarily avoids the thin mountain range near Tema which, as identified by the field review, may pose a few risks during construction. The route follows main roads to exit Akosombo before merging with route 1D (via the railway line ROW) to Kumasi.

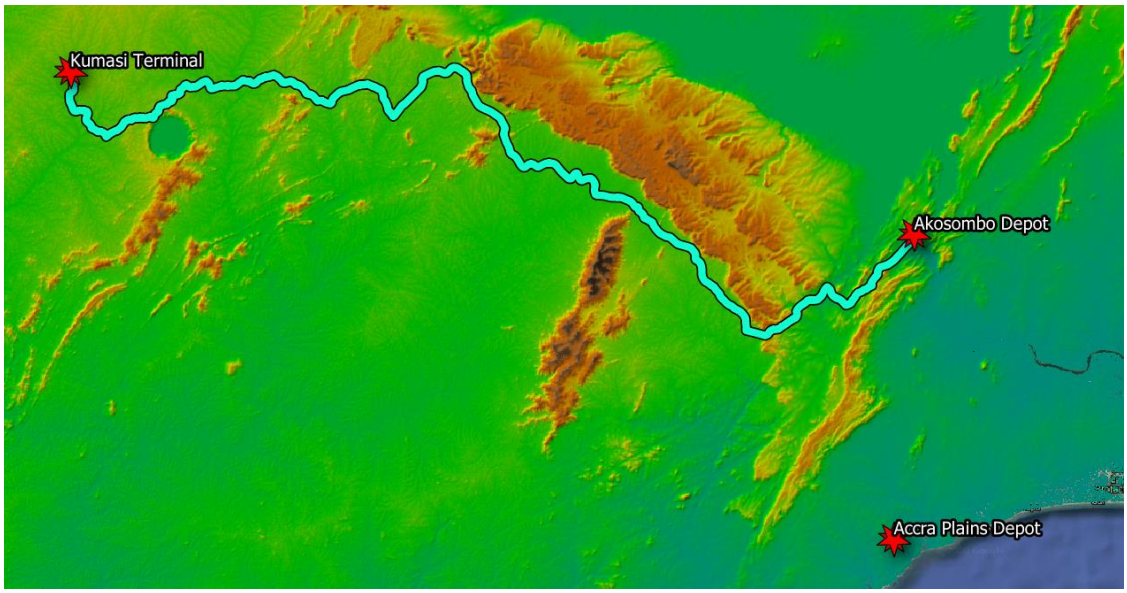


Figure 8-22: Detailed Route Option 2A

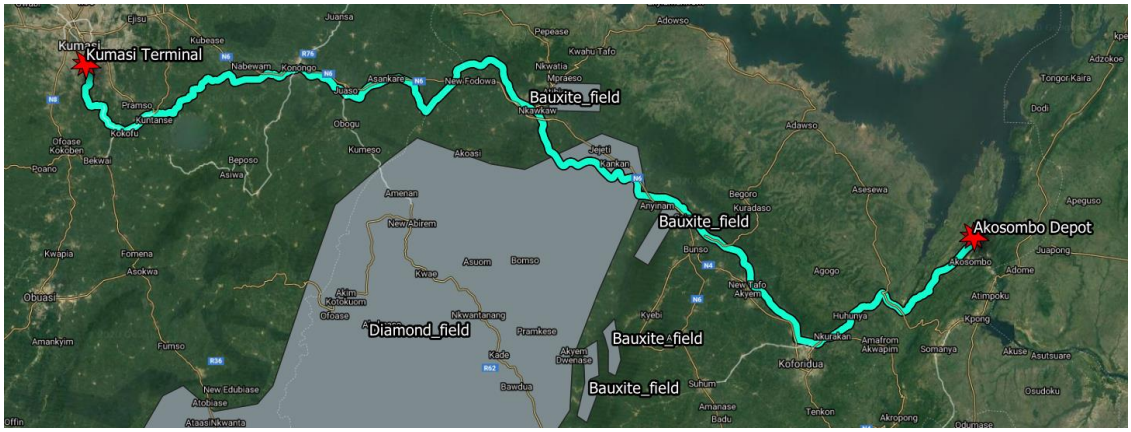


Figure 8-23: Route 2A interaction with mineral sources

8.2.2 2B

Route 2B runs around the back of the mountain range near Tema and then crosses it at an identified low elevation point (no existing infrastructure here). The detailed route follows main roads to exit Akosombo and then joins route 1B (via the railway line ROW) to Kumasi.

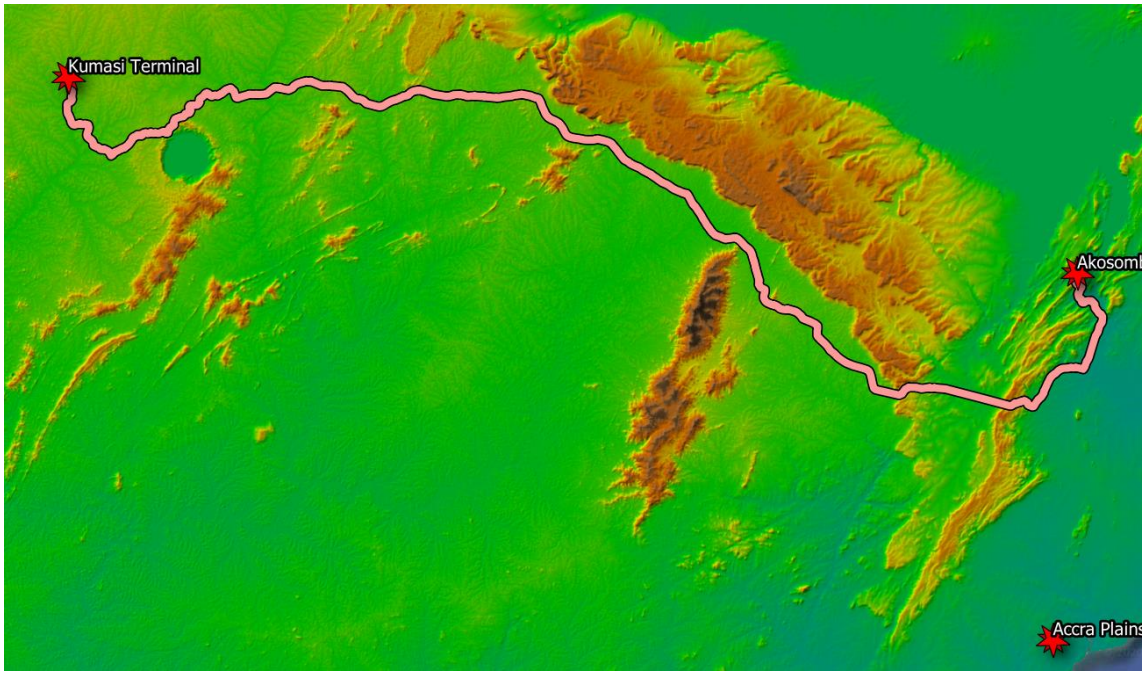


Figure 8-24: Detailed Route Option 2B

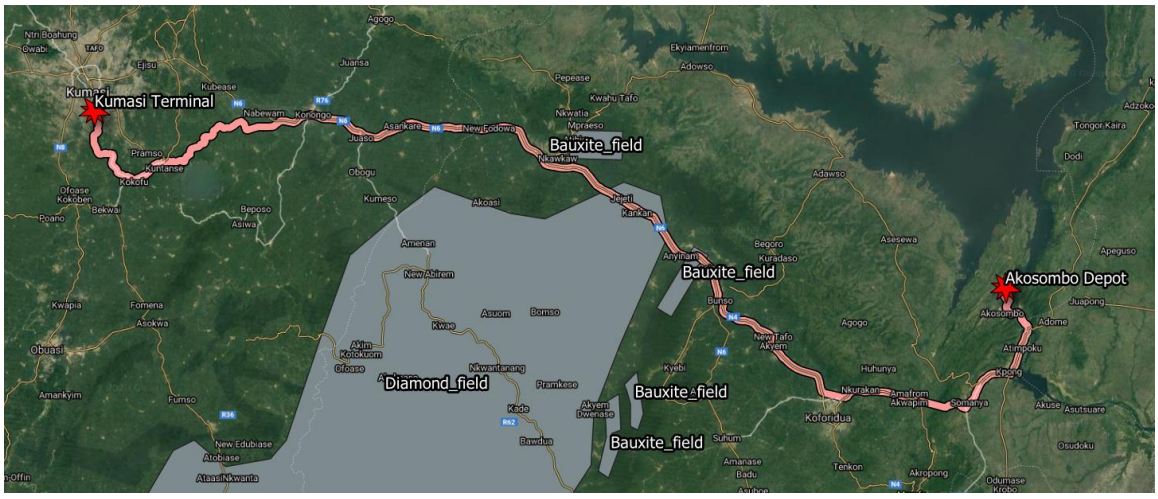


Figure 8-25: Route 2B interaction with mineral sources

8.2.3 2C

Route 2C is a new route identified during the field review phase. The proposed route follows the existing pipeline ROW to exit Akosombo and then joins route option 1D (via the railway ROW) to Kumasi.

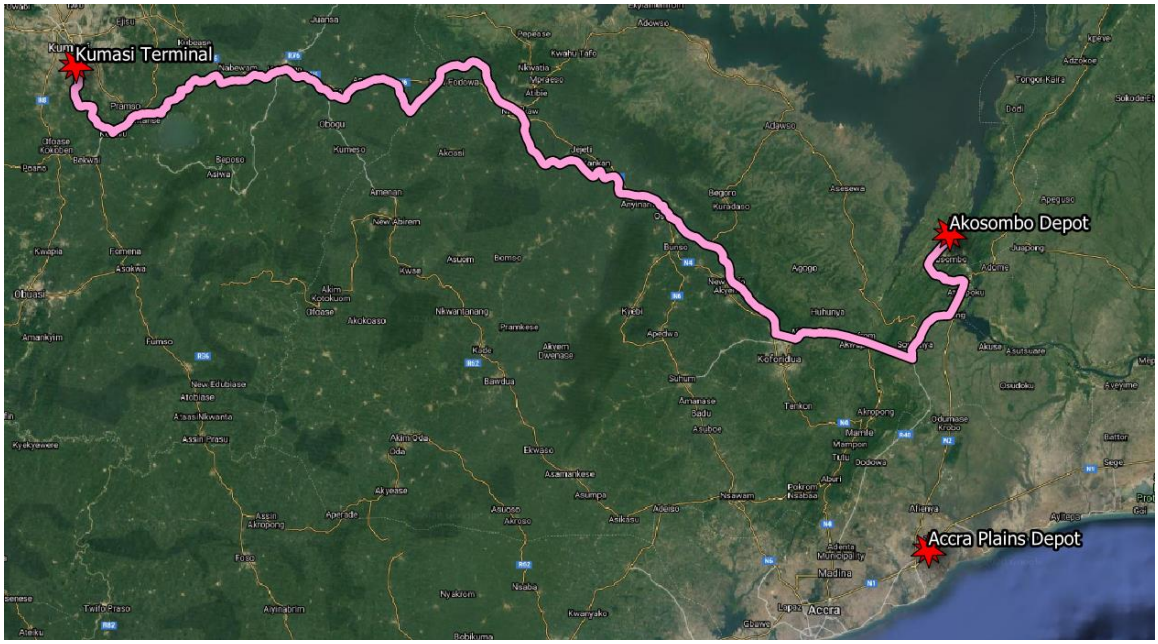


Figure 8-27: Detailed Route Option 2C

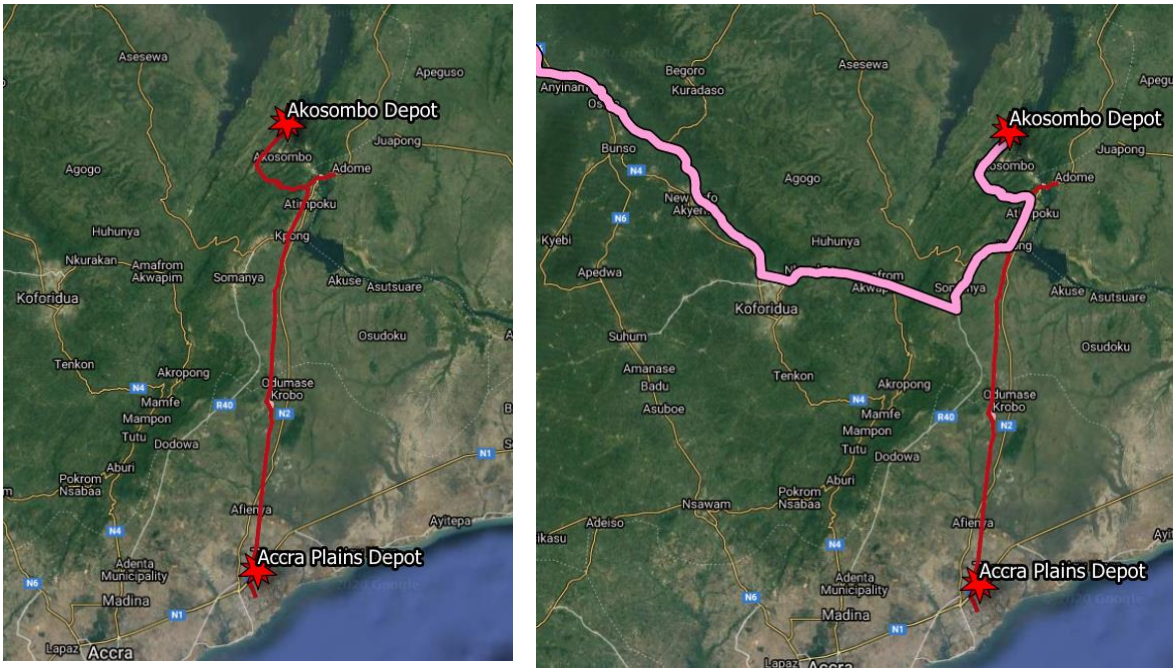


Figure 8-26: Route 2C within pipeline ROW existing Akosombo

8.2.4 2D

Route Option 2D a new route identified during the field review phase. The proposed route follows the existing power line ROW to exit Akosombo and continues along the power line ROW all the way to enter BOST Kumasi.

