Appendix G: Impacts Assessments

February 2020

CONTENTS

Appendix G1 Erosion Risk Assessment
Appendix G2 Acoustic Impact Assessment
Appendix G3 Emissions Calculations – Construction

Appendix G1: Soil Erosion Risk Assessment

February 2020

CONTENTS

G1 SOIL EROSION RISK ASSESSMENT 1-1
G1.1 Purpose and Scope of Report 1-1
G1.2 Study Boundary 1-1
G1.3 Methods 1-1
G1.3.1 Secondary Data 1-1
G1.3.2 Field Survey 1-1
G1.3.3 Data Analysis 1-2
G1.3.4 Data Considerations 1-2
G1.4 Soil Erosion Conditions 1-3
G1.4.1 Tilenga Feeder Pipeline 1-3
G1.5 Site-Specific Review – Very High Erosion Risk 1-6
G1.5.1 Tilenga Feeder Pipeline 1-6
G1.6 Summary of Results 1-6
G1.7 Recommendations 1-6
G1.7.1 Mitigation Measures for High to Very High Risk Zones 1-6
G1.7.1.1 Erosion Control Methods 1-6
G1.7.1.2 Timing of Works 1-7
G1.7.2 Drainage 1-7
G1.7.3 Breaking the Slope 1-7
G1.7.4 Stockpiles 1-7
G1.7.5 Stabilising Soils 1-8
G1.7.6 Reinstating Soils 1-8
G1.7.7 Sediment Control 1-8
G1.8 References 1-8

TABLES

Table G1.3-1 Erosion Risk Category Based on Soil Texture and Slope 1-2
Table G1.4-1 Description of Erosion Risk 1-4
Table G1.5-1 Very High Erosion Risk 1-6

ATTACHMENTS

ATTACHMENT G1.1 EROSION RISK MAP 1-10
ATTACHMENT G1.2 GIS SURVEY DATA 1-18
ATTACHMENT G1.3 SOIL SURVEY DATA 1-20

G1 SOIL EROSION RISK ASSESSMENT

G1.1 Purpose and Scope of Report

The purpose of this report is to:

- identify areas along the proposed Tilenga feeder pipeline route that are of high or very high risk of soil erosion
- screen each high and very high risk site against its proximity upslope of receptors sensitive to sediment runoff
- identify the type of extra mitigation measures that may be needed in high and very high risk areas and the general scope of work of any further assessment and site survey that may need to be undertaken.

The precise choice and number of mitigation measures to be applied is not within the scope of this report.

G1.2 Study Boundary

The study boundary will encompass all land within 2 km of the right of way (ROW).

G1.3 Methods

G1.3.1 Secondary Data

A desktop study of available information on climate, soils and slopes along the pipeline route was undertaken.

GIS maps showing the soil types were created using data from Isabirye et al., (2004) and Kaizzi (2017) (see Appendix A5). The soil types were then categorised into textures according to the table in Attachment G1.2. The gradient along the pipeline was derived using 30 m Advanced Spaceborne Thermal Emission and Reflection Radiometer digital elevation model data (ASTER GDEM 2009).

G1.3.2 Field Survey

Soil surveys were undertaken on the Tilenga feeder pipeline corridor in November 2017 as part of the ESIA soil baseline study. Data from the soil survey was used to verify the soil classifications and confirm soil texture descriptions. The soil types were categorised into textures based on the table in Attachment G1.3.

The soil type classifications based on the Tilenga feeder pipeline baseline soil survey did not always correspond with the mapped soil type GIS maps. This was due to the reconnaissance scale of the survey, which was only able to identify the predominant soil type within each mapping unit rather than the specific soil type at any particular location.

G1.3.3 Data Analysis

Soil descriptions were transposed into the following textural classes:

- sandy, light silty soils, peaty
- medium, calcareous
- heavy.

The textural classes were then cross-referenced with the landscape gradients of the area near the pipeline, using ASTER GDEM data (2009), under the following categories:

- very steep >11°
- steep 7–11°
- moderate 3–7°
- gentle 2–3°
- level ground <2°.

Terrain within 2 km of the pipeline corridor was categorised to identify areas at high and very high risk of soil erosion. The categorisation was based on the risk assessment in Table G1.3-1, which was developed using the Department for Environment, Food and Rural Affairs (DEFRA) manual on controlling soil erosion (DEFRA 2005).

Table G1.3-1 Erosion Risk Category Based on Soil Texture and Slope

Soil or Slope	Very Steep Slopes >11°	Steep Slopes 7–11°	Moderate Slopes 3–7°	Gentle Slopes 2–3°	Level Ground <2°
Sandy soils Light silty soils Peat soils	Very high	Very high	High	Moderate	Lower
Medium and calcareous soils	Very high	High	Moderate	Lower	Lower
Heavy soils	Very high	Lower	Lower	Lower	Lower

Very high risk sites were screened against the proximity of upslope VECs sensitive to sediment runoff according to the ESIA sensitivity ranking (see Appendix D of the ESIA).

G1.3.4 Data Considerations

Table G1.3-1 is a guide to assessing the risk of erosion. In a more comprehensive assessment, professional judgement would also be used to assess each site in situ.

Land use and cropping calendars have not been incorporated into the risk assessment. This is because the soil will be exposed within the temporary working areas during the works and the calendars therefore will not be relevant, as crops will not be present.

The scale on the GIS maps enclosed in Attachment G1.1. is sufficient to identify risk of erosion for this preliminary risk assessment. However, an assessment of erosion risk derived from the table and maps alone should be dismissed if visible signs of erosion are already present or appear during the preliminary phases of pipeline construction.

Due to the variability of terrain and soil types across the corridor, further detailed assessment should be undertaken on site, and professional judgement should be exercised to confirm or revise a site's erosion risk. Such judgements should take into account additional factors such as:

- microtopography and valley features, which may concentrate surface runoff
- long unbroken slopes
- uncommon landscape features
- organic matter and soil structure
- vegetation cover
- distance to sensitive VECs.

G1.4 Soil Erosion Conditions

Much of the land in East Africa is already badly degraded, with numerous soil erosion research projects undertaken in the area over many decades. The Montpellier Panel (2014) states that in Africa, the impacts of land degradation are substantial where 65% of arable land, 30% of grazing land and 20% of forests are already damaged.

G1.4.1 Tilenga Feeder Pipeline

The Tilenga feeder pipeline erosion risk map is in Attachment G1.1.

The Tilenga feeder pipeline corridor is adjacent to Lake Albert. The landscape is dominated by gentle slopes and light to medium textured soils with low to moderate erosion risk. However, there are several areas with high to very high erosion risk.

Table G1.4-1 Description of Erosion Risk

KP	Erosion Risk	Description	Sensitive VECs		
			KP	**Description**	**Distance Downslope of Pipeline (km)**
KP0–KP20	Low	Medium-textured soils on near-level ground.	0	Village of Kasinyi	<1
			5–10	Village of Kibambura	<1
			5–10	Sambiye River crossing	<1
			5–10	Two road crossings	<1
			10–15	Road crossing	<1
KP20–KP45	Low	Sandy soils on near-level ground.	20–25	Waiga River and associated wetlands	<1
			25–30	Waisoke River	<1
			25–40	Local road	<1
			25–45	Lake Albert	1–2
			30–35	Village of Serule B	<1
			35–40	Sonso River, a number of local rivers, and associated wetlands	<1
KP45–KP50	Low–very high	Low erosion risk along the pipeline itself but high to very high on the steeper land in Bugahya County.	40–45	Local road	<1
			45	Village of Booma	1–2
			45–50	Waki River, and associated wetlands	<1
			50–55	River, and associated wetlands	<1
			50–55	Lake Albert	1–2

Table G1.4-1 Description of Erosion Risk

KP	Erosion Risk	Description	Sensitive VECs		
			KP	**Description**	**Distance Downslope of Pipeline (km)**
KP55	Very high	There is a steep ridge cutting across the pipeline corridor at KP55.	55	River	<1
KP55–KP90	Moderate–very high	Past the ridge, this area is predominantly moderate risk, with many rivers cutting across the area of investigation and a few steep hills.	55–90	Numerous rivers, and associated wetlands	<1
			West of 75	Village of Katugo	<1
			75–85	A local road and a main road	<1
			South west of 85	Village of Rwamutonga and a local road	<1
			85–90	Two tributaries of the Wambabya River, and associated wetlands	<1
KP90–KP95	Moderate–very high	Predominantly moderate risk, with a few very high risk zones adjacent to or crossing the pipeline.	N/A	N/A	N/A

NOTE: N/A = not detected

G1.5 Site-Specific Review – Very High Erosion Risk

Using GIS mapping, areas where the pipeline traverses sections of very high erosion risk have been identified and described in more detail. From a review of the low-resolution aerial imagery of the corridor, areas where erosion appeared to be occurring already have also been noted.

G1.5.1 Tilenga Feeder Pipeline

Table G1.5-1 Very High Erosion Risk

Starting KP	Ending KP	Soil Classification	Signs of Existing Erosion
54.25	55.5	Acric Ferralsol	Yes
91.5	91.5	Acric Ferralsol	No

G1.6 Summary of Results

The risk of soil erosion within the study area is highly variable, reflecting the change in soil and slopes. There is a large number of high to very high risk areas along the corridor.

The Tilenga feeder pipeline corridor is adjacent to Lake Albert where the terrain is gentle to very low and soils slightly heavier. There are a few ridges, however, which increase the risk of erosion due to increased slope. The most notable area of very high erosion risk is an escarpment around KP55. Here the land has slopes greater than 15 degrees directly along the route.

G1.7 Recommendations

G1.7.1 Mitigation Measures for High to Very High Risk Zones

Locations identified as high to very high erosion risk will be further assessed and mitigation measures implemented to reduce impacts.

The suite of mitigation measures that can applied to control erosion is described in Sections 2 and 8.5 of the ESIA. The precise choice and number of mitigation measures to be applied in these high-risk areas will be determined on the basis of the risk assessments.

G1.7.1.1Erosion Control Methods

Soil erosion on susceptible soils can be reduced by lowering the erosive risk of rainfall, and ensuring soils remain permeable thereby reducing surface flow. This can be achieved by:

- protecting the soil from impact, usually with vegetation cover
- avoiding smooth flat soil surfaces, so that water cannot infiltrate
- avoiding compaction, tramlines, wheelings or any features that could concentrate water flow

- ensuring the soil remains stable.

G1.7.1.2 Timing of Works

- Any disturbance of the soil surface during the rainy season or high rainfall events should be avoided.
- Plan operations to minimise the total area of vulnerable soils worked at any one time or left exposed. Planning should include soil-stripping proposals and haul-route mitigation measures.
- Avoid working during heavy rainfall periods, and protect any disturbed site soils if heavy rain is predicted.

G1.7.2 Drainage

- Any runoff from buildings, concreted areas, roads and tracks should be effectively channelled into ditches and drains so no excess water flows over the soil surface.
- Construct shallow channels with catch pits to intercept any runoff and encourage settlement of soil particles.
- Install drains to intercept existing land drains or springs (where present) or to intercept surface water when an open channel would be unstable.
- Protect excavated areas by intercepting and diverting surface water on the upslope side of the site.
- Prevent any drainage water with a high suspended sediment loading from leaving the site.
- Onsite channels should be kept clean of blockages to allow the controlled flow of runoff.
- Install remedial drains to replace damaged original land drains and to aid soil recovery.

G1.7.3 Breaking the Slope

- Break up long slopes with benching or a ditch along the contour to reduce the chances of surface flow causing rills and gullies.

G1.7.4 Stockpiles

- Minimise soil damage by stripping topsoil and subsoils carefully and keep different soil types separated in distinct stockpiles.
- Ensure stockpiles of the stripped soils are treated carefully. They should be designed to allow water to run off the sides, not become too wet, and not made too large.
- Sow stockpiles with native grass or wildflowers to protect them from any erosion. Steep banks, waterlogged areas, or compacted soils, where grass cover is unlikely to take, may need artificial covers. Consider hydroseeding.
- Ensure stockpiles are located away from drains and watercourses.
- Bund the stockpiles to keep runoff away from them.
- Keep soil storage periods as short as possible.

G1.7.5 Stabilising Soils

- Geotextiles or matting can be used in places where vegetation has been removed to provide temporary protection before new vegetation is established.

G1.7.6 Reinstating Soils

- Reinstate differing soils in the pipeline trench on a first-out-last-back basis to re-establish the original soil profile.
- Construct trench breakers where there is a risk of water migrating down the pipeline trench.
- Reinstate soils under dry conditions and control machinery movement so there is no unnecessary trafficking of the topsoil or subsoil.
- Try to restore the site at an appropriate time, to aid fast re-establishment of ground cover.
- Aim to place soils loosely to allow them to settle naturally.
- Remove compaction from the soils during reinstatement, eliminate ruts and wheelings and re-establish drainage where necessary.
- Ensure the subsoil surface is rough before the topsoil is placed. Do not compact any layers of the soil profile.

G1.7.7 Sediment Control

Erosion control is much more effective than treating sediment-laden runoff in preventing water pollution. However, it is likely that sediment control measures will be required in most areas but more intensively in areas of high to very high erosion risk.

Several methods are available to help slow down runoff and settle out sediment, including:

- check dams and sediment traps
- silt fences
- straw bales or similar natural material
- settlement tanks
- settlement pond.

More information on methods of controlling sediment can be found in CIRIA C648 (2006).

