TILENGA PROJECT

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

Volume II

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06 – Air Quality and Climate

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6.1 Introduction

This Environmental and Social Impact Assessment (ESIA) chapter presents an assessment of the atmospheric emissions associated with the Tilenga Project. In particular it includes an appraisal of the potential impacts associated with each of the Project phases which are: Site Preparation and Enabling Works; Construction and Pre-Commissioning; Commissioning and Operations; and Decommissioning.

Impacts on air quality can affect the integrity of the environment and human health, and are therefore an important consideration in the ESIA process.

In order to facilitate the assessment of these potential impacts, this ESIA chapter provides a description of the legislation and policy framework, assessment methodology, baseline conditions at the site and its surroundings, an estimate of the anticipated air emissions associated with each of the Project phases, the mitigation measures required to prevent, reduce, or offset any significant adverse effects, and the likely residual effects after these measures have been employed. The likely potential for cumulative impacts when considered along with other schemes in the surrounding area has also been discussed.

Existing major pollutant sources in the area are scarce, with limited industrial emissions in the area, as well as low vehicle ownership and minimal public transport. The largest towns in these districts are not expected to cause significant air quality impacts from vehicular and/or domestic combustion emissions, however the limited emissions sources in developing economies are generally uncontrolled and often incorporate dated technology. Some agricultural activity, such as tillage or bush burning, which may be undertaken in nearby rural areas, can also be a potential source of dust or other atmospheric emissions that may affect baseline conditions within the Study Area. The Study Area is not considered to be within a degraded airshed, although it is noted that airborne particulate concentrations are elevated, due predominantly to natural sources associated with an arid environment.

There are some existing industrial emissions associated with other oil and gas exploration in the Albertine Rift Region that could impact on the regional air quality in northern and western Uganda. The contribution of these regional sources to pollutant concentrations are accounted for in the baseline data gathered to inform this assessment.

This chapter also presents the estimated greenhouse gas emissions (GHG) associated with the Project, as required by International Finance Corporation (IFC) Performance Standard (PS) 1. These are the atmospheric emissions that have the potential to cause climate change, according to the general scientific community.

In 2007, the Inter-governmental Panel on Climate Change (IPCC) defined climate change as: *"…a change in the state of the climate that can be identified … by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer*". The main cause of climate change is the anthropogenic increase in GHG concentrations in the earth's atmosphere.

6.2 Scoping

The Scoping process identified the potential impacts to air quality and climate that could occur as a result of the Project. These potential impacts are summarised in Table 6-1. It is worth noting that the Project phasing and identified list of potential impacts have evolved during the completion of this ESIA and consequently build and expand on those originally identified in Table 6-1 during the Scoping phase.

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Table 6-1: Potential Air Quality and Climate Impacts identified during Scoping

Potential Impact	Potential Cause	Potential Sensitivity	Phase
Potential for fugitive emissions of particulate matter (dust) from construction / decommissioning phase activities (e.g. demolition and earthworks etc.).	All construction / decommissioning activities undertaken at Central Processing Facility, well pads, Water Abstraction System, pipeline routes and Waste Storage areas including but not limited to quarrying, and movement of material.	Residential and agricultural areas, protected areas including Murchison Falls National Park (MFNP), and other sensitive ecological areas within close proximity to the construction works.	Construction Decommissioning.
Potential for road traffic exhaust emissions (e.g. NOx, PM etc.), including dust.	Vehicle movements during construction / decommissioning (e.g. delivering equipment, moving waste) and operation (e.g. operating personnel).	Residential areas and receptors located close to access roads, sensitive ecological areas close to access roads.	All phases
Potential for atmospheric emissions associated with other Project activities (e.g. generators and flaring).	Power generation, venting and flaring.	Residential areas and agricultural, protected areas including MFNP, and other sensitive ecological areas within close proximity to the well pad sites, Central Processing Facility, and Water Abstraction System.	Operation
Potential for increased greenhouse gas emissions to contribute to climate change.	All construction and operational activities undertaken at Central Processing Facility, well pads, Water Abstraction System, pipeline routes and Waste Storage areas.	n/a	All phases

6.3 Legislative Framework

6.3.1 National Standards

The requirement to set air quality standards for the protection of human health was established within Part VI of The National Environment Act (Cap153, 1995). The draft Air Quality Standards for Uganda (2006 and updated in 2013) (Ref. 6-1) set out ambient air quality standards for specific pollutants. The draft standards are aimed at the protection of human health, and are focused on improving urban air quality. The pollutants that could be of concern to the ESIA for the potential emissions associated with the Project are summarised in Table 6-2. There are no Ugandan air quality standards that relate to the protection of ecological sites. Concentrations are presented in micrograms pollutant per cubic metre of air (µg/m^3).

Table 6-2: Draft National Air Quality Standards

Pollutant	Averaging Period	Standard for Ambient Air
Carbon dioxide (CO_2)	1 hr	63,000 µg/m^{3} * ^
	8 hr	17,300 µg/m^{3} ^ #
Carbon monoxide (CO)	15 mins	100,000 µg/m^{3} #
	30 mins	60,000 µg/m^{3} #
	1 hr	23,000 µg/m^{3} #
	8 hr	11,100 µg/m^{3} *

Pollutant	Averaging Period	Standard for Ambient Air
Hydrocarbons	24 hr	5,000 µg/m^3 *
Hydrogen sulphide (H_2S)	24 hr	15 µg/m^3 #
Nitrogen dioxide (NO_2)	1 hr	200 µg/m^3 #
	1 yr	40 µg/m^3 #
Nitrogen oxides (NO_X)	24 hr	203 µg/m^3 *
Sulphur dioxide (SO_2)	10 min	500 µg/m^3 #
	24 hr	20 µg/m^3 #
Total Suspended Particulate (TSP)	24 hr	300 µg/m^3 *
Soot	24 hr	500 µg/m^3 * #
Volatile Organic Compounds (VOCs)	24 hr	6,000 µg/m^3 * #

* 2006 Draft Air Quality Standards
^ Greenhouse gas pollutant considered in Section 6.9
# 2013 Draft Air Quality Standards

6.3.2 International Standards

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). These General EHS Guidelines are designed to be used together with the relevant Industry Sector EHS Guidelines which provide guidance to users on EHS issues in specific industry sectors. For complex projects, use of multiple industry-sector guidelines may be necessary.

The following IFC Environmental, Health and Safety Guidelines are of relevance to this assessment:

- General EHS Guidelines: Introduction (International Finance Corporation, 2007a) (Ref. 6-2);
- General EHS Guidelines: Environmental – Air Emissions and Ambient Air Quality (International Finance Corporation, 2007b) (Ref. 6-3);
- General EHS Guidelines: Construction and Decommissioning (International Finance Corporation, 2007c) (Ref. 6-4);
- Environmental, Health, and Safety Guidelines: Onshore Oil and Gas Development (International Finance Corporation, 2007d) (Ref. 6-5); and
- Environmental, Health, and Safety Guidelines: Thermal Power Plants (International Finance Corporation, 2008) (Ref. 6-6).

These EHS guidelines include relevant values taken from the World Health Organisation (WHO) Air Quality guidelines (Ref. 6-7) for the assessment of air quality impacts associated with the Project. These are summarised in Table 6-3. In addition to the WHO guidelines, the relevant European Union (EU) air quality limit values are also provided in Table 6-3 (Council of European Communities, 2008) (Ref. 6-8).

Table 6-3: International Ambient Air Quality Criteria

Pollutant	Averaging Period	WHO Guideline Value (µg/m^3 unless stated)	EU Limit Value Value (µg/m^3 unless stated)
Sulphur dioxide (SO_2)	10 minute	500	n/a
	1 hour	-	350 [1]
	24 hour	50 [3]	125 [2]

Pollutant	Averaging Period	WHO Guideline Value (µg/m³ unless stated)	EU Limit Value Value (µg/m³ unless stated)
Nitrogen dioxide (NO_2)	1 hour	200	200 [4]
	Annual	40	40
Particulate matter (PM_{10})	24 hour	50	50 [5]
	Annual	20 [6]	40
Particulate matter ($PM_{2.5}$)	24 hour	25	n/a
	Annual	10 [7]	n/a
Carbon monoxide (CO)	Maximum daily 8 hour running average	n/a	10 mg/m³
Benzene	Annual	n/a	5
Lead	Annual	n/a	0.5
Ozone (O_3)	8 hour daily maximum	100 [8]	n/a

[1] Not to be exceeded more than 24 times in a calendar year [2] Not to be exceeded more than 3 times in a calendar year [3] Guideline limit of 20 µg/m³. Based on Interim Target 2 of 50 µg/m³. Interim Target 1 is 125 µg/m³. [4] Not to be exceeded more than 18 times in a calendar year. [5] Not to be exceeded more than 35 times in a calendar year. [6]. Guideline of 20 µg/m³. Interim Target 1 of 70 µg/m³, Interim Target 2 of 50 µg/m³, Interim Target 3 of 30 µg/m³ [7]. Guideline of 10 µg/m³. Interim Target 1 of 35 µg/m³, Interim Target 2 of 25 µg/m³, Interim Target 3 of 15 µg/m³ [8]. Interim Target 1 of 160 µg/m³

For the protection of ecological sites, reference is made to the air quality standards set by the WHO (2005) for the consideration of effects on ecological habitat. The WHO guidelines (Ref. 6-9) specify Critical Levels and Loads for various habitats. These are listed in Table 6-4. The WHO guidelines do not attempt to specify the importance of any one habitat over another. It is standard practice for air quality impact assessments to focus on sites with particular sensitivity to airborne pollutants and deposition, such as internationally or nationally designated nature conservation sites.

Table 6-4: WHO Air Quality Guidelines and EU Limit Values for the Protection of Ecological Habitat

Pollutant	Averaging Period	WHO Guideline and EU Limit Values (µg/m³)
Sulphur dioxide (SO_2) concentration	Annual mean	10 µg/m³ *
	Annual mean	20 µg/m³ ^
Sulphur (S) acid deposition rate	Annual mean	250 – 1500 eq/ha/yr Ω #
Oxides of nitrogen (NO_X) concentration	Annual mean	30
	Daily mean	75
Nitrogen (N) nutrient nitrogen deposition rate	Annual mean	5 – 35 kg N/ha/yr ¥
Ozone (O_3)	6 month mean	10
	3 month mean	3

* Lichens ^ Forests and natural vegetation Ω Molar equivalent of potential acidity
# The Critical Load range of acid deposition (from SO_2 emissions), depends predominantly on the rate of base cation weathering within the habitat. For terrestrial ecosystems, the weathering rate can be estimated by combining information on soil parent material and texture properties
¥ The Critical Load range of nutrient nitrogen deposition (from NO_X emissions), depends predominantly on the main species within the habitat (e.g. the predominant habitats within the Study Area are grassland, humid forest and wetland).

The relevant EHS guidelines to this assessment do not include international standards for construction dust or operational odour emissions. Instead, this assessment focuses on the reduction of dust and odour emissions through the application of suitable mitigation measures and good site practices, to ensure that impacts do not cause a significant effect to the amenity of nearby dust and odour sensitive receptors.

6.4 Spatial and Temporal Boundaries

Air quality is affected by the levels of pollutants found in the air which if present at sufficient concentrations over a certain period of time have the potential to affect human health and well-being along with sensitive ecological receptors.

The Study Area with respect to air quality is considered to encompass the key elements of the Project footprint having the potential to affect local air quality (i.e. Central Processing Facility (CPF), well pads, water abstraction system, Masindi vehicle check point, construction areas, base camps and roads), with relevant surrounding buffer. International guidance such as that from United Kingdom (UK) Environment Agency (Ref. 6-10) suggests that the impact of permitted point source emissions, such as flares and larger energy generation plant stacks (over 50 Megawatt (MW)), should be considered at ecologically sensitive receptors up to 15 kilometres (km) away from the source, due to such sources generally having a greater level of emissions and the more efficient dispersion of those emissions from taller stacks. Worst case impacts at human health sensitive receptors are likely to occur within a few hundred metres of the source of emissions to air. A 15 km buffer zone for the multiple sources of emissions to air at the CPF is therefore considered, to account for ecological receptors at this distance, in line with the UK guidance, which will also include the worst affected human health sensitive receptors. A 1 km buffer for other Project sites has been considered, where there are fewer emissions sources at each individual site and where these sources are emitted at locations nearer to the ground, resulting in impacts that are closer to the emissions source.

The averaging periods included in the national and international air quality standards as presented within Table 6-3 and Table 6-4 above will be used to ensure impacts are assessed consistently against the relevant air quality standards.

The proposed timescales for the different phases of the Project are set out in ***Chapter 4: Project Description and Alternatives***. A brief summary of the timescales are provided below:

- Site Preparation and Enabling Works Phase expected to take approximately 5 years;
- Construction and Pre-Commissioning is expected to take up to 7 years;
- Commissioning and Operations is expected to commence approximately 36 months after effective date of the main construction contract award. The lifetime of the Project is 25 years; and
- Decommissioning is planned for the end of the 25 year operation.

The duration of activities which may lead to potential air quality impacts differ between short and long term episodes, all of which are included within the assessment.

The ESIA will consider the Project Area of Influence (AoI) (as presented in ***Chapter 1: Introduction***) to account for assessing impacts on air quality from unplanned/accidental events (***Chapter 20: Unplanned Events***), and cumulative impacts (***Chapter 21: Cumulative Impact Assessment***).

6.5 Baseline Methodology

6.5.1 Introduction

Baseline air quality and climatic conditions are established through a review of publically available information and from the undertaking of baseline surveys. There is, however, limited publically available air quality information for Uganda. As such, a baseline monitoring campaign was undertaken in 2014, with supplementary surveys undertaken in 2016 and 2017.

The purpose of air quality survey activities undertaken to date as part of the Environmental Baseline Survey (EBS) (Ref. 6-11) were to collect a representative dataset to provide further understanding of air quality within the Study Area during different seasons of the year. Four field campaigns were undertaken throughout 2014 to cover both wet and dry seasons, within Contract Area 1 (CA-1). The first two campaigns covered the North, South and West Nile areas, while the remaining two campaigns covered only the North and South Nile areas (identified as potential Project areas).

The requirement for additional surveys was defined during a gap analysis exercise and these were undertaken in 2016 and 2017 (referred to as the ESIA survey) to assist in the characterisation of air quality conditions in CA-1 / Exploration Area 1A (EA-1A) and License Area 2 (LA-2).

6.5.2 Data Gap Analysis

A data gap analysis was undertaken during the scoping phase of the Project where available information sources were reviewed to identify any areas for which further data collection would be required in the characterisation of baseline conditions. This data gap analysis highlighted a number of areas for which further data could be obtained including:

- Recent meteorological and climate data for the period mid-2014 to present to assist in descriptions of current climatic conditions;
- Air quality measurements in close proximity to key Project infrastructure to ascertain average concentrations of air quality pollutants; and
- Information on air quality over a number of years to establish trends in air quality.

This information was used when planning for the baseline data collection activities, which are discussed in more detail below. The field campaign was established in November 2016 and continued for eight months, ending in June 2017. This field campaign spanned sections of the dry and wet seasons experienced in Uganda.

6.5.3 Baseline Data Collection Methods

Primary data is that which has been gathered specifically for the Project over the course of several monitoring campaigns, as described below. Secondary data is that which has been gathered from published material.

This section provides details of air quality surveys undertaken within the Study Area, as well as providing data sourced from secondary sources. All of this information has been used to help identify the baseline conditions.

The location of previous air quality monitoring surveys are shown in Figure 6-1, whilst the monitoring locations of the specific ESIA survey are shown in Figure 6-2.

6.5.3.1 Primary Data - 2014 Baseline Surveys

A series of short term air quality measurements, using passive Radiello samplers (NO_2, CO_2, VOC, H_2S and O_3) and portable electronic monitors (NO_2, SO_2, VOC, H_2S, O_3, CO and particulate matter) were undertaken in 2014 at selected areas identified as having relevant sensitive receptor exposure (residential areas, tourist facilities, schools), natural areas (virgin areas, MFNP and Ramsar Site), and areas with existing petroleum activities (field camps, storage areas). The pollutants considered in the survey were those that the construction and/or operation of the Proposed Development could most affect. Air quality measurement locations were spread throughout the Block 1 study area comprising:

- 7 measurement locations across the North Nile area (including virgin areas (Ramsar, MFNP); and built up areas (Tangi Camp, Paraa river crossing));
- 6 measurement locations across the South Nile area (built up areas (Murchison River Lodge, and Wanseko Town Council/Primary school) and petroleum exploration activities (Bugungu Camp, and Ngiri – two well pads)); and
- 5 measurement locations across the West Nile area (virgin areas (Panyimur), built up areas (Panyimur settlement centre, Pakwach Town Council and Police station), and community areas (Panyigoro village)).