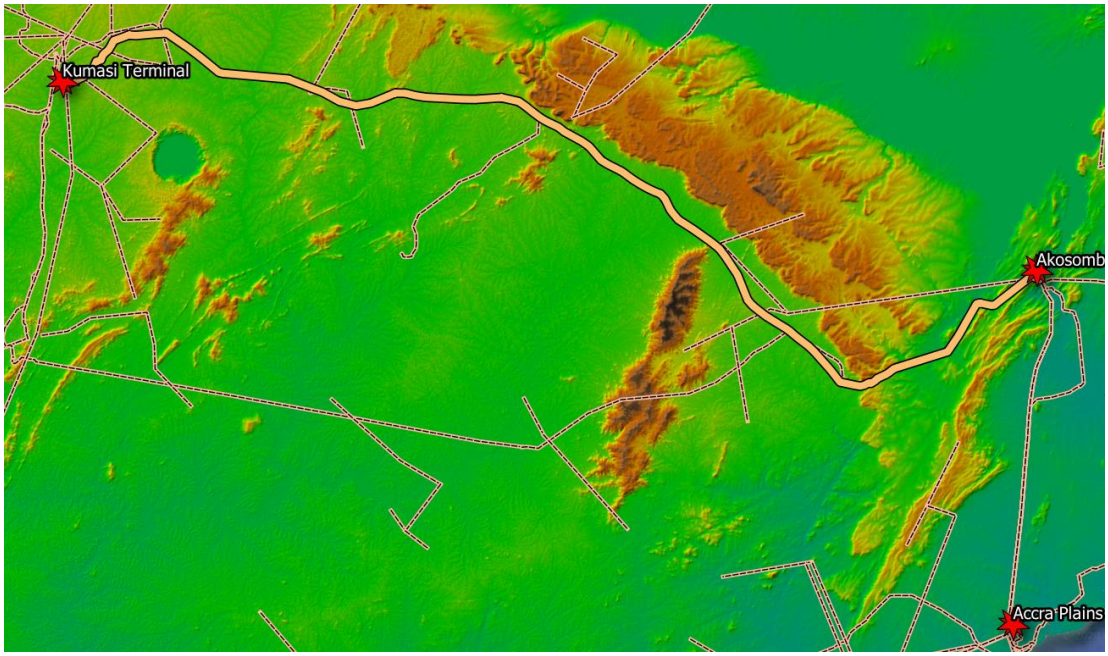


Figure 8-29: Detailed Route Option 2D



Figure 8-28: Route 1D within electricity ROW throughout

8.3 Route Corridor 3

The final route corridor part of the pipeline routing analysis is to utilise barges via Lake Volta to transport the fuels from Akosombo to an identified jetty point in Adowso, before utilising a pipeline from Adowso to Kumasi (on land)

8.3.1 3A & 3B

This route has been detailed to follow main roads exiting Adowso towards Nkawkaw before joining pipeline route 1D (via the railway ROW) and route 1B (via the power line ROW) to enter Kumasi from the south.

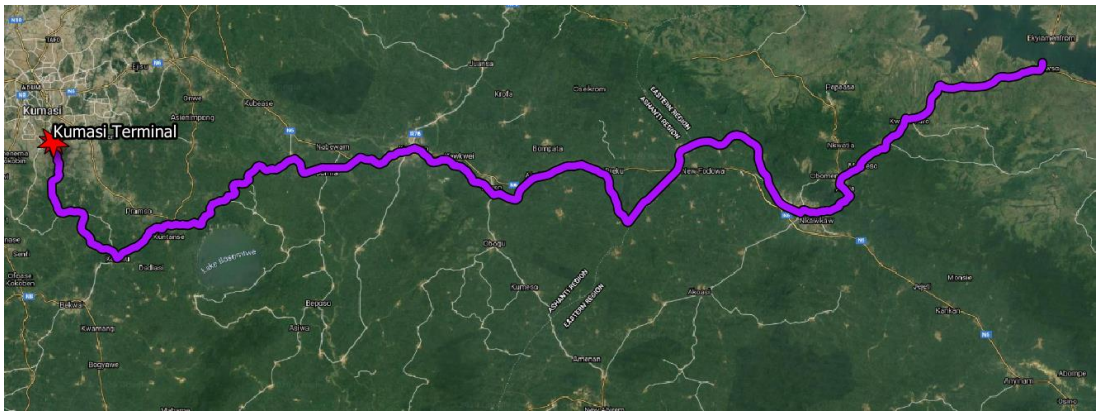


Figure 8-30: Detailed Route Option 3A

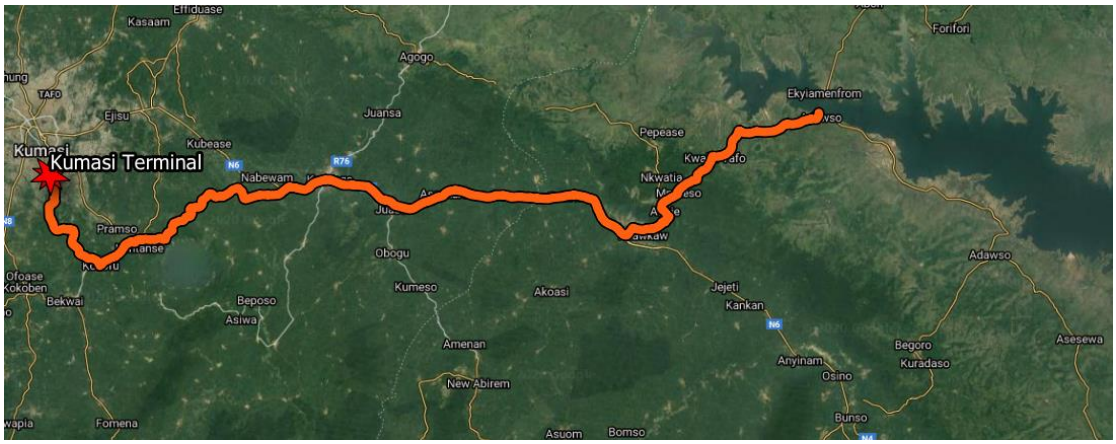


Figure 8-31: Detailed Route Option 3B

The overall corridor locality for route option 3 is highly dependent on the proposed location of the jetty. The field review team identified the optimal jetty location to be near Adowso as depicted in the images below.



Figure 8-32: Proposed jetty location on Lake Volta near Adowso

Population density in the vicinity of the jetty is not a major concern. There is sufficient space for required construction activities to exit the populated area.

It is visible from the spatial database that there is a elevation increase a small distance away from Lake Volta. Drone footage and photographs from the field review indicate that the elevation increase is not significant enough to influence the constructibility of the route.



Figure 8-33: Elevation increase near Lake Volta



Figure 8-34: High elevation points near Lake Volta

Drone footage and photographs from the field review indicate that the area is accessible by a few tar roads. Photos from areas a distance away from Adowso also indicate that the terrain is appropriate for construction (i.e. accessible) and there is a road for accessibility.

8.3.2 Barging

The table below shows the scenarios being considered in the route study and associated volumetric flowrates:

Table 8-1: Required volumetric flowrates

Scenario	Flow case	Volumetric flowrate (m^3/h)	
		2020	2040
Kumasi	1	129	144
Kumasi + Buipe / Bolgatanga	2	171	230
Kumasi + Buipe / Bolgatanga + Exports	3	682	1269

Flow cases 1 and 2 only consider local consumption, while flow case 3 also takes into account projected export volumes.

A response received to RFI025 (Bathymetry survey on Lake Volta) clarified that a possible option for a jetty location along Lake Volta would be at Adowso. Therefore, barging will occur from Akosombo to Adowso, where a terminal will need to be constructed to receive and store fuel. A pipeline from the Adowso depot to Kumasi will then be required.

Currently, the barges that are operational are as follows:

- 2 x 900 m^3 (BOST – gasoline, kerosene and gasoil)
- 1 x 700 m^3 (VLTC – gasoline and kerosene)
- 1 x 800 m^3 (VLTC - gasoil)

The BOST tugboat MV DBRE is designed to push 6 barges at a **maximum** speed of 7.5 knots (13.89 km/h).

By using the QGIS database, it was approximated that the distance between Akosombo and Adowso is approximately 100 km, using the possible barge route shown in the figure below:



Figure 8-35: Proposed barging route along Lake Volta

Therefore, by using the **maximum** speed of 13.89 km/h, it would take approximately 8 hours to barge.

Assuming that:

- 1 x 900 m^3 barge and 1 x 700 m^3 barge transports gasoline (total volume = 1600 m^3)
- 1 x 900 m^3 barge and 1 x 800 m^3 barge transports gasoil (total volume = 1700 m^3)

The volumetric flowrate that will be achieved through barging is as follows:

Table 8-2: Barging volumetric flowrate

Fuel	Volume that can be transported (m^3)	Time to barge (h)	Volumetric flowrate (m^3/h)
Gasoline (PMS)	1600	8	200
Gasoil (AGO)	1700	8	212.5

From comparison of the volumetric flowrate achieved with barging Table 8-2 to the volumetric flowrate required Table 8-1, it is observed that the current barging option will only be feasible for flow case 1 and flow case 2 (2020).

Flow case 2 (2040) and flow case 3 will not be feasible as there is insufficient barging capacity to meet the requirements.

This restricts route option 3 in that it will not be able to transport fuel for the projected 2040 Kumasi and Buipe / Bolgatanga requirements and both 2020 and 2040 export volumes.

9. HYDRAULIC CALCULATIONS

Hydraulic calculations were carried out to determine the flowrate options that can be considered (local consumption versus exports), line size options and preliminary pump requirements (power and head) per route option.

The hydraulic calculations were split into three parts:

1. Optimal line size evaluation
2. Existing pipelines analysis
3. Hydraulic simulations for each route option to determine pump requirements (The simulations were based on a base flowrate case and desktop study route options).

The key objectives of the hydraulic calculations and line size analysis are:

a) Confirm whether the proposed 18" pipe diameter will be sufficient to accommodate an internal growth factor in both local consumption and export volumes

b) Confirm whether the existing pipeline network in Ghana will be able to accommodate an internal growth factor in both local consumption and export volumes

c) Determine whether considerations a) and b) influence the optimal corridor selection

The flowrates developed for parts 1 and 2, as well as key objectives a) and b) as mentioned above were based on the following RFIs received:

- RFI007 (received mid-August) (Reference 1)
- RFI028 (Received 21 September) (Reference 13)

The method in which the flowrates were developed for each RFI are detailed in section 9.3

9.1 Key assumptions

The key assumptions made in the development of this report are listed in the table below:

Table 9-1: Key assumptions for line sizing analysis

Assumption	Reference
Pipe schedule 80 is appropriate for the calculations/simulations, where applicable	SIENNA assumption
Fuel export amount in 2018 is split 50/50 between PMS and AGO	SIENNA assumption
PMS and AGO will be transported separately in the pipeline (separated by a pig as detailed in RFI014)	RFI014 – Transmix Philosophy
Pipeline has been assumed to be operational for 333 days per annum, after allowing for maintenance and unplanned shutdowns/outages	SIENNA assumption
Pumping of the fuel will occur as a continuous operation (24 hours/day)	SIENNA assumption
Kerosene will not influence the pipe size selection and is therefore excluded from the analysis	SIENNA assumption

9.2 Fluid properties

The following fluid properties for PMS and AGO was used based on information received on the design basis of the 12" line from Accra Plains Depot to Akosombo (Reference 3):

Table 9-2: PMS fluid properties

PMS	
Property	**Value**
Density	770.8 kg/m^3
Viscosity	0.39 cP
Vapour pressure	20 kPa

Table 9-3: AGO fluid properties

AGO	
Property	**Value**
Density	877 kg/m^3
Viscosity	6.8 cP
Vapour pressure	≅ 0.01 kPa (Negligible)

9.3 Flowrate Development

Multiple options were presented in terms of the depots' consumption and time frames to be considered to establish a flowrate. That is:

- Flow case 1: Kumasi consumption – 2020 and 2040
- Flow case 2: Kumasi + Buipe / Bolgatanga consumption – 2020 and 2040
- Flow case 3: Kumasi + Buipe / Bolgatanga + Exports consumption – 2020 and 2040

The flowrates for PMS and AGO in 2020 and 2040 were determined according to the methodology described below.