G1.8 References

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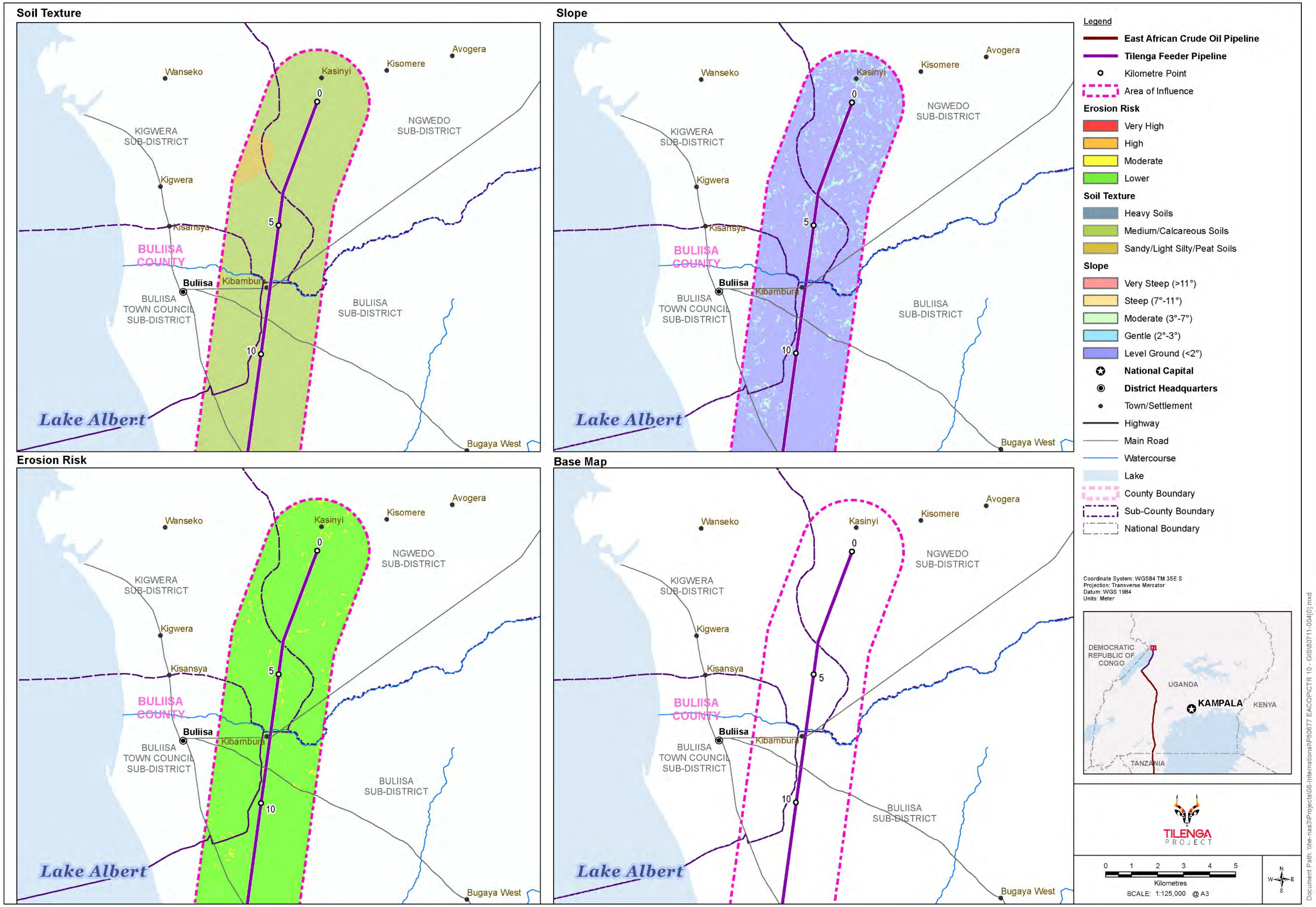
ATTACHMENT G1.1 EROSION RISK MAP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BULIISA SUB-DISTRICT
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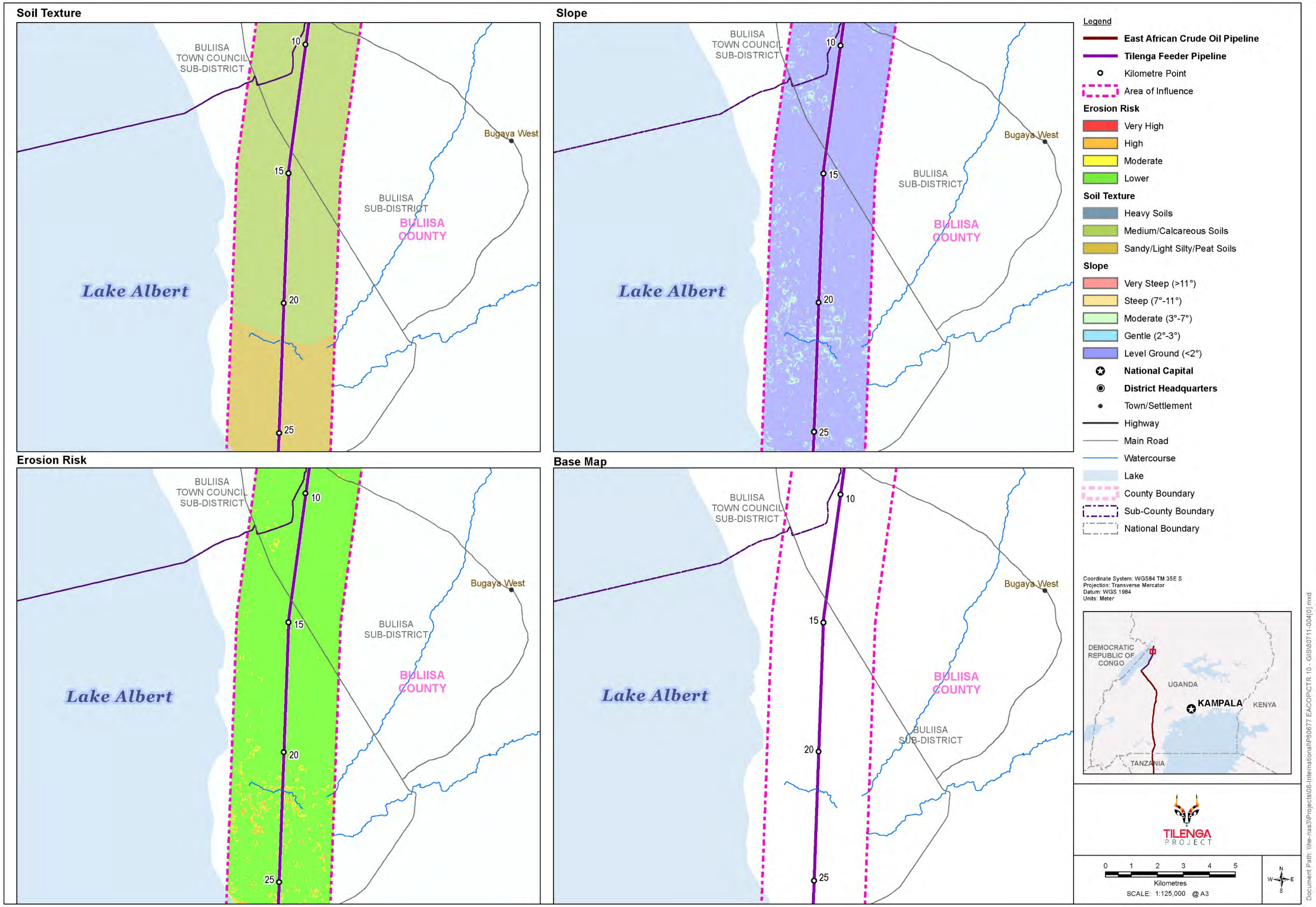
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Tilenga Feeder Pipeline
Kilometre Point
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Erosion Risk
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Moderate
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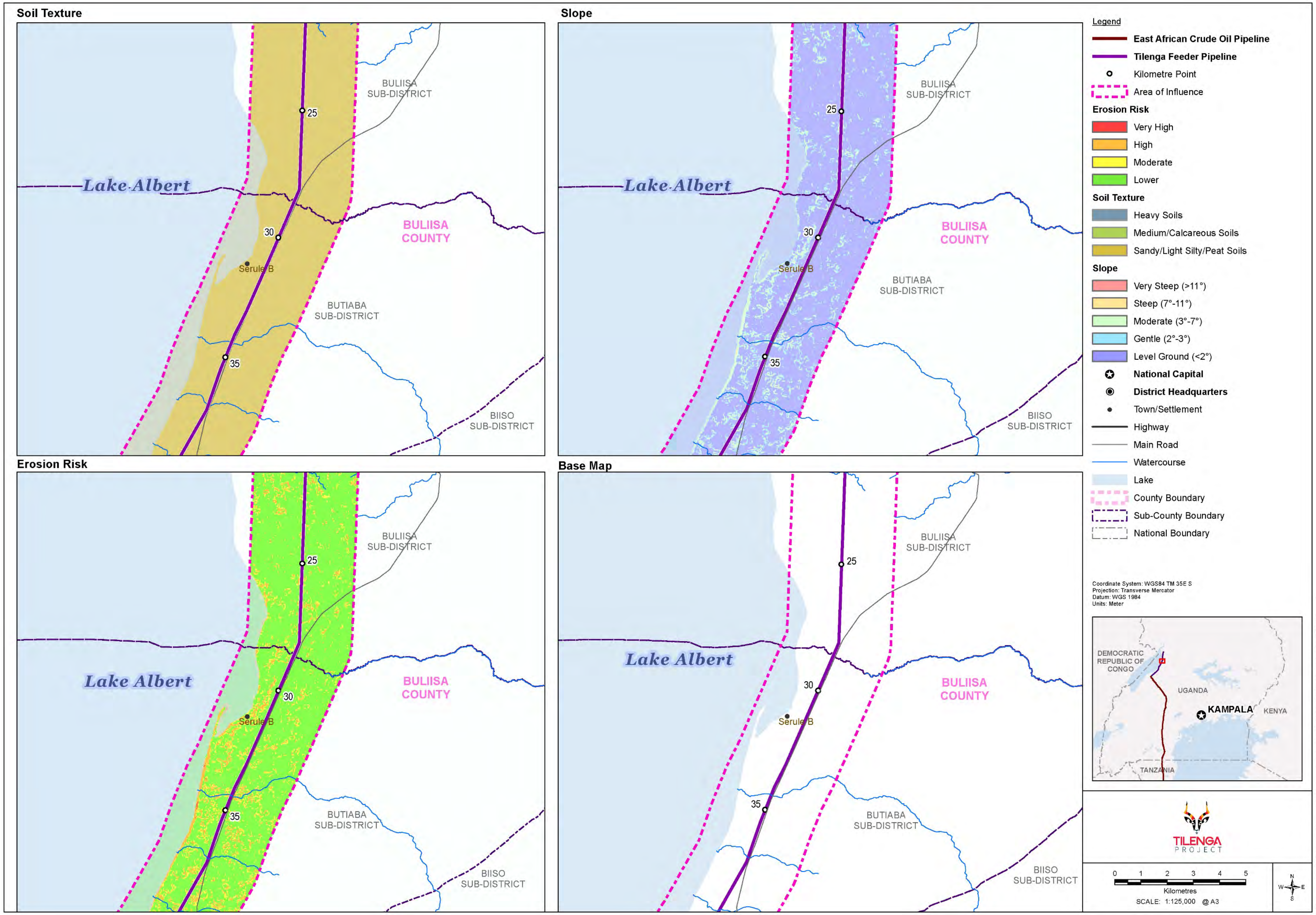