Short term monitoring data was gathered over four monitoring campaigns that were undertaken as follows:

- Campaign 1: 5th February 2014 – 12th February 2014;
- Campaign 2: 8th May 2014 – 17th May 2014;

- Campaign 3: 3rd July 2014 – 10th July 2014; and
- Campaign 4: 18th September 2014 – 24th September 2014.

Long-term air quality monitoring recorded in 2014 has been gathered by two static continuous Air Quality (AQ) Mesh monitoring stations (NO_2, SO_2, CO and O_3) installed by Tilenga ESIA team in the North (Pakuba Lodge) and South Nile (Kasinyi village, approximately 1.5 km west from the proposed CPF site) areas, which recorded both ambient air quality and meteorological conditions. Temperature, atmospheric pressure, and relative humidity were recorded.

Figure 6-1 identifies the monitoring locations of this survey, along with the locations of other relevant survey data established from secondary sources.

6.5.3.2 Primary Data - 2016/2017 ESIA Baseline Surveys

The 2016/2017 air quality survey aimed to further establish the baseline air quality environment at locations within and around the Study Area. The ESIA surveys commenced at the identified locations in November 2016 and were completed in June 2017. Measurements were carried out to determine the typical level of pollutant concentrations that are representative of conditions normally experienced at locations within the Study Area. The survey focused on the pollutants that are most sensitive to potential impacts from the Project, at locations that were representative of relevant sensitive exposure. The survey methods were based on established techniques to provide a picture of baseline conditions over a range of averaging periods. Further details are included in Appendix H (Annex 3).

The timescales of the monitoring campaign were:

- Campaign 1: 4th November 2016 to 6th December 2016;
- Campaign 2: 7th December 2016 to 3rd January 2017;
- Campaign 3: 4th January to 1st February 2017;
- Campaign 4: 2nd February to 1st March 2017;
- Campaign 5: 2nd March to 30th March 2017;
- Campaign 6: 31st March to 28th April 2017;
- Campaign 7: 29th April to 30th May 2017; and
- Campaign 8: 31st May to 29th June 2017.

The chosen sampling locations were informed by the findings of a detailed desktop study and data gap analysis as discussed above, which resulted in twelve monitoring locations being selected with reference to key Project infrastructure and nearby air quality sensitive receptors located across the Study Area. The monitoring locations for this air quality survey are shown on Figure 6-2 and can be grouped as follows:

- Three locations in proximity to the CPF and associated construction and base camps;
- Three locations within CA-1/ EA-1A; and
- Six locations in the northern part of LA-2.

Measurements were gathered at a series of locations that are representative of relevant exposure within the Study Area, including residential areas, sections of the MFNP, well sites, the CPF, adjacent to access roads, areas of existing base camp facilities and at ecologically sensitive receptors. There is no national guidance on monitoring of baseline air quality and the survey methods undertaken for the surveys were therefore based on established international techniques for measuring air quality.

The field measurements being undertaken comprised:

- Long term passive monitoring of monthly and representative annual average concentrations of NO_X, NO_2, SO_2, O_3 and VOCs (Benzene), using Palmes diffusion tube devices;

- Short term passive monitoring of 24 hour average concentrations of NO_2, SO_2, and H_2S, using Radiello diffusion tube devices; and
- Short term (15 minute and 1 hour averages) monitoring of particulate matter <10 micrometers (PM_{10}) and <2.5 micrometers ($PM_{2.5}$) and Total Suspended Particulate (TSP) using a portable handheld light scattering device.

All measurements were accompanied by detailed site notes to identify all visible existing emissions to air sources recorded on the Field Data Log and to provide context of the air quality environment at each location.

The Palmes diffusion tubes were setup and then left in situ to monitor monthly mean concentrations of NO_X, NO_2, SO_2, O_3 and VOCs (Benzene). The diffusion tubes required a change of sampling medium approximately every four weeks. By the end of the survey, enough data was gathered to cover the full range of meteorological conditions experienced in the Study Area. Therefore the average of the monthly data gathered is considered to be representative of an annual mean value at each monitoring location.

The Radiello samplers were setup to measure short-term concentrations of NO_2, SO_2 and H_2S (24 hour mean) at the majority of monitoring sites visited on each day of the initial site visit, undertaken in November 2016, and on each day of the second site visit, undertaken in December 2016, to gain a representative indication of baseline conditions for this averaging period.

A non-passive method was used to monitor short-term concentrations of particulate matter (1 hour mean and 15 minute mean), as TSP, PM_{10} and $PM_{2.5}$, using an electronic light-scattering device (Turnkey DustMate). Monitoring was undertaken and field data logs completed at selected locations by staff as part of the monthly regime to change over the passive sampling devices. The data logs contain information describing all pertinent observations for each sample taken during the site visits, including evidence of local emission sources, evidence of windblown dust and wildfire at the time of sampling, and the proximity of the location to relevant exposure.

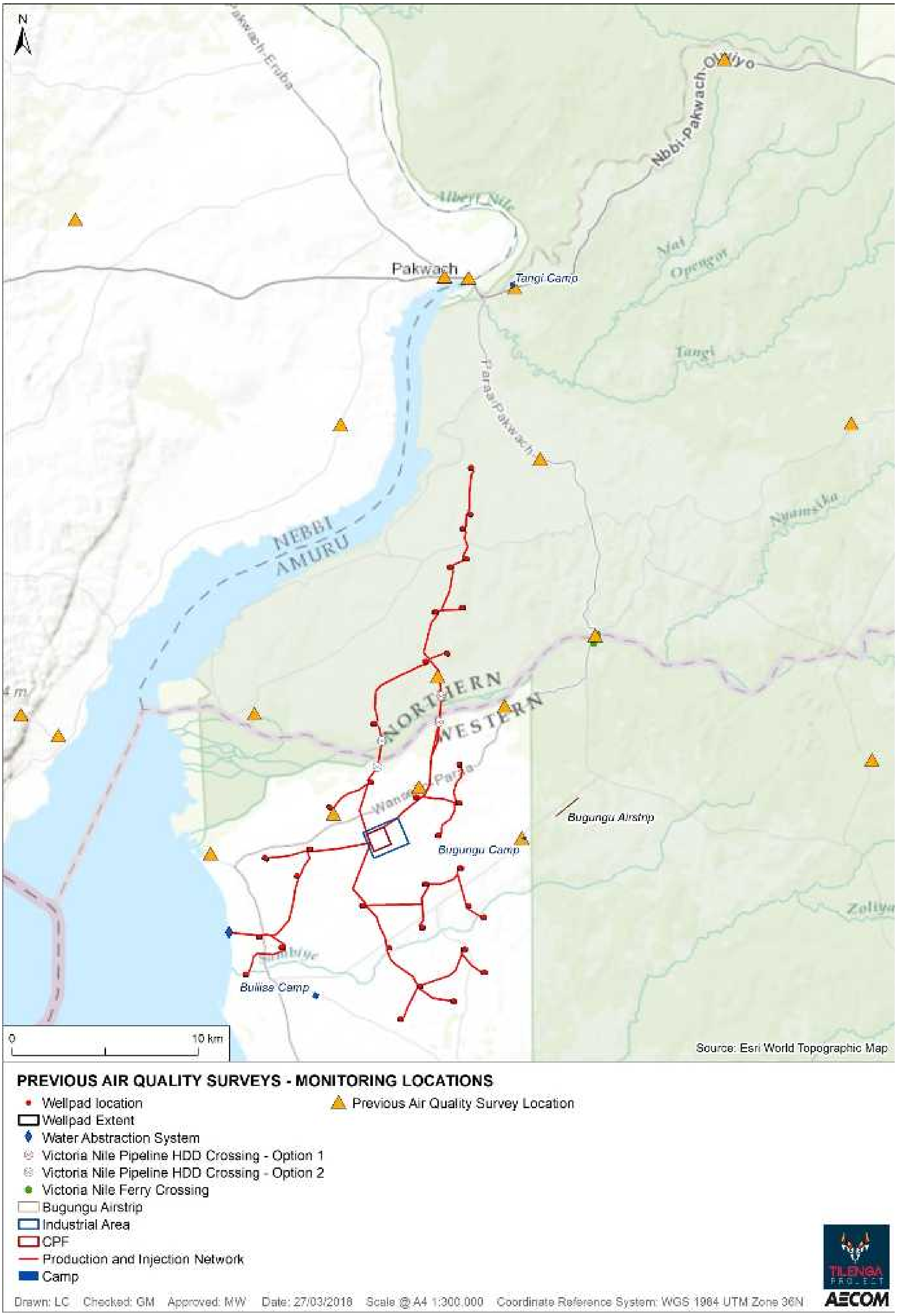

Figure 6-1: 2014 Air Quality Surveys – Monitoring Locations

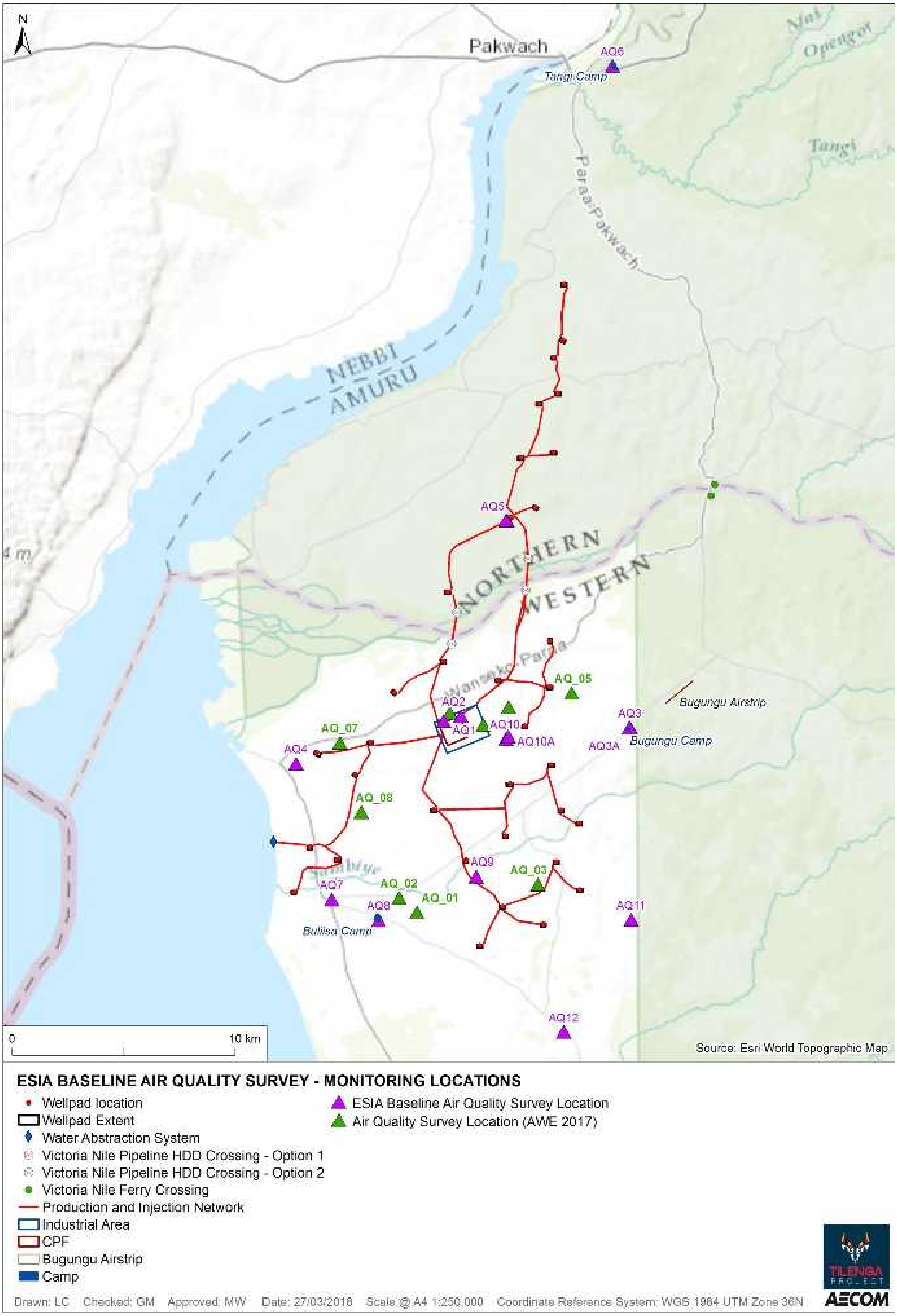

Figure 6-2: 2016/2017 Air Quality Baseline Survey – Monitoring Locations

6.5.3.3 Primary Data - 2017 Early Works Project Brief Baseline Survey

Air Quality field surveys were undertaken by AWE in June 2017 as part of the Early Works Project Brief (PB). During the field surveys, baseline ambient air quality was measured using active sampling methods to monitor short term concentrations of particulates, using a factory-calibrated electronic light-scattering device (Casella Microdust nm880) that can monitor short term concentrations of $PM_{2.5}$, PM_{10} and TSP. Light-scattering devices are not considered to be a reference method for quantifying airborne concentrations of particulate, due to the potential level of error. However, they do provide a useful guide for establishing local conditions.

Measurements of 10 minute average concentrations over an hourly period were undertaken at each monitoring location throughout each day of the survey. Each particulates sampling session lasted 60 minutes. The height of the measuring equipment was between 1 to 3 metres above ground level. All conditions (such as vehicle traffic, human activity, engines running, weather) during measurements were recorded.

The nine chosen measurement stations were placed according to prevailing winds and considering potentially affected households, communities and facilities. The locations can be grouped as follows:

- One location in proximity to the Industrial Area to target potentially sensitive receptors at the Industrial Area fence line;
- Four locations within the southern part of CA-1 (to target potentially sensitive receptors in the vicinity of a potential borrow pit location and the proposed A1 and A4 upgrade road works);
- Four locations in the northern part of LA-2 (to target potentially sensitive receptors in the vicinity of the proposed B1, B2, A2, and A3 upgrade road works).

6.5.3.4 Secondary Data

6.5.3.4.1 Surveyed Pollutant Data

A review has been undertaken of publically available pollutant data referenced in other environmental assessment reports in the vicinity of the Project Area. These data are summarised in Section 6.6.

6.5.3.4.2 Surveyed Climate Data

The data on temperature, precipitation, wind and humidity is available from various weather stations in the vicinity of the Project Area, including those located at Wadelai (north of the Project Area), and Bugoma, Kisinja and Mbegu in the south. The location of these weather stations is shown in Figure 6-3.

For the dispersion modelling assessment, local data have been supplemented with data gathered at Entebbe International Airport, to provide a full year meteorological data as well as multiple years of data for sensitivity analysis. Wind rose plots in Figure 6-6 show the frequency and speed of winds experienced at Entebbe International Airport 2012 and 2016.

6.5.4 Data Assumptions and Limitations

The main assumption associated with the collection of primary data is that data gathered over an eight month period, when averaged, will be representative of long-term conditions (annual mean). This is based on the theory that an eight month monitoring period will contain within it the full range of meteorological conditions (including seasons) typically experienced over a year in this part of Uganda.

It is also assumed that the two months of 24 hour average Radiello monitoring undertaken in the first two months of the survey are representative of typical conditions within the Study Area during any 24 hour period. Short-term concentrations are less susceptible to seasonal variation and measured concentrations are so low that there is little risk of further monitoring confirming any risk of an exceedance of the relevant air quality standards.

The main limitation with the collection of primary data is the error associated with the monitoring methods. Passive monitoring has inherent error, known as bias, which can cause tubes to under or over measure concentrations by as much as 20%. Such error can be caused by practices in the laboratory during tube preparation and analysis, from the change in temperature and pressure during the transport of the tubes from the laboratory and the Study Area and back again and from the conditions the tubes are stored in when not exposed on site.

Regarding the secondary baseline air quality data referred to, this is limited by the methods used in those assessments for monitoring pollutant concentrations.

6.6 Baseline Characteristics

This section draws upon all available information (secondary and primary) to provide an overview of the baseline conditions at the Study Area.

6.6.1 Meteorological and Climatic Conditions

At a regional level, the climate can be characterised as generally hot and humid, with average monthly temperatures varying between 27°C and 31°C. The majority of Uganda experiences a double rainy season. The long rains occur March to June whilst the short rains occur October to November. In the northern regions, within which the Project site exists, the two rainy seasons tend to merge into a single long wet period. The rainy season is eight months long in the North spanning late March to late November, with the main peak in precipitation between August to October and a secondary peak in April/May (Ugandan National Meteorological Authority, 2016)) (Ref. 6-12). The wettest areas are along the shores of Lake Victoria and the western mountain districts which receive over 1,500 millimetres (mm) of rain per year. Parts of central and northeast Uganda are markedly drier receiving less than 1,000 mm of rain per year with some areas experiencing less than 100 mm during extreme years. Temperatures do not display a large seasonal range but diurnal temperature ranges are sufficient to produce cool evenings.