9.3.1 Local Flowrates - 2020

The forecasted 2020 consumption values provided by Sienna (RFI007, Reference 1, see Appendix D) at Kumasi and Buipe / Bolgatanga were used to develop the flowrates for those scenarios.

9.3.2 Annual Growth Factor

RFI028 (Reference 13, see Appendix D) were used to determine the growth in PMS and AGO consumption.

For RFI028: A growth percentage was determined by using the Kumasi and Buipe consumption values provided for PMS and AGO between the years 2010 and 2018. The results were as follows:

Table 9-4: Growth factors

	Kumasi	Buipe
PMS	47.29 %	46.66 %
AGO	44.38 %	25.94 %

Based on these results, the highest growth factor percentages were used in further calculations.

Since the growth percentage was calculated between 2010 and 2018, this indicates that the growth percentages are over 8-year periods.

9.3.3 Export Volumes - 2020

It is assumed that the 3 million MT exported in 2018 (Reference 2) is split equally between PMS and AGO to give 1.5 million MT per fuel type. This value was used as the starting point for PMS and AGO and the respective growth percentages as stated above for each RFI were applied to this value to get the exports volume.

Since the RFIs' growth factor percentages are in intervals of 8 years, interpolation was carried out to get the exports volume for PMS and AGO in 2020.

These two values added together would give the total exports volume in 2020. The results are presented below.

Table 9-5: PMS and AGO 2020 export volumes

PMS export volume (MT/annum)	AGO export volume (MT/annum)
RFI028	
1 677 355.87	**1 666 437.90**
TOTAL = 3 343 793.77 ≅ 3.3 million MT/annum	

The final flowrates used in the simulation for 2020 are shown in the table below:

Table 9-6: 2020 flowrates

Item	Volumetric flowrate (m^3/h)
Kumasi	129
Kumasi + Buipe / Bolgatanga	171
Kumasi + Buipe / Bolgatanga + Exports	682

Since the exports in 2020 are relatively similar and RFI007 was used to calculate the local consumption flowrates (Kumasi and Kumasi + Buipe / Bolgatanga), the 2020 flowrates for both RFIs are the same.

9.3.4 Local and Export Flowrates - 2040

A similar approach to the exports volume for 2020 was carried out to determine the flowrates for 2040.

(a) RFI028

The growth percentage values from **Error! Reference source not found.** were applied to the Kumasi and Buipe consumption volumes provided from 2010 to 2018 (Reference 13), to determine the consumption at Kumasi and Buipe for AGO and PMS in 2040.

The same approach as described for the exports volume in 2020 was applied here. The results are presented below:

Table 9-7: PMS and AGO 2040 export volumes for RFI028

PMS export volume (MT/annum)	AGO export volume (MT/annum)
4 408 730.71	4 167 884.77
TOTAL = 8 576 615.48 ≅ 8.6 million MT/annum	

RFI028's final flowrates used in the line sizing simulation for 2040 are shown in the table below:

Item	Volumetric flowrate (m^3/h)
Kumasi	330
Kumasi + Buipe / Bolgatanga	421
Kumasi + Buipe / Bolgatanga + Exports	1 732

9.3.5 Summary

A consolidated representation of the flowrates developed for 2020 and 2040 using RFI007and RFI028 are shown below.

Note: RFI007 was used to develop flowrates for 2020 as this RFI deals specifically with a 2020 consumption forecast. RFI028 was used to develop flowrates for 2040 based on the historical consumption data provided.

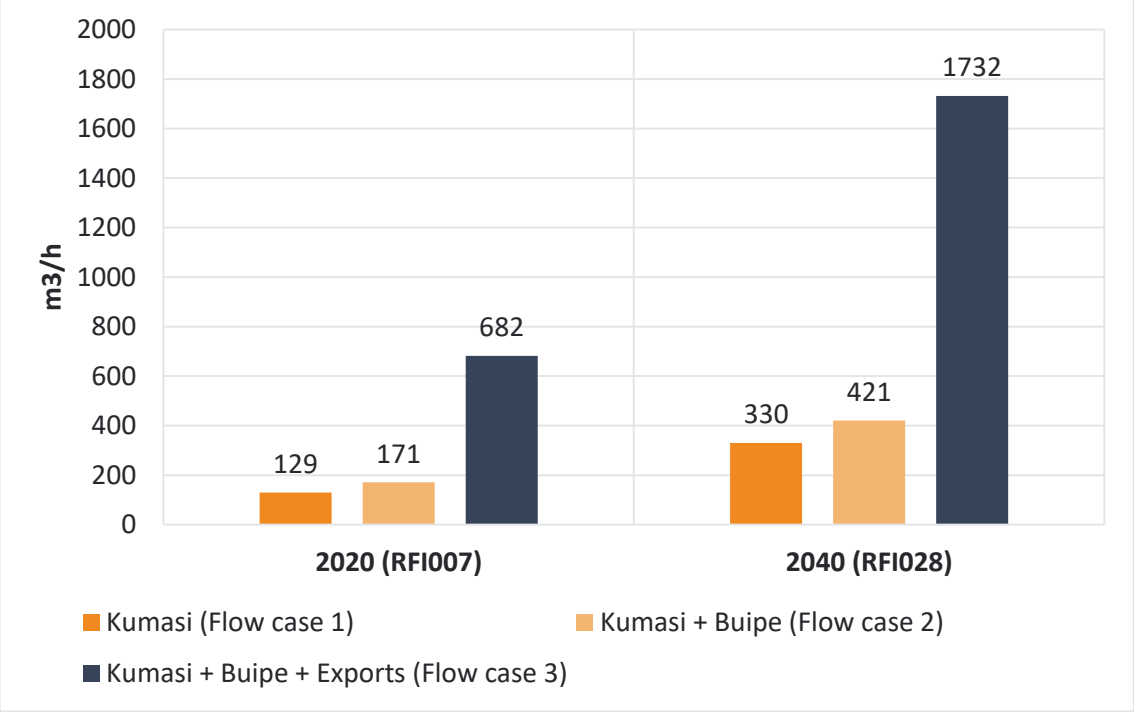


Figure 9-1: Flowrate comparison (m^3/h) between RFIs for each flow case

9.4 Line sizing evaluation

Overall pressure drop and fluid velocity for each scenario were evaluated to establish the optimal line size for each case and each fuel.

The scope of the study referenced the use of an 18" pipeline. SIENNA has assessed the viability of this line size as part of this hydraulic study.

There are also existing pipelines in the BOST network:

- Dual 6" line from Tema Oil Refinery (TOR) to Accra Plains Depot (APD) for PMS and AGO
- 18" line from Conventional Buoy Mooring (CBM) to APD
- 12" line (yet to be constructed) from APD to Akosombo
- 6" line from APD via Mami Water to Akosombo
- 8" line from Buipe to Bolgatanga

These lines were analysed with all available existing information to verify the capacities in line with the required flowrates, to support the selection of an optimal pipeline route.

9.4.1 Optimal line size criteria

The optimal line size for a particular flowrate and fluid will be the line size at which:

- Velocity is approximately 1 m/s (for cross-country pipelines and clean service) and below erosional velocity (see Appendix D for erosional velocity limits)
- Maximum allowable operating pressure (MAOP) is not exceeded at any one point

However, the MAOP is dependent on the line size (which will be determined in this section) and schedule (which has been specified as 80) of the pipeline. Therefore, a line size range of 6" to 24" was selected for the purposes of the simulation and the MAOP for each line size at schedule 80 is shown in the table below. For larger line sizes (from 26" and larger), since schedule 80 is not typically available, the highest value for wall thickness (as per ASME B36.10M-2015) was used as appropriate to determine the MAOP.

Prevention of potential overpressure will be investigated during the FEED analysis.

Table 9-8: MAOP at each line size

Line size (in)	Schedule or Wall thickness	MAOP (bar)
6	Sch 80	161.66
8	Sch 80	143.97
10	Sch 80	137.69
12	Sch 80	134.97
14	Sch 80	133.93
16	Sch 80	132.07
18	Sch 80	130.69
20	Sch 80	129.17
22	Sch 80	128.05
24	Sch 80	127.09
26	Wall thickness 25.4 mm	95.51
28	Wall thickness 25.4 mm	88.49

Once an optimal line size has been selected, different schedules or wall thickness at that line size can be analysed together with the pressure drop in the pipeline to select the most appropriate schedule or wall thickness

9.4.2 Optimal Line Size Summary

Due to their different fluid properties, the pressure drop, pump power required and pump head required differ for PMS and AGO, with AGO resulting in larger numbers for these parameters since it is more dense and viscous compared to PMS. It is for this reason that AGO was used primarily as the deciding fluid for the optimal line size.

The optimal line sizes for PMS and AGO are shown in the table below. Detail of each flow scenario can be found in Appendix d: Supplementary hydraulic calculations/information)

Table 9-9: Summary of optimal line size per scenario

Scenario	Flow Case	Item	Year 2020 (RFI007)	Year 2040 (RFI028)
Kumasi	1	Operating volumetric flowrate (m^3/h)	129	330
		Optimal line size (in)	10	14
Kumasi + Buipe / Bolgatanga	2	Operating volumetric flowrate (m^3/h)	171	421
		Optimal line size (in)	10	16
Kumasi + Buipe / Bolgatanga + Exports	3	Operating volumetric flowrate (m^3/h)	682	1 732
		Optimal line size (in)	20	28

Note: All line sizes are at schedule 80 except for flow case 3 for RFI028 where a wall thickness of 25.4 mm was used.

9.4.3 Two pipelines evaluation

Since the optimal line size of 28-inch for the flowrate of 1 732 m^3/h (flow case 3, 2040) is large, the feasibility of installing 2 smaller pipelines in parallel (within the same corridor) was evaluated.

Two configurations were evaluated, and a simulation was modelled to determine the optimal line sizes and pump requirements for each configuration, according to the following model:

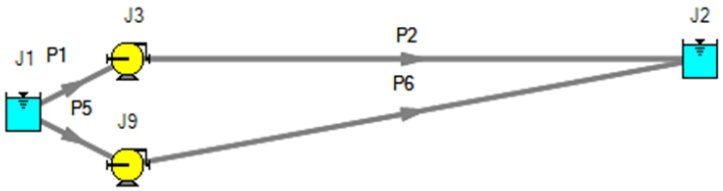


Figure 9-2: Simulation model to evaluate two pipelines

(a) Configuration 1:

- Pipeline 1 = 1 300 m^3/h
- Pipeline 2 = 432 m^3/h

Table 9-10: Line size and pump requirements for configuration 1

Pipeline	Line size (in)	MAOP (bar)	Pressure drop (bar)	Pump power (kW)	Pump head (m)	Velocity (m/s)
1	24	127.09	102.5	3 697	1 191	1.53
2	16	132.07	101.7	1 219	1 182	1.16

These pipelines would typically be installed simultaneously to keep the project capital expenditure as low as possible, but the second, smaller pipeline would only be commissioned and utilised when the export demand exceeds the available capacity in the first pipeline (approx. 15 years from construction completion).

(b) Configuration 2:

- Pipeline 1 = 866 m^3/h
- Pipeline 2 = 866 m^3/h

Table 9-11: Line size and pump requirements for configuration 2

Pipeline	Line size (in)	MAOP (bar)	Pressure drop (bar)	Pump power (kW)	Pump head (m)	Velocity (m/s)
1	20	129.17	116.7	2 805	1 357	1.48
2	20	129.17	116.7	2 805	1 357	1.48

These 2 pipelines would be constructed and commissioned simultaneously. The key advantage with this configuration is the commonality of the pumping, metering and valve stations. This configuration would enhance the efficiency of the pipeline system and allow for backup during maintenance or other down time scenarios.

9.4.4 18” line size profile (APD or Akosombo to Kumasi)

The original project brief entailed analysis of the optimal route for a proposed 18” multifuels pipeline. For this reason, the proposed 18” line size was analysed in detail to determine which of the possible flow scenario capacities would be best suited. The line size was simulated per flowrate at schedule 80, and the velocity and pressure drop in the line was used to determine its feasibility.

The MAOP for an 18” line at schedule 80 was calculated to be 130.69 bar.

In order for the line size to be appropriate for the scenario, the pressure drop in the line had to be lower than the MAOP and velocity had to be approximately 1 m/s with no cavitation problems in the line.

The results for PMS and AGO are shown below.

Cells highlighted in green have an acceptable hydraulic profile, while those highlighted in orange have minor concerns. Those highlighted in red yield unacceptable hydraulic results.

Table 9-12: 18" line feasibility for each scenario with PMS

PMS			
Flow case	**Item**	**Year 2020 (RFI007)**	**Year 2040 (RFI028)**
1	Volumetric flowrate (m^3/h)	129	330
	Velocity (m/s)	0.27	0.70
	Pressure drop (bar)	17.80	31.33
2	Volumetric flowrate (m^3/h)	171	421
	Velocity (m/s)	0.36	0.89
	Pressure drop (bar)	19.74	40.94
3	Volumetric flowrate (m^3/h)	682	1 732
	Velocity (m/s)	1.44	3.65
	Pressure drop (bar)	80.37	415.6

Table 9-13: 18" line feasibility for each scenario with AGO

AGO			
Flow case	**Item**	**Year 2020 (RFI007)**	**Year 2040 (RFI028)**
1	Volumetric flowrate (m^3/h)	129	330
	Velocity (m/s)	0.27	0,70
	Pressure drop (bar)	22.64	46.51
2	Volumetric flowrate (m^3/h)	171	421
	Velocity (m/s)	0.36	0.89
	Pressure drop (bar)	26.23	62.57
3	Volumetric flowrate (m^3/h)	682	1 732
	Velocity (m/s)	1.44	3.65
	Pressure drop (bar)	125.4	609.4

A line size of 18” at schedule 80 would work for all flow cases **except** flow case 3 (2040) for both RFIs as the pressure drop exceeds the MAOP and the velocities are high.