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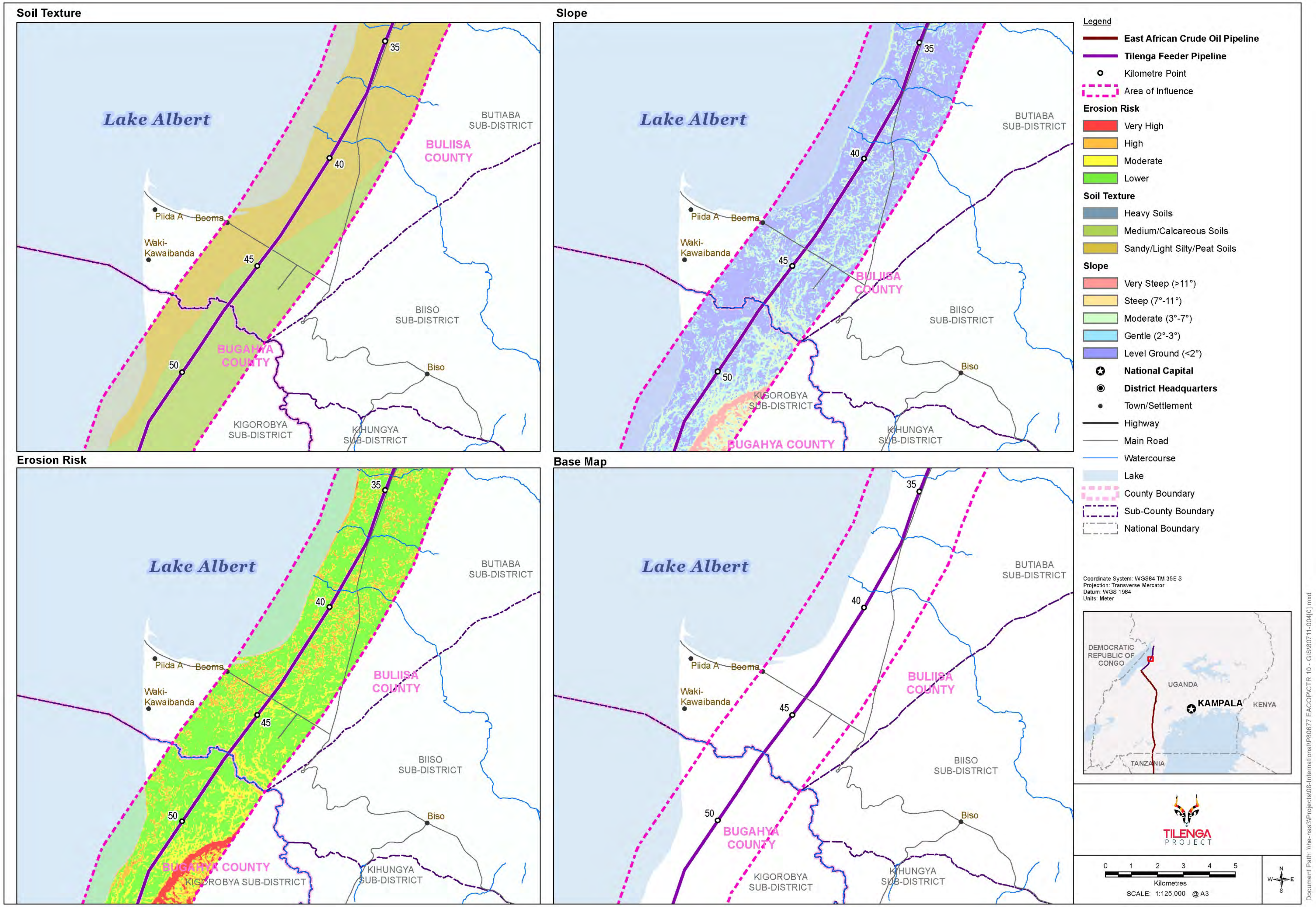
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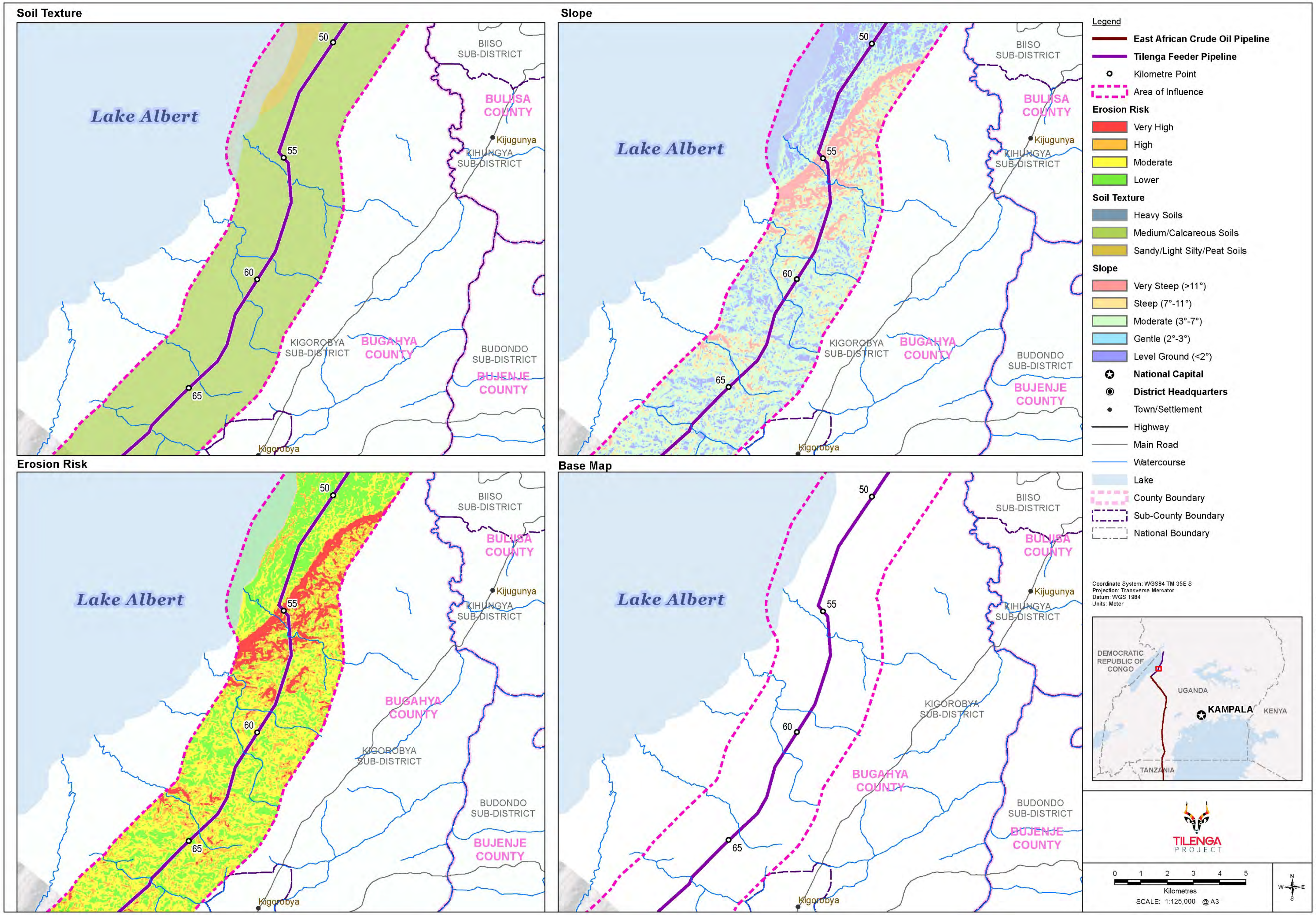
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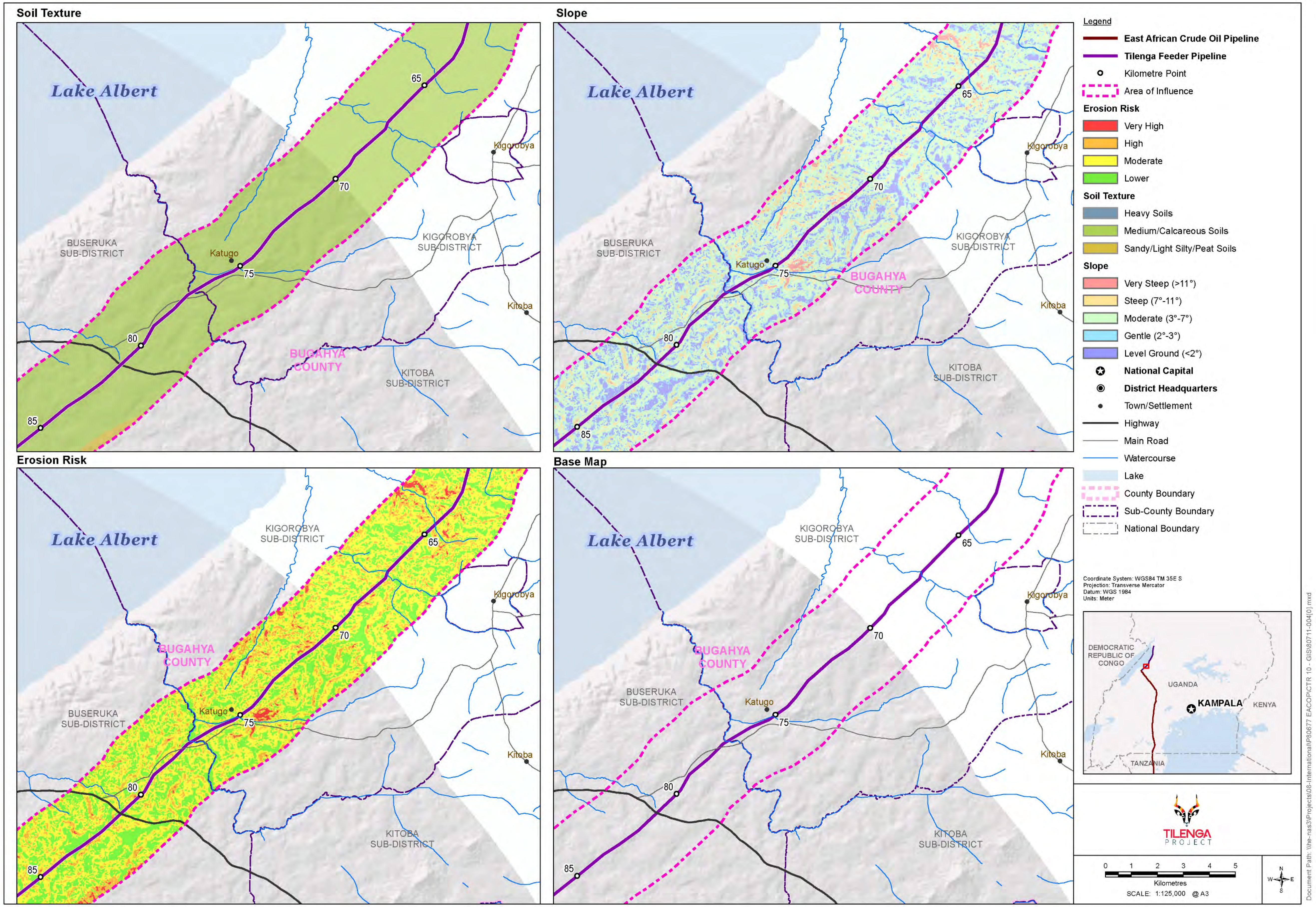
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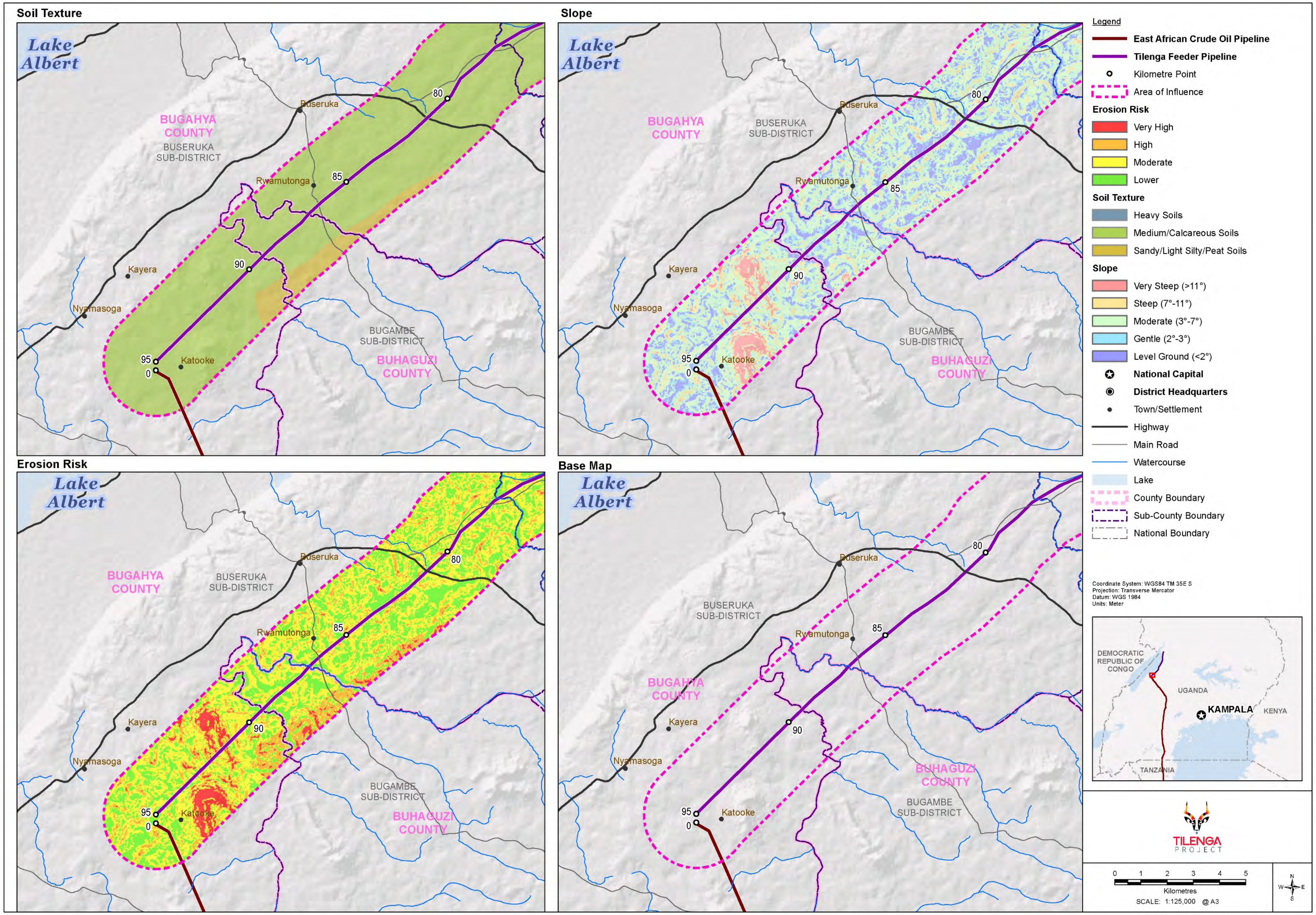
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ATTACHMENT G1.2 GIS SURVEY DATA

Table AttG1.2-1 GIS Soil Layers with Texture

Predominant Soil Types along Pipeline (FAO)	Description of Soil Type	Texture
Acric Ferralsol	Good physical properties, poor fertility, less susceptible to erosion than most other intensely weathered tropical soils. Dominated by low-activity iron-rich clays	Medium
Arenosol	Deep sandy soil, sometimes calcareous, low water and nutrient storage capacity	Sandy
Calcisol	Calcareous, mostly alluvial, colluvial and aeolian deposits, occasionally salt affected	Calcareous
Dystric Regosol	Weakly developed, fine grained, extensive on eroded land	Sandy
Gleyic Arenosol	Deep sandy soil, sometimes calcareous, low water and nutrient storage capacity. Wet	Sandy
Gleysol	Saturated, heavy clay or silt. Ecologically valuable	Heavy
Histosol	Organic peaty, swamp forest soil, fragile, nutrient rich	Organic
Leptosol	Coarse and thin, probably gravely, maybe thin layer of peat. Common on slopes. Can be fertile but prone to erosion.	Sandy
Lixic Ferralsol	Good physical properties, poor fertility, less susceptible to erosion than most other intensely weathered tropical soil types. Dominated by low-activity iron-rich clay.	Medium
Luvisol	Higher clay content in subsoil than topsoil. Podzolic. Common on flat or gently sloping land. Fertile, high silt content and prone to erosion on slopes.	Medium

Table AttG1.2-1 GIS Soil Layers with Texture

Predominant Soil Types along Pipeline (FAO)	Description of Soil Type	Texture
Nitisol	Deep, well-drained, red tropical soil with at least 30% clay and moderate to strong angular blocky structure. Rich in iron. Very productive land	Medium
Petric Plinthosol (Acric)	Iron rich, humus poor, kaolinitic clay, strongly cemented	Heavy
Planosol	Periodically waterlogged, coarse topsoil over dense slowly permeable clay subsoil. Medium fertility	Medium

ATTACHMENT G1.3 SOIL SURVEY DATA

Table AttG1.3-1 Summary of All Soil Survey Data

Corridor	Sampling Point (KP)	Published Soil Type (Description and FAO Classification)	Field Description and Classification	Brief Description of Soil Type and Probable Classes According to WRB (FAO 2014)	Classification of Soil for Risk
Tilenga feeder pipeline	0 (CPF)	Reddish-brown sandy loam with occasional ironstone. Lixic Ferralsol	Dark greyish brown sandy horizon over brown sandy horizon. Arenosol	Dark greyish brown (10YR 4/2) sandy horizon from 0 to 20 cm over brown (7.5YR 4/4) sandy horizon between 20 and beyond 100 cm depth. The soil structure was single grains in both horizons. The major soil diagnostic property is arenic typical of Arenosol.	SANDY
Tilenga feeder pipeline	20	Black clay and sand. Calcisol	Very dark grey loamy sand with sub-angular structure over brown sandy clay horizon.	Very dark grey (7.5YR 3/1) loamy sand with sub-angular blocky structure over brown (7.5YR 4/2) heavily compacted sandy clay horizon with lumbs between 30 and more than 60 cm depth.	SANDY
Tilenga feeder pipeline	40	Reddish-brown sandy loam with occasional ironstone. Lixic Ferralsol	Dark brown loamy sand horizon sitting on brown sandy loam horizon. Ferralsol	Dark brown (7.5YR 3/2) from 0 to 20 cm loamy sand horizon sitting on brown (7.5YR 4/4) sandy loam horizon. The structure in all the horizons was sub-angular blocky. More close to Ferralsol	SANDY

Table AttG1.3-1 Summary of All Soil Survey Data

Corridor	Sampling Point (KP)	Published Soil Type (Description and FAO Classification)	Field Description and Classification	Brief Description of Soil Type and Probable Classes According to WRB (FAO 2014)	Classification of Soil for Risk
Tilenga feeder pipeline	60	Shallow dark brown or black sandy loam often very stony. Acric Ferralsol	Very dark grey sandy clay loam over yellowish red sandy clay horizon.	Very dark grey (7.5YR 3/1) sandy clay loam from 0 to 30 cm over yellowish red (5YR 4/6) sandy clay horizon between 30 to over 70 cm depth. All the horizons had sub-angular blocky structure. Some cracks showed that there was some 2:1 clay. We expect some vertic properties due to presence of cracks on the soil surface but the cracks were not very pronounced as in typical Vertisol. Confirmation shall be made after release of laboratory analysis of the soil samples.	HEAVY
Tilenga feeder pipeline	80	Shallow dark brown or black sandy loam often very stony. Acric Ferralsol	Black sandy clay loam horizon sitting over dark brown sandy clay loam horizon. Cambisol	Black (7.5YR 2.5/1) sandy clay loam horizon from 0 to 30 cm sitting over dark brown (7.5YR 3/2) sandy clay loam horizon from 30 and beyond 80 cm depth with sub-angular blocky structure. The soil is within the transition stage. It is within the deposition position because of the materials brought from the upper slope	MEDIUM

Table AttG1.3-1 Summary of All Soil Survey Data

Corridor	Sampling Point (KP)	Published Soil Type (Description and FAO Classification)	Field Description and Classification	Brief Description of Soil Type and Probable Classes According to WRB (FAO 2014)	Classification of Soil for Risk
Tilenga feeder pipeline	0 (PS1)	Reddish and reddish brown gritty clay loam. Acric Ferralsol	All the three horizons had dark reddish brown soil with distinct indurations in the lower two horizons. Petric Plinthosol	All the three horizons had dark reddish brown (5YR 2.5/2) soil with distinct indurations in the lower two horizons (plinthic material). Granular structure in the A and B2 horizon and sub-angular blocky structure in the B1 horizon. Soil displays typical characteristic of Petric Plinthosol.	HEAVY