A summary of meteorological data gathered from weather stations located at Bugoma, Kisinja and Mbegu is summarised in Table 6-5.

Table 6-5: Summary of Meteorological Data

Location	Monitoring Period	Parameter				
		Average Wind Speed (m/s)	Average Wind Direction from (º)	Total Precipitation (mm)	Average Temperature (ºC)	Average Humidity (%)
Bugoma	29/05/2014 - 04/02/2015	2.3	172	782	26	71
Kisinja	03/06/2014 - 03/02/2015	1.9	167	705	25	70
Mbegu	28/05/2014 - 05/10/2014	1.2	178	-	-	-

The wind speed and wind direction data for the weather stations and periods described in Table 6-5 is illustrated in Figure 6-6. The windroses demonstrate the predominant south-easterly winds in the region and the infrequency of wind speeds in excess of 3.1 metres per second (m/s).

The analysis of the long term dataset available from the meteorological station of Wadelai confirms that the Study Area receives a mean annual rainfall of approximately 1,000 mm/year and has a bi-modal rainfall pattern.

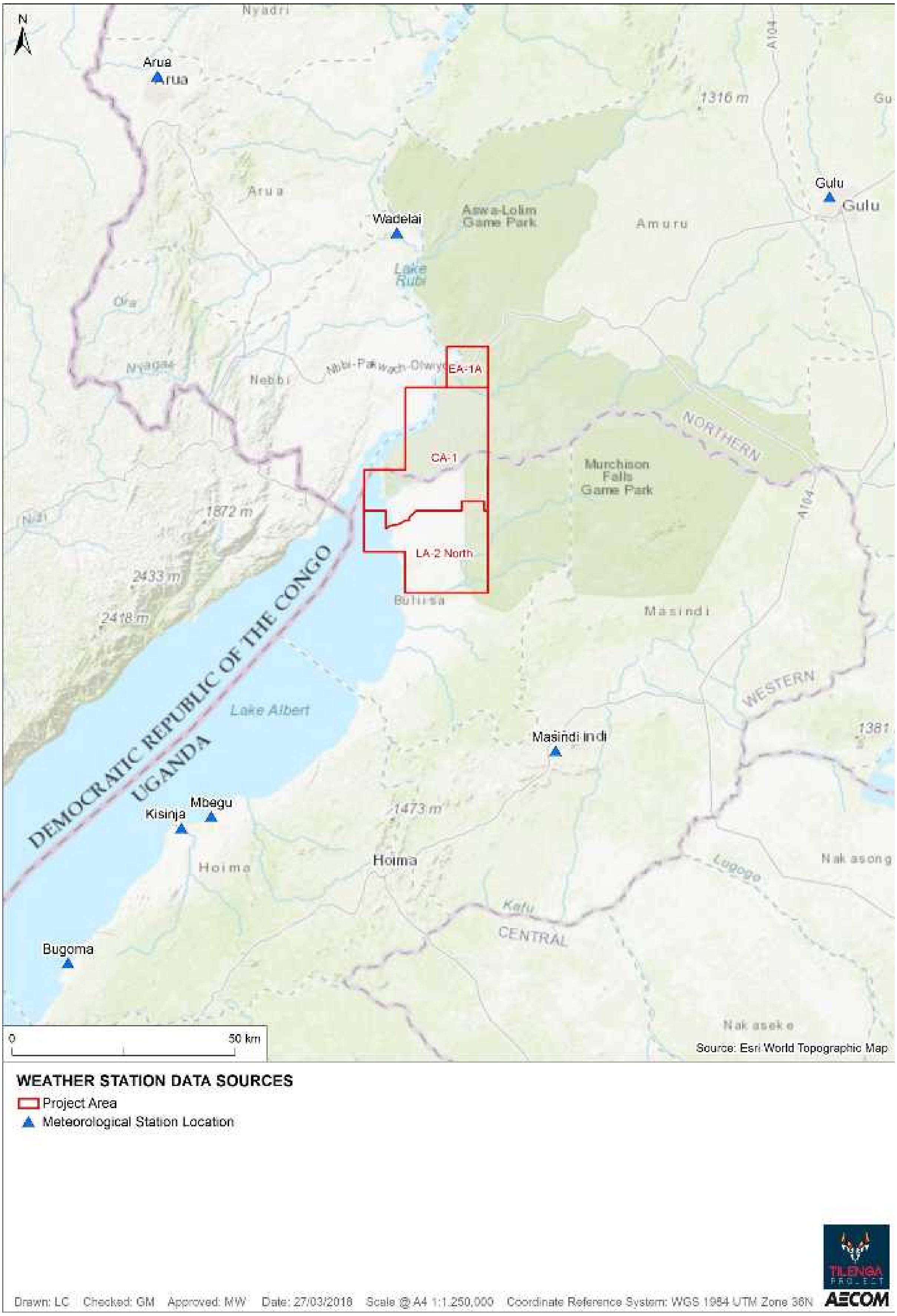

Figure 6-3: Weather Station Data Sources

6.6.2 Baseline Air Quality

6.6.2.1 2014 Primary Data

A summary of the baseline data gathered within the Study Area in 2014 is provided in Table 6-6. The summarised data includes the average concentrations measured and monitored at all sites during the survey. It is noted that the monitoring periods varied at each location for each campaign, with portable monitored samples gathering data for periods ranging from one to four hours, and passive measured samples for periods ranging from 3 to 7 days. Therefore, direct comparison to the national or international standards cannot be made. Whilst the spot measurements cannot be directly compared to the standards because of the averaging periods, they still provide an indication of whether the monitored pollutant is likely to be at risk of exceeding the relevant air quality standard. The data suggests that air quality is generally of a good standard in the area. Elevated levels of particulate matter (dust) were observed during the dry season in the areas surrounding roads or housing infrastructure however this is not unexpected in a dry, hot country. The generally good standard of air quality identified is likely due to the absence of major industrial sources of the air pollutants considered. The primary sources of atmospheric emissions in the area include traffic and the combustion of wood, charcoal and kerosene for domestic needs.

Table 6-6: Summary of 2014 Monitoring Data

Parameter	Unit	Monitoring Campaign				National Air Quality Standard	International Air Quality Standard
		1	2	3	4		
Passive and Portable Monitoring Device Methods – Averaged Across All Sites							
NO_2	µg/m^3	unavailable	3.2	3.0	2.6	-	200 (1h) 40 (year)
SO_2	µg/m^3	unavailable	1.0	2.2	1.5	-	20 (year)
CO	mg/m^3	1.7	1.0	1.0	1.0	9 (24hr)	-
O_3	µg/m^3	unavailable	26.7	22.8	20.8	196 (0.1 ppm) (1h)	-
H_2S	µg/m^3	unavailable	0.4	0.1	0.6	15 (24hr)	-
Total Suspended Particulate	µg/m^3	86.0	12.2	103.9	20.1	300 (24hr)	-
PM_{10}	µg/m^3	64.1	7.8	62.1	13.6	-	50 (24hr) 20 (year)
$PM_{2.5}$	µg/m^3	8.6	0.7	4.5	2.0	-	25 (24hr) 10 (year)
VOC	µg/m^3	-	9.6	18.7	21.7	6,000 (24hr)	-
Benzene	µg/m^3	-	0.7	0.5	0.9	-	5 (year)
AQ Mesh Monitoring Device Methods – Averaged Across Both Sites							
NO_2	µg/m^3	6.7				-	200 (1h) 40 (year)
SO_2	µg/m^3	0.6				-	20 (year)
CO	mg/m^3	0.1				9 (24hr)	
O_3	µg/m^3	36.1				196 (0.1 ppm) (1h)	

To increase the spatial coverage of data collection, including at locations of new Project elements that were unknown during the 2014 survey, further primary data was collected during the 2016/17 monitoring campaign.

6.6.2.2 2016/2017 Primary Data

The period mean concentrations measured are provided in Table 6-7 to Table 6-14 and summarised in Table 6-15. The results of the sampling analysis indicate that long-term (annual mean) concentrations of NO_X, NO_2, and SO_2 are well below their respective air quality standard values (30 µg/m^3 (ecological), 40 µg/m^3 (human health) and 10 µg/m^3 (ecological) respectively), and typical of an unindustrialised area. Monitored long-term PM_{10} concentrations (represented as half of the 1 hour average PM_{10} measurement data gathered) are in exceedance of the air quality standard value for this pollutant (20 µg/m^3 (human health)). Long-term $PM_{2.5}$ concentrations (represented as half of the 1 hour average $PM_{2.5}$ measurement data gathered) are within 25% of the air quality standard value for this pollutant (10 µg/m^3 (human health)). Elevated concentrations of PM_{10} (and to a lesser extent, $PM_{2.5}$) are likely due to the often arid conditions experienced within the Study Area during the drier months.

Medium-term (6 month and 3 month mean concentrations) of O_3 appear likely to be at risk of exceeding the ecological air quality standards for that pollutant (10 µg/m^3 (ecological) and 3 µg/m^3 (ecological) respectively), with average concentrations of around 67 µg/m^3 over the eight month survey period. Again, this is typical of unindustrialised and unurbanised areas, where there are limited existing sources of NO_X emissions to react with and diminish O_3 levels. It should be noted that the Project will not have notable emissions of O_3 during any phase.

The monitoring of short-term pollutant concentrations (24 hour averaging periods or less) identified no existing risk of exceeding the air quality standard values for NO_X (75 µg/m^3 as a 24 hour average (ecological)), NO_2 (200 µg/m^3 as a 1 hour average (human health)), SO_2 (500 µg/m^3 as a 10 minute average (human health), 350 µg/m^3 as a 1 hour average (human health) and 50 µg/m^3 as a 24 hour average (human health)), H_2S (15 µg/m^3 as a 24 hour average (human health)), $PM_{2.5}$ (25 µg/m^3 as a 24 hour average (human health)) and VOCs/Hydrocarbons (6,000 / 5,000 µg/m^3 as 24 hour average (human health)). 24 hour mean concentrations of PM_{10} (represented as three-quarters of the 1 hour average PM_{10} measurement data gathered) are within 10% of the air quality standard value (50 µg/m^3). Elevated PM_{10} concentrations are again likely due to the often arid conditions experienced within the Study Area during the drier months.

Table 6-7: Summary of Survey Data Gathered on Month 1 November 2016 (Wet Season)

Monitoring Site (See Figure 6-2)	Period Mean Pollutant Concentrations													
	Monthly Mean (µg/m³)					24 Hour Mean (µg/m³)			1 Hour Mean (µg/m³)			15 Minute Mean (µg/m³)		
	NO_x	NO_2	SO_2	O_3	VOC	NO_2	SO_2	H_2S	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
AQ1	4.3	2.1	1.0	55.0	1.0	4.1	1.4	0.8	n/a	n/a	n/a	n/a	n/a	n/a
AQ2	2.7	1.4	0.8	58.3	0.5	3.8	1.6	0.7	n/a	n/a	n/a	n/a	n/a	n/a
AQ3	3.4	2.2	0.7	79.8	0.6	5.1	1.6	1.1	41.7	21.8	3.1	62.4	34.5	3.2
AQ4	6.0	3.5	0.8	50.8	0.6	4.4	1.9	1.0	n/a	n/a	n/a	22.0	12.2	4.0
AQ5	n/a	n/a	n/a	n/a	n/a	3.8	1.9	1.0	20.1	11.2	3.7	25.5	13.0	4.0
AQ6	5.3	4.1	1.0	62.9	0.7	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
AQ7	6.3	2.0	0.9	42.1	2.5	5.1	1.3	0.7	45.7	22.2	5.3	n/a	n/a	n/a
AQ8	5.7	3.6	0.7	70.8	0.5	5.6	1.4	0.8	n/a	n/a	n/a	38.4	19.7	4.8
AQ9	4.1	2.5	0.7	49.0	0.5	4.9	2.8	0.7	n/a	n/a	n/a	24.6	12.4	4.1
AQ10	4.5	3.8	0.7	41.6	0.9	6.2	1.5	0.9	n/a	n/a	n/a	n/a	n/a	n/a
AQ11	4.5	2.6	0.8	42.6	0.7	5.1	1.5	0.8	n/a	n/a	n/a	50.5	21.7	5.7
AQ12	5.6	2.7	0.8	37.5	0.6	5.2	1.4	0.7	n/a	n/a	n/a	36.0	23.0	9.4

Table 6-8: Summary of Survey Data Gathered on Month 2 – December 2016 (Dry Season)

Monitoring Site (See Figure 6-2)	Period Mean Pollutant Concentrations													
	Monthly Mean (µg/m³)					24 Hour Mean (µg/m³)			1 Hour Mean (µg/m³)			15 Minute Mean (µg/m³)		
	NO_x	NO_2	SO_2	O_3	VOC	NO_2	SO_2	H_2S	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
AQ1	7.1	4.8	0.9	73.2	1.2	6.1	1.3	0.7	n/a	n/a	n/a	62	26.9	5.12
AQ2	7.3	4.7	1.2	84.5	1.0	4.7	1.6	0.6	n/a	n/a	n/a	39.1	22.2	5.6
AQ3	9.0	6.9	0.9	88.4	1.0	5.7	1.5	1.2	n/a	n/a	n/a	57.5	27.2	5.46
AQ4	8.3	5.6	3.0	81.3	1.2	4.3	1.1	0.8	n/a	n/a	n/a	81.3	39.4	11.73
AQ5a*	15.1	7.7	0.8	86.7	1.1	5.3	1.0	0.5	n/a	n/a	n/a	94.6	32	6.48
AQ6	10.5	11.9	1.3	83.3	1.5	n/a	n/a	n/a	n/a	n/a	n/a	43.8	23.7	7.67
AQ7	7.5	7.1	1.8	73.6	1.5	4.6	1.3	0.5	n/a	n/a	n/a	119.1	55.3	11.68
AQ8	9.9	7.8	1.0	91.4	1.3	6.0	1.2	0.7	67.5	34.9	8.2	55	31.7	7.61
AQ9	9.2	7.4	0.9	74.0	1.4	7.9	2.4	0.7	n/a	n/a	n/a	47	25.1	7.26
AQ10	8.3	7.4	2.8	74.7	1.2	5.5	1.0	0.5	n/a	n/a	n/a	118.6	58	8.7
AQ11	10.6	8.0	1.0	70.6	1.1	5.4	1.9	0.8	n/a	n/a	n/a	434.2	292.2	9.32
AQ12	11.2	7.3	0.9	60.2	1.6	4.8	1.0	0.7	n/a	n/a	n/a	67.2	30.3	7.72

* AQ5 was relocated due to interference with the site in November and the new location was named AQ5a from December onwards

Table 6-9: Summary of Survey Data Gathered on Month 3 – January 2017 (Dry Season)

Monitoring Site (See Figure 6-2)	Period Mean Pollutant Concentrations													
	Monthly Mean (µg/m³)					24 Hour Mean (µg/m³)			1 Hour Mean (µg/m³)			15 Minute Mean (µg/m³)		
	NO_x	NO_2	SO_2	O_3	VOC	NO_2	SO_2	H_2S	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
AQ1	11.7	9.0	1.4	75.3	3.6	n/a	n/a	n/a	n/a	n/a	n/a	138.4	72.9	15.7
AQ2	8.6	7.5	1.5	92.9	8.0	n/a	n/a	n/a	134.1	78.4	12.5	n/a	n/a	n/a
AQ3	10.5	9.1	1.8	96.4	6.3	n/a	n/a	n/a	156.5	83.9	22.6	n/a	n/a	n/a
AQ4	11.1	8.0	1.3	85.5	1.6	n/a	n/a	n/a	227.5	133.4	25.9	n/a	n/a	n/a
AQ5a	5.0	9.6	1.8	78.2	3.5	n/a	n/a	n/a	108.2	40.8	7.2	n/a	n/a	n/a
AQ6	11.2	10.7	1.8	82.1	1.6	n/a	n/a	n/a	n/a	n/a	n/a	204.4	62.3	4.9
AQ7	n/a	n/a	n/a	71.7	n/a	n/a	n/a	n/a	n/a	n/a	n/a	98.2	48.8	7.5
AQ8	11.1	9.3	1.4	102.7	6.6	n/a	n/a	n/a	n/a	n/a	n/a	144.3	74.2	13.8
AQ9	11.4	7.9	1.5	78.8	2.3	n/a	n/a	n/a	119.7	14.0	14.0	n/a	n/a	n/a
AQ10	11.9	7.4	1.2	76.1	8.6	n/a	n/a	n/a	159.6	18.8	18.8	n/a	n/a	n/a
AQ11	11.7	8.8	1.4	78.2	2.2	n/a	n/a	n/a	224.0	11.6	11.6	n/a	n/a	n/a
AQ12	15.0	9.9	1.0	70.3	1.8	n/a	n/a	n/a	146.9	14.2	14.2	n/a	n/a	n/a