9.4.5 Existing pipelines analysis

There are multiple existing pipelines in the BOST network. Throughout the pipeline route study, details pertaining to the design of each pipeline have come to light, as shown in the figure below:

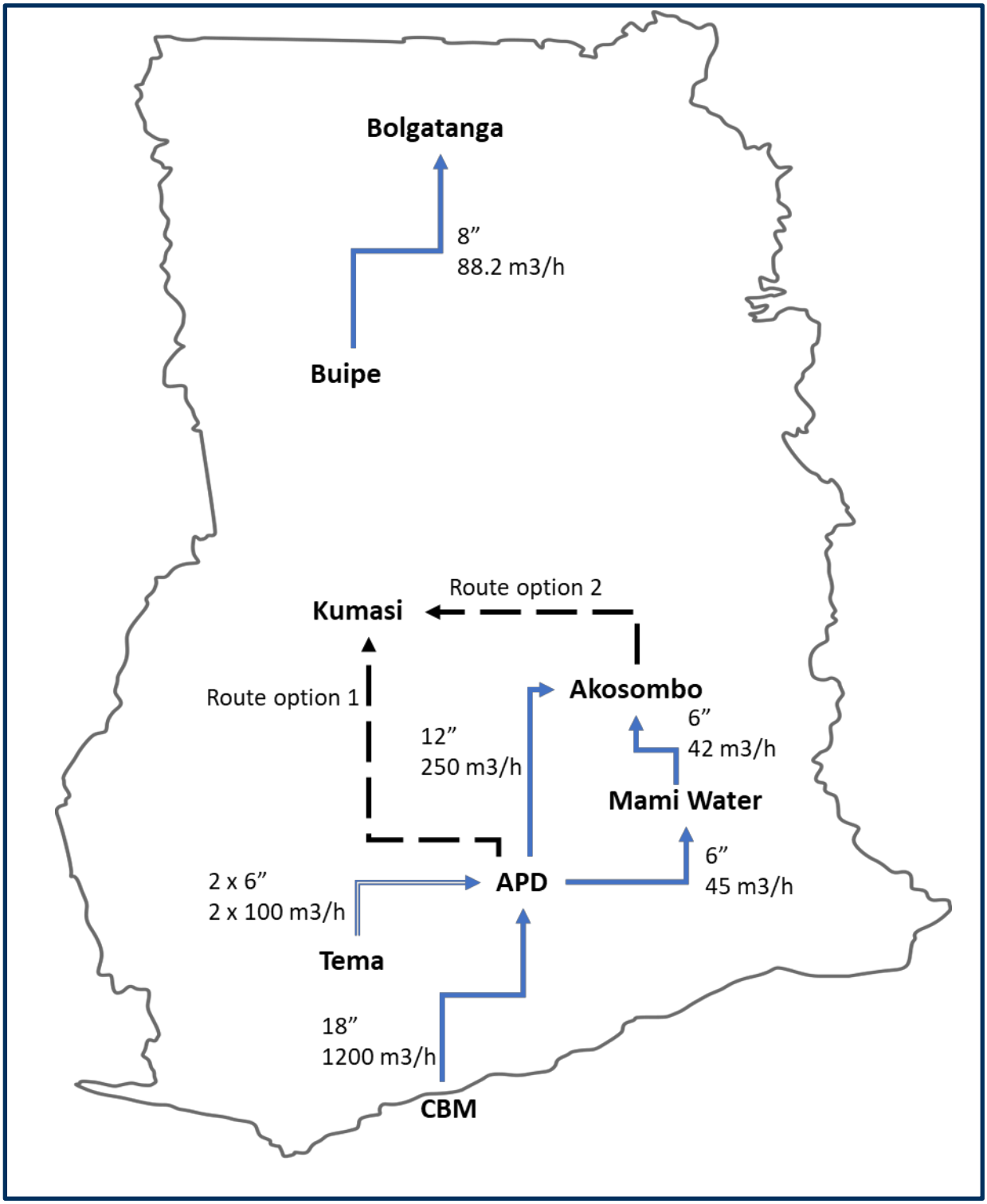


Figure 9-3: Existing pipelines network

An analysis was carried out on each of these lines to determine the volumetric flowrate capacities to assess the feasibility of each accommodating the volumetric rate for the flow cases listed in the table shown with the above figure.

The results are as follows:

Table 9-14: Summary of existing pipelines feasibility with required flowrates

Flow Case	Volumetric flowrate (m3/h)		Line size (in)	Feasibility of route corridor		
	2020	2040	2040	Corridor 1 (APD to Kumasi)	Corridor 2 (Akosombo to Kumasi)	Corridor 3 (Akosombo to Kumasi via Lake Volta)
1 (Kumasi)	129	330	14	✓	X	X
2 (Kumasi + Buipe)	171	421	16	✓	X	X
3 (Kumasi + Buipe + Export)	682	1 732	28	X	X	X

The impact of this analysis on the route selection is summarised in the table below:

Table 9-15: Impact of existing pipelines hydraulic analysis on route selection

Route corridor	Pros	Cons
1 (APD to Kumasi)	• Sufficient pipeline & storage capacity to APD to accommodate export requirements • No notable hydraulic challenges • Will require upgrades to existing pipeline network within next 15 years	
2 (Akosombo to Kumasi)		• Insufficient pipeline capacity from APD to Akosombo for exports • Insufficient storage capacity at Akosombo for exports
3 (Akosombo to Kumasi via Lake Volta)		• Insufficient pipeline capacity from APD to Akosombo for exports • Insufficient storage capacity at Akosombo for exports • Barges insufficient & inefficient

The analysis shows that route corridor 1 is most favourable and preferred when considering the hydraulic analysis.

9.4.6 Optimal flowrate determination and evaluation

In a presentation delivered to BOST on the 22nd of October 2020, it was determined that the total volumetric flowrate for flow case 3 (2040) of 1732 m^3/h need not be transferred through the pipeline exclusively. That is, a maximum flowrate of 1400 m^3/h could be used in the pipeline, while the remaining flowrate (332 m^3/h) could be transported via BRVs.

A line analysis using this flowrate was then carried out, to determine the optimal line size. The results for each route are presented below.

Table 9-16: Optimal line size per route for 1400 m3/h flowrate

	Option 1 (APD to Kumasi)				Option 2 (Akosombo to Kumasi)				Option 3 (Adowso to Kumasi)	
Route	1A	1B	1C	1D	2A	2B	2C	2D	3A	3B
MAOP (bar)	127	127	127	95.5	127	127	127	127	127	127
Pressure drop (bar)	125.6	120.6	120.6	86.4	117.3	114.5	124.3	96.15	84.24	74.08
Velocity (m/s)	1.65	1.65	1.65	1.33	1.65	1.65	1.65	1.65	1.65	1.65
Power required (kW)	6 104	5 857	5 857	4 199	5 696	5 563	6 038	4 671	4 092	3 599
Head required (m)	1 461	1 402	1 402	1 005	1 363	1 332	1 445	1 118	979.5	861.4
Optimal line size (in)	24	24	24	26	24	24	24	24	24	24

Note: The 24” line sizes all have a wall thickness of 30.96 mm (schedule 80), while the 26” line size has a wall thickness of 25.4mm (no specific schedule allocated).

9.5 Storage Capacity Analysis

By utilising the volumetric flowrate from RFI028 flow case 3 (2040), it was calculated that 41 568 m^3 of fuel would be transported via the new pipeline per day.

APD currently has a storage capacity of 197 200 m^3 in twelve operational tanks; six of which store AGO (108 500 m^3) and six of which store PMS (88 700 m^3) (Reference 11). This depot has sufficient capacity to receive and store the fuel required for flow case 3, which makes route option 1 feasible.

The Akosombo depot currently has a storage capacity of 12 000 m^3. AGO capacity is 7 000 m^3 and PMS capacity is 5 000 m^3. In line with the existing pipeline analysis carried out, this terminal has insufficient capacity to store fuel for flow case 3 (2040) and will need to be upgraded if route option 2 is to be considered.

The Kumasi depot currently has a storage capacity of 87 000 m^3 in nine tanks; six of which store AGO (53 000 m^3) and three of which store PMS (34 000 m^3) (Reference 11). The terminal may only be able to store fuel for approximately 2 days before the capacity will be reached. BRVs will likely not be able to operate quickly enough to ensure that the terminal does not reach full capacity before 2 days are over.

Therefore, a new terminal outside of Kumasi would be beneficial in that it can be built in a sparsely populated area and can be designed specifically with larger tanks to provide strategic buffer volume to sustain operations. This new terminal can be built to accommodate the necessary storage tanks, pig receiving facilities, fiscal metering, utility systems, future export pumps systems and would be provided with BRV loading facilities to satisfy all distribution requirements until such time that the pipeline network is expanded further, as shown in the high-level figure below. As noted in **Error! Reference source not found.** a smaller transfer pipeline from this new terminal could be directed to the Kumasi BOST Terminal. It is recognised that there is significant facility already established in Kumasi for tanker operation that can continue to be utilised for local fuel storage and distribution.

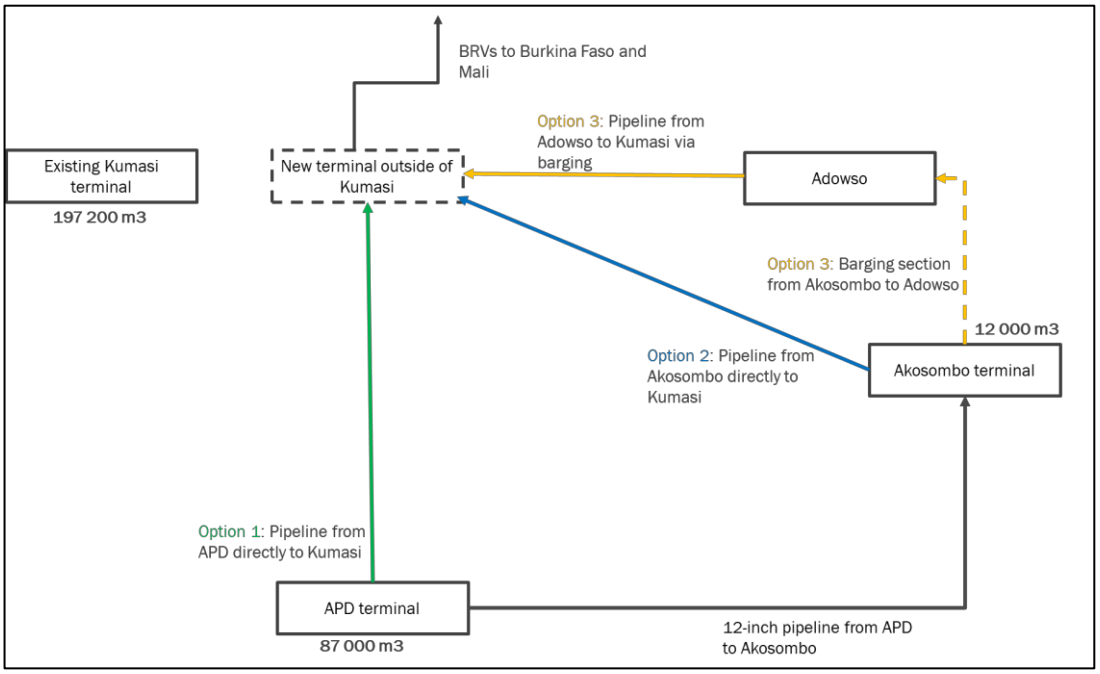


Figure 9-4: High level layout of terminals and pipeline route options

10. WEIGHTED CRITERIA COMPARISON

Each identified route is critically compared with the others in a detailed weighted criteria comparison exercise in order to identify the optimal route option.

10.1 Criteria

10.1.1 Constructability & accessibility

The terrain of the land along each routing was addressed during field reviews. Key challenges were avoided where possible, and this criterion has a low weighting due to the engineering and construction technologies available to traverse challenging terrain.