Appendix G2: Acoustic Impact Assessment

February 2020

CONTENTS

G2 ACOUSTIC IMPACT ASSESSMENT 2-1
G2.1 Introduction 2-1
G2.2 Assessment Methodology 2-1
G2.2.1 Overview 2-1
G2.2.2 Assessment Criteria 2-2
G2.2.2.1 Noise 2-2
G2.2.2.2 Vibration 2-4
G2.2.3 Area of Influence and Receptor Identification 2-4
G2.2.3.1 Area of Influence Boundary 2-4
G2.2.3.2 Study Area Boundary 2-4
G2.2.3.3 Receptors 2-4
G2.2.4 Baseline Noise Environment 2-5
G2.2.5 Baseline Vibration Environment 2-5
G2.2.6 Noise Source Considerations 2-6
G2.2.6.1 Construction 2-6
G2.2.6.2 Commissioning 2-7
G2.2.6.3 Operation 2-7
G2.2.6.4 Decommissioning 2-7
G2.2.6.5 Traffic 2-7
G2.2.6.6 Source Data 2-9
G2.2.6.7 General Exclusions and Assumptions 2-11
G2.2.7 Vibration Source Considerations 2-12
G2.2.7.1 Construction 2-12
G2.2.7.2 Commissioning 2-12
G2.2.7.3 Operation 2-12
G2.2.7.4 Decommissioning 2-13
G2.2.7.5 Traffic 2-13
G2.2.7.6 Source Data 2-13
G2.2.8 Modelling and Calculation Methodology 2-14
G2.3 Noise Impact Assessment 2-15
G2.3.1 Construction 2-16
G2.3.1.1 Pipeline 2-16
G2.3.1.2 Main Camps and Pipe Yards 2-18
G2.3.1.3 Decommissioning 2-19
G2.3.1.4 Traffic 2-19
G2.3.2 Commissioning 2-22
G2.3.3 Operation 2-22
G2.3.3.1 Traffic 2-22
G2.4 Vibration Impact Assessment 2-22
G2.4.1 Construction 2-22
G2.4.1.1 Pipeline 2-22
G2.4.2 Commissioning 2-23
G2.4.3 Operation 2-23
G2.4.4 Traffic 2-23

G2.4.5 Decommissioning 2-24
G2.5 Impact Assessment Overview 2-24
G2.6 References 2-25

TABLES

Table G2.2-1 Summary of Baseline Noise Levels 2-5
Table G2.2-2 Construction Activities – Noise 2-6
Table G2.2-3 Construction Activities – Noise 2-8
Table G2.2-4 Noise Source Data 2-9
Table G2.2-5 Construction Activities - Vibration 2-12
Table G2.2-6 Vibration Source Data (Construction Only) 2-14
Table G2.2-7 Noise Model Parameters – Construction, Commissioning and Decommissioning... 2-15
Table G2.2-8 Vibration Calculation Parameters – Construction Only 2-15
Table G2.3-1 Construction of Right-of-Way – Impact Assessment Prior to Mitigation 2-16
Table G2.3-2 Existing Road Use – Potential Impacts Prior to Mitigation 2-20
Table G2.3-3 New Road Use – Potential Impacts Prior to Mitigation (Short Term during Construction) 2-21
Table G2.5-1 Project Summary of Noise Change Prior to Mitigation 2-24

ATTACHMENTS

ATTACHMENT G3.1 CONSTRUCTION SOURCE DATA 2-26
ATTACHMENT G3.2 ROCK BREAKING SOURCE DATA 2-34
ATTACHMENT G3.3 CONSTRUCTION NOISE PREDICTION SEPARATION DISTANCES 2-35

GLOSSARY AND ACRONYMS

Symbols	
dB	decibel
dB(A)	A-weighted Decibel
dB(lin)	zero or flat weighted decibel
hr	hour
km	kilometre
kgm^{-2} or kg/m^2	kilograms per square metre
$L_{eq(T)}$	sound level in decibels equivalent to the total sound energy measured over a stated period of time. T is over a general period of time where a number illustrates a specific averaging or measurement period (typically $L_{eq,1hr}$).
$L_{90(T)}$	noise level exceeded for 90% of the time of the measurement duration. Often taken to represent the ambient or background noise level. For time (T) see $L_{eq,(T)}$.
$L_{10(T)}$	noise level exceeded for 10% of the time of the measurement duration. Often taken to represent traffic related noise. For time (T) see $L_{eq,(T)}$.
L_{max}	root mean squared maximum level of a noise source or given environment.
L_W	sound power level
L_P	sound pressure level
m	metre
mm	millimetre
min	minute
mms^{-1} or mm/s	millimetre per second
A	
A-weighting	‘A’ weighting is standard weighting of the audible frequencies designed to reflect the response of the human ear to noise. At low and high frequencies, the human ear is not very sensitive, but between 500 Hz and 6 kHz the ear is much more sensitive.
AOI	area of influence
AGI	aboveground installation
L	
linear weighting (zero weighting or flat weighting)	‘l’ or ‘z’ or ‘0’ sound level meter frequency weighting, flat over a frequency range that must be stated. No weighting is applied.
M	
masl	metres above sea level
O	
octas	unit of measurement used to describe the amount of cloud cover at any given location. Ranging from 0 to 8

P	
PES	project environmental standards
R	
RoW	right-of-way
S	
surface density	calculated as mass per unit area (kg/m^2 or kgm^{-2})
SLM	sound level meter

G2 ACOUSTIC IMPACT ASSESSMENT

G2.1 Introduction

This appendix presents the methodology, source data, predicted impacts and overview of considered mitigation for the valued environmental component (VEC) of acoustics across the Tilenga feeder pipeline. It is intended to be technical in nature and provide the basis for the acoustics impact assessment (Section 8.10).

The appendix includes the following:

- assessment methodology, including:
    - the way assessment criteria have been derived
    - the method used to identify the area of influence (AOI) and sensitive receptors
    - an overview of the baseline noise section for context
    - source considerations
    - modelling and calculation parameters, methods and algorithms
- impact assessment
- mitigation considerations.

G2.2 Assessment Methodology

G2.2.1 Overview

The VEC has been separated into noise and vibration, and the impacts of these have been considered for the following project phases:

- construction of the pipeline and access roads. Construction also includes the use of construction specific access roads.
- commissioning – pipeline pigging and hydrotesting
- operation of the access roads
- decommissioning of the pipeline, including removal and ground restoration.

Assumptions relating to noise and vibration source emission data, construction methodology and programmes are reported in Sections G2.2.6 and Section G2.2.7

Noise and vibration sources from the project phases with the potential to cause disturbance have been derived using field baseline measurements, manufacturer data, relevant standards and guidance, or experience of previous projects. The calculated source data has subsequently been predicted across the AOI.

The predictions have been used to identify the number of sensitive receptors exposed to project noise and vibration levels which are ranked as being significant in accordance with the project magnitude and sensitivity criteria. In addition, where the predicted noise levels exceed the project environmental standards (PES) (derived from national standards), this is identified.

G2.2.2 Assessment Criteria

G2.2.2.1 Noise

The noise impact assessment criteria and derivation of significance scores (SS) are presented in Appendix D of the ESIA. Noise magnitude, significance criteria have been derived from relevant national and international standards (see Section 4 of the ESIA).

Some impact ranks are fixed for construction and operational noise, which means that there is little variance in the overall SS and the maximum possible score is limited. This is particularly relevant for construction noise where the duration is always ‘short term’ and impact extent is ‘local’.

The national guidelines relevant to noise and vibration include The National Environment (Noise Standards and Control) Regulations, 2003. These cover aspects of operational and construction noise.

The national standards are derived from the World Health Organisation (WHO) Guidelines on Community Noise which in summary stipulate the following:

- maximum (L_{Amax}) of 45 dB (internal) for no more than 10-15 single instantaneous events during a night time period to avoid sleep disturbance;
- internal noise level of no more than 30 dB(A) $L_{eq,night}$ within a bedroom.

The WHO guidelines stress the importance of events as much as the ‘steady’ noise environment when determining impacts of noise on sleep disturbance. This is the reason for the maximum noise criterion. In addition to the national standards Section 1.7 of the IFC Environmental, Health, and Safety (EHS) Guidelines ‘General EHS Guidelines: Environmental’ on noise management sets out criteria for assessing noise (operational noise only). In simple terms, there are two sets of criteria which should be met:

- Noise impacts should not result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site, or
- Exceed an upper limit shown in Table G2.2-1.

Table G2.2-1 International Finance Corporation Absolute Limits (Operational Noise - Internal)

Receptor	One Hour L_{Aeq}, dB	
	Daytime 07:00–22:00	Night time 22:00–07:00
Residential, Institutional and educations	55	45
Industrial and commercial	70	70

The IFC criteria are derived from background measurements, a summary of Uganda data is presented below with the equivalent derived IFC criteria.

Table G2.2-2 Uganda International Finance Corporation Criteria (Daytime - Internal)

	$L_{A90,1hr}$, dB (background)	Equivalent IFC, dB(A)
Highest recorded hour	54.7	55.0
Lowest recorded hour	28.7	31.7
Mean	35.5	38.5
Mode	32.0	35.0

Table G2.2-3 Uganda International Finance Corporation Criteria (Night Time - Internal)

	$L_{A90,1hr}$, dB (background)	Equivalent IFC, dB(A)
Highest recorded hour	47.4	45.0
Lowest recorded hour	26.1	29.1
Mean	38.9	41.9
Mode	47.0	45.0

The above standards are all based on an internal assessment and therefore for setting assessment criteria a factor needs to be applied to allow comparison with external predictions. For buildings with brick/stone walls, double glazed window units and insulated roof a worst-case attenuation for an open window is typically given as 10 dB. However, for the dwellings located across the AOI, this is considered an over estimation of potential building facade acoustic performance. Therefore, a level difference of 5 dB is considered a reasonable estimation of the building facade attenuation.

As the AGIs have the potential to operate with the same level of noise emission for 24 hours each day, the night-time criteria (or lowest daytime) is considered the determining factor and has been chosen for the design or compliance criteria.

A comparison of potential assessment criteria for dwellings (high sensitivity receptors) is summarised in Table G4.2-4, alongside the derived PES.

Table G2.2-4 Noise Criteria Summary (Lowest Average Operational)

Standard	Internal Criteria $L_{Aeq,T}$, dB	External Criteria $L_{Aeq,T}$, dB
National Standards	35	40
IFC (lowest mean day or night)	39	44
WHO	30	35
Assumed PES	**30**	**35**

In general practice, national standards and WHO guidelines take precedent over the IFC unless there is a significant variance in criteria. In this case, the IFC criteria is higher than WHO criteria. Therefore, for the operational assessment 35 dB(A) is set as the PES using the WHO criterion. Due to the relatively consistent nature of the noise emissions from the AGIs the assessment of maximum noise events is not considered appropriate, hence the derivation of PES for an $L_{Aeq,T}$ rather than a L_{Amax}.

G2.2.2.2 Vibration

The vibration impact assessment criteria and derivation of SS are presented in Appendix D of the ESIA. In terms of magnitude, significance criteria have been derived from international standards (see Section 4 of the ESIA). A more cautious approach has been taken with regards to vibration, as the immediate consequences of higher magnitudes of vibration (including structural damage to buildings) have the potential to be more severe than noise. Therefore, where magnitude levels are close to a high or very high score, the worst-case level is assumed to provide a more conservative approach. There are no Ugandan standards for vibration; however, British Standard BS 5228:-2:2009+A1:2014 'Code of practice for noise and vibration control on construction and open sites Part 2:Vibration' has been used to derive the PES. This has been set at 15 mm/s PPV and is considered appropriate for buildings and structures identified across the AOI relating to transient construction activities. For heritage items, a lower limit of 3 mm/s PPV has been identified, as referenced in German Standard DIN 4150–3:1999–02 Vibration in buildings—Part 3: effects on structures.

Blasting is not required for construction of the Tilenga feeder pipeline.

G2.2.3 Area of Influence and Receptor Identification

G2.2.3.1 Area of Influence Boundary

AOIs apply to existing, planned new and upgraded construction access roads, Feeder main camp and pipe yard (MCPY) and the RoW.

The AOI for noise was set at a 500 m radius, based on review of engineering information and satellite images taking into consideration likely noise emission levels and to identify the location of potential receptors. The vibration AOI has been set to 50 m.

For the temporary construction access roads and MCPY, the temporal AOI is the period of construction.

G2.2.3.2 Study Area Boundary

The study area boundary is the same as the AOI boundary for the RoW, MCPY and construction access roads as the potential acoustic impacts will be negligible beyond the 500 m AOI.

G2.2.3.3 Receptors

The project size and large quantity of receptors makes it impractical to predict noise levels at all potentially sensitive receptors within the AOI. Therefore, using the VEC specific sensitivity and magnitude definitions and the results of the noise modelling and vibration calculations, the number of terrestrial sensitive receptors within magnitude bands has been identified.

Terrestrial receptors (i.e., habitable, religious, educational, and health care structures) have been from the GIS database. There will be occasions where a structure may be identified incorrectly. However, where uncertain, the assessment assumes the structure is a sensitive receptor.

G2.2.4 Baseline Noise Environment

A baseline noise survey has been undertaken through the acoustics AOI. The survey included daytime monitoring at five locations throughout the RoW. Night time measurements were not undertaken as works are restricted to daytime periods only. Monitoring comprised of 1-hour samples to quantify the noise environment; sources of the measured levels were gained through observations by the field consultant.

Although the landscape and environment changes throughout the acoustics AOI, the noise sources are similar owing to the scarcity of fixed structures or substantial transport network. The main noise sources are:

- wind through vegetation
- insects, birds and amphibians
- traffic (with a higher proportion of small engine motorbikes, some cars and more trucks when close to sealed roads)
- human interactions
- farming (mostly hand tools, some livestock movements).

As a result, the noise environment across the acoustics AOI does not vary significantly and is consistent with levels expected in a rural environment away from major road networks, towns and industry. A summary of the range in noise levels across the acoustics AOI is presented in Table G2.2-1. The detailed baseline noise report is presented in Appendix A8.

Table G2.2-1 Summary of Baseline Noise Levels

Period	Noise Level Range, dB(A)	
	$L_{eq,1hr}$	$L_{90,1hr}$
Daytime	38.0 to 55.2	24.3 to 46.7

The ranking magnitude criteria are derived from absolute noise limits specified in the in-country standards and relevant international standards, rather than being relative to existing noise levels. Therefore, the existing noise environment does not influence the magnitude criteria, but it can often be used to provide context for the impact.

G2.2.5 Baseline Vibration Environment

The existing vibration environment has not been quantified and no discernible sources of vibration were observed during the field survey.

G2.2.6 Noise Source Considerations

G2.2.6.1Construction

Construction activities have the potential to generate noise of a high magnitude, however the duration of construction emissions is often short and will usually be restricted to the daytime.

The construction activities assessed as part of this study are presented in Table G2.2-2 also includes notes on the method used to assess each construction type, construction hours and general observations. Some activities include construction and operation, but are classed as a ‘construction’ related. For example, the MCPYs require construction and are then operated to allow the construction of a section of the pipeline.

Table G2.2-2 Construction Activities – Noise

Construction Activity	Construction Hours[1]	Activities	Method of Calculation[2]	Method of Assessment	Temporal Use[3]
RoW	Standard	Pipeline laying including rock breaking/ripping Reinstatement	Generic	Construction criteria	<1 year
MCPY (construction)	Standard	Earthworks including rock breaking/ripping Prefabrication installation M&E installation	Generic	Construction criteria	<1 year
MCPY (operation)	Standard	Power generation	Generic	Operational criteria[4]	1-5 years
Access road construction. (Impacts from use discussed in Section G2.2.6.5)	Standard	Earthworks	Generic	Construction criteria	<1 year

NOTES: [1] Relevant *The National Environment (Noise Standards and Control) Regulations 2003* do not specify daytime or night time hours for construction although throughout daytime is referred to as 06:00–22:00, with night time classed as 22:00–06:00. However, under other international guidelines specific to Construction noise such as British Standard BS 5228 -1:2009+A1:2014 ‘Code of practice for noise and vibration control on construction and open sites’, standard construction hours are taken as Monday – Friday 08:00–18:00, and Saturday 09:00–13:00. Therefore, for clarity, standard hours will be in line with BS 5228. Extended hours for this document mean 24 hours a day potentially 7 days a week.