Table 6-10: Summary of Survey Data Gathered on Month 4 – February 2017 (Dry Season)

Monitoring Site (See Figure 6-2)	Period Mean Pollutant Concentrations													
	Monthly Mean (µg/m³)					24 Hour Mean (µg/m³)			1 Hour Mean (µg/m³)			15 Minute Mean (µg/m³)		
	NO_x	NO_2	SO_2	O_3	VOC	NO_2	SO_2	H_2S	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
AQ1	10.9	8.9	1.1	86.7	3.0	n/a	n/a	n/a	602.9	390.4	77.0	n/a	n/a	n/a
AQ2	10.3	6.3	1.3	86.5	18.1	n/a	n/a	n/a	415.3	251.0	48.0	n/a	n/a	n/a
AQ3	10.7	6.8	1.3	98.3	12.1	n/a	n/a	n/a	741.3	465.6	86.5	n/a	n/a	n/a
AQ4	12.5	6.2	1.1	77.3	11.3	n/a	n/a	n/a	152.8	76.6	13.3	n/a	n/a	n/a
AQ5a	12.5	6.6	1.1	72.7	4.2	n/a	n/a	n/a	155.6	96.1	26.4	n/a	n/a	n/a
AQ6	11.0	8.1	1.1	94.1	1.8	n/a	n/a	n/a	153.3	93.4	22.5	n/a	n/a	n/a
AQ7	11.4	7.8	1.1	65.0	7.9	n/a	n/a	n/a	311.6	188.7	33.8	188.9	113.7	20.5
AQ8	10.8	8.0	6.7	89.6	6.7	n/a	n/a	n/a	160.9	81.3	15.6	n/a	n/a	n/a
AQ9	11.6	6.8	1.1	72.9	14.5	n/a	n/a	n/a	271.3	162.0	30.7	n/a	n/a	n/a
AQ10	10.0	6.2	n/a	n/a	11.0	n/a	n/a	n/a	258.1	157.0	31.4	n/a	n/a	n/a
AQ11	12.5	7.2	1.0	77.9	19.3	n/a	n/a	n/a	425.7	196.2	19.3	n/a	n/a	n/a
AQ12	11.5	7.8	1.0	64.7	6.4	n/a	n/a	n/a	254.9	111.5	24.3	n/a	n/a	n/a

Table 6-11: Summary of Survey Data Gathered on Month 5 – March 2017 (Wet Season)

Monitoring Site (See Figure 6-2)	Period Mean Pollutant Concentrations													
	Monthly Mean (µg/m³)					24 Hour Mean (µg/m³)			1 Hour Mean (µg/m³)?			15 Minute Mean (µg/m³)		
	NO_X	NO_2	SO_2	O_3	VOC	NO_2	SO_2	H_2S	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
AQ1	9.5	7.0	1.1	73.1	0.8	n/a	n/a	n/a	45.8	27.8	10.2	n/a	n/a	n/a
AQ2	11.2	6.5	1.1	67.9	15.1	n/a	n/a	n/a	52.8	28.6	9.5	n/a	n/a	n/a
AQ3	7.4	5.8	1.1	83.2	0.7	n/a	n/a	n/a	n/a	n/a	n/a	36.2	23.0	7.7
AQ4	7.9	7.5	1.1	66.6	6.9	n/a	n/a	n/a	35.5	21.8	7.5	n/a	n/a	n/a
AQ5a	7.0	5.7	1.1	63.6	5.2	n/a	n/a	n/a	n/a	n/a	n/a	39.8	18.7	5.7
AQ6	6.8	8.0	1.5	76.4	1.3	n/a	n/a	n/a	n/a	n/a	n/a	28.4	16.9	6.0
AQ7	9.5	7.8	1.1	55.4	0.6	n/a	n/a	n/a	52.8	34.3	9.9	n/a	n/a	n/a
AQ8	10.7	11.6	1.1	78.3	2.2	n/a	n/a	n/a	34.0	20.5	7.4	n/a	n/a	n/a
AQ9	10.7	7.5	1.1	63.4	4.8	n/a	n/a	n/a	n/a	n/a	n/a	34.6	21.7	7.4
AQ10	6.0	n/a	1.1	n/a	n/a	n/a	n/a	n/a	29.8	19.2	7.1	n/a	n/a	n/a
AQ11	9.4	6.6	1.1	59.7	0.6	n/a	n/a	n/a	145.1	64.3	7.2	n/a	n/a	n/a
AQ12	10.1	6.9	1.1	57.3	5.4	n/a	n/a	n/a	48.3	24.5	7.1	n/a	n/a	n/a

Table 6-12: Summary of Survey Data Gathered on Month 6 – April 2017 (Wet Season)

Monitoring Site (See Figure 6-2)	Period Mean Pollutant Concentrations													
	Monthly Mean (µg/m³)					24 Hour Mean (µg/m³)			1 Hour Mean (µg/m³)			15 Minute Mean (µg/m³)		
	NO_X	NO_2	SO_2	O_3	VOC	NO_2	SO_2	H_2S	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
AQ1	9.0	5.4	0.9	69.7	3.0	n/a	n/a	n/a	22.0	13.4	4.0	n/a	n/a	n/a
AQ2	8.7	5.2	0.9	79.4	87**	n/a	n/a	n/a	31.2	16.5	3.4	n/a	n/a	n/a
AQ3	8.2	5.7	0.9	80.9	6.3	n/a	n/a	n/a	n/a	n/a	n/a	73.2	31.1	7.2
AQ4	10.0	7.4	0.9	64.7	22.2	n/a	n/a	n/a	28.8	17.5	3.9	n/a	n/a	n/a
AQ5a	6.7	4.7	0.0	42.9	1.9	n/a	n/a	n/a	n/a	n/a	n/a	37.0	17.4	3.5
AQ6	9.2	7.7	0.9	94.8	65**	n/a	n/a	n/a	40.6	22.5	5.1	n/a	n/a	n/a
AQ7	10.0	6.0	0.9	54.2	3.8	n/a	n/a	n/a	n/a	n/a	n/a	25.9	16.3	4.5
AQ8	8.5	8.4	3.1	78.5	4.9	n/a	n/a	n/a	14.2	9.2	3.2	n/a	n/a	n/a
AQ9	9.5	5.9	0.9	71.5	41**	n/a	n/a	n/a	21.1	12.3	3.1	n/a	n/a	n/a
AQ10	6.4	4.3	8.0	56.4	1.9	n/a	n/a	n/a	n/a	n/a	n/a	24.5	15.6	4.5
AQ11	7.0	4.4	0.9	63.5	6.2	n/a	n/a	n/a	46.9	24.3	5.5	n/a	n/a	n/a
AQ12	7.6	5.4	0.9	60.9	11.8	n/a	n/a	n/a	67.2	38.9	7.1	n/a	n/a	n/a

** Tubes were received with a cap off. Results may be compromised.

Table 6-13: Summary of Survey Data Gathered on Month 7 – May 2017 (Wet Season)

Monitoring Site (See Figure 6-2)	Period Mean Pollutant Concentrations													
	Monthly Mean (µg/m³)					24 Hour Mean (µg/m³)			1 Hour Mean (µg/m³)			15 Minute Mean (µg/m³)		
	NO_X	NO_2	SO_2	O_3	VOC	NO_2	SO_2	H_2S	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
AQ1	7.0	3.3	0.9	47.7	3.2	n/a	n/a	n/a	16.6	8.5	2.1	n/a	n/a	n/a
AQ2	4.7	3.2	1.1	49.7	11.8	n/a	n/a	n/a	30.8	14.3	2.8	n/a	n/a	n/a
AQ3a*	7.3	4.6	1.6	57.3	2.4	n/a	n/a	n/a	n/a	n/a	n/a	49.0	27.0	13.1
AQ4	5.7	3.7	1.1	39.0	1.0	n/a	n/a	n/a	n/a	n/a	n/a	22.8	10.6	2.1
AQ5a	n/a	2.8	1.9	46.3	1.4	n/a	n/a	n/a	n/a	n/a	n/a	11.6	6.7	2.3
AQ6	6.7	4.9	1.1	60.5	2.0	n/a	n/a	n/a	n/a	n/a	n/a	11.0	6.1	2.0
AQ7	8.0	5.2	1.1	42.6	3.2	n/a	n/a	n/a	33.9	17.6	2.6	n/a	n/a	n/a
AQ8	6.1	8.2	1.1	42.6	0.7	n/a	n/a	n/a	n/a	n/a	n/a	12.2	5.9	1.7
AQ9	7.6	6.2	1.1	45.0	0.7	n/a	n/a	n/a	n/a	n/a	n/a	11.4	5.6	1.4
AQ10	6.0	5.9	1.1	41.8	1.7	n/a	n/a	n/a	n/a	n/a	n/a	39.9	17.2	2.1
AQ11	7.7	4.9	1.1	34.8	6.5	n/a	n/a	n/a	27.6	12.8	1.6	n/a	n/a	n/a
AQ12	10.5	6.0	1.1	42.4	1.1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

* AQ3 was relocated due to works at Bugungu camp in April and the new location was named AQ3a from May onwards

Table 6-14: Summary of Survey Data Gathered on Month 8 – June 2017 (Dry Season)

Monitoring Site (See Figure 6-2)	Period Mean Pollutant Concentrations													
	Monthly Mean (µg/m³)					24 Hour Mean (µg/m³)			1 Hour Mean (µg/m³)			15 Minute Mean (µg/m³)		
	NO_X	NO_2	SO_2	O_3	VOC	NO_2	SO_2	H_2S	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
AQ1	6.4	2.8	1.5	57.4	0.5	n/a	n/a	n/a	37.3	19.6	4.9	n/a	n/a	n/a
AQ2	5.7	3.8	1.5	63.0	4.5	n/a	n/a	n/a	37.3	17.6	4.5	n/a	n/a	n/a
AQ3a	7.3	4.6	1.5	67.9	0.6	n/a	n/a	n/a	n/a	n/a	n/a	42.6	28.4	3.2
AQ4	8.1	5.6	1.5	58.2	0.7	n/a	n/a	n/a	n/a	n/a	n/a	28.2	13.7	4.1
AQ5a	6.2	4.3	1.5	54.5	1.0	n/a	n/a	n/a	n/a	n/a	n/a	47.4	19.2	3.5
AQ6	7.3	6.0	1.5	57.3	0.5	n/a	n/a	n/a	21.4	11.5	3.0	n/a	n/a	n/a
AQ7	8.1	6.3	1.5	49.5	0.4	n/a	n/a	n/a	17.6	9.0	2.8	n/a	n/a	n/a
AQ8	8.2	7.3	1.5	57.8	0.7	n/a	n/a	n/a	n/a	n/a	n/a	28.4	14.6	4.1
AQ9	2.9	3.2	1.5	58.1	0.9	n/a	n/a	n/a	n/a	n/a	n/a	63.6	32.1	3.0
AQ10a*	16.1	3.1	1.5	63.2	0.9	n/a	n/a	n/a	n/a	n/a	n/a	57.7	23.2	4.5
AQ11	6.3	2.8	1.5	49.1	0.5	n/a	n/a	n/a	72.4	29.1	3.8	72.4	29.1	3.8
AQ12	7.0	5.1	1.5	47.7	1.4	n/a	n/a	n/a	28.0	12.6	2.6	n/a	n/a	n/a

*AQ10 was relocated at the request of the community residents at the end of April and the new location was named AQ10a from May onwards

Table 6-15: Summary of 2016/2017 Survey Data Gathered (Survey Average)

Monitoring Site (See Figure 6-2)	Period Mean Pollutant Concentrations													
	Monthly Mean Average (µg/m³)					24 Hour Mean Average (µg/m³)			1 Hour Mean Average (µg/m³)			15 Minute Mean Average (µg/m³)		
	NO_x[1,2]	NO_2[1,3]	SO_2[1,4]	O_3[5]	VOC[1,6]	NO_2	SO_2	H_2S	TSP	PM_{10}[7,8]	$PM_{2.5}$[9,10]	TSP	PM_{10}	$PM_{2.5}$
AQ1	8.2	5.4	1.1	67.3	3.8	5.1	1.4	0.8	144.9	91.9	19.6	100.2	49.9	10.4
AQ2	7.4	4.8	1.2	72.8	8.6	4.3	1.6	0.7	116.9	67.7	13.5	39.1	22.2	5.6
AQ3	8.0	5.7	1.2	81.5	4.1	5.4	1.5	1.2	313.2	190.4	37.4	53.5	28.5	6.7
AQ4	8.7	5.9	1.3	65.4	5.8	4.4	1.5	0.9	111.2	62.3	12.7	38.6	19.0	5.5
AQ5	8.7	5.9	1.2	63.6	2.6	4.6	1.5	0.8	94.6	49.4	12.4	42.7	17.8	4.3
AQ6	8.5	7.7	1.3	76.4	3.7	n/a	n/a	n/a	71.8	42.5	10.2	71.9	27.3	5.2
AQ7	8.7	6.0	1.2	56.7	52.4	4.9	1.3	0.6	92.3	54.4	10.9	108.0	58.5	11.1
AQ8	8.9	8.0	2.1	76.5	3.0	5.8	1.3	0.8	69.2	36.5	8.6	55.7	29.2	6.4
AQ9	8.4	5.9	1.1	64.1	3.6	6.4	2.6	0.7	137.4	62.8	15.9	36.2	19.4	4.6
AQ10	8.7	5.5	2.3	59.0	3.9	5.9	1.3	0.7	149.2	65.0	19.1	60.2	28.5	5.0
AQ11	8.7	5.7	1.1	59.5	4.7	5.3	1.7	0.8	157.0	56.4	8.2	185.7	114.3	6.3
AQ12	9.8	6.4	1.0	55.1	4.0	5.0	1.2	0.7	109.1	40.3	11.1	51.6	26.7	8.6
Average	8.6	6.1	1.3	66.5	8.3	5.2	1.5	0.8	130.5	68.3	15.0	70.3	36.8	6.6

6.6.2.3 2017 Primary Data - 2017 Early Works PB Baseline Survey

At all nine locations where air quality monitoring was conducted, TSP levels conformed to the Draft National Air Quality Standard of 300 µg/m³.

At all nine locations where air quality monitoring was conducted, $PM_{2.5}$ measurements were above the IFC / WHO guideline of 25 micrograms per cubic metre (µg/m³). At five of the nine locations at which air quality monitoring was conducted, PM_{10} measurements were above the IFC/WHO guideline of 50 µg/m³. These guideline exceedances could be attributed to the loose nature of the soils in the Study Area and the survey being completed during a dry season, the winds blowing from the eastern direction during the survey, and the proximity of measurement locations to the roads with presence of vehicular traffic.

A copy of the Executive Summary of the Early Work PB is located in Appendix C.

6.6.2.4 Secondary Data

There is limited existing baseline air quality data available in Uganda, with no national monitoring programme being undertaken by the Government. Available data is limited to that described within existing ESIA reports for projects proposed or completed in the country, although the description on the methods on data collection is limited.

One such example is the Ugandan Ministry of Energy and Mineral Development (MEMD) ESIA (Ref.6-13) for the Isimba 132 Kilovolt (kV) Power Transmission Line Substation in 2012, which describes the monitoring of TSP at locations in that study area. A statistical summary of the data gathered during that survey is provided in Table 6-16. Data were gathered over 5 minute average periods at various locations in that study, although the method and locations of the monitoring was not specified.

Table 6-16: Summary of Measured TSP Concentrations – Isimba 132 kV Power Transmission Line Substation ESIA (2012)

Average 5 Minute Mean Pollutant Concentrations (µg/m³)	
Statistic	**TSP Concentration (µg/m³)**
Minimum	45
Maximum	97
Average	79

It is not possible to directly compare the TSP data gathered to establish the baseline for the Isimba 132 kV Power Transmission Line Substation baseline with the relevant air quality standards discussed, due to the difference in averaging periods. However, the concentrations monitored over the 39 individual five minute average data set gathered suggest that the 24 hour mean draft Ugandan air quality standard of 300 µg/m³ was unlikely to have been exceeded on the day of sampling.

ESIAs have also been undertaken for hydropower projects on the Kyoga Nile, within the MFNP. Two of these, Ayago and Karuma, are located in close proximity to the Study Area for the Project.

Baseline air quality reported within the ESIA for the Ayago Hydropower Project (Ref. 6-14) was based on 15 minute mean monitoring data gathered at numerous locations near to that project site and adjacent to existing roads that lead to it. The average 15 minute mean concentrations monitored over the baseline survey period for that project are provided in Table 6-17. Data was gathered over 15 minute average periods using a CASELLA Microdust meter, at various locations in that study, periodically over a weekly period in October 2012, January 2013, and June 2013.