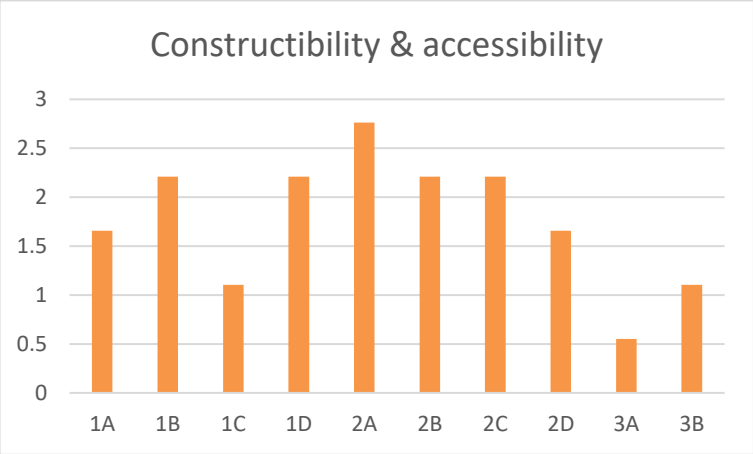


Figure 10-1: Weighted scores per route for criteria "Constructability & Accessibility"

10.1.2 Pipeline capital cost

The project capital expenditure is considered the most critical in deciding between the various route options and is given the highest weighting for this reason. The pipeline capital cost is proportional to the pipeline length and pump requirement.

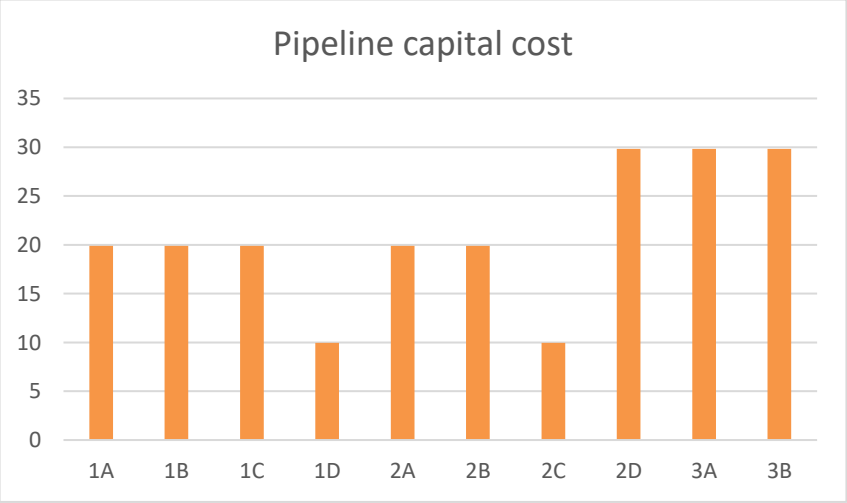


Figure 10-2: Weighted scores per route for criteria "Pipeline Capital Cost"

10.1.3 Long term environmental impact

Interaction of each route with identified nature reserves and mineral (Bauxite, diamond and gold) reserves were considered when comparing the environmental impact of each route.

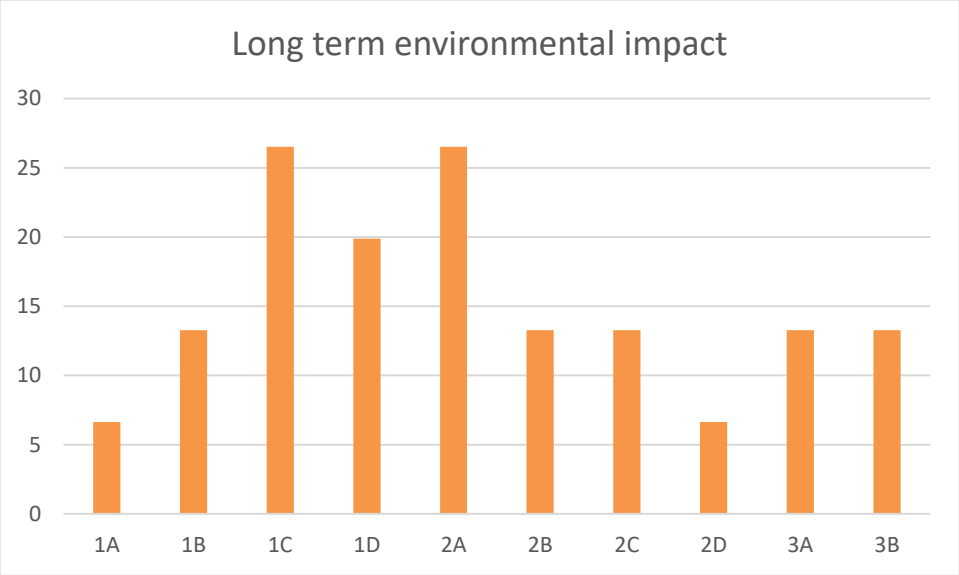


Figure 10-3: Weighted scores per route for criteria "Long Term Environmental Impact"

10.1.4 Proximity to potential branch zones

This criterion is related to the proximity of the proposed pipeline route to Adowso and Bunso, two small towns identified during the project as potential branch points for future pipelines or storage units.

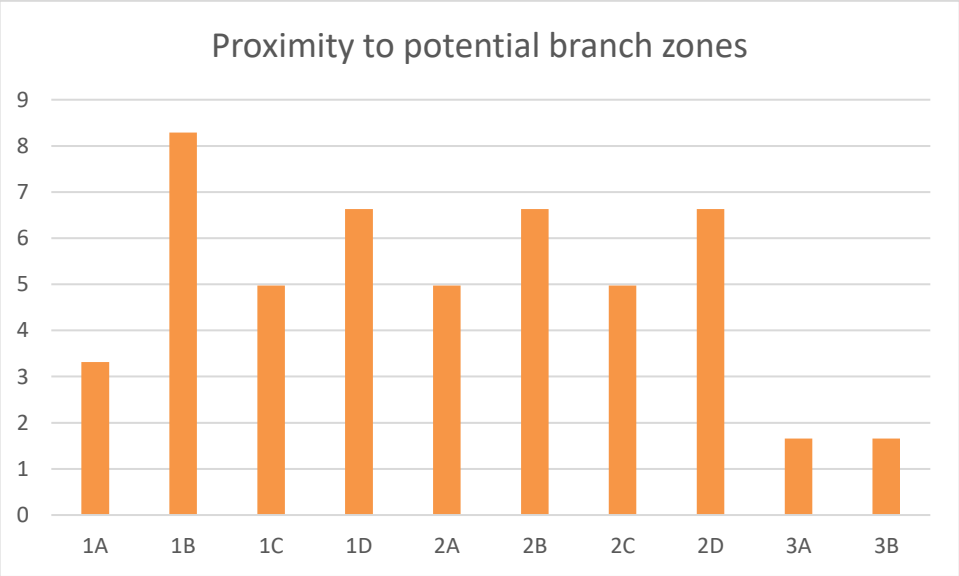


Figure 10-4: Weighted scored per route for criteria "Proximity to Potential Branch Zones"

10.1.5 Population density - societal risk

A significant effort was made during the field and desktop portions of the project to avoid highly densely populated centres in the detailed routing, such that the project impact on the local community is minimised. Under this category, routes that deviate away from dense areas including residential and market places are scored high, while those near to populated centres are scored poorly.

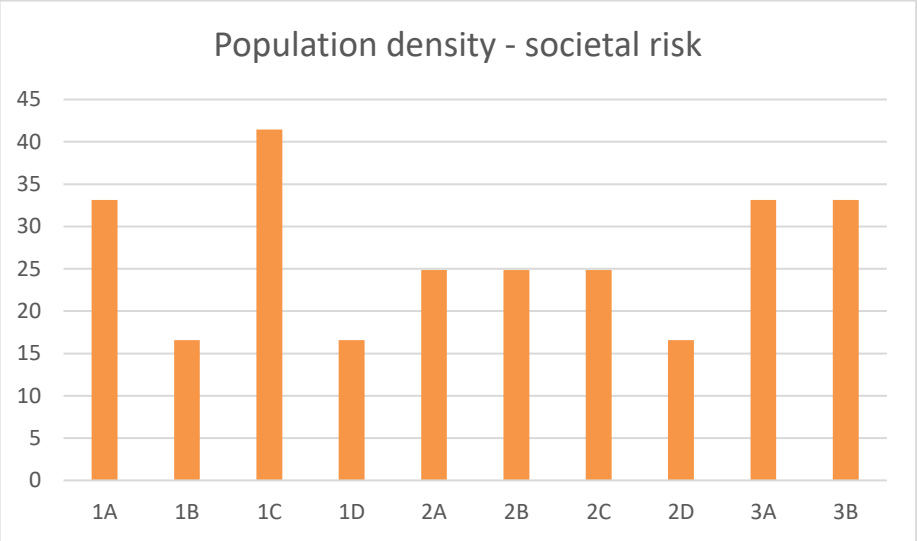


Figure 10-5: Weighted scores per route for criteria "Population Density - Societal Risk"

10.1.6 Access to market & utilities

While interaction with populated areas is seen as a disadvantage and a risk, there are some benefits to routing the pipeline through identified towns at certain intervals in order to allow the project access to food and cooking supplies, water, sanitary requirements, power supplies and other items required for day-to-day operation.

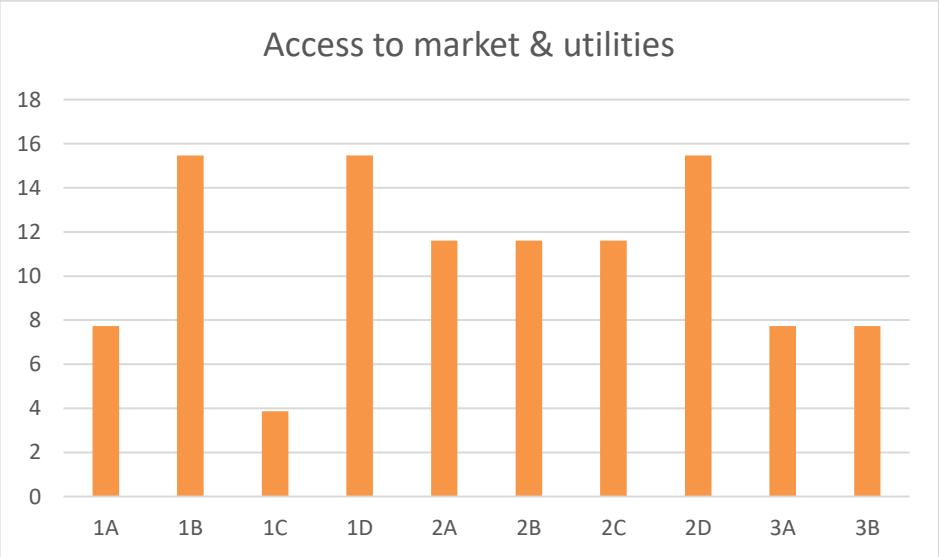


Figure 10-6: Weighted scores per route for criteria "Access to Market & Utilities"

10.1.7 Proximity to existing power supply

In addition to the above, closer proximity to populated areas improves accessibility to existing power supplies required for pumping, metering and pigging stations. These areas may be selected strategically according to the hydraulic profile of the various routes.

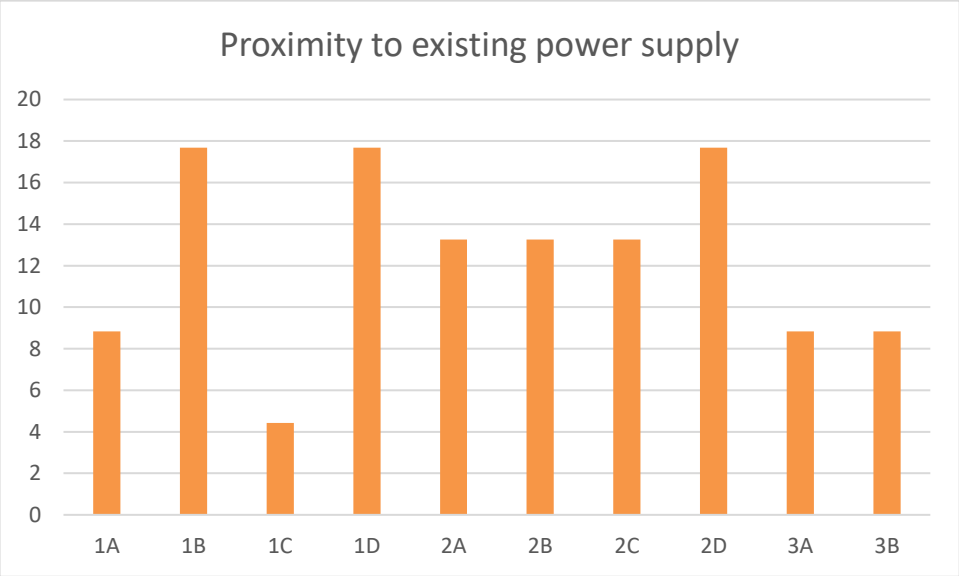


Figure 10-7: Weighted scores per route for criteria "Proximity to Existing Power Supply"

10.1.8 Cathodic protection requirement

The cathodic protection requirement of each route is connected to the number of railway line and power line crossings and has an influence on operability, cost and complexity of construction.