[2] Generic means the same noise emissions are expected across duplicate sites and the impacts can be assessed on a wider scale.

[3]Based on each site rather than the whole area. I.e. per 500-m section of RoW rather than the whole RoW

[4]Operational noise criteria is used for these to account for the extended nature of the construction exercise in a fixed location. Construction criteria allows for elevated levels over a shorter period of time but this is not the case for construction facilities such as the MCPY.

G2.2.6.2 Commissioning

Through the commissioning phase, hydrostatic testing, pigging and cleaning, and drying pipe have the potential to generate high-magnitude noise.

Before hydrostatic testing, the pipeline will be gauged and cleaned by pigging, with associated generator and compressor noise. The pig launchers and receivers will be placed throughout the RoW. Each pigging exercise will typically last less than 24 hours.

Following pipe gauging and cleaning, the pipeline will be pressure tested using hydrostatic tests over 24 hours in 35–50-km segments. The noise associated with these tests will be from pumps, compressors and generators.

The pipeline will then be cleaned and dried using similar noise-emitting equipment as used for the initial pigging exercise.

The noise from each of these commissioning activities will be local and of short duration.

G2.2.6.3 Operation

No operational noise sources are considered for the Tilenga feeder pipeline.

G2.2.6.4 Decommissioning

The decommissioning and construction processes will be similar, but in reverse, and with cutting rather than welding plant, and excavators rather than trenchers. Similar to construction, the decommissioning plant have been identified and noise calculations undertaken to determine the likelihood of impact.

G2.2.6.5 Traffic

Potential project traffic noise sources include construction traffic (moving plant and materials), workforce traffic (buses) and operational traffic (movements associated with pipeline maintenance). These will use existing, and new temporary and permanent roads. The RoW will also be used in some locations as a temporary access road. This section considers traffic noise associated with the pipeline construction and operation, rather than noise from the construction or upgrade of roads.

There is the potential for project traffic to change the noise environment in two ways, through:

- an increase in construction and operational traffic on existing roads
- new traffic noise source on new temporary and permanent roads.

Traffic data are not available for most roads through Uganda and therefore it is not possible to undertake a ‘typical’ quantitative noise assessment of existing roads. It is also difficult to assess the current conditions owing to the general surface, variance in gradients of roads used, high percentage of motorbikes, low flows[1] and variance in vehicle usage. In a similar way, the possible traffic use on new

[1] According to Calculation of Road Traffic Noise, low flows typical ranked as fewer than 200 vehicles in a single hour or fewer than 4000 per day.

temporary and permanent roads is difficult to estimate accurately for assessment purposes. Therefore, a qualitative assessment has been undertaken to identify possible impacts.

The assessment of existing and new roads is based on the following theoretical principles (generic noise levels presented in Table G2.2-3). Many variables can affect traffic noise (as mentioned above), so these principles provide an indication of noise change rather than report absolute noise levels. The principles are:

- a 25% traffic increase is estimated to result in a 1 dB increase over existing traffic noise, with a 3 dB increase requiring a 100% increase in traffic flows
- an increase from 10% to 50% heavy goods vehicles (HGV), rather than light vehicles, in the traffic composition will increase noise by around 4 dB[2]
- an increase from 25% to 50% HGVs will result in a noise increase of approximately 2 dB.

Table G2.2-3 Construction Activities – Noise

Number of Truck Movements Per Hour	Distance between Road and Receptor				
	Corresponding $L_{eq,T}$, dB(A)				
	5 m	10 m	25 m	50 m	100 m
5	62	59	55	52	49
10	65	62	58	55	52
25	69	66	62	59	56

NOTES:

$$L_{Aeq,T} = L_{WA} - 33 + 10\log_{10}Q - 10\log_{10}V - 10\log_{10}d \quad (F.6)$$

where:

L_{WA} is the sound power level of the plant, in decibels (dB);

Q is the number of vehicles per hour;

V is the average vehicle speed, in kilometres per hour (km/h);

d is the distance of receiving position from the centre of haul road, in metres (m).

Truck Sound Power (L_W) =110 dB(A)

Vehicle speed average=30 kmh^{-1}

Angle of view = 180 degrees

The qualitative assessment for traffic noise includes the following assumptions:

- traffic on existing roads will not increase by more than 25%, but the composition of heavy vehicles will increase by up to 25% and therefore the increase in traffic noise is likely to be less than 3 dB based on theoretical principles above
- where a new permanent road is constructed within 100 m of high sensitivity receptors, the impacts will be ranked as significant
- where a new temporary road is constructed within 50 m of high sensitivity receptors, the impacts will be ranked as significant
- 90% of the project traffic will be in the daytime (06:00–22:00 as defined in national standards).

[2] Based on BS 5228:2009-1 Haul Road Calculation method

The qualitative assessment for construction traffic is presented in Section G2.3.1.4.

G2.2.6.6 Source Data

Source data for inclusion in noise models and calculations have been taken from manufacturers, international standards and engineering assumptions based on previous project experience. All input data have been agreed with the project engineers. Where assumptions in noise emissions for unknown plant are provided, these will become a design target for the detailed design and plant choice.

The source input for the noise modelling/calculation exercise is summarised in Table G2.2-4.

Table G2.2-4 Noise Source Data

Activity	Input Data	Assumptions	Source of Data
Construction/Decommissioning			
Pipeline	See Attachment G2.1 for construction plant list	Up to 1 month per kilometre of pipeline installation RoW works will be linear and transient Where multiple teams work on different sections, they will be spaced far enough so that there will be no noise increases associated with simultaneous working on the RoW.	Type and quantity of plant presented in EACOP Project Volumes and Quantities and Estimate[3]. Sound emission data taken from BS 5228:1 and manufacturer data. Operational percentage on-times assumptions made.
Access roads (construction, not use)		Up to 2 weeks per kilometre of new road Haul road works will be linear and transient Where multiple teams work on different sections, they will be spaced far enough so that there will be no noise increases associated with simultaneous working on the access roads	
Access roads (use of by construction traffic)	No quantitative assessment	No quantitative assessment	No quantitative assessment
MCPY	See Attachment G2.1 for construction plant list	Construction period up to three months	Type and quantity of plant presented in EACOP Project

[3] EACOP Project Volumes and Quantities Estimate. Document No UT-MID-60-0010-000330 Rev00 Dated 13 Sept 2017

Table G2.2-4 Noise Source Data

Activity	Input Data	Assumptions	Source of Data
			Volumes and Quantities and Estimate Sound emission data taken from BS 5228:1 and manufacturer data Operational percentage on-times assumptions made.
Commissioning			
Pigging (gauging and cleaning)	Pig Launcher and pig receiver inclusive of compressor units, generators and pumps.	In absence of specific locations for launch and receivers, a generic assessment of the pigging activity has been undertaken Noise emission for pig launching is assumed to be 68 dB(A) at 10 m (allowing for a single compressor, single generator and single pump, all screened with local barriers)	Project engineers
Hydrostatic testing	Hydrostatic testing inclusive of compressor units, generators and pumps.	Testing to be undertaken at 35–50 km intervals, but the exact locations are not specified and the assessment will be in line with the pigging methodology Noise emission for pig launching is assumed at 68 dB(A) at 10 m (allowing for a single compressor, single generator and single pump, all screened with local barriers)	Project Engineers

Table G2.2-4 Noise Source Data

Activity	Input Data	Assumptions	Source of Data
Pipeline drying	Drying of pipeline following hydrostatic testing and cleaning.	Drying and cleaning to be undertaken at 35–50 km intervals, but the exact locations are not specified and assessment will be in line with the pigging methodology Noise emission for drying is assumed at 68 dB(A) at 10 m (allowing for a single compressor, single generator, single blower and single pump, all screened with local barriers)	Project engineers
Operation			
RoW	Operational noise from RoW not considered	Operational noise from RoW not considered	Operational noise from RoW not considered
Roads (long term operation of new and existing roads. See Section G2.3.3.1 for further information)	No quantitative assessment	No quantitative assessment	No quantitative assessment
One MCPY	4 x Aggreko 350 kVA generators with design to provide a sound pressure level of 80 dB(A) at 1 m. Layout as per Figure 2.3-9 in Section 2 Project Background and Description in the ESIA	3-m high noise wall around generators at a distance of 2 m Free field noise level target of maximum 80 dB(A) at 1 m from generator enclosure 1 operating during the night, 3 during the day, 1 on standby Located centrally within the MCPY	Project engineers

G2.2.6.7 General Exclusions and Assumptions

The noise sources with the potential to generate noise at a magnitude likely to be discernible above the existing environment beyond the site boundary are considered. Project components and equipment not assessed include:

- substations
- main line block valve stations
- tunnelling crossings under rail and road.

Impacts from noise and vibration generated by tunnelling for road and rail crossings will be minimal due to the localised and short-term nature. Entry and exit pits will not be piled and the drill head will be below ground level. Therefore, it has not be included within the detailed assessment.

This report does not consider occupational health impacts associated with noise or vibration. All criteria, noise predictions and mitigation recommendations are specific to environmental and social impacts. It is acknowledged that some mitigation measures will also assist with protecting project workers although this is not the primary intent.

Concrete batch plants have been excluded from the assessment as they do not form part of the project.

G2.2.7 Vibration Source Considerations

G2.2.7.1Construction

The greatest vibration risk is during construction, as many construction activities generate vibration. However, in most cases, vibration generation is largely imperceptible. Exceptions include high-impact compaction activities, rock breaking, blasting and piling, with the level of vibration dependent on the construction method, plant and energy component of the vibration source. Rock breaking is proposed for small, discreet areas and not across the whole acoustics AOI. However, no piling or blasting is proposed for construction of the Tilenga feeder pipeline. In addition, a low-impact compaction method is proposed for ground reinstatement along the RoW and therefore only the vibration sources in Table G2.2-5 are considered.

Table G2.2-5 Construction Activities - Vibration

Construction Phase	Activities
Pipeline	Rock breaking and rock ripping

The activities should be undertaken during daytime periods only.

In a similar way to the prediction and assessment of noise, the vibration levels from each of the above activities will be predicted using empirical formulae and the distances to which magnitude bands are exceeded presented. The number of sensitive structures within such bands is to be reported.

G2.2.7.2Commissioning

No plant has been identified with the potential to generate vibration at a magnitude detectable beyond the site boundary. Therefore, vibration has not been predicted or assessed for the commissioning phase.

G2.2.7.3Operation

No plant has been identified with the potential to generate vibration at a magnitude detectable beyond the site boundary. Therefore, vibration has not been predicted or assessed for the operational phase.

G2.2.7.4 Decommissioning

No plant has been identified with the potential to generate vibration at a magnitude detectable beyond the site boundary. Therefore, vibration has not been predicted or assessed for the commissioning phase. However, further investigation into the decommissioning plant should be undertaken towards the end of the project life.

G2.2.7.5 Traffic

The use of unsealed roads during the construction phase increases the potential for vibration induced damage to structures along these roads.

Unsealed roads are more susceptible to damage and deterioration (the creation of ruts, corrugations and pot holes) compared with sealed roads. The movement of trucks and buses along the unsealed roads accelerates their deterioration and increases the potential for higher magnitude vibration events from uneven and abnormal load and axle movement.

Quantification of the vibration associated with such movements is dependent on many variables and is therefore not easily quantified. These variables include the:

- road condition
- road foundations
- geology between the road foundations and receptor
- distance between the receptor and road
- vehicle speed
- vehicle weight
- load (the weight distribution across the vehicle, and whether the load is loose or fixed)
- tyre condition
- receptor structure condition
- number of vehicles.

Therefore, a qualitative assessment has been undertaken (see Section G2.4.4) taking into account the mitigation measures to be embedded in the construction management plans. These measures will include speed restrictions, sympathetic routing, regular road maintenance, load management and vehicle maintenance.

The above impacts could be noticed during the operation of the pipeline, but the risk is significantly reduced owing to the exceptionally low and intermittent nature of expected vehicle movements during the operational phase compared with the construction phase. Smaller vehicles are also likely to be used. Vibration from operational vehicle movements has therefore been discounted from the assessment.

G2.2.7.6 Source Data

The vibration emission levels generated through the construction phase have largely been calculated using empirical formulae, based on plant data provided by project engineers. Where data are unavailable, file data from RSK measurements of similar activities have been used to provide an indication of the impacts.

However, these data should be reviewed and refined once specific methods are identified.

The source input for the noise modelling/calculation exercise is summarised in Table G2.2-6.

Table G2.2-6 Vibration Source Data (Construction Only)

Construction Phase	Activity	Input Data	Assumptions	Source of Data
RoW	Rock breaking and rock ripping	See Attachment G2.2	Excavator rock breaker or ripper	Tilenga Project-approved assumption

G2.2.8 Modelling and Calculation Methodology

The parameters and assumptions for noise modelling and general calculations are presented in Table G2.2-7 and Table G2.2-8 for construction noise, and construction vibration, respectively. The data source for the noise model and project calculations has been discussed in Section G2.2.6.6 and Section G2.2.7.6.

To determine the propagation of noise from the different project phases, a computer noise model has been produced using Soundplan v7.4 software.

For operational noise modelling and calculations, the noise predictions are based on International Standard ISO 9613-2:1996 ‘Attenuation of sound during propagation outdoors – general method of calculation’. ISO 9613 provides a method for the prediction of noise levels in the community from sources of known sound emission.

The noise prediction method described in ISO 9613 is suitable for a wide range of engineering applications where the outdoor noise level is of interest. The noise source(s) may be moving or stationary and the method considers the following major noise-attenuation mechanisms:

- geometrical divergence (also known as distance loss or geometric damping)
- atmospheric absorption
- ground effect
- reflection from surfaces
- screening by obstacles and buildings.

The ISO 9613 method predicts noise levels under meteorological conditions favourable to noise propagation from the sound source to the receiver, such as downwind propagation, or equivalently, propagation under a moderate ground-based temperature inversion as commonly occurs at night.

For construction noise modelling and calculations, the predictions are based on British Standard BS 5228-1:2009+A1:2014 ‘Code of practice for noise and vibration control on construction and open sites-Part 1’. In a similar way to ISO 9613, the BS 5228 calculation method takes account of environmental variables.

Table G2.2-7 Noise Model Parameters – Construction, Commissioning and Decommissioning

Item	Setting/Information
Algorithms	British Standard BS 5228 -1:2009+A1:2014 'Code of practice for noise and vibration control on construction and open sites-Part 1 Noise'
Ground absorption	Acoustically hard (assumed 0.1 coefficient) – roads, water, pavements and hard standing areas; Acoustically soft (assumed 0.8 coefficient) – grassed areas, vegetation;
Meteorological conditions	28°C 70% humidity Wind from source to receiver
Façade corrections	No corrections applied with all predictions classed as free-field
Receptor height	All at 1.5 m above ground as assumed single storey properties
Source modelling/ calculations	Construction Plant lists derived from project description (see Attachment G3.1). Plant lists assume a percentage operating time and modelled/calculated in a way so that the highest $L_{eq,T}$ is predicted for all receptors, i.e. assuming worst case. **RoW** – Spreadsheet calculations using BS 5228 algorithm to predict highest $L_{eq,T}$ from the works. As works are linear these predictions are used to identify sensitive receptor numbers within the magnitude criteria bands. **MCPY**– Noise predictions for the one MCPY have been made using modelling software. As the construction activities are varied, mobile and not time constant the noise emission data is applied across the MCPY site extents which allow the worst-case noise levels to be predicted.
Traffic information	Not assessed quantitatively
Terrain and source height	All sources from a construction perspective are averaged at a height of 1.5 m aboveground. Terrain used in modelling and calculations is set to be flat.
Barriers	Noise barriers to a height of 2 m have been included around the pipe yards. Localised 3-m-high barriers around MCPY generators and generators across the project.
Site layout	Indicative site layouts for MCPY provided by Tilenga and used for the purpose of modelling.