Table 6-17: Summary of Monitoring Data – Ayago Hydropower Project (2013)

Average 15 Minute Mean Pollutant Concentrations (parts per million (ppm))			
Particles (µg/m³)	Sulphur dioxide	Nitrogen dioxide	Carbon monoxide
48.2	<0.1 (<282 µg/m³)	0.1 (203 µg/m³)	0.7 (<0.863 mg/m³)

Baseline air quality reported within the ESIA for the Karuma Hydropower Project 4 (Energy Infratech Private Limited, 2011) (Ref. 6-15) was based on monitoring data that was weighted as an 8-hour average, to represent a typical working day. Monitoring was undertaken at several locations, including in Karuma Village. The 8-hour time weighted concentrations reported in that ESIA are displayed in Table 6-18. Measurement of the airborne particulate matter (PM_{10}) was done using a respirable dust sampler. The sampling of CO, SO_2, and NOx was undertaken using a Draeger air sampler and passive tubes (CHP-71).

Table 6-18: Summary of Monitoring Data – Karuma Hydropower Project (2014)

Location	Time-Weighted 8 Hour Mean Pollutant Concentrations			
	Particles (µg/m³)	Sulphur dioxide (µg/m³)	Nitrogen dioxide (µg/m³)	Carbon monoxide (µg/m³)
Dam Site	100	BDL[1]	BDL[1]	BDL[1]
Power House	100	BDL[1]	BDL[1]	BDL[1]
Karuma Village	150	BDL[1]	BDL[1]	2470
Karuma Bridge	130	BDL[1]	BDL[1]	1850

[1] BDL – Below Detection Limit. The Karuma report does not provide what the Detection Limit is for the method of monitoring used.

Both existing ESIAs for the local hydropower projects conclude that baseline air quality within their study areas is of a good standard. Whilst the limited evidence doses support this, the conclusions do have some major limitations.

The monitoring undertaken for the Ayago Hydropower project was based on 15 minute mean concentrations. The monitoring undertaken for the Karuma project was done so by gathering data via an undefined method and reporting it as an 8-hour time weighted average. The pollutant averaging periods reported in both ESIAs generally do not match the averaging periods set for the draft Ugandan air quality standards, nor the WHO's international air quality guidelines. As such, the comparison of monitored values against the standards cannot be considered like for like.

Despite this, the limited data that has been gathered suggests that baseline air quality is likely to be of a good standard within the air quality Study Area for the Project, due to its remoteness from major pollution sources. It is considered highly unlikely that the draft Ugandan Air Quality Standards for gaseous pollutants are currently exceeded within the Study Area. However, there the standards for PM_{10} and TSP could be at risk, particularly during the drier months of the year, from December to February. During this seasonally dry period, the ground is likely to dry out, increasing the risk of dust generation when there is less natural dust suppression through rainfall.

6.6.3 Baseline Summary

The baseline section has considered the existing climatic and air quality conditions at representative locations across the study area.

The climate data has been sourced from a series of meteorological stations located in the region. Air quality baseline conditions have been derived using a combination of secondary data, obtained from a literature review of other environmental assessment reports undertaken in the region, and baseline surveys specifically undertaken for this ESIA.

The regional climate can be characterised as generally hot and humid. It has average monthly temperatures varying between 27°C and 31°C and consists of a double rainy season resulting in annual rainfall ranging between 1,000 and 1,500 mm.

The primary data gathered by the 2016/2017 survey shows that over the course of the survey period, there are no exceedances of national standards or international guidelines in relation to human health for the majority of pollutants considered. However, the projection of monitored hourly mean PM_{10} data to represent annual mean conditions suggests that there is likely to be an exceedance of the following air quality standard for the protection of human health at a minimum of one monitoring location:

- WHO guideline value for annual mean PM_{10} concentrations (20 µg/m^3).

Elevated concentrations of PM_{10} are typical of locations that experience arid conditions, particularly during drier months. Much of the particulate monitored is likely due to natural mineral material picked up from the ground by winds, rather than toxic particles generated by combustion or other pollutant generating activities.

There are exceedances of the following air quality standards for ecological protection at a minimum of one monitoring location:

- WHO guideline and EU limit value for 6 month mean O_3 concentrations (10 µg/m^3); and
- WHO guideline and EU limit value for 3 month mean O_3 concentrations (3 µg/m^3).

Elevated concentrations of O_3 are typical of rural locations where there are limited sources of emissions associated with combustion. In more urban environments, O_3 is limited by its reaction with NO_X in the atmosphere. The WHO guidelines and EU limit values listed relate to the effect of O_3 on sensitive ecological habitat only and exceedances of these values are only relevant at sites of designated ecological importance. In the Study Area, this includes conservation areas located within 15 km of the Industrial Area (the MFNP and conservation areas within, which include Murchison Falls Conservation Area, Bugungu Wildlife Reserve and Karuma Wildlife Reserve).

No other national or international air quality standards have been exceeded from the pollutants considered in the 2016/2017 survey. Elevated average concentrations of VOCs were measured at location AQ7 (52.4 µg/m^3) but the concentrations are still well below the national standard of 6 mg/m^3 (6000 µg/m^3). This elevated concentration is due to a value of 348 µg/m^3 recorded at this location in month 1 of the survey. This single value appears to be an outlier in the dataset gathered, as during all other months, VOC concentrations at this location were typical of the VOC concentrations measured at the other survey locations and typically less than 10 µg/m^3.

The review of both primary data collection activities and reviews from other secondary data sources confirms that baseline air quality in the region is of a good standard and that most measured concentrations are significantly below the applicable national and international air quality standards.

6.7 Impact Assessment and Mitigation

6.7.1 Impact Assessment Methodology

This assessment considers the significance of potential air quality impacts on human health and amenity, and sensitive ecological habitats, relative to baseline conditions, for the Site Preparation and Enabling Works, Construction and Pre-Commissioning, Commissioning and Operations, and Decommissioning phases of the Project.

The method used follows an internationally recognised approach for assessing air quality impacts and takes into account Ugandan national and international air quality standards, Total Exploration & Production (E&P) Uganda B.V (TEP Uganda) company standards (Project Emission Limits) and recognised GIIP, regarding the assessment and control of air quality emissions. In particular it is consistent with the following national and international guidelines:

- Ugandan National Environment Management Authority (NEMA): Environmental Impact Assessment Guidelines for the Energy Sector (Ref. 6-16);
- IFC General EHS Guidelines: Environmental – Air Emissions and Ambient Air Quality (Ref. 6-3);
- IFC General EHS Guidelines: Environmental – Construction and Decommissioning (Ref. 6-4);
- IFC EHS Guidelines: Onshore Oil and Gas Development (Ref. 6-5); and
- IFC EHS Guidelines: Thermal Power Plants (Ref. 6-6).

The assessment of impacts has been undertaken by identifying and evaluating a range of activities and scenarios that are likely to occur throughout the phases of the Project. The key activities likely to generate emissions to air during each of the Project phases are included below in Table 6-19.

Table 6-19: Project Activities which may lead to Potential Impacts

Phase	Activity
Site Preparation and Enabling Works	Particulate emissions (coarse dusts and PM_{10}) associated with abrasive land clearance, earthworks, and construction associated with the following activities: ◦ Site Clearance and land preparation across the Project Area, including for the Industrial Area, well pads, Water Abstraction System, ferry crossing, and new roads and tracks; ◦ Civil works for well pads and Water Abstraction System; ◦ Construction of new roads and the upgrading of existing roads; ◦ Construction of the Victoria Nile ferry crossing jetty and associated buildings; ◦ Upgrade of Bugungu airstrip; ◦ Construction of Masindi vehicle Check Point; and ◦ Extraction of murram from the borrow pits.
	Vehicle and Non-Road Mobile Machinery (NRMM) emissions and associated construction traffic generated during the Site Preparation and Enabling Works.
	Combustion emissions (NO_X, CO, VOC, PM_{10}, $PM_{2.5}$) associated with the energy generation plant required to facilitate the Site Preparation and Enabling Works.
	Waste management activities, which may result in dust and odour associated with the temporary storage of waste generated by the Project.

Phase	Activity
Construction and Pre-Commissioning	Particulate emissions (coarse dusts and PM_{10}) associated with abrasive land clearance, earthworks and construction associated with the following activities: ◦ Construction, installation and pre-commissioning of the plant and equipment within the Industrial Area; ◦ Erection of temporary facilities at the Industrial Area; ◦ Construction, installation and pre-commissioning of the plant and equipment at the Water Abstraction System, including associated pipelines (onshore and offshore); ◦ Construction, installation and pre-commissioning of plant and equipment at each well pad; and ◦ Construction, installation and pre-commissioning of the plant and equipment required for the pipeline network (production and injection network and fibre optic cables).
	Particulate emissions (coarse dusts and PM_{10}) associated with drilling, mud mixing and cuttings management.
	Vehicle and NRMM emissions associated with construction traffic generated during the Construction and Pre-Commissioning works.
	Combustion emissions (NO_X, CO, VOC, PM_{10}, $PM_{2.5}$) associated with the energy generation plant required to facilitate the Construction and Pre-Commissioning works.
	Waste management activities, which may result in dust and odour associated with the temporary storage of waste generated by the Project.
Commissioning and Operations	Combustion emissions (NO_X, CO, VOC, PM_{10}, $PM_{2.5}$) associated with the energy generation plant located at the Central Processing Facility.
	Combustion emissions (NO_X, CO, VOC, PM_{10}, $PM_{2.5}$) associated with the operation of emergency generation plant at the CPF (emergency generators and fire water pumps).
	Combustion emissions (NO_X, CO, VOC, PM_{10}, $PM_{2.5}$) associated with start-up, plant stabilisation, maintenance activities and plant upsets, including the flaring of gas and the operation of emergency generators at the CPF.
	Venting of gas (VOC) associated with unplanned events, from storage tanks at the CPF.
	Venting emissions associated with maintenance activities on the well pads.
	Particulate emissions (coarse dusts and PM_{10}) and combustion emissions (road traffic and NRMM) associated with maintenance and repair activities.
	Waste management activities, which may result in dust and odour associated with the temporary storage of waste generated by the Project.
	Vehicle emissions (NO_X, PM_{10} and $PM_{2.5}$) associated with operational traffic generated during Commissioning and Operations phase.
Decommissioning	Particulate emissions (coarse dusts and PM_{10}) associated with demolition, site clearance and reinstatement activities associated with decommissioning.
	Fugitive venting of gas associated with decommissioning of oil storage tanks
	Waste management activities, which may result in dust and odour associated with equipment and vessel decommissioning activities.
	Vehicle and NRMM emissions associated with traffic generated during the Site decommissioning and infrastructure removal works.
	Combustion emissions associated with the energy generation plant required to facilitate the decommissioning and infrastructure removal activities.

In line with the Montreal Protocol on Substances that Deplete the Ozone Layer, the Project will not use ozone depleting substances including chlorofluorocarbon (CFCs), halons, 1,1,1-trichloroethane, carbon tetrachloride, methyl bromide or hydrobromofluorocarbon (HBFCs).

6.7.1.1 Impact Assessment Criteria

Criteria have been developed for assessing the potential impacts on air quality from Site Preparation and Enabling Works, Construction and Pre-Commissioning, Commissioning and Operations, and Decommissioning phases of the Project, and includes impact magnitude and receptor sensitivity. The impact significance matrix in ***Chapter 3: ESIA Methodology*** is used to determine the significance of each impact.

6.7.1.2 Receptor Sensitivity

In setting the air quality standards referred to in this assessment, the Ugandan Government, WHO, and EU have already taken into account the sensitivity of the human population's exposure to the pollutants considered. The purpose of the standards is to protect the health of the complete population including the very young, the elderly, and those with pre-existing health conditions. Therefore, the sensitivity of human health receptors in this air quality assessment is based on their likelihood of exposure to the pollutants considered, relative to the air quality standards (referred to here on in as *Environmental Assessment Levels (EALs)*). Some countries have separate standards for workforce exposure set in national law, which are typically an order of magnitude greater than the standards concerning ambient air quality. The EALs used in this assessment are considered more appropriate for inclusion within this ESIA, which focuses on local air quality impacts and public exposure.

The sensitivity of receptors relating to harm to amenity due to dust deposition/soiling and odour, is defined by the use of the land and whether or not an increase in dust deposition/soiling or odour would affect people's usage of that land.

The sensitivity of ecological sites to air quality impacts is determined by the value of the habitat, which is determined by level of importance attributed to them and whether or not the species within the habitat is susceptible to harm from the emissions to air associated with the Project.

Where the air quality assessment identifies the potential for impacts associated with fugitive dust and combustion emissions at ecologically sensitive areas, the determination of whether or not the effect of potential impacts is significant is considered in ***Chapter: 13 Terrestrial Vegetation***.

The closest human receptors to the Project activities listed have been identified and used to define the spatial scope of the assessment; as defined in ***Chapter 1: Introduction***. The sensitivities of individual receptors have been categorised by their nature using the criteria in Table 6-20 to help determine the potential significance of effects.

Table 6-20: Air Quality Receptor Sensitivity

Sensitivity	Description		
	Human Health	Amenity	Ecology
High	A location where there is relevant exposure for a period of time equal to the long term and short term pollutant averaging periods of the Project EALs (see Table 6-4) (e.g. dwellings, medical facilities, schools), where existing pollutant concentrations are 75% or more of the relevant EAL.	A location where users can reasonably expect enjoyment of a high level of amenity, or the appearance, aesthetics or value of their property would be diminished by soiling or odour, where the people or property would reasonably be expected to be present continuously, or at least regularly for extended periods, as part of the normal pattern of use of the land (e.g.	Habitat type which is recognised to be of ecological importance at an international scale (i.e. IFC defined Critical Habitat (Ref. 6-17)), and Natural Habitat that is highly sensitive to the

Sensitivity	Description		
	Human Health	Amenity	Ecology
		dwellings, and culturally important sites).	pollutants considered.
Moderate	A location where there is relevant exposure for a period of time that could potentially be equal to the short term averaging period of the Project EALs (see Table 6-4) (e.g. places of work); OR A location where there is relevant exposure for a period of time equal to the long term and short term pollutant averaging periods of the Project EALs (e.g. dwellings, medical facilities, schools), where existing pollutant concentrations are between 50% and 75% of the relevant EAL.	A location where people would expect to enjoy a reasonable level of amenity, but would not reasonably expect to enjoy the same level of amenity as in their home, or the appearance, aesthetics or value of their property could be diminished by soiling or odour, where people or property wouldn't reasonably be expected to be present here continuously or regularly for extended periods as part of the normal pattern of use of the land (e.g. places of work).	Habitat type which is recognised to be of ecological importance at a national scale (i.e. IFC defined Legally Protected and Internationally Recognised Areas (Ref. 6-17)), and Transient Habitat that is sensitive to the pollutants considered.
Low	A location where there is unlikely to be relevant exposure for a period of time that could potentially be equal to the averaging period of the Project EALs (see Table 6-4) (e.g. transient locations such as markets and public footpaths); OR A location where there is relevant exposure for a period of time equal to the long term and short term pollutant averaging periods of the Project EALs (see Table 6-4) (e.g. dwellings, medical facilities, schools), where existing pollutant concentrations are less than 50% of the relevant EAL.	A location where the enjoyment of amenity would not reasonably be expected, or property would not reasonably be expected to be diminished in appearance, aesthetics, or value by soiling or odour, or there is transient exposure, where the people or property would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land (e.g. farmland and footpaths).	Habitat type which is recognised to be of ecological importance at a local scale (i.e. IFC defined Modified Habitat (Ref. 6-17)).
Negligible	A location where there is no relevant exposure for a period of time that could potentially be equal to the averaging period of the Project EALs; OR There is exposure but they are workers and should therefore be considered against relevant occupational health exposure standards, which are an order of magnitude greater than EALs used in this assessment.	A location where little or no enjoyment of amenity is expected, or no property sensitive to soiling or odour that would diminish appearance, aesthetics or value, or there is little or no transient exposure where the people or property would reasonably be expected to be present (e.g. Industrial land and roads).	Habitat type which is not recognised to be of ecological importance.

6.7.1.3 Impact Magnitude

The EALs used in this assessment are described in Section 6.7.1.5 and summarised in Table 6-22. These values are consistent with the national standards that are applicable in Uganda, where appropriate, and WHO guidelines and/or interim target values adopted by the EU where not. Where EALs) are given for the same pollutant by more than one standard, the most stringent is used in the assessment.

The IFC General EHS Guidelines suggest that if developments cause impacts that are equivalent to or less than 25% of the relevant EAL, it will allow sufficient headroom for further development to take place in the general vicinity without causing unacceptable cumulative effects upon ambient air quality (other requirements apply to projects located in ecologically sensitive areas and are discussed in ***Chapter 13: Terrestrial Vegetation***). Based on this, the impact magnitude used in this assessment is summarised in Table 6-21.