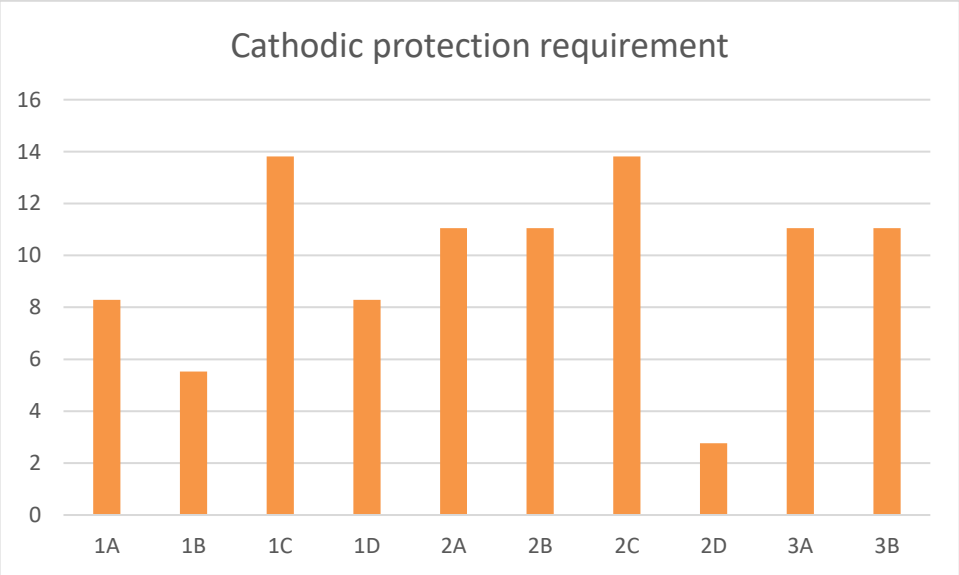


Figure 10-8: Weighted scores per route for criteria "Cathodic Protection Requirement"

10.1.9 Regulatory requirements

The extent to which regulatory approvals, licenses, wayleaves and permits are required is largely unknown at this stage of the project, but would typically be related to the number of different properties (with different owners) through which the pipeline route traverses, as well as the number of different regions and districts traversed. Typically, separate permits or wayleaves for each government department (i.e. roads & stormwater, electrical, etc.) would be required from each district.

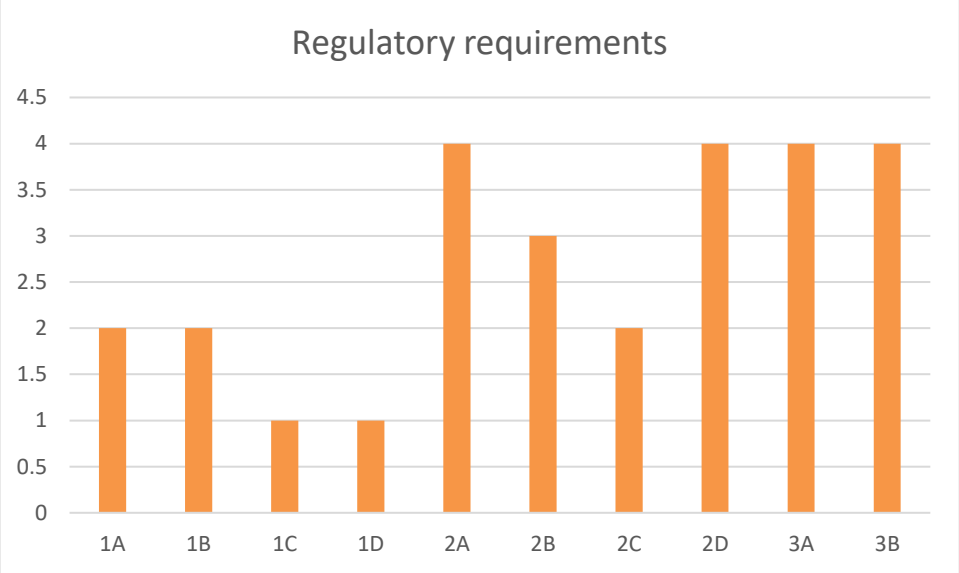


Figure 10-9: Weighted scores per route for criteria "Regulatory Requirements"

10.1.10 Utilisation of existing rights of way

The importance of utilising existing pipeline, railway, electricity and road rights of way has been emphasised throughout the project. There are multiple advantages for constructing pipelines along existing rights of way, including:

- Reduced environmental risk – existing rights of way will have had environmental impact studies carried out on them already
- Reduced societal impact – established rights of way will typically not traverse through homes, schools, churches, markets, etc.
- Increased accessibility – existing rights of way need to be maintained and accessed throughout the year, meaning that there are typically roads or favourable terrain in the vicinity.

In this category, routes utilising rights of way other than the road reserve are given high scores. That is, routes utilising existing railway ROWs (typically no longer in use), power line ROWs and existing pipeline ROWs score higher than those following road reserves for long distances.



Figure 10-10: Weighted scores per route for criteria "Utilisation of Existing ROWs"

10.1.11 **Seismic activity areas interaction**

Earthquake zones are typically investigated during pipeline route analysis exercises. This criterion was scored based on risk as per the image below.

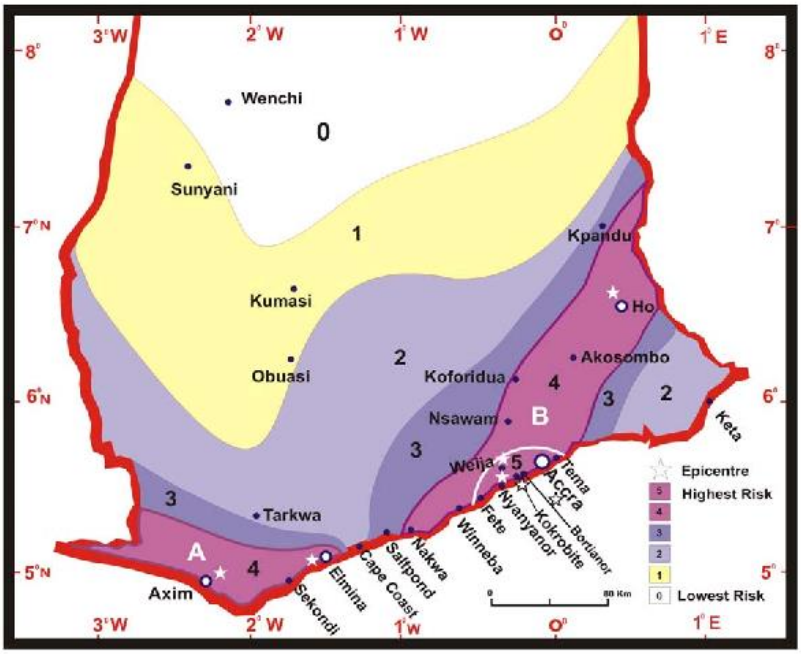


Figure 10-11: Earthquake risk zones

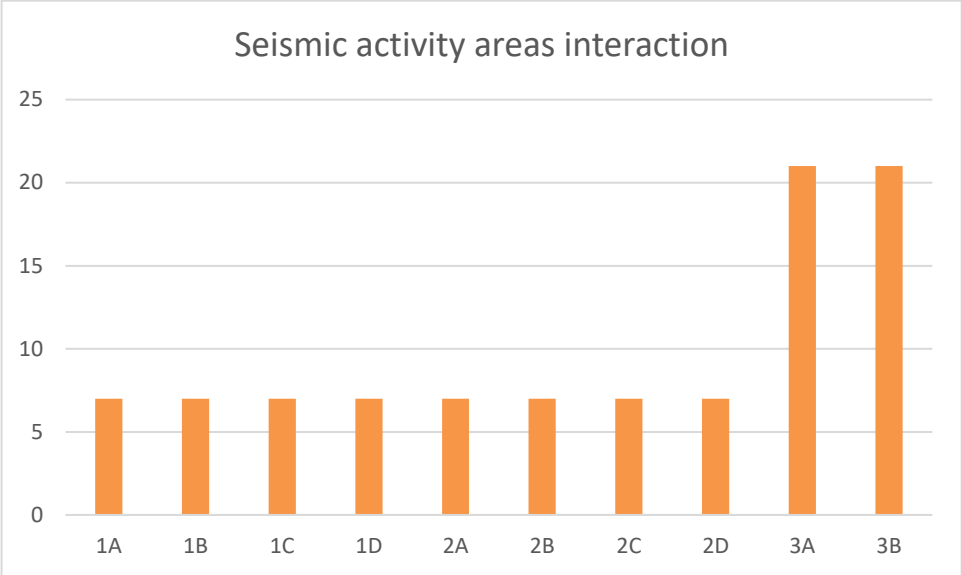


Figure 10-12: Weighted scores per route for criteria "Seismic Activity Areas Interaction"

10.1.12 **Efficiency**

Pipeline efficiency is reduced when there is dependence on barging and bulk road vehicles to achieve the required flows (particularly considering exports).

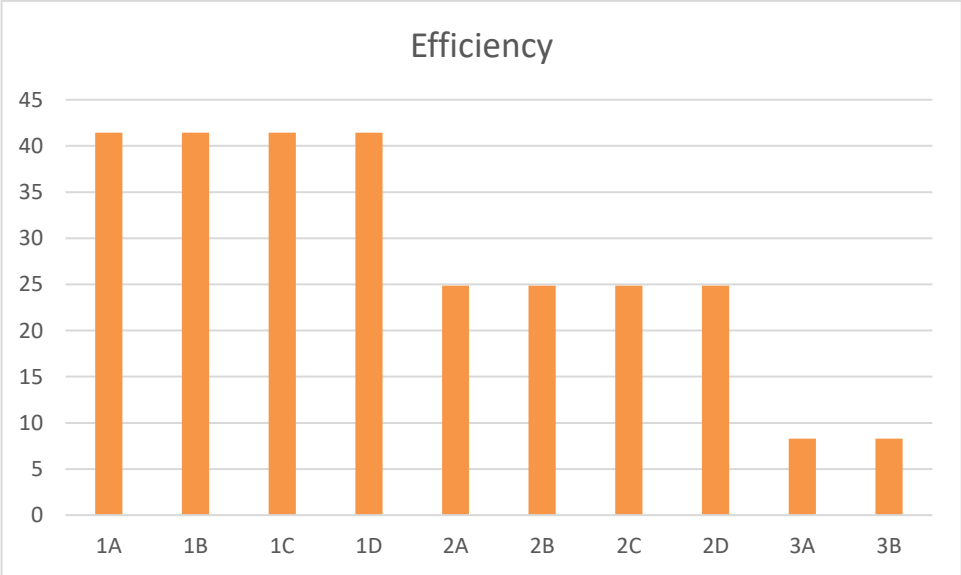


Figure 10-13: Weighted scores per route for criteria "Efficiency"

10.1.13 Ability to support exports

Throughout the pipeline route study project, there has been an emphasis on the long term fuel demands within Ghana and its neighbouring countries. This criterion analyses the ability of the proposed pipeline route (when considering the dependence of each route on existing storage and pipeline infrastructure) to achieve the forecasted capacity requirements. This is considered a critical criterion and is therefore given a high weighting.

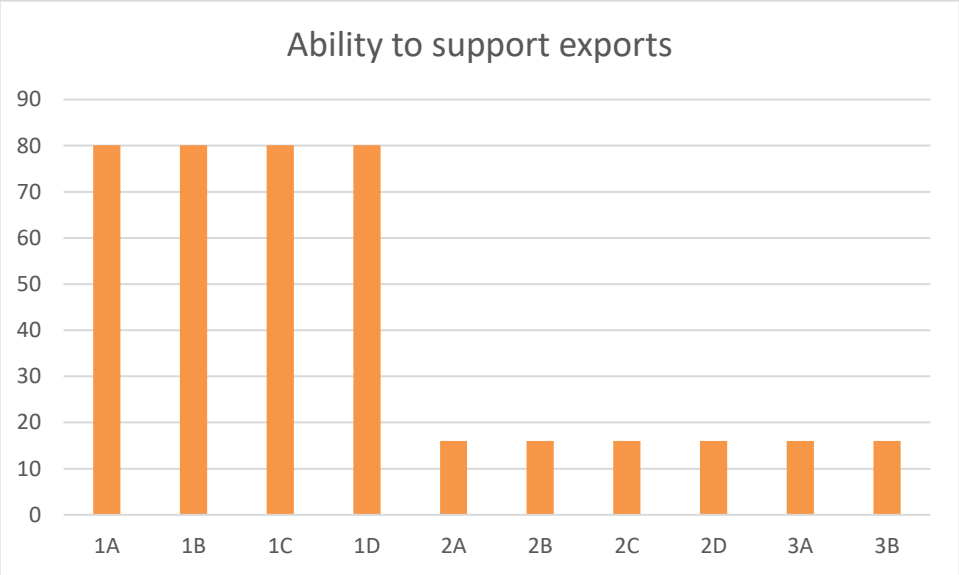


Figure 10-14: Weighted scores per route for criteria "Ability to Support Exports"

10.1.14 Favourability of hydraulic profile

The favourability of the hydraulic profile of each pipeline route is determined by comparing the respective pump kW requirements and overall head requirements or pressure drop over the pipeline length.