Table G2.2-8 Vibration Calculation Parameters – Construction Only

Item		Setting/Information
RoW	Rock breaking and ripping	See Section G2.2.7.1

G2.3 Noise Impact Assessment

The noise associated with each project phase has been predicted through specific computational noise modelling software or spreadsheet calculations (see above methodologies). The predictions have been used to identify the number of sensitive receptors within magnitude bands. The overall impact (SS) at each of these receptors has then been calculated using the predictions (see Section G2.2.2.1).

These tables report the highest SS for any phase and activity, and the number of receptors exposed to that SS.

The following impact assessments are based on noise predictions for the worst case, with plant operating simultaneously at the same location (with closest separation distance between a work site extent and receptor). In reality, this scenario will occur infrequently and for short durations.

Many scores are not dependent on location, but fixed as a definition of the works. For example, all linear works for the RoW are less than 1 year in duration when considered in sections, therefore resulting in a 1-point duration score. Likewise, the impact score will always be 2 as the impact will be on the local community only. No VEC ‘very high sensitivity’ receptors have been identified within 100 m of the RoW, therefore the highest sensitivity ranking for receptors is 4. For this reason, the only varying factor is magnitude and this changes with distance from the work or operational areas depending on noise emissions. The scores for the ‘duration’ (D), ‘sensitivity’ (S), and ‘extent’ (E) impacts are defined under each impact assessment table (see below). This means that the highest SS are similar across phases and activities. This is a consequence of the mathematics and not an error. This is the same for noise predictions across the AOI where the ranges in noise are similar given the similarity in plant.

The highest SS is presented in the tables, with the number of receptors exposed to the impact and the magnitude responsible for the impact. The measured baseline noise levels are provided below the tables for reference.

G2.3.1 Construction

See Appendix D for the tables used to rank magnitude, duration, extent and sensitivity, and to calculate SS. The distance at which magnitude criteria is exceeded for each activity is presented in Attachment G2.3.

G2.3.1.1Pipeline

Table G2.3-1 shows the impact assessment for the construction of the pipeline prior to mitigation.

Table G2.3-1 Construction of Right-of-Way – Impact Assessment Prior to Mitigation

Activity	Period	Highest SS	Magnitude Score	Number of Receptors with Highest SS Prior to Mitigation	Significant Impact Prior to Mitigation (i.e., Greater than 19 SS)
Clearing and grubbing	Day	17	Very large	46	Not significant
Camp/site establishment	Day	17	Very large	35	Not significant
Road construction	Day	17	Very large	46	Not significant

Table G2.3-1 Construction of Right-of-Way – Impact Assessment Prior to Mitigation

Activity	Period	Highest SS	Magnitude Score	Number of Receptors with Highest SS Prior to Mitigation	Significant Impact Prior to Mitigation (i.e., Greater than 19 SS)
General earthworks	Day	17	Very large	46	Not significant
Trenching	Day	17	Very large	46	Not significant
Pipe laying/installation	Day	17	Very large	54	Not significant
Backfilling/reinstatement	Day	17	Very large	56	Not significant
Rock breaking	Day	17	Very large	62	Not significant

NOTES: For the Noise VEC RoW has the following fixed impacts scores defined:
D = 1 point, E = 2 points, S = 4 points RoW AOI baseline noise levels – Daytime 38.0-55.2 dB(A) $L_{eq, 1hr}$, 24.3-46.7 dB(A) $L_{90, 1hr}$

Noise levels are predicted to range from 50–70 dB(A) $L_{Aeq,T}$ throughout the AOI prior to mitigation for works associated with pipeline construction. These levels are higher than the existing ambient noise environment (compared with $L_{eq,1hr}$) and are likely to be perceptible as a result of the different character to the existing environment and increase over the baseline L_{A90}.

During pipeline construction along the RoW, the noise levels from some activities have the potential to exceed the 'very large' magnitude ranking at receptors classed as 'high sensitivity'. However, the highest SS is 17 and therefore not ranked as significant prior to mitigation. In addition, the linear and transient nature of the of the pipeline works means that the exposure time to the highest levels at individual receptors will be short and far less than the lowest duration raking of 1 year. The highest noise levels are likely to be experienced for up to a week when the works are undertaken at the closest separation distance to receptors.

No PES exceedances are noted.

G2.3.1.2Main Camps and Pipe Yards

Table G2.3-1 Construction of MCPYs – Sensitivity Points Prior to Mitigation

Phase	Activity	Period	Highest SS	Magnitude Score	Number of Receptors with Highest SS Prior to Mitigation	Significant Impact Prior to Mitigation (i.e. Greater than 19 SS)
Feeder MCPY	Clearing and Grubbing	Day	11	Small	2	Not significant
Feeder MCPY	General Earthworks	Day	11	Small	2	Not significant
Feeder MCPY	Prefabrication Installation	Day	9	Negligible	0	Not significant
Feeder MCPY	M&E Installation	Day	11	Small	2	Not significant
Feeder MCPY	Operation	Day	12	Small	2	Not significant

NOTES: For the Noise VEC MCPY has the following fixed impacts scores defined:0
D = 2 points for operation, and 1 point for other activities, E = 2 points, S = 4 points
MCPY AOI baseline noise levels (Monitoring point TFP3) – Daytime 43.2 dB(A) $L_{eq,1hr}$, 25.1 dB(A) $L_{90,1hr}$

Noise levels are predicted to range between 50 dB(A) and 75 dB(A) $L_{Aeq,T}$ throughout the construction of the main camp pipe yard AGIs prior to mitigation. When compared with the baseline noise environment levels are in general higher than the existing ambient noise environment (compared with $L_{eq,1hr}$) and are likely to be perceptible because of the different character to the existing environment and increase over the baseline L_{A90}.

During the construction of the MCPY the noise levels from some activities have the potential to exceed the ‘negligible’ magnitude ranking at receptors classed as ‘high sensitivity’. However, accounting for pre-mitigated design (i.e., the 2 m high boundary fence which will be installed at an early phase in the construction), the highest SS is 11 and therefore not ranked as significant prior to mitigation.

During the operation of the MCPYs noise levels are predicted to range between 40 dB(A) and 65 dB(A) $L_{Aeq,T}$ throughout the AOI prior to mitigation. When compared with the baseline noise environment levels are in general higher than the existing ambient noise environment (compared with $L_{eq,1hr}$) and are likely to be perceptible because of the different character to the existing environment and increase over the baseline $L_{A90.}$

No PES exceedances are noted during construction or operation of the MCPYs.

G2.3.1.3 Decommissioning

Noise associated with the decommissioning phase is likely to closely resemble the predictions and impacts from the construction phase and therefore no further assessment has been undertaken at this stage.

G2.3.1.4 Traffic

There is the potential for project traffic to change the noise environment in two ways, through:

- an increase in construction and operational traffic on existing roads
- new traffic noise source on new temporary and permanent roads.

Traffic data for most of the roads through Uganda is not available and therefore it is impractical to undertake a 'typical' quantitative noise assessment of existing roads. As a result, a generic assessment has been undertaken for road upgrades and the use by construction traffic of new permanent roads and using the general principles for traffic noise presented in Section G2.2.6.5.

Table G2.3-2 shows the potential change in noise level because of construction traffic on existing roads. This looks beyond the existing road upgrades and assumes that construction traffic will use the wider road network.

The significance scoring for impact is fixed in certain categories. See notes below the tables for assumed scores. For the extent (E) score, to account for impacts across the wider road network, a level of 3 (subnational) has been assumed as there is the potential for changes in traffic flows beyond the area around the construction works. Although the changes in traffic noise further afield are much less than local changes (i.e., magnitude impacts will be much smaller), a change is still possible.

Table G2.3-2 Existing Road Use – Potential Impacts Prior to Mitigation

Facility Type	Vicinity[1]	Existing Noise Environment, dB(A) $L_{eq,T}$[2]	Traffic Flow Assumptions[5]	Potential Numerical Change, dB[6]	Perception[3]	Impact SS[4]	Significance Prior to Mitigation
Construction Facilities							
RoW	Local	55.4	Approximately 1000 trucks. Max 10 movements in any single hour across a road segment. No night movements.	+5	Most in local vicinity will notice	16	Not significant
	Area	55.4	Approximately 10 trucks. No more than 1 trucks along a road segment in a single hour	<1	Imperceptible	13	Not significant
MCPY	Local	54.8	Approximately 1000 trucks. Maximum 10 movements in any single hour across a road segment. No night movements.	5	Most in local vicinity will notice	16	Not significant
	Area	58.7	Approximately 10 trucks. No more than 1 truck along a road segment in a single hour	<1	Imperceptible	13	Not significant

NOTES: [1] Extent for local is 2 points, extent for area is 3 points. Area is further than the local road network and assume that there will be traffic coming from greater distances than the local area, and the only purpose is for this project.

[2]Taken from the highest measurements as the highest levels will be experienced near roads, as this was the main noise source across most areas. For 'Area' baseline, a level taken from the highest RoW measurements has been used.

[3]Perception taken as <3 dB change barely noticeable, change by 5 dB most will perceive a change, change by 10 dB a perceived doubling of loudness, change in 20 dB a perceived quadrupling of loudness. This is based on general acoustic principles.

[4]Duration for all <5 years therefore 1 point, Sensitivity assume very high as potential for hospitals, schools to be located within 100 m of the road therefore 5 points,

[5]Derived from Traffic Assessment, see Section 8. Total construction traffic per phase divided by number of facilities in phase. Not taking into account worker movements. 'Truck movement' numbers are considered for local road impacts where 'truck numbers' are considered for area as the there is a high likelihood of return trips by trucks along the same roads for local in a single day whereas this is unlikely to be the case for trucks coming from further afield.

[6]Based on theoretical assumptions in Section G2.2.6.5

Table G2.3-3 presents the potential impacts from new road use prior to mitigation.

Table G2.3-3 New Road Use – Potential Impacts Prior to Mitigation (Short Term during Construction)

Facility Type	Vicinity[1]	Existing Noise Environment, dB(A) $L_{eq,T}$[2]	Traffic Flow Assumptions[5]	Potential Numerical Change, dB[6]	Perception[3]	Impact SS[4]	Significance Prior to Mitigation
RoW	Local	55.4	Approximately 1000 trucks. Max 10 movements in any single hour across a road segment. No night movements.	+10	Local community will notice change	17	Not significant

NOTES: [1] Extent for local is 2 points, no 'Area' impacts associated with new roads.

[2]Taken from the highest measurements as the highest levels will be experienced near roads, as this was the main noise source across most areas. For 'Area' baseline, a level taken from the highest RoW measurements has been used.

[3]Perception taken as <3 dB change barely noticeable, change by 5dB most will perceive a change, change by 10 dB a perceived doubling of loudness, change in 20 dB a perceived quadrupling of loudness.

[4]Duration for all <5 years therefore 1point, Sensitivity assume high as routing will be chosen to avoid hospitals and schools therefore 4 points.

[5]Derived from Traffic Assessment, see Section 8. Total construction traffic per phase divided by number of facilities in phase. Not taking into account worker movements. 'Truck movement' numbers are considered for local road impacts where 'truck numbers' are considered for area as the there is a high likelihood of return trips by trucks along the same roads for local in a single day whereas this is unlikely to be the case for trucks coming from further afield.

[6]Based on theoretical assumptions in Section G2.2.6.5

The noise associated with project construction traffic movements along new and existing roads will not result in a significant impact prior to mitigation. The existing noise environment around the proposed access routes will increase. Increases in noise magnitude are likely to be very high in areas with proposed new roads. However, given the short-term nature of construction, the impact is not ranked as significant.

For new roads which will remain after the construction phase, the change in noise associated with the pipeline operational traffic will be less than 1 dB, far lower than the levels reported above, and will the impacts will therefore not be significant. There is a likelihood that these permanent new roads will have long-term use by non-pipeline traffic, but these numbers are challenging to estimate and doing so is beyond the scope of this assessment.

G2.3.2 Commissioning

Specific locations for commissioning noise sources are not defined and therefore these activities, although localised, have the potential to be undertaken along the RoW. Therefore, the RoW has been used as the extent for prediction purposes.

Noise emission (in isolation) of pig launching, hydrostatic testing, cleaning and drying is assumed to be 68 dB(A) at 10 m (allowing for a single compressor, blower and dryer generator, and pump, all screened with 2-m-high barriers).

This noise emission is lower than for the pipeline construction sources, and therefore, considering that commissioning will take place along the RoW, the impacts will be lower than those predicted for pipeline construction. Therefore, the noise associated with commissioning is ranked as not significant.

Although classed as not significant, the noise from these activities will be perceptible at receptors close to each commissioning location. This will particularly be the case for drying which will potentially be continuous for up to 48 hours.

G2.3.3 Operation

There are no Above Ground Installations (AGI) across the Tilenga feeder pipeline with noise emissions of a magnitude or duration considered to be discernible beyond facility boundaries. Therefore, no assessment has been undertaken.

G2.3.3.1 Traffic

Operational traffic movements will be low level and infrequent and so quantitative assessment is unnecessary. The impacts would therefore be negligible.

G2.4 Vibration Impact Assessment

G2.4.1 Construction

G2.4.1.1 Pipeline

The potential for vibration across the RoW for linear works will be restricted to discreet rock breaking (rock ripping)/soil stripping.

Rock breaking and ripping has the potential to occur throughout the RoW where rock obstructions cannot be removed using standard trenching methods. However, the location of such activity will not be defined until work commences. Therefore, the risk of impact is based on generic predictions for the activities and resultant offset distances.

The vibration resulting from rock breaking and rock ripping is presented in Table G2.4-1 using the methodology in Section G2.2.7.1. This also shows the highest possible SS assuming a 'Very high' sensitivity receptor and a heavy rock breaker (Attachment G2.2).

Table G2.4-1 Rock Breaking and Ripping – Vibration Predictions

Magnitude[1]	Corresponding Vibration PPV, mms^{-1}	Distance from Activity, m[2]	Number of Receptors	Highest Possible SS	Significant Impact (i.e. Greater than 19 SS)
Negligible	< 0.11	50	>500	12	Not significant
Small	0.12–1.00	15–50	98	14	Not significant
Medium	1.01–10.00	2–15	40	16	Not significant
Large	10.01–15.00	< 2	0	18	Not significant
Very Large	>15.01	N/A	-	-	Not significant

NOTES: In a similar way to noise certain impact scores are the set: D = 3 point, E = 2 points, S = 5 points
Assessment and reporting at medium, large and very large magnitudes not applicable due to the small predicted separation distances.
[1]See Section G2.2.2.2
[2]Distance at which magnitude level is exceeded

The above table shows that rock breaking would be suitable along the RoW as significant impacts will not be expected at any sensitive receptors. No exceedances of the PES are predicted.

G2.4.2 Commissioning

No commissioning-phase vibration sources have been identified that require assessment.

G2.4.3 Operation

No operational phase vibration sources have been identified that require assessment.

G2.4.4 Traffic

The use of existing and proposed unsealed roads during the construction phase increases the potential for vibration-induced damage to structures along the roads.

Unsealed roads are more susceptible to damage and deterioration (the creation of ruts, corrugations and pot holes) compared with sealed roads. The movement of heavy trucks and buses along the unsealed roads accelerates their deterioration and increases the potential for higher magnitude vibration events from uneven and abnormal load and axle movement.