Table 6-21: Impact Magnitude

Magnitude	Description	
	Controlled Emissions	Fugitive Emissions
High	A change of more than 25% of the EAL where the total predicted concentration (taking into account the baseline conditions and impact attributed to the Project) exceeds the limit value; OR A change of greater than 50% of the EAL where the total predicted concentration complies with the limit value.	Impact is likely to be intolerable for any more than a very brief period of time and is very likely to cause complaints from local people or long term harm to an ecological habitat. Increase in PM_{10} and/or VOC concentrations at a location where concentrations are already elevated and to the extent that the short term PM_{10} and/or VOC EAL is likely to be exceeded. A significant effect that is likely to be a material consideration in its own right.
Moderate	A change of 15% to 25% of the EAL where the total predicted concentration exceeds the limit value; OR A change of 25-50% of the EAL where the total predicted concentration complies with the limit value.	Impact is likely to cause annoyance and might cause complaints, but can be tolerated if prior warning and explanation has been given and/or may cause reversible harm to an ecological habitat over weeks or months. Increase in PM_{10} and/or VOC concentrations at a location where concentrations are already elevated and to the extent that the short term PM_{10} and/or VOC air EAL is at risk of being exceeded. A significant effect that may be a material consideration in combination with other significant effects, but is unlikely to be a material consideration in its own right.
Low	A change of 5% to 15% of the EAL where the total predicted concentration exceeds the limit value; OR A change of 10-25% of the EAL where the total predicted concentration complies with the limit value.	Impact may be perceptible, but of a magnitude or frequency that is unlikely to cause annoyance to a reasonable person or to cause complaints and/or would results in visible deposits on ecological habitat but would not cause harm. Limited increase in PM_{10} and/or VOC concentrations. An effect that is not significant but that may be of local concern.
Negligible	A change of less than 5% of the EAL where the total predicted concentration exceeds the limit value; OR A change of less than 10% of the EAL where the total predicted concentration complies with the limit value.	Impact is unlikely to be noticed by and/or have an effect on sensitive receptors. Negligible increase in PM_{10} and/or VOC concentrations. An effect that is not significant change.

[1] Controlled emissions is a collective term for sources where the amount and rate of emission is known

For amenity impacts associated with dust deposition and odour, there are no relevant national or international standards. Instead, the aim of the amenity assessment is to identify the level of mitigation required to ensure that a significant effect does not occur.

6.7.1.4 Receptor Identification

Representative human health and amenity sensitive receptors have been selected to identify the likely worst case impacts associated with emissions to air from the Project at locations where there is relevant exposure. Relevant exposure includes all residential properties, medical and educational facilities within the Study Area that were identified during the Project social survey. These locations are displayed in Figure 6-4, which shows that the majority of human health and amenity sensitive receptors are located to the south of the River Nile, with some limited dwellings located to the north of the River. Each receptor is representative of conditions experienced at other sensitive receptors in their vicinity, and/or other receptors located near to identical emissions sources.

As described, receptor sensitivity is determined by the standard of air quality that is currently experienced and the use of the land at that location. The human health receptors shown on Figure 6-4 are comprised of residential dwellings, schools, and medical facilities that are located within the potential range of air quality impacts from Project sources. Current air quality within the Study Area has been measured at several locations and the averaged concentrations taken to represent typical conditions across the Project Area. Based on the low concentrations measured, human health receptors within the Study Area may be concluded to have a low sensitivity to all pollutants considered, with the exception of annual and daily mean PM_{10} and annual mean $PM_{2.5}$, for which receptors would have a high and a moderate sensitivity respectively.

Whilst the Draft Ugandan Air Quality Standards include values for PM_{10} and $PM_{2.5}$, the Project standards considered for PM_{10} and $PM_{2.5}$ have been set by the WHO (Ref. 6-7). They are considerably more stringent than the Draft Ugandan Standards for PM_{10} and $PM_{2.5}$. As demonstrated by the data gathered during the baseline surveys, there are elevated PM_{10} and $PM_{2.5}$ concentrations in Uganda when compared to the WHO guideline values and other African nations. These are due to the often arid conditions experienced particularly during the drier months, where PM_{10} and $PM_{2.5}$ concentrations are already elevated above the Project standard due to natural background sources. Because the predominant contribution to the PM_{10} and $PM_{2.5}$ concentrations measured is from natural sources (i.e. mineral material), rather than combustion or other industrial sources (i.e. toxic material), the elevated PM_{10} and $PM_{2.5}$ concentrations are not considered to represent a high level of sensitivity in this assessment. Instead, the human health receptors are considered to have a moderate sensitivity to annual mean and daily mean PM_{10} and annual mean $PM_{2.5}$.

As well as predicting air quality conditions at existing sensitive locations (such as residential receptors) where there is known relevant exposure to air quality impacts, the assessment has also considered sensitive receptor locations where there is the potential for relevant exposure in the future. This includes sensitive locations within the Project's Operational Camp, where people will be present regularly at locations close to the main Project emissions sources during the Commissioning and Operations phase. As these locations are not receptors in the baseline scenario, the focus of the assessment is in the total pollutant concentrations experienced there and comparison against the Project standards, rather than the change in concentrations as a result of Project emissions.

Representative ecological receptors have also been selected for consideration in this assessment. The Murchison Falls Protected Area (MFPA) includes the MFNP, Bugungu Wildlife Reserve, Budongo Forest Reserve, and Karuma Wildlife Reserve, where there are habitats that support a number of priority species (Ref. 6-17). These specific areas within the MFPA are considered to be highly sensitive to air quality impacts, where the majority of the habitat is natural and undisturbed. The other areas of the MFNP are considered to be moderately sensitive to air quality impacts. Whilst the ecology survey (***Chapter 13: Terrestrial Vegetation*** *and* ***Chapter 14: Terrestrial Wildlife)*** has identified discrete and transient locations where priority species have been noted outside of the MFPA, the ecological habitat here is considered to have a lower sensitivity to air quality impacts, where the habitat has been modified for domestic and agrarian use. The location of these ecologically sensitive areas are shown in Figure 6-4. Figure 6-5 provides a representation of air quality sensitive receptors in relation to key Project elements, including the Industrial Area (Construction and Operational Support Bases and CPF), well pads, Water Abstraction System, Victoria Nile Ferry Crossing, Construction Camps, pipelines and roads.

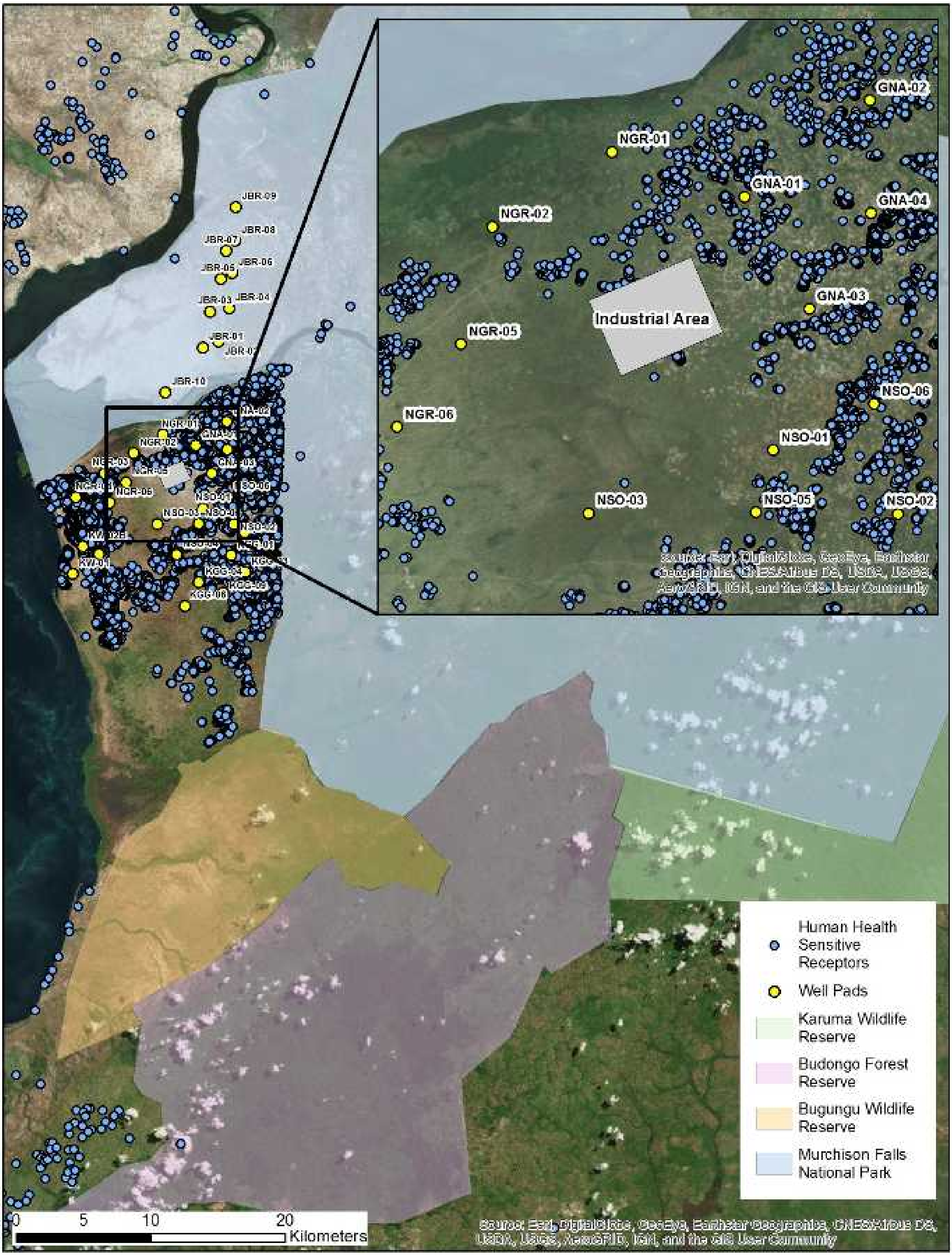

Figure 6-4: Air Quality Sensitive Receptors

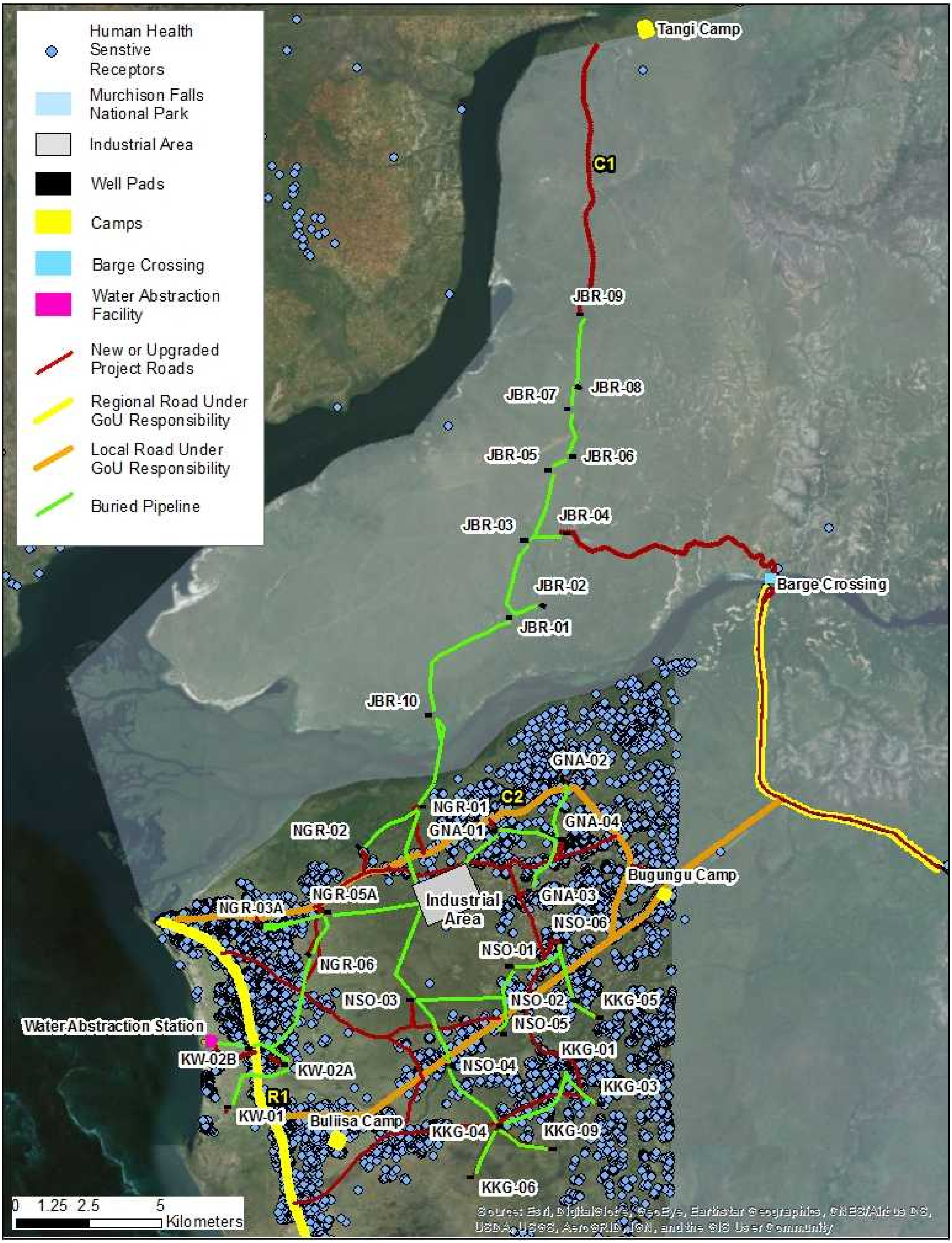

Figure 6-5: Air Quality Study Area

6.7.1.5 Standards and Guidance

The standards utilised in this assessment are based on applicable Ugandan legislation, international guidance (e.g. IFC performance standards), and recognised GIIP. The required standards for air quality are described below and set out in Table 6-22 and Table 6-23.

The 2013 draft Air Quality Standards for Uganda (Ref. 6-1) set out ambient EALs for specific pollutants. The majority of the draft standards are aimed at the protection of human health, and are focused on improving urban air quality. The Ugandan air quality standard values, averaging periods, and scope of pollutants differs from air quality standards applied in the European Union (Ref. 6-8) and the United States (USA) (Ref. 6-19), and from those recommended by the WHO (Ref. 6-7). As such, the EALs referred to in this assessment are based on an amalgamation of the national and international air quality standards, as summarised in Table 6-22.