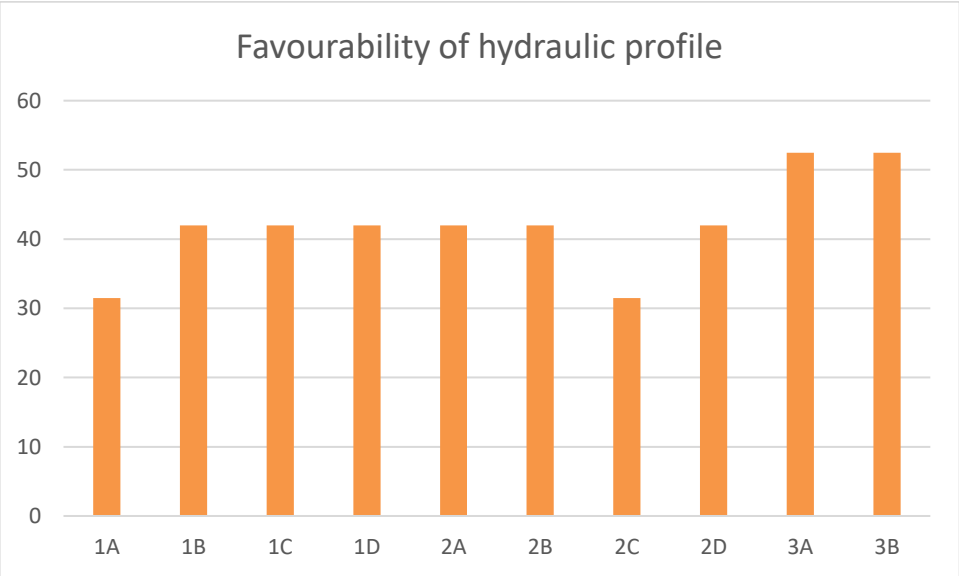


Figure 10-15: Weighted scores per route for criteria "Favourability of Hydraulic Profile"

10.2 Pipeline Comparison

Table 10-1: Comparison of Route Options Parameters

		Option 1				Option 2				Option 3	
		APD to Kumasi Depot on Land				Akosombo Depot to Kumasi Depot on Land				Lake Volta Jettee to Kumasi Depot on Land	
		1A	1B	1C	1D	2A	2B	2C	2D	3A	3B
Constructability	Highest point	489	423	508	424	350	434	424	462	533	518
	Lowest point elevation	17	17	24	19	95	37	35	33	75	75
	Total length	279	266	266	299	278	271	296	224	181	155
	Road crossings	15	18	13	15	9	13	13	11	7	5
	Length within existing road ROW	238	225	253	85	86	258	79	0	72	72
	Length within existing pipeline ROW	28	28	0	28	0	0	25	0	0	0
	Length within existing railway ROW	13	13	13	186	192	13	192	0	109	83
	Length within existing power line ROW	0	0	0	0	0	0	0	224	0	0
Environmental	Diamond field crossing length	65	16	75	30	30	16	30	16	0	0
	Bauxite crossing length	10	0	0	0	0	0	0	0	7	7
	Nature reserve crossing length	2.5	7.2	0	2.5	0	6.5	4.5	11	10	14
Integrity	Qty power line crossings	10	20	11	15	10	20	11	12	10	11
	Distance parallel to power line (within 200m)	20	55	0	20	8	20	0	224	2	8
	Qty railway line crossings	6	13	6	10	9	7	10	11	5	4
	Distance parallel to railway line	13	13	13	270	13	13	270	5	20	20

		Option 1				Option 2				Option 3	
		APD to Kumasi Depot on Land				Akosombo Depot to Kumasi Depot on Land				Lake Volta Jettee to Kumasi Depot on Land	
		1A	1B	1C	1D	2A	2B	2C	2D	3A	3B
Regulatory	Qty regions crossed	3	3	3	3	2	2	2	2	2	2
	Qty districts crossed	18	19	21	20	16	18	19	12	9	9
Hydraulics	Optimal pipeline diameter	24	24	24	26	24	24	24	24	24	24
	Total pump head required (m)	1461	1402	1402	1005	1363	1332	1445	1118	979.5	861.4
	Total pump power required (kW)	6104	5857	5857	4199	5696	5563	6038	4671	4092	3599
	MAOP (bar)	127.09	127.09	127.09	95.51	127.09	127.09	127.09	127.09	127.09	127.09
	dP (bar)	125.6	120.6	120.6	86.42	117.3	114.5	124.3	96.15	84.24	74.08
	Velocity (m/s)	1.65	1.65	1.65	1.33	1.65	1.65	1.65	1.65	1.65	1.65
	Pump efficiency % (Assumed)	80									
	Starting point receiving capacity sufficient?	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO
	Starting point storage capacity sufficient?	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO
	Ending point storage capacity sufficient?	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

As can be seen in the previous table, the existing Kumasi Terminal storage capacity is not optimal to support the export flowrates for which the pipeline is sized. When considering the long term goal to expand the pipeline network further north into Ghana to service Buipe and Bolgatanga as well as export demands in Burkina Faso and Mali, it may be worth considering the value of building a new terminal on the outskirts of Kumasi to provide a base for an export pipeline. A smaller transfer pipeline from this new terminal could be directed to the Kumasi BOST Terminal. It is recognised that there is significant facility already established in Kumasi for tanker operation however the storage capacity may not be sufficient to meet the export strategic storage volume requirements.

The weighted criteria are presented in the following table. Weightings were critically established by weighing up each criterion against one another and then using the total scores per criteria to distribute the weighting out of 100.

10.3 Weighted Criteria Summary

Table 10-2: Weighted Criteria Analysis

		Weighting	Option 1								Option 2								Option 3			
			APD to Kumasi Depot on Land								Akosombo Depot to Kumasi Depot on Land								Lake Volta Jettee to Kumasi Depot on Land			
			1A		1B		1C		1D		2A		2B		2C		2D		3A		3B	
			Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score
CON	Constructibility & accessibility	1	3	2	4	2	2	1	4	2	5	3	4	2	4	2	3	2	1	1	2	1
COST	Pipeline capital cost (length)	10	2	20	2	20	2	20	1	10	2	20	2	20	1	10	3	30	3	30	3	30
ENV	Long term environmental impact	7	1	7	2	13	4	27	3	20	4	27	2	13	2	13	1	7	2	13	2	13
PROX	Proximity to potential branch zones	2	2	3	5	8	3	5	4	7	3	5	4	7	3	5	4	7	1	2	1	2
POP	Population density - societal risk	8	4	33	2	17	5	41	2	17	3	25	3	25	3	25	2	17	4	33	4	33
UTI	Access to market & utilities	4	2	8	4	15	1	4	4	15	3	12	3	12	3	12	4	15	2	8	2	8
POW	Proximity to existing power supply	4	2	9	4	18	1	4	4	18	3	13	3	13	3	13	4	18	2	9	2	9
CP	Cathodic protection requirement	3	3	8	2	6	5	14	3	8	4	11	4	11	5	14	1	3	4	11	4	11
REG	Regulatory requirements	1	2	2	2	2	1	1	1	1	4	4	3	3	2	2	4	4	4	4	4	4
ROW	Utilisation of existing right of way	19	3	58	3	58	3	58	5	97	4	77	1	19	4	77	5	97	3	58	3	58
SEI	Seismic activity areas interaction	7	1	7	1	7	1	7	1	7	1	7	1	7	1	7	1	7	3	21	3	21
EFF	Efficiency	8	5	41	5	41	5	41	5	41	3	25	3	25	3	25	3	25	1	8	1	8
EXP	Ability to support exports	16	5	80	5	80	5	80	5	80	1	16	1	16	1	16	1	16	1	16	1	16
HYD	Favourability of hydraulic profile	10	3	31	4	42	4	42	4	42	4	42	4	42	3	31	4	42	5	52	5	52
		100	**38**	**310**	**45**	**329**	**42**	**346**	**46**	**365**	**44**	**286**	**38**	**215**	**38**	**253**	**40**	**288**	**36**	**266**	**37**	**266**

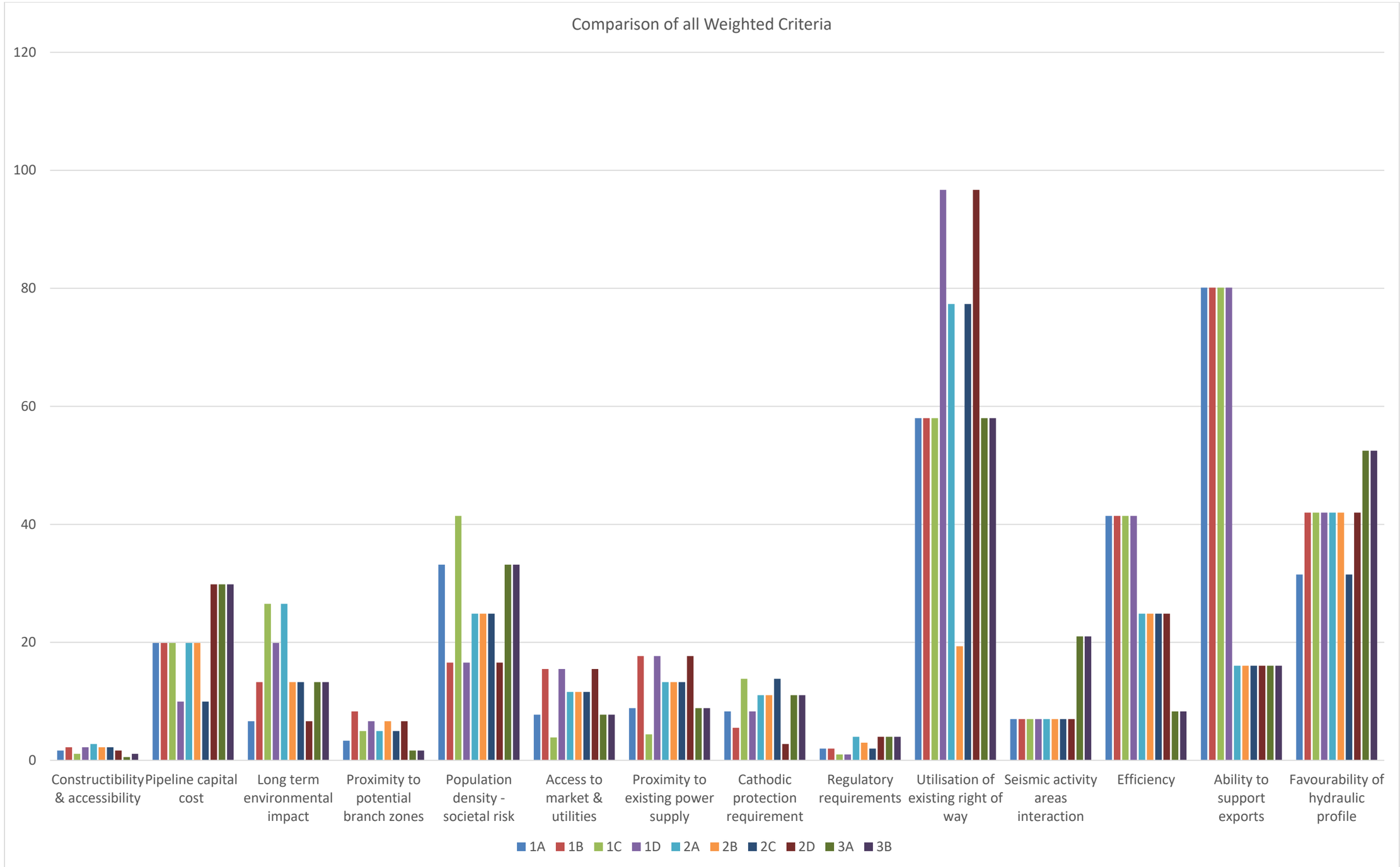


Figure 10-16: Comparison of Weighted Criteria per Pipeline Option

11. RECOMMENDED ROUTE OPTION

The identified optimal route option is Route 1D which exits Accra via the existing pipeline ROW and then follows the Kumasi-Accra railway line ROW until near to Nabewam. From there, the route follows existing roads for a short distance before joining the Kumasi-Takoradi railway line ROW to enter BOST Kumasi Depot.

This route option is identified as the most favourable due to maximised use of existing rights of way, high pipeline efficiency and ability to accommodate exports, as well as it's proximity to existing populated areas which improves accessibility to food, water, sanitation and day-today site requirements, as well as power supplies for required cathodic protection and pumping systems.

Route 1D is the longest pipeline and will require a diameter of 26-inches to achieve the desired flowrate of 1400 m^3/h. This results in Route 1D having the largest capital outlay when compared to the other routes, but this does not outweigh the multiple other advantages of this optimal route.

The detailed pump sizing, cost estimate and project schedule are provided in the sections which follow for Route Option 1D.

12. PUMP SIZING

A key element in identifying an optimum route was an evaluation of pipeline hydraulic and operability considerations. The hydraulic calculations assisted to determine the pressure, volumetric flowrate, and velocity profiles along the pipelines, as well as the pumps and line size requirements on a non-linear basis.

12.1 Simulation model

The simulation model was built based on a flowrate of 1400 m^3/h, as determined in the Line Sizing Optimisation section of this report.

Route options 1A, 1B, 1C and 1D model different routes from APD to Kumasi, while route options 2A, 2B, 2C and 2D model different routes from Akosombo to Kumasi. Route options 3A and 3B model different routes from a jetty location at Adowso to Kumasi.

The objective of the simulation model was to establish a preliminary pumping requirement for each route in terms of how many pumps may be needed along the route and what their power and head requirements would be. This will assist in the selection of the optimum route through establishing if available power/ substations, etc will be able to meet the power requirements of the pumps. More detailed hydraulic simulations will be carried out during the FEED phase.