Therefore, for this study, it is assumed that where damage to a sealed or unsealed road is within 10 m of a sensitive structure, there is the potential for vehicle movement to generate vibration through interactions between the axle and vehicle structure, suspension or load movement. The magnitude of the vibration is hard to quantify but has the potential to be generated at a magnitude which causes early signs of structural damage on the lightest of structures.

G2.4.5 Decommissioning

Vibration associated with the decommissioning phase is likely to closely resemble the predictions and impacts from the construction phase and therefore no further assessment has been undertaken at this stage.

G2.5 Impact Assessment Overview

A general summary of the changes in noise levels across the AOI prior to mitigation is presented in Table G2.5-1 for each of the modelled and calculated phases. This compares the project noise with the measured background noise throughout the AOI as a function of distance. This can be used to provide a high-level indication of noise impacts on people and wildlife across the project.

For reference and context, a 3 dB change in noise is often taken as the lowest perceptible change for humans, most people notice a 5 dB change, a 10 dB change is perceived as a doubling of the sound in loudness and a 20 dB change heard as fourfold increase in perceived loudness. In energy terms, a 3 dB change represents a doubling of energy, a 10-dB change a 10x increase in energy and a 20 dB change a 100x increase in energy. Therefore, a sudden change in 20 dB is perceived as 4x the loudness, but has 100x the energy.

Table G2.5-1 Project Summary of Noise Change Prior to Mitigation

Phase	Activity	Period	Possible Change in Baseline Noise with Distance from Source, dB (All Increases in Noise)					
			<50 m	50–100 m	100–250 m	250–500 m	500 m–1 km	>1 km
Construction	RoW	Day	20–30	10–20	5–10	1–5	<1	0
	MCPY	Day	20–30	10–20	5–10	1–5	<1	0
Commissioning	Pigging	Day	20–30	10–20	5–10	1–5	<1	0
	Hydro. Testing	Day	20–30	10–20	5–10	1–5	<1	0

The impact assessment has not identified any phases or activities across the Tilenga feeder pipeline where noise or vibration could be classed as significant prior to mitigation.

G2.6 References

British Standard BS 6472-1:2008 'Guide to evaluation of human exposure to vibration in buildings- Vibration sources other than blasting

British Standard BS 5228-1:2009+A1:2014 'Code of practice for noise and vibration control on construction and open sites. Noise'

British Standard BS 5228-2:2009 'Code of Practice for noise and vibration control on construction and open sites- Vibration

British Standard BS 7385-1:1990 'Evaluation and measurement for vibration in buildings. Guide for measurement of vibrations and evaluation of their effects on buildings

British Standard BS 7385-2:1993 'Evaluation and measurement for vibration in buildings. Guide to damage levels from groundborne vibration

British Standard BS EN 61672-1:2013 'Electroacoustics. Sound level meters. Specifications'

British Standard BS7445-1:2003 'Description and measurement of environmental noise. Guide to quantities and procedures'

CRTN-:1988 'Calculation of road traffic noise, Department of Transport UK

EMDC_5_(4145)-Noise_Limits._P3 – Draft . Acoustic – General Tolerance limits for Environmental and Occupational Noise Rev(TZS 932:2007)

German Standard DIN 4150-3:1999 ‘Structural vibration Part 3: Effects of vibration on structures

Uganda 21. Noise and Vibration regulations 2011

Uganda.15 The National Environment (Noise Standards and Control) Regulations, 2003

UK DMRB-7:2008 'Design manual for roads and bridges. Noise and vibration

ATTACHMENT G3.1 CONSTRUCTION SOURCE DATA

RoW

Table AttG3.1-1 Cleaning and Grubbing (ROW and MCPY)

Plant	Noise Data			On Time (%)	Number of Plant Items	Screening/dB	Total Correction/dB	Total Lp at 10 m dB(A)
	Plant Ref	Type	Lp (at 10 m) dB(A)					
Excavator	C2.17	28t	76	30	1	0	-5	71
Dozer	C7.8	50t	75	20	2	0	-4	71
Hand Tools	-	-	-	-	-	-	0	-
Skip Wagon	C8.21	-	78	25	1	0	-6	72
Dumper	C4.1	25t	81	20	1	0	-7	74
TOTAL L_p								78
L_w								106

Table AttG3.1-2 Camp/Site Establishment (ROW and MCPY)

Plant	Noise Data			On Time (%)	Number of Plant Items	Screening/dB	Total Correction/dB	Total Lp at 10 m dB(A)
	Plant Ref	Type	Lp (at 10 m) dB(A)					
Lorry with lifting boom	C4.53	6t	77	25	1	0	-6	71
Hand tools	--	--	--	--	--	--	0	--
MEWP	C4.57	8t	67	70	2	0	1	68
Tracked excavator	C2.17	28t	76	30	1	0	-5	71
TOTAL Lp								75
Lw								103

Table AttG3.1-3 Road Construction (ROW)

Plant	**Noise Data**			**On Time (%)**	**Number of Plant Items**	**Screening/dB**	**Total Correction/dB**	**Total Lp at 10 m dB(A)**
	Plant Ref	**Type**	**Lp (at 10 m) dB(A)**					
Hand tools								
Tracked excavator	C2.17	28t	76	30	1	0	-5	71
Dumper	C4.1	25t	81	10	1	0	-10	71
grader	C6.31	25t	86	10	1	0	-10	76
Tipper lorry	C8.20		79	10	1	0	-10	69
Roller	C5.19	22t	80	10	1	0	-10	70
TOTAL L_p								79
L_w								107

Table AttG3.1-4 General Earthworks (ROW and MCPY)

Plant	Noise Data			On Time (%)	Number of Plant Items	Screening/dB	Total Correction/dB	Total Lp at 10 m dB(A)
	Plant Ref	Type	Lp (at 10 m) dB(A)					
Articulated dump truck	C5.16	25t	81	10	1	0	-10	71
Excavator	C2.17	28t	85	10	1	0	-10	75
Hand tools	-	-	-	-	-	-	0	0
Hand trolley	-	-	-	-	-	-	0	0
Dozer	C2.13	11 t	78	20	1	0	-7	71
TOTAL Lp								78
Lw								106

Table AttG3.1-5 Trenching (ROW)

Plant	Noise Data			On Time (%)	Number of plant items	Screening/dB	Total Correction/dB	Total Lp at 10 m dB(A)
	Plant Ref	Type	Lp (at 10 m) dB(A)					
Excavator	C2.17	28t	76	30	1	0	-5	71
Dumper	C4.1	25t	81	10	1	0	-10	71
Hand tools	-	-	-	-	-	-	0	
Trencher	4.63	40t	77	20	1	0	-7	70
Trench wacker	Manufacturer Data	Wacker BS 50-4	79	30	1	-5	-10	69
Wacker plate	C2.41	-	80	15	1	0	-8	72
TOTAL Lp								78
Lw								106

Table AttG3.1-6 Pipe Laying/Installation (ROW)

Plant	Noise Data			On Time (%)	Number of Plant Items	Screening/dB	Total Correction/dB	Total Lp at 10 m dB(A)
	Plant Ref	Type	Lp (at 10 m) dB(A)					
Excavator	C2.17	28t	76	20	1	0	-7	69
Dumper	C4.1	25t	81	25	1	0	-6	75
Hand tools	-	-	-	-	-	-	0	-
Generator	C4.78	-	66	40	1	-10	-14	52
Lorry with lifting boom	C4.53	6t	77	20	1	0	-7	70
Hand trolleys	-	-	-	-	-	-	-	-
Welding equipment	C3.31	-	73	40	1	0	-4	69
Circular saw	C4.70	9kg	91	10	1	-5	-15	76
TOTAL Lp								80
Lw								108

Table AttG3.1-7 Backfilling and Reinstatement (ROW)

Plant	Noise Data			On Time (%)	Number of Plant Items	Screening/dB	Total Correction/dB	Total Lp at 10 m dB(A)
	Plant Ref	Type	Lp (at 10 m) dB(A)					
Excavator	C2.17	28t	76	30	1	0	-5	71
Dumper	C4. 1	25t	81	20	1	0	-7	74
Hand tools	-	-	-	-	-	-	0	-
Wacker plate	C2.41	-	80	15	1	0	-8	72
Roller	C2.37	18t	79	15	1	0	-8	71
Telescopic handler	C2.35	10t	71	20	1	0	-7	64
TOTAL L_p								78
L_w								106

Table AttG3.1-8 Rock Breaking (ROW and MCPY)

Plant	Noise Data			On Time (%)	Number of Plant Items	Screening/dB	Total Correction/dB	Total Lp at 10 m dB(A)
	Plant Ref	Type	Lp (at 10 m) dB(A)					
Breaker mounted on excavator	C1.9	15t	90	10	1	0	-10	80
Dumper	C4.1	25t	81	20	1	0	-7	74
Hand tools	-	-	-	-	-	-	-	-
TOTAL Lp								81
Lw								109

ATTACHMENT G3.2 ROCK BREAKING SOURCE DATA

Table AttG3.2-1 Typical Maximum Vibration Levels from Rock Hammering

Distance from Activity (m)	PPV Vibration Level (mm/s) at Distance (m)					
	5	**10**	**20**	**30**	**40**	**50**
Heavy rock hammer (1.5 t)	4.5	3	1.5	0.4	0.35	0.3
Medium rock hammer (0.6 t)	0.2	0.06	0.02	0.01	-	-

ATTACHMENT G3.3 CONSTRUCTION NOISE PREDICTION SEPARATION DISTANCES

Based on these distance this is where receptors are likely to be exposed to magnitude criteria as a result of the plant included in the assessment for each task, activity or AGI. Many distances are the same due to similar noise emissions and the way in which the works have been modelled to account for worst case and without defined construction plans.

Table AttG3.3-1 Separation Distance for Exceedance of Magnitude Criteria (Construction)

Phase	Activity	Period	Distance at Which Magnitude is Exceeded, m				
			Magnitude 2 (55 (dB(A))	Magnitude 4 (60 (dB(A))	Magnitude 6 (65 (dB(A))	Magnitude 8 (70 (dB(A))	Magnitude 10 (75 (dB(A))
RoW	Clearing and grubbing	Day	100	56	32	18	18
RoW	Camp/site establishment	Day	71	40	22	13	13
RoW	Road construction	Day	100	56	32	18	18
RoW	General earthworks	Day	100	56	32	18	18
RoW	Trenching	Day	100	56	32	18	18
RoW	Pipe laying/ installation	Day	126	71	40	22	22
RoW	Backfilling/ reinstatement	Day	100	56	32	18	18
RoW	Rock breaking	Day	141	79	45	25	25

Appendix G3: Emissions Calculations – Construction

February 2020

CONTENTS

G3 EMISSIONS CALCULATIONS - CONSTRUCTION ... 3-1
G3.1 Purpose and Scope of Report ... 3-1
G3.2 Basis of Emissions Inventory ... 3-1
G3.2.1 Introduction ... 3-1
G3.2.2 Categories ... 3-1
G3.2.3 Category 1: Non-road Equipment on the Pipeline Spread ... 3-2
G3.2.4 Category 2: Road Vehicle Use on the Pipeline Spread ... 3-4
G3.2.5 Category 3: Generators at the Main Camp Pipe Yard ... 3-5
G3.2.6 Category 4: Transport of Workers ... 3-5
G3.2.7 Category 5: Transport of Pipe and Cables ... 3-6
G3.2.8 Category 6: Local Supplies to the MCPY ... 3-7
G3.2.9 Category 7: Transport of Equipment for Pipeline Spread ... 3-7
G3.2.10 Category 8: Transport of Equipment for Establishment of the MCPY ... 3-8
G3.2.11 Category 9: Transport of Murram for Road Upgrades and New Roads ... 3-8
G3.2.12 Results Summaries ... 3-9
G3.3 References ... 3-11
G3.3.1 Literature Cited ... 3-11

TABLES

Table G3.2.1 Construction Emission Source Categories ... 3-2
Table G3.2.2 Activity and Fuel Consumption ... 3-9
Table G3.2.3 Emissions ... 3-10

GLOSSARY AND ACRONYMS

Symbols	
%	percent
C	
CH_4	methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent, a standard unit for measuring greenhouse gas emissions (carbon footprints). The impact of each different greenhouse gas is expressed in terms of the amount of carbon dioxide that would create the same amount of warming. A greenhouse gas emission consisting of different greenhouse gases can be expressed as a single number.
E	
ESIA	environmental and social impact assessment
G	
GHG	greenhouse gas
GWP	global warming potential
M	
m^3	cubic metre
MW	megawatt
N	
N_2O	nitrous oxide
T	
tCO_2e	tonnes of carbon dioxide equivalent

G3 EMISSIONS CALCULATIONS - CONSTRUCTION

G3.1 Purpose and Scope of Report

This report describes the inputs, methods and assumptions used to calculate the predicted emissions to air from the Tilenga feeder pipeline project.

The emissions are estimated only for the construction phase of the project. With the power supply for the Tilenga feeder pipeline coming from the Tilenga central processing facility, emissions from the operational phase will not be significant and have not been estimated.

G3.2 Basis of Emissions Inventory

G3.2.1 Introduction

The emissions for the construction phase are from a diverse range of sources, spread across the project's activities and transient, both geographically and temporally. The emissions are subject to a degree of uncertainty at this stage, before the precise methods, quantities and sources are fully defined by the construction execution plan.

This section summarises the basis of the emissions data presented in Section 8.22.2. It details the methods, data sources and assumptions used.

The basic method is to multiply a quantity of **activity** by an **emission factor** or set of emission factors. The activity is done by a defined **population** of sources (a fleet of vehicles or equipment made up of various types, or a set of stationary sources such as power generators).

Emission factors are available for many types of atmospheric emission in published literature. The primary source used in this study was the Emep[1]/EEA air pollutant emission inventory guidebook 2019 (EEA 2019, internet site), which will be referred to as the EIG from this point.

G3.2.2 Categories

The major construction activities were divided into categories as described in Table G3.2.1.

[1] The co-operative programme for monitoring and evaluation of the long-range transmission of air pollutants in Europe (known as Emep, stemming from the unofficial name of 'European Monitoring and Evaluation Programme')

Table G3.2.1 Construction Emission Source Categories

Category	Description	Type
1	The non-road construction equipment used on the pipeline spread	Non-road
2	The road vehicles used on the pipeline spread	Road
3	The power generators at the main camp/pipe yard (MCPY)	Stationary
4	The transport of workers to and from the camp, and their daily travel to and from the right-of-way (RoW)	Road
5	The transport of pipe and cable materials to the MCPY and on to the ROW	Road
6	The transport of supplies to the MCPY from local sources	Road
7	The transport of the construction equipment and vehicles used for a pipeline spread. This means the mobilisation and demobilisation to and from the sites. The equipment's activity in actually working the spread is captured in categories 1 and 2	Road
8	The transport of the equipment for MCPY construction (except the pipe, which is covered in Category 5)	Road
9	The transport of murram from local sources for new roads and road upgrades	Road

The types of the category define the activity data that is required as an input:

- Road source emission factors are based on the distance travelled by various types of road going vehicle and are in units of grams of emitted substance per kilometre (g/km).
- Non-road emission factors are based on the energy output of the engine, which in turn is based on its power rating (maximum power output), a load factor (what fraction of that maximum power it typically operates at) and the hours of operation of the source type. These emission factors are in grams per kilowatt-hour (g/kWh).
- The stationary emission source factors used in this assessment are based on the energy content of the fuel input. They are US factors and are originally published in units of lb/MMBtu.

The following subsections cover each category in turn and describe the data sources, assumptions and full calculation methodology for the three main input types: source population, activity and emission factors.