Table 6-22: Summary of Relevant Project Air Quality Standards

Pollutant[1]	Averaging Period	Air Quality Standards ($\mu g/m^3$)			
		Ugandan	WHO	EU	Selected Project EAL
Human Health					
Nitrogen Dioxide (NO_2)	Annual Mean	40	40	40	40
	Hourly Mean	200[3]	200[3]	200[9]	200[1]
Total Suspended Particulate (TSP)[2]	Daily Mean	300[3]	n/a	n/a	300[1]
Particulate Matter (PM_{10})	Annual Mean	60	20[4]	40	20[2]
	Daily Mean	100	50[5,6]	50[12]	50[3,4]
Fine Particulate Matter ($PM_{2.5}$)	Annual Mean	40	10[7]	25	10[5]
	Daily Mean	60	25[5,8]	n/a	25[3,6]
Sulphur Dioxide (SO_2)	Daily Mean	20[3]	20[3]	125[13]	20[1]
	10 Minute Mean	500[3]	500[3]	n/a	500[1]
Carbon Monoxide (CO)	8 Hour Mean	11,100[3]	10,000[3]	10,000[3]	10,000[3]
	1 Hour Mean	23,000[3]	30,000[3]	n/a	23,000[3]
	30 Minute Mean	60,000[3]	n/a	n/a	60,000[3]
	15 Minute Mean	100,000[3]	n/a	n/a	100,000[3]
Hydrocarbons (HCs)	Daily Mean	5,000[3]	n/a	n/a	5,000[3]
Volatile Organic Compounds (VOCs)	Annual Mean	6,000	n/a	5	5

Pollutant[1]	Averaging Period	Air Quality Standards ($\mu g/m^3$)			
		Ugandan	WHO	EU	Selected Project EAL
Hydrogen Sulphide (H_2S)	Daily Mean	15[3]	n/a	n/a	15[3]
Soot	Daily Mean	500[3]	n/a	n/a	500[3]
Ecology					
Oxides of Nitrogen (NO_X)	Annual Mean	n/a	n/a	30	30
Sulphur Dioxide (SO_2)	Annual Mean	n/a	n/a	20/10[14]	20/10[14]
Nutrient Nitrogen Deposition (NDep)	Annual Mean	n/a	5-10 kg N/ha/yr[9] 15-35 kg/N/ha/yr[10]	n/a	5-10 kg N/ha/yr[9] 15-35 kg/N/ha/yr[10]
Nitrogen and Sulphur Acid Deposition (ADep)	Annual Mean	n/a	500 eq/ha/yr[11]	n/a	<500 eq/ha/yr

[1] There are also Project Air Quality Standards for carbon dioxide (CO_2) and ozone (O_3). CO_2 impacts are not considered to be relevant to local air quality and the impact and emissions of this pollutant are discussed in the Greenhouse Gas section. There are no emissions of O_3 associated with any phase of the Project. These pollutants have therefore been omitted from this table and are not considered in this assessment.
[2] Total Suspended Particulate (TSP) is not listed as a Project Air Quality Standard, but is included in this table and the assessment.
[3] Not to be exceeded (100th percentile)
[4] Guideline value of 20 $\mu g/m^3$. Based on Interim Target 1 of 70 $\mu g/m^3$, Interim Target 2 of 50 $\mu g/m^3$ and Interim Target 3 of 30 $\mu g/m^3$
[5] Not to be exceeded more the three times in a year (99th percentile)
[6] Guideline value of 50 $\mu g/m^3$. Based on Interim Target 1 of 150 $\mu g/m^3$, Interim Target 2 of 100 $\mu g/m^3$ and Interim Target 3 of 75 $\mu g/m^3$
[7] Guideline value of 10 $\mu g/m^3$. Based on Interim Target 1 of 35 $\mu g/m^3$, Interim Target 2 of 25 $\mu g/m^3$ and Interim Target 3 of 15 $\mu g/m^3$
[8] Guideline value of 25 $\mu g/m^3$. Based on Interim Target 1 of 75 $\mu g/m^3$ Interim Target 2 of 50 $\mu g/m^3$ and Interim Target 3 of 37.5 $\mu g/m^3$
[9] Assuming the following habitat: 'Forests in humid climates' (Budongo Forest Reserve)
[10] Assuming 'Species-rich grassland' (Murchison Falls National Park, Bugungu Wildlife Reserve, Karuma Wildlife Reserve)
[11] Assuming an intermediate parent material and low soil clay content
[12] Not to be exceeded more than 18 times per year (99.79th percentile)
[13] Not to be exceeded more than 35 times per year (90.41st percentile)
[14] 20 $\mu g/m^3$ where no lichens are present. 10 $\mu g/m^3$ where lichens are present

The IFC EHS Guidelines are technical reference documents with general and industry-specific examples of GIIP. When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These General EHS Guidelines are designed to be used together with the relevant Industry Sector EHS Guidelines which provide guidance to users on EHS issues in specific industry sectors. For complex projects, use of multiple industry-sector guidelines may be necessary. The IFC EHS Guidelines of relevance to this assessment are listed in Section 6.3.2.

The General EHS Guidelines for Air Emissions and Ambient Air Quality provide guidance that applies to facilities that generate emissions to air at any stage of the project life-cycle. The guidelines consider air emissions and the impact of those emissions on ambient air quality in two separate ways:

- Emissions Guideline values based on emission rates that are achievable by using GIIP, are defined in the guidelines for activities generating controlled emissions of air pollution. Controlled emissions is a collective term for sources where the amount and rate of emission is known. For activities generating 'fugitive' emissions of air pollution, mitigation measures representing GIIP are described. The magnitude of the emission rates from industrial facilities (such as power plant) are compared against emission guideline values and provide a means of demonstrating that the plant design is consistent with GIIP.
- Emissions from the proposed Project should *not "result in pollutant concentrations that reach or exceed relevant ambient [air] quality guidelines and standards by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines or other internationally recognised sources"*. The EALs presented in Table 6-4 are used to assess the impact on ambient air pollution at relevant receptor locations.

A summary of the relevant guideline air emission levels described in the IFC guidance documents is provided in Table 6-23. Concentrations are presented in parts per million (ppm) or milligrams per Normal (standardised) metre cubed (mg/Nm^3).

Table 6-23: Summary of Applicable Emissions Standards

Plant	Pollutant	Fuel	IFC Guidance Standard		
			Turbines	Engines	Boilers
Small Combustion Facilities (3 Megawatts thermal (MWth) – 15 MWth) (IFC EHS Guideline: Air Emissions and Ambient Air Quality) (1) Application: Diesel generators used during Site Preparation and Enabling Works; Construction and Pre-commissioning; and Decommissioning Phases Note: No turbines or boilers in this category	NO_X	Gas	n/a	n/a	n/a
		Liquid	n/a	1,460 mg/Nm^3 (bore size <400mm 1,850 mg/Nm^3 (bore size >400mm)	n/a
	SO_2	Liquid	n/a	<1.5% sulphur content in fuel	n/a
	PM	Liquid	n/a	100 mg/Nm^3	n/a
Small Combustion Facilities (15 MWth – 50 MWth) (IFC EHS Guideline: Air Emissions and Ambient Air Quality) (1) Application: Large diesel generators for construction activities; Emergency diesel generators and heaters for Commissioning and Operations. Note: No turbines in this category	NO_X	Gas	n/a	200 mg/Nm^3	240 mg/Nm^3
		Liquid	n/a	1,460 mg/Nm^3 (bore size <400mm 1,850 mg/Nm^3 (bore size >400mm)	240 mg/Nm^3
	SO_2	Liquid	n/a	<1.5% sulphur content in fuel	400mg/Nm^3
	PM	Liquid	n/a	50 mg/Nm^3	50 mg/Nm^3
	VOC	Liquid	n/a	n/a	20 mg/Nm^3

Plant	Pollutant	Fuel	IFC Guidance Standard		
			Turbines	Engines	Boilers
Large Combustion Facilities (50 MWth – 300 MWth) (IFC EHS Guideline: Thermal Power) (2)(3) Application: dual fuel (gas/crude/diesel) turbines and boilers which will constitute the main sources of power and heat generation for the Commissioning and Operations Phase	NO_X	Gas	152 mg/Nm^3 (74 ppm) (A)	200 mg/Nm^3	240 mg/Nm^3 (B)
		Liquid	152 mg/Nm^3 (74 ppm) (A)	1,460 mg/Nm^3	240 mg/Nm^3 (B)
	SO_2	Liquid	400 mg/Nm^3	1.5 % S or up to 3.0 % S if justified by project specific considerations (A)	400 mg/Nm^3 (B)
	PM	Liquid	50 mg/Nm^3 (A)	50 mg/Nm^3 up to 100 mg/Nm^3 if justified by project specific considerations (B)	50 mg/Nm^3
	VOC	Liquid	20 mg/Nm^3	n/a	20 mg/Nm^3 (4)

(1) Source: General EHS Guidelines: Environmental – Air Emissions and Ambient Air Quality, 2007.
(2) Source: EHS Guidelines for Thermal Power Plants, 2007, Table 6 (A) with following assumptions:
- Tilenga Project dual fuel 85 MWth turbines fuelled with fuel gas and diesel (back up in case of emergencies): selected guidelines "fuels other than Natural Gas";
- Airshed considered "Non-degraded" as highlighted by EBS results but the lower value could also be selected as Central Processing Facility located close to the Ramsar site and MFNP;
- Dry gas, excess O_2 content = 15%; and
- Emission levels should be evaluated on a one hour average basis and be achieved 95% of annual operating hours.
(3) Source: EHS Guidelines for Thermal Power Plants, 2007, Table 6 (B) with following assumptions:
- Tilenga Project Fire Tube boilers fuelled mainly with LP fuel gas, condensate and potentially at the end of project life with crude oil so IFC selected guidelines here are "other gaseous fuels" boilers;
- Airshed considered "Non-degraded" as highlighted by EBS results but the lower value could also be selected as Central Processing Facility located close to the Ramsar site and MFNP;
- Dry gas, excess O_2 content = 3%; and
- Emission levels should be evaluated on a one hour average basis and be achieved 95% of annual operating hours.
(4) Source: Draft Uganda Air Quality Standards.

6.7.1.6 Qualitative Assessment of Fugitive Emissions

Qualitative assessment methods are necessary where there is too much uncertainty in the variables required to undertake a quantitative assessment method. This is often the case for fugitive emissions sources, where the exact locations of emissions are not fixed, the emissions themselves are intermittent and the rate of emissions variable at any given time.

In line with IFC EHS guidelines (Ref. 6-3, Ref. 6-4, Ref. 6-5 and Ref. 6-6) the assessment of fugitive emissions focuses on the emphasis that the regulation and control of such emissions should be through the adoption of good working practices on-site. Good design practice is a process that is informed by impact assessments and is able to avoid the potential for significant adverse environmental effects at the design stage. This approach assumes that mitigation measures, beyond those inherent in the proposed design, that are identified as being necessary in the impact assessment will be applied during works to ensure that adverse effects do not occur.

Examples of accepted good site practice include international guidelines published by the IFC Construction and Decommissioning guidelines (Ref. 6-4) and Crude Oil and Petroleum Product Terminals (Ref. 6-20), US guidance published by the Western Regional Air Partnership (Ref. 6-21), National Pollutant Inventory guidance published by the Australian Government (Ref. 6-22), and South African legislation (Ref. 6-23).

The qualitative assessment method used is undertaken to assess the significance of any effects on sensitive receptors from the emissions sources described below. The steps in the assessment process are to consider potential sources of fugitive emissions and the likelihood of impacts occurring, based on the magnitude of the sources and their proximity to receptors, as well as the sensitivity of those receptors. This then informs the level of mitigation required to ensure that any effect is not significant.

6.7.1.6.1 Construction Dust

Fugitive emissions of dust (and PM_{10}) during the Site Preparation and Enabling Works, Construction and Pre-Commissioning, and Decommissioning phases will be readily produced through the action of abrasive forces on materials and therefore a wide range of these activities have the potential to generate this type of emission, including:

- Demolition work associated with land clearance activities during the Site Preparation and Enabling Works, and Decommissioning phases;
- Earthworks, including the handling, working and storage of materials, during the Site Preparation and Enabling Works, and Decommissioning phases;
- Construction of Project infrastructure during the Site Preparation and Enabling Works; and
- The re-suspension of dust and the transfer of dust making materials from the sites onto the local road network by Project vehicles during the Site Preparation and Enabling Works, and Decommissioning phases.

6.7.1.6.2 Non-Road Mobile Machinery

During the Site Preparation and Enabling Works, Construction and Pre-Commissioning, and Decommissioning phases, there will also be emissions from Non-Road Mobile Machinery (NRMM). Within the assessment, such emissions are treated as a fugitive emissions source, due to the variability in the routes that NRMM will take within each construction worksite, and the intermittent nature of their use (i.e. they will only release emissions as and when they are required to be operational)[1]. Activity specific plant, such as excavators and earthmovers will only need to be operational when those specific activities are required). Guidance in the UK (Ref. 6-24) also states that experience of quantitatively assessing the controlled emissions from on-site plant (such as NRMM) suggests that they are unlikely to make a significant impact on local air quality. Professional experience concurs in that a significant impact is highly unlikely where sensitive receptor locations are not located in close proximity to operational NRMM.

6.7.1.6.3 Fugitive VOC Emissions

During the Site Preparation and Enabling Works and Construction and Pre-Commissioning phases, VOC emissions will be limited and generated from the use of solvents, chemicals and paints used for welding (pickling passivation), painting/coating activities and fuel transfer activities. Most of these activities will be done within Industrial Area in dedicated facilities at the Construction Support Base. Some site welding and touch up and fuel transfer will also be done away for the Industrial Area, including at each well pad.

It is not possible to quantify the contribution of such emissions to total VOC concentrations with any accuracy, due to the uncertainty in the location of emissions and the frequency and rate of the emissions.

During the Commissioning and Operations and Decommissioning phases there will be a risk of fugitive emissions of VOCs associated with well pads for maintenance and annulus gas management if required, and the storage and handling of materials such as chemicals, oils, paints and solvents. During

[1] Such an approach is commonplace in air quality assessments for major EIAs in the UK (Ref. 6-25) and ESIAs in Uganda (Ref. 6-13, Ref. 6-14, Ref. 6-15) and Africa (Ref. 6-26, Ref. 6-27, Ref. 6-28), with the emphasis being on controlling emissions through site planning and/or a commitment to the use of NRMM plant with emissions standards that are appropriate for the Study Area.

the Commissioning and Operations, the majority of VOC emissions will be controlled through the use of an onsite Vapour Recovery Unit (VRU) located at the CPF.

In addition to the fugitive VOC emissions, some controlled VOC emissions may occur at the well pad sites to facilitate maintenance and/or the management of annulus gas (where emissions are <100 sm^3/hr). To account for this VOC emissions source, this chapter refers to the assessment undertaken to inform the design of the Project, which quantified VOC concentrations at site boundary locations at a selection of well pads assuming emissions of 100 sm^3/hr (with a gas exit velocity 13.6 m/s at a temperature of 313.15 K from a stack 5 m high and 0.05m in diameter) and 200 sm^3/hr (with a gas exit velocity 32.0 m/s at a temperature of 313.15 K from a stack 5 m high and 0.05 m in diameter). In reality, emissions of this magnitude will be routed via annulus gas compressor spreads into the production flowline for treatment at the VRU.

6.7.1.6.4 Waste Management

During all phases of the Project, waste will be created from Project activity and the various accommodation camps. Whilst the waste generated will not be treated within the Project Area and will instead be disposed of via a third party outside of the Project Area, the storage of waste prior to collection by the third party will be required. The storage of waste could generate fugitive emissions of dust and odour, depending on the nature of the material awaiting collection.

6.7.1.7 Quantitative Assessment of Controlled Emissions

The air quality impacts associated with the Site Preparation and Enabling Works, Construction and Pre-commissioning, and Commissioning and Operations phase emissions have been evaluated using a refined, near field (less than 50 km from the emission source) Gaussian Plume Dispersion Model, which is able to calculate maximum ground level concentrations at worst-case receptor locations where there is relevant sensitive exposures.

The assessment has been undertaken using the UK based Cambridge Environmental Research Consultancy's ADMS 5 software. This software was selected because of its versatility, which also allows the modelling of emissions using the US Environmental Protection Agency (EPA) preferred model AERMOD, which was developed by the American Meteorological Society and AMS/EPA Regulatory Model Improvement Committee (AERMIC). The main results reported in this chapter are those based on ADMS 5 model output. The AERMOD model output is then provided as a sensitivity analysis in Appendix H.

Due to the complexity of the Project, several modelled scenarios have been considered and these are described in Table 6-24, along with the sources included in each scenario. The assessment considers a single scenario to represent the Site Preparation and Enabling Works, and Construction and Pre-commissioning phases (C1), and two scenarios to represent the Commissioning and Operations phase (Op1 and Op2), to account for two different power generation options (as described in ***Chapter 4: Project Description and Alternatives***).

The two Commissioning and Operations phases have been sub-divided between the excess gas phase of field life (Op1a and Op2a), where gas generated from Project activity will be used to fuel the power generation plant, and a gas deficient phase of field life (Op1b and Op2b). During the gas deficient phase, when produced gas is no longer available, an option will be to import power for the site facilities from the Uganda National Grid. However, the power generation plant will retain the option to run on crude oil to satisfy the heat demand for the plant. Further information on the excess gas and gas deficient phases of field life are explained in ***Chapter 4: Project Description and Alternatives***. An emergency operation scenario has also been considered (Em1), which quantifies the impact of emissions associated with unplanned events, including the operation of emergency generators, fire water pumps, emergency flaring and unplanned venting from storage tanks at the CPF.

Each scenario considers emissions from the main processes associated with the relevant phase of the Project. The impact assessment reports the maximum concentrations and impacts for each pollutant at selected representative receptors, during all phases of the Project.