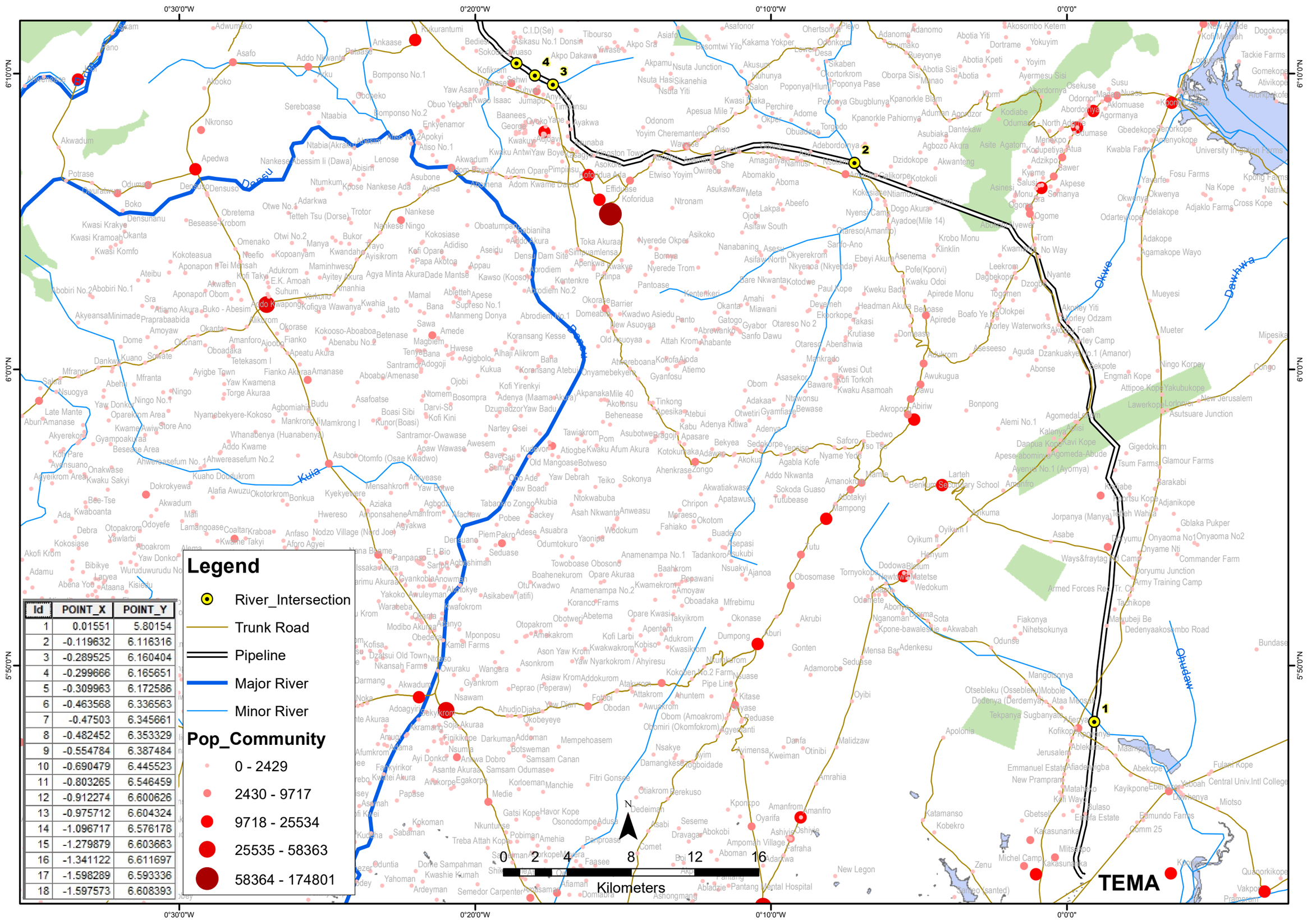
All routes were evaluated at the optimal line size of 24" and wall thickness of 30.69 mm, except route 1D as its optimal line size is 26" and wall thickness is 25.4 mm.

The corrosion allowance used to determine the MAOP, and hence determine the viability of each route option based on its pressure drop was used as 3 mm, as per ASME B31.3, 304.1.1 (a).

Appendix 3: ESIA Reference Map of Proposed Pipeline

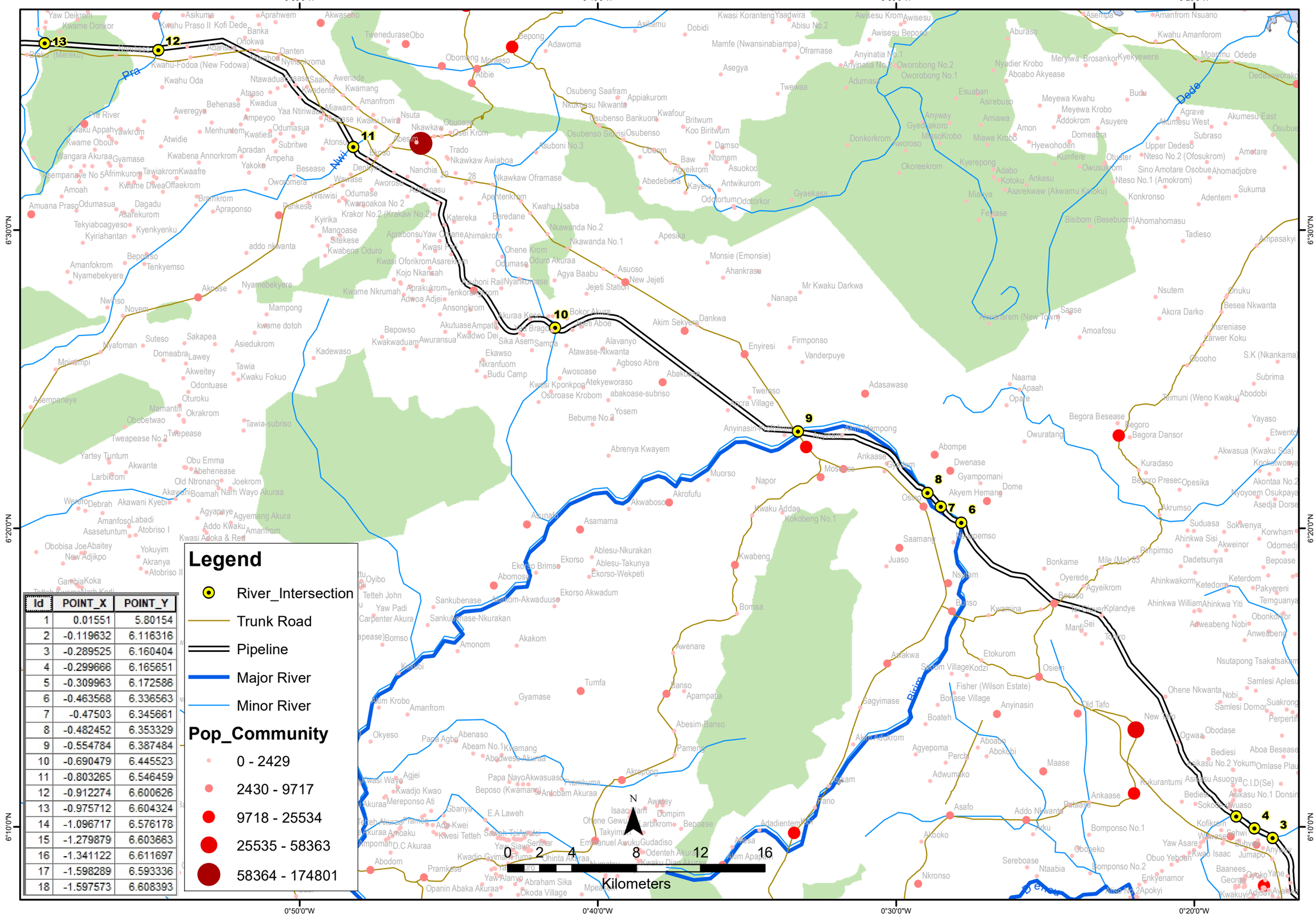

Pipeline Route
18" x 269km Pipeline Route from Accra to Kumasi.
Legend
Depot
Proposed Route - Option 1D
Kumasi Depot
Konongo
Nkawkaw
Adawso
Eastern
New Tafo Akyem
Koforidua
Oda
Dodowa
Adenta Municipality
Twifo Praso
Central
Google Earth
US Dept of State Geographer
Image Landsat / Copernicus
Map Data © 2021 AND
© 2021 Google
60 km
N

100Km



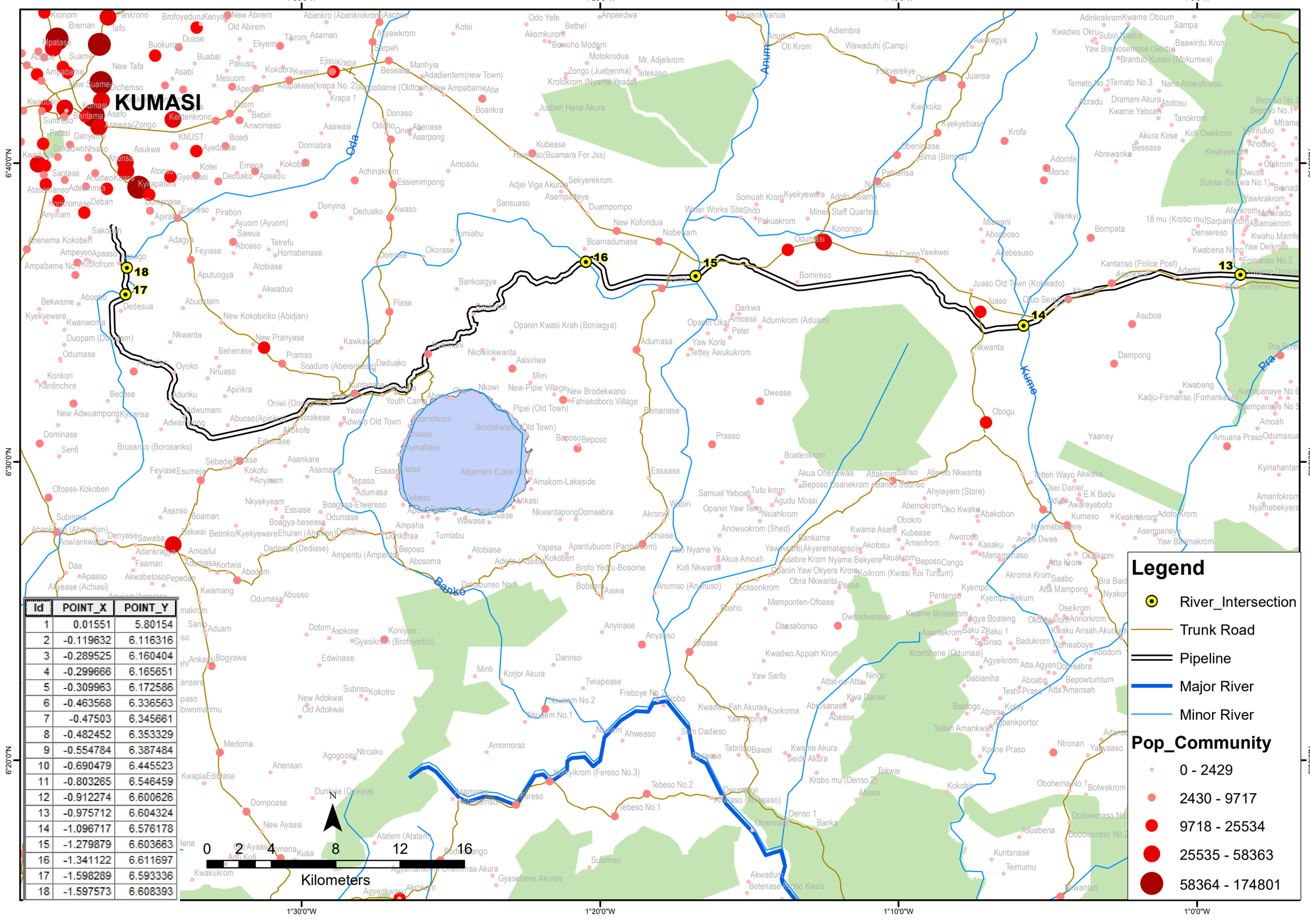
Id	POINT_X	POINT_Y
1	0.01551	5.80154
2	-0.119632	6.116316
3	-0.289525	6.160404
4	-0.299666	6.165651
5	-0.309963	6.172586
6	-0.463568	6.336563
7	-0.47503	6.345661
8	-0.482452	6.353329
9	-0.554784	6.387484
10	-0.690479	6.445523
11	-0.803265	6.546459
12	-0.912274	6.600626
13	-0.975712	6.604324
14	-1.096717	6.576178
15	-1.279879	6.603663
16	-1.341122	6.611697
17	-1.598289	6.593336
18	-1.597573	6.608393

200Km



Id	POINT_X	POINT_Y
1	0.01551	5.80154
2	-0.119632	6.116316
3	-0.289525	6.160404
4	-0.299666	6.165651
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16	-1.341122	6.611697
17	-1.598289	6.593336
18	-1.597573	6.608393

Appendix 4: ESIA Team Profile

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