G3.2.3 Category 1: Non-road Equipment on the Pipeline Spread

G3.2.3.1 Source Population

The equipment to be used for a pipeline spread is set out in Appendix 3 of the project document 'Volumes and Quantities Estimate' (UT-MID-60-0010-000330, rev 00, 13 September 2017), hereafter "V&Q". This is separated into road vehicles and non-road equipment based on the description. The road vehicles are covered in Category 2.

G3.2.3.2 Emission Factors

The emission and fuel consumption factors and the quantification method used were as per the EIG, part B, chapter 1.A.4 'non road mobile machinery' and specifically the Tier 3 equipment-specific and technology-stratified approach described in section 3.4 of that document.

The equipment was classified into categories according to both the US EPA's MOVES model and table C1 in the EIG chapter and the typical power ratings obtained from a model simulation run in MOVES.

The base emission factors were taken from table 3-6 of the EIG chapter, according to the power ratings. Stage V technologies were assumed for all equipment[2].

The emission factors were adjusted according to equations 5 and 18 in the EIG chapter. The load factor adjustment is 1 for all stage V equipment. To calculate the deterioration factor adjustment according to equation 18, average equipment lifetimes were taken from table C1 and the age of all the items of equipment to be used was assumed to be three years. Deterioration factors were taken from table 3-11 of the EIG chapter.

The adjusted emission factors were multiplied by the activity for each equipment type, derived as described below.

Additional emission factors were added for carbon dioxide and sulphur dioxide based on the calculated fuel consumption and mass balance-based equations as follows:

$CO_2 = FC \times 3.186$

where CO_2 = carbon dioxide emission (tonne), FC = calculated fuel consumption (tonne), 3.186 = emission factor (CO_2/FC) (GHG Protocol 2014, internet site)

$SO_2 = FC \times 50 / 1{,}000{,}000 \times 2$

where SO_2 = sulphur dioxide emission (kg), FC = calculated fuel consumption (kg), 50 = maximum sulphur content of diesel fuel in Uganda in parts per million by weight (UNEP 2018, internet site), 2 = (rounded) mass ratio of SO_2 to sulphur.

The three greenhouse gases, CO_2, methane (CH_4) and nitrous oxide (N_2O), were additionally aggregated into carbon dioxide equivalent (CO_2e). This is done by applying a global warming potential (GWP) to each GHG. The GWPs (100-year time horizon, climate-carbon feedbacks included) used are:

- CO_2: 1
- CH_4: 34
- N_2O: 298

(Myhre et al. 2013)

These methods of CO_2, SO_2 and CO_2e determination apply to all the categories. There are no methane or nitrous oxide factors for Category 3 (camp generators). These GHGs therefore do not contribute to the CO_2e in that category cases. This

[2] Stage V is the latest (2016) set of emissions control technology requirements for non-road mobile machinery as explained in section 2.6 of EIG B1.A.4. It is assumed that all equipment used on the project will be of this standard.

will not cause a material misstatement, as CH_4 and N_2O are not significant relative to CO_2 in GHG emissions from fuel combustion, as shown in other categories.

G3.2.3.3 Activity

Activity for non-road equipment is calculated by

P × LF × H

where P is the power rating (kW), LF is the load factor (dimensionless) and H is the hours of operation over the period of interest.

P was obtained as described in the emission factors section above, LFs were taken from appendix A of the "Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling" (US EPA 2010, internet site) and the hours were assumed to be 10 hours per day (assumed). Further factors for the source population (number of each type of equipment in use) were used to derive the total activity (kWh).

The total duration of construction was estimated to be 150 days.

G3.2.4 Category 2: Road Vehicle Use on the Pipeline Spread

G3.2.4.1 Source Population

See the equivalent part of Section G3.2.3.

G3.2.4.2 Emission Factors

The emission factors and the quantification method used were as per the EIG, part B, chapter 1.A.3.b.i-iv, 'road transport' and specifically the Tier 2 approach described in section 3.3 of that document.

Heavy duty vehicles were classified into weight categories using the unit weights specified in appendix 1 of V&Q, other vehicle categories were assigned using judgement.

The emission and fuel consumption factors were taken from table 3-17 to table 3-27 of the EIG chapter, according to the assigned vehicle type. Euro 6 equivalent emissions performance was assumed for all vehicles. If further delineation was required, the 2017-2019 subcategory was used. The exception is methane, for which there is no Tier 2 factor. The factors from Tier 3 in table 3-48 were used, with rural driving assumed.

The emission factors were multiplied by the activity for each vehicle type, derived as described below.

G3.2.4.3 Activity

Every vehicle in this category was assumed to drive 30 km/day over the 150-day construction period. A further factor for the source population (number of each type of vehicle in use on each spread) was used to derive the total activity (km).

G3.2.5 Category 3: Generators at the Main Camp Pipe Yard

G3.2.5.1 Source Population

Power generation is assumed to be provided by four Aggreko 350-kVA canopy generators at the MCPY, though under no expected (normal operation) scenario are all four operational at the same time. This assumption is consistent with that of the acoustics assessment (Appendix G2, Table G2.2-4).

G3.2.5.2 Emission Factors

The emission factors used are from the US EPA's Compilation of Air Pollutant Emission Factors, AP42 (US EPA 1996, internet site), chapter 3.3, 'Gasoline and Diesel Industrial Engines'. The diesel, fuel-input-based factors from table 3.3-1 are used. The CO_2 and SO_x factors are not used; these emissions are instead calculated from the fuel consumption rate as described in Section G3.2.3.

G3.2.5.3 Activity

The occupation of a camp is split into a main occupied period of 90 days and a 270-day period of lower occupation and less activity.

In the main occupied period, three generators are assumed to operate at full load during the day and one at night (acoustics assessment, Appendix G2, Table G2.2-4). In the lower activity period, one generator is assumed to operate at full load during the day and at half load during the night. The day-night split is 12 hours for each.

The fuel consumption rates per generator are:

- at full load – 62.7 l/h
- at half load – 33.3 l/h.

(Aggreko 2019, internet site)

The fuel input rate is converted from a volumetric basis to an energy basis using the calorific value for diesel of 38.6 MJ/l, and to a mass basis for the CO_2 and SO_2 calculations using a density of 0.846 kg/l (Engineering Toolbox 2019, internet site).

G3.2.6 Category 4: Transport of Workers

G3.2.6.1 Emission Factors

The road vehicle factors as described in Section G3.2.4 were used. For transport by car, the type 'diesel medium' was assumed and for transport by bus, the type 'coaches standard' was assumed.

G3.2.6.2 Source Population and Activity

This category estimated the emissions from three journey types:

- initial mobilisation of workers who will reside in the camp (and their demobilisation)
- daily commuting of more locally based workers between their homes and the camp

- daily transfers between the camp and the RoW.

The number of workers operating from the camp was assumed to be 1000 people, with 785 residing at the camp and 215 commuting locally. Of the commuters, 50% were assumed to travel by car and 50% by bus.

The 785 residents were assumed to all travel to the camp initially by bus, with 30 people per bus (traffic assessment) meaning 785/30 = 26 trips. Each trip was assumed to be 200 km (one way). These buses are assumed to return to their bases once they have transferred the workers. The process is repeated for demobilisation of these workers at the end of the construction period.

Therefore, the activity for this journey type is:

785 people/30 per bus = 26.2 trips × 400 km return journey distance × 2 (mobilisation and demobilisation) = 20,934 km.

The car commuters are assumed to travel 3 people per car on average, 20 km (one way), therefore the activity for this journey type is:

215 commuters × 0.5 fraction by car/3 people per car × 40 km daily return journey distance × 90 days main occupational period = 129,000 km

The equation is the same for the bus commuters except the bus capacity is 30 rather than 3, therefore the distance is 12,900 km

For the daily transfer between the camp and the RoW, 300 people are assumed to make this journey on a daily basis. The same 30-person buses are assumed to make the 30 km (average) one-way journey and return to the camp, then repeat at the end of the working day, i.e., 120 km travelled in total. The total activity is therefore:

300 workers/30 people per bus = 10 buses × 120 km/day × 90 days = 108,000 km.

G3.2.7 Category 5: Transport of Pipe and Cables

G3.2.7.1 Emission Factors

The road vehicle factors as described in Section G3.2.4 were used. The only type of vehicle active in this category was deemed to be the ‘Diesel 16-32 t’ heavy duty vehicle.

Source Population and Activity

All pipe and cable is assumed to come from Tanzania, either from the coating yard or directly from the ports. This inventory is only concerned with the Ugandan parts of the journeys, therefore distances begin at the border.

The number of pipe pieces for the feeder pipeline is 5700 (Section 2.4.2.1).

For the cabling, the trips were calculated from the total weight of cable of 5937 tonnes (traffic assessment) for all six spreads of the EACOP system and Tilenga pipeline. This means that 5937/6 = 989.5 tonnes are delivered to the Tilenga feeder pipeline spread. The trips to the MCPY were then calculated based on a truck capacity of 20 tonnes (as assumed in the ESIA traffic assessment).

The distance from the Tanzanian border to the feeder MCPY was estimated using an internet-based distance calculator; 30 km was added to the one-way distance to include the final delivery from the MCPY to the RoW.

The total activity was then calculated by number of trips (pipe + cables) × one way distance from border to RoW × 2 (for return journey).

G3.2.8 Category 6: Local Supplies to the MCPY

G3.2.8.1 Source Population

The activity in this category is by heavy-duty vehicles delivering fuel and goods from local sources to the MCPY and the spread. Fuel is assumed to be delivered by HDVs in the ‘Diesel 16-24 t’ class, and other goods by ‘Diesel 7.5 – 16 t’ trucks.

G3.2.8.2 Emission Factors

The road vehicle factors as described in Section G3.2.4 were used.

G3.2.8.3 Activity

As with other categories relating to the MCPY, the activity is split into a peak period of three months, when the spread is principally supported from the MCPY and occupation is at its peak, and a nine month-period of lower activity

Fuel deliveries include those for the camp generators and the pipeline spread equipment. Other supplies will include food, general goods and waste collection, but are aggregated for the purposes of this inventory, as they are assumed to be made by the same vehicle type.

The activity schedule is as follows:

Peak period (3 months, per other categories): fuel – 40 trips per month (ESIA traffic assessment); other supplies – 261 supply trips per month (also ESIA traffic assessment, being the sum of 80 ‘MCPY supplies’ and 181 ‘general materials’).

Off-peak period (9 months, per other categories): all deliveries reduced to a quarter of peak period (assumption).

All trips are assumed to be 50 km one way. The return journey is accounted for.

G3.2.9 Category 7: Transport of Equipment for Pipeline Spread

G3.2.9.1 Source Population

The activity in this category is of two types:

- the transport of the non-road construction equipment for the pipeline spread on heavy duty vehicles from overseas via Tanzania
- the mobilisation of the road-going construction equipment for the pipeline spread under its own power from Tanzania.

The construction equipment is that whose actual activity onsite is covered in categories 3 (non-road) and 4 (road-going). This category is concerned with its mobilisation and demobilisation to and from the pipeline spread.

G3.2.9.2 Emission Factors

The road vehicle factors as described in Section G3.2.4 were used. The non-road equipment is deemed to be transported by 'Diesel 16-32 t' heavy duty vehicles. The road going fleet consists of a variety of vehicle types, classified into the EIG categories by their weight or by judgement based on their description, including 150 'Toyota Hilux pickups' per spread, classified as 'light commercial vehicles').

G3.2.9.3 Activity

The total weight of non-road equipment to be transported by HDVs to the spread was calculated using the fleet composition and weights as per category 1, plus the 719 t of 'screw anchors' (data from Appendix 3 of V&Q). The total weight is 3093 t.

Total 3093 t/20 t per truck (ibid) = 155 trips to the start of the Tilenga feeder pipeline spread (505 km to Buliisa) and demobilising from PS1 (425 km).

The road-going vehicle fleet per spread as per Category 2 makes the same journeys under its own power.

G3.2.10 Category 8: Transport of Equipment for Establishment of the MCPY

G3.2.10.1 Emission Factors

The road vehicle factors as described in Section G3.2.4 were used. The only type of vehicle active in this category was deemed to be the 'Diesel 16-32 t' heavy duty vehicle.

G3.2.10.2 Source Population and Activity

The weight to be transported is 3088 t (V&Q, Appendix 3). Truck capacity is 20 t (ibid), therefore 154 trips are required. The distances to the MCPY was calculated as previously described.

Demobilisation activity was estimated at 20% of the mobilisation of the camp equipment, as it is assumed that much of the camp equipment will either be left in place or reused locally.

G3.2.11 Category 9: Transport of Murram for Road Upgrades and New Roads

G3.2.11.1 Emission Factors

The road vehicle factors as described in Section G3.2.4 were used. The only type of vehicle active in this category was deemed to be the 'Diesel 16-32 t' heavy duty vehicle.

G3.2.11.2 Source Population and Activity

There are no new roads to be built for the feeder pipeline, but there are road upgrades at the feeder MCPY. The traffic assessment deemed 300 trips to be required.

Each trip was estimated to be a distance of 50 km (each way) from a relatively local source of murram. The return journey was accounted for.

G3.2.12 Results Summaries

Table G3.2.2 Activity and Fuel Consumption

Category		Activity	Activity Units	Diesel Consumption (Tonne)
Non-road				
1	Non-road equipment on the pipeline spread	67,715	MWh engine output	16,929
3	Generators at the MCPY[1]	2,271	MWh engine output	492
Road				
2	Road vehicle use on the pipeline spread	909,000	km	101
4	Transport of workers	270,833	km	42
5	Transport of pipe and cables	999,475	km	210
6	Local supplies to the MCPY	158,025	km	26
7	Transport of equipment for pipeline spread	475,494	km	81
8	Transport of equipment for establishment of MCPY	174,163	km	37
9	Transport of murram for roads	30,000	km	6
Total (road km only for activity)		3,016,990	km	17,924

NOTE: [1] The power output of the generators at the MCPY (Category 3) was converted from the energy input in the fuel (the actual activity data used in the calculation) for comparison with the other non-road categories using an engine efficiency of 7000 BTU/hp.hr (note a under table 3.3-1, US EPA 1996).

Table G3.2.3 Emissions

Category		Air Pollutants (Tonne)					Greenhouse Gases (Tonne)			
		NOx	NMVOC	CO	PM	SO_2	CO_2	CH_4	N_2O	CO_2e
3	Non-road equipment on the pipeline spread	216.7	8.9	104.8	3.3	1.7	53,935	0.2	2.4	54,648
4	Road vehicle use on the pipeline spread	0.4	0.0	0.1	0.0	0.0	322	0.0	0.0	326
5	Generators at the MCPY	42.6	3.5	9.2	3.0	0.0	1,568	No factor	No factor	1,568
6	Transport of workers	0.1	0.0	0.0	0.0	0.0	134	0.0	0.0	136
7	Transport of pipe and cables	0.4	0.0	0.1	0.0	0.0	669	0.1	0.0	681
9	Local supplies to the MCPY	0.0	0.0	0.0	0.0	0.0	82	0.0	0.0	83
10	Transport of equipment for pipeline spread	0.2	0.0	0.0	0.0	0.0	259	0.0	0.0	263
11	Transport of equipment for establishment of MCPY	0.1	0.0	0.0	0.0	0.0	117	0.0	0.0	119
12	Transport of murram for roads	0.0	0.0	0.0	0.0	0.0	20	0.0	0.0	20
Total		**260.6**	**12.4**	**114.3**	**6.3**	**1.8**	**57,106**	**0.4**	**2.4**	**57,844**

G3.3 References

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