Table 6-24: Modelled Scenarios and Sources

Scenario	Description
Site Preparation and Enabling Works and Construction and Pre-commissioning	
Scenario C1	Emissions of NO_X, PM_{10} and $PM_{2.5}$ from construction phase vehicle movements on public roads at the following locations[2]: - between JBR-09 and Tangi Construction Camp / Support Base - R1 at Buliisa - L2 to the south of the Nile on the approach to and from the Industrial Area, Emissions of NO_X, PM_{10}, CO and HCs from diesel generation plant at the following locations: - Industrial Area Camp - Tangi Construction Camp - Tangi Construction Support Base Generator - Bugungu Construction Camp - Buliisa Construction Camp - Bugungu Airstrip - Masindi Vehicle Check Point - Victoria Nile Ferry Crossing Facility (including Ferry engines) - Industrial Area Construction Camp - Industrial Area Construction Support Base - Water Abstraction System - Well Pads - Hydrotesting Generators - Nile Pipeline Crossing Construction Area
Commissioning and Operations Phase	
Scenario Op1	**a)** Emissions of NO_X, PM_{10}, CO, HCs and VOCs associated with the following energy generation plant during the excess gas phase: - Gas-fired steam boilers at the CPF - Diesel-fired generators at the Victoria Nile Ferry Crossing Facility (including Ferry engines) **b)** Emissions of NO_X, CO, HCs and VOCs associated with the following energy generation plant during the gas deficient phase: - Oil-fired steam boilers at the CPF - Diesel-fired generators at the Victoria Nile Ferry Crossing Facility (including Ferry engines)
Scenario Op2	**a)** Emissions of NO_X, PM_{10}, CO, HCs and VOCs associated with the following energy generation plant during the excess gas phase: - Gas-fired turbines at the CPF - Gas-fired fired heaters at the CPF - Diesel-fired generators at the Victoria Nile Ferry Crossing Facility (including Ferry engines) **b)** Emissions of NO_X, CO, HCs and VOCs associated with the following energy generation plant during the gas deficient phase: - Oil-fired turbines at the CPF - Oil-fired fired heaters at the CPF - Diesel-fired generators at the Victoria Nile Ferry Crossing Facility (including Ferry engines)

Scenario	Description
Scenario Em1 and Em2[1]	Emissions of NO_X, PM_{10}, CO, HCs and VOCs from the following sources: - Diesel-fired emergency generators at the CPF - Diesel-fired fire water pump generators at the CPF - Waste gas flare at the CPF[2] - Venting of gases from tanks at the CPF - Diesel-fired emergency generator at the Water Abstraction System
[1] Two emergency options are considered separately, including an elevated open flare in scenario Em1 and enclosed ground flare in scenario Em2. [2] The roads listed experience the maximum traffic impact (north and south of the Nile) during the Site Preparation and Enabling Works and Construction and Pre-commissioning phases and air quality impacts at locations adjacent to these roads are considered representative of impacts likely to be experienced by receptors located adjacent to other roads used by Project vehicles.	

It has not been considered necessary to model emissions associated with the Decommissioning phase. After the well pads, pipeline network and CPF have been depressurised and all hydrocarbons removed from the facilities, the air emissions during the Decommissioning phase are expected to be similar to those associated with the Site Preparation and Enabling Works and the Construction and Pre-commissioning phases. The decommissioning phase will also benefit from improved technology and emissions controls that are likely to be in place at the end of the 25 year production lifetime of the Project.

The following tables (Table 6-25 and Table 6-26) provide the details of the model inputs used to quantify the contribution of emissions sources to total pollutant concentrations, based on design information and the Projects Standards. Table 6-25 lists model input data for the point source emissions considered, i.e. gases and particulates generated by combustion plant and released to atmosphere via a stack (or exhaust). These sources include stacks associated with the various temporary power generation plant required during the Site Preparation and Enabling Works, and Construction and Pre-commissioning phases, and those associated with the main power generation plant during the Commissioning and Operations phase. Point source emissions at the CPF also include exhausts from the diesel-fired emergency energy generation plant, fire water pumps, and the flare stack at the CPF, as well emergency venting from the storage tanks. It should be noted that the Project Proponents have undertaken detailed assessments of air emissions for each project phase. Every endeavour has been taken to comply with applicable Emissions Standards as defined in Table 6-22. Where compliance with these standards is not practicable, a detailed review of available technologies has been adopted, taking into account impacts on local receptors and compliance with ambient air quality standards.

Table 6-26 lists the model input data for the non-point sources modelled in this assessment, i.e. gases and particles released as a linear line across the land, rather than a specific point, such as roads. The road sources considered will emit pollutants to air primarily during the Site Preparation and Enabling Works and Construction and Pre-commissioning phases and Decommissioning phase, and will include emissions of NO_X, PM_{10} and $PM_{2.5}$. During the Commissioning and Operations phase, the number of Project vehicles is expected to be significantly less comparing to Site Preparation and Enabling works and Construction and Pre-Commissioning Phase, and will mainly comprise journeys associated with well pad maintenance, staff transport, supply of goods for Operations Phase waste management and well workover activities. The assessment focuses on roads that experience the greatest number of average daily vehicle movements in the study area, including C1 to the north of the Nile within the MFPA, L2 to the south of the Nile on the approach to and from the Industrial Area, and R1 at Buliisa, amongst the southern well pads. Impacts adjacent to other roads in the Study Area will be no worse than those predicted adjacent to these roads, which are anticipated to experience the greatest levels of Project-related vehicle movements.

Table 6-25: Model Input Data for Point Source Emissions

<table>
<tr><th rowspan="2">Source</th><th rowspan="2">Modelled Location</th><th rowspan="2">Emission Release Point Height (m)</th><th rowspan="2">Emission Release Point Diameter (m)[8]</th><th rowspan="2">Gas Exit Temp. (ºC)</th><th rowspan="2">Volume Flux (m^3/s)
Mass Gas Flow (kg/s)</th><th colspan="5">Mass Emission Rate (g/s)[9]</th></tr>
<tr><th>NO_X</th><th>PM_{10}</th><th>CO</th><th>HC</th><th>VOC</th></tr>
<tr><td colspan="11">Site Preparation and Enabling Infrastructure and Construction and Pre-commissioning (Scenario C1)</td></tr>
<tr><td>x1 1750 Kilovolt-Ampere (kVA) diesel generator at the Industrial Pioneer Camp</td><td>Industrial Camp Generator Compound</td><td rowspan="5">15</td><td rowspan="5">0.45</td><td rowspan="5">485</td><td rowspan="5">5.45 m^3/s</td><td rowspan="5">4.98</td><td rowspan="5">0.050</td><td rowspan="5">0.75</td><td rowspan="5">0.210</td><td rowspan="5">n/a</td></tr>
<tr><td>x1 1750 kVA diesel generator at the Industrial Area Construction Camp</td><td>Industrial Area Construction Camp Generator Compound</td></tr>
<tr><td>x1 1750 kVA diesel generator at the Industrial Area Construction Support Base</td><td>Industrial Area Construction Support Base Generator Compound</td></tr>
<tr><td>x1 1750 kVA diesel generator at the Water Abstraction System</td><td>Water Abstraction System Generator Compound</td></tr>
<tr><td>x1 1750 kVA diesel generator at the Horizontal Directional Drilling site[1]</td><td>Horizontal Directional Drilling Site Generator Compound</td></tr>
</table>

Source	Modelled Location	Emission Release Point Height (m)	Emission Release Point Diameter (m)[8]	Gas Exit Temp. (°C)	Volume Flux (m^3/s) Mass Gas Flow (kg/s)	Mass Emission Rate (g/s)[9]				
						NO_X	PM_{10}	CO	HC	VOC
x1 1138 kVA diesel generator at the Tangi Construction Support Base	Tangi Construction Support Base Generator Compound	15	0.35	386	3.23 m^3/s	3.03	0.030	0.46	0.130	n/a
x1 1138 kVA diesel generator for Hydrotesting at the Industrial Area Construction Support Base	Industrial Area Construction Support Base Generator Compound									
x1 800 kVA diesel generator at the Masindi Vehicle Check Point (Operation)	Masindi Check Point Generator Compound	15	0.3	476	2.48 m^3/s	1.88	0.025	0.32	0.079	n/a
x2 152 kVA diesel generators on the Nile Ferry Crossing ferry[2]	Ferry when moored at the Nile Crossing	10	0.15	527	0.43 m^3/s	0.17	0.006	0.11	0.017	n/a
x2 60 kVA diesel generators at the Nile Ferry Crossing facility	Ferry Crossing Facility Generator Compound	10	0.15	538	0.27 m^3/s	0.05	0.003	0.05	0.006	n/a
x1 25 kVA diesel generators at each Well Pad site	All Well Pad Generator Compounds	5	0.1	546	0.12 m^3/s	0.03	0.001	0.02	0.003	n/a
x4 10 kVA diesel generators at each Well Pad site	All Well Pad Generator Compounds	5	0.05	545	0.03 m^3/s	0.01	0.001	0.01	0.001	n/a

Source	Modelled Location	Emission Release Point Height (m)	Emission Release Point Diameter (m)[8]	Gas Exit Temp. (°C)	Volume Flux (m^3/s) Mass Gas Flow (kg/s)	Mass Emission Rate (g/s)[9]				
						NO_X	PM_{10}	CO	HC	VOC
10 kVA diesel generator at the Tangi Construction Camp	Tangi Construction Camp Generator Compound									
10 kVA diesel generator at the Bugungu Construction Camp	Bugungu Construction Camp Generator Compound									
10 kVA diesel generator at the Buliisa Construction Camp	Buliisa Construction Camp Generator Compound									
10 kVA diesel generator at the Bugungu Airstrip	Bugungu Airstrip Generator Compound									
10 kVA diesel generator at the Masindi Vehicle Check Point	Masindi Check Point Generator Compound									
10 kVA diesel generator at the Nile Ferry Crossing (construction)	Nile Ferry Crossing Facility Generator Compound									

Source	Modelled Location	Emission Release Point Height (m)	Emission Release Point Diameter (m)[8]	Gas Exit Temp. (°C)	Volume Flux (m^3/s) Mass Gas Flow (kg/s)	Mass Emission Rate (g/s)[9]				
						NO_X	PM_{10}	CO	HC	VOC
Commissioning and Operations Phase (Scenario Op1a)										
(x+1) Dual fuel 72 barg steam boilers at the Central Processing Facility[3] operating on fuel gas	Fluor Design CPF Power Generation Plant Compound	20	1.5	135	228 kg/s	43.2	n/a	18.0	n/a	3.6
x2 152 kVA diesel generators on the Nile Ferry Crossing ferry[2]	Ferry when moored at the Nile Crossing	10	0.15	527	0.43 m^3/s	0.17	0.006	0.11	0.017	n/a
x2 60 kVA diesel generators at the Nile Ferry Crossing facility	Nile Ferry Crossing Facility Generator Compound	10	0.15	538	0.27 m^3/s	0.05	0.003	0.05	0.006	n/a
Commissioning and Operations Phase (Scenario Op1b)										
(x3+1) Dual fuel 72 barg steam boilers at the CPF[3] operating on crude oil	Fluor Design CPF Power Generation Plant Compound	20	1.5	135	228 kg/s	72.0	9.0	18.0	n/a	3.6
x2 152 kVA diesel generators on the Nile Ferry Crossing Ferry[2]	Ferry when moored at the Nile Crossing	10	0.15	527	0.43 m^3/s	0.17	0.006	0.11	0.017	n/a
x2 60 kVA diesel generators at the Nile Ferry Crossing facility	Nile Ferry Crossing Facility Generator Compound	10	0.15	538	0.27 m^3/s	0.05	0.003	0.05	0.006	n/a

Source	Modelled Location	Emission Release Point Height (m)	Emission Release Point Diameter (m)[8]	Gas Exit Temp. (°C)	Volume Flux (m^3/s) Mass Gas Flow (kg/s)	Mass Emission Rate (g/s)[9]				
						NO_X	PM_{10}	CO	HC	VOC
Commissioning and Operations Phase (Scenario Op2a)										
(x5+1) Dual fuel 26 MW turbines at the CPF[4] operating on fuel gas	CBI Design CPF Power Generation Plant Compound	13	3.5	487	115 kg/s	6.42	n/a	8.91	n/a	1.78
(x9+1) gas-fired 21 MW fired heaters at the Central Processing Facility[5]	CBI Design CPF Power Generation Plant Compound	10	1.5	184	10 kg/s	0.79	n/a	0.79	n/a	0.16
x2 152 kVA diesel generators on the Nile Ferry Crossing ferry[1]	Ferry when moored at the Nile Crossing	10	0.15	527	0.43 m^3/s	0.17	0.006	0.11	0.017	n/a
x2 60 kVA diesel generators at the Nile Ferry Crossing facility	Nile Ferry Crossing Facility Generator Compound	10	0.15	538	0.27 m^3/s	0.05	0.003	0.05	0.006	n/a

Source	**Modelled Location**	**Emission Release Point Height (m)**	**Emission Release Point Diameter (m)**[8]	**Gas Exit Temp. (°C)**	**Volume Flux (m^3/s) Mass Gas Flow (kg/s)**	**Mass Emission Rate (g/s)**[9]				
						NO_X	**PM_{10}**	**CO**	**HC**	**VOC**
Commissioning and Operations Phase (Scenario Op2b)										
(x5+1) Dual fuel 26 MW turbines at the CPF operating on crude oil	CBI Design CPF Power Generation Plant Compound	13	3.5	487	115 kg/s	17.79	4.45	8.9	n/a	1.78
(x9+1) oil-fired 21 MW fired heaters at the CPF	CBI Design CPF Power Generation Plant Compound	10	1.5	184	10 kg/s	1.94	0.15	0.78	n/a	0.16
x2 152 kVA diesel generators on the Nile Ferry Crossing ferry[2]	Ferry when moored at the Nile Crossing	10	0.15	527	0.43 m^3/s	0.17	0.006	0.11	0.017	n/a
x2 60 kVA diesel generators at the Nile Ferry Crossing facility	Nile Ferry Crossing Facility Generator Compound	10	0.15	538	0.27 m^3/s	0.05	0.003	0.05	0.006	n/a
Unplanned Events (Scenario Em1a)										
x2 6 MW diesel generators at the CPF	Fluor Design CPF Power Generation Plant Compound	20	1.0	350	23.9 m^3/s	15.3	1.05	2.63	0.55	n/a

Source	Modelled Location	Emission Release Point Height (m)	Emission Release Point Diameter (m)[8]	Gas Exit Temp. (°C)	Volume Flux (m^3/s) Mass Gas Flow (kg/s)	Mass Emission Rate (g/s)[9]				
						NO_X	PM_{10}	CO	HC	VOC
x2 2000 kVA diesel generator for the fire water pumps at the CPF	Fluor Design CPF Power Generation Plant Compound	20	0.5	506	7.56 m^3/s	5.22	0.13	1.06	0.13	n/a
x1 2000 kVA diesel generator for the fire water pumps at the Water Abstraction Facility	Fluor Design CPF Water Abstraction Facility									
x1 elevated open flare at the CPF	Fluor Design CPF Flare Compound	50	0.45	86.5	16.3 m^3/s	24.0	44.5	107.8	n/a	177.1
x1 export oil tank at the CPF[6]	Fluor Design CPF	10	0.41	75.0	0.77 kg/s	n/a	n/a	n/a	n/a	770[10]
x1 off-spec oil tank at the CPF[7]	Fluor Design CPF	10	0.41	75.0	0.77 kg/s	n/a	n/a	n/a	n/a	770[10]
x1 water buffer storage tank at the CPF	Fluor Design CPF	10	0.76	75.0	2.62 kg/s	n/a	n/a	n/a	n/a	2,620
x1 gas floatation tank at the CPF	Fluor Design CPF	10	0.76	75.0	0.20 kg/s	n/a	n/a	n/a	n/a	200
x1 north water injection tank at the CPF	Fluor Design CPF	10	0.76	75.0	1.52 kg/s	n/a	n/a	n/a	n/a	1,520
x1 south water injection tank at the CPF	Fluor Design CPF	10	0.76	75.0	1.53 kg/s	n/a	n/a	n/a	n/a	1,530

Source	Modelled Location	Emission Release Point Height (m)	Emission Release Point Diameter (m)[8]	Gas Exit Temp. (°C)	Volume Flux (m^3/s) Mass Gas Flow (kg/s)	Mass Emission Rate (g/s)[9]				
						NO_X	PM_{10}	CO	HC	VOC
Unplanned Events (Scenario Em1b)										
X3 2000kVA diesel generators at the CPF	CBI Design CPF Power Generation Plant Compound	20	0.5	506	7.56 m^3/s	5.22	0.13	1.06	0.13	n/a
X3 2000 kVA diesel generator for the fire water pumps at the CPF	CBI Design CPF Power Generation Plant Compound	20								
x1 2000 kVA diesel generator for the fire water pumps at the Water Abstraction Facility	Fluor Design CPF Water Abstraction Facility	20								
x1 enclosed ground flare at the CPF	CBI Design CPF Flare Compound	10	13	1100	43.0 kg/s	48.2	n/a	219.7	64.2	390.3
x1 export oil tank at the CPF[6]	CBI Design CPF	10	0.41	75.0	0.77 kg/s	n/a	n/a	n/a	n/a	770[10]
x1 off-spec oil tank at the CPF[7]	CBI Design CPF	10	0.41	75.0	0.77 kg/s	n/a	n/a	n/a	n/a	770[10]
x1 water buffer storage tank at the CPF	CBI Design CPF	10	0.76	75.0	2.62 kg/s	n/a	n/a	n/a	n/a	2,620

Source	Modelled Location	Emission Release Point Height (m)	Emission Release Point Diameter (m)[8]	Gas Exit Temp. (°C)	Volume Flux (m^3/s) Mass Gas Flow (kg/s)	Mass Emission Rate (g/s)[9]				
						NO_X	PM_{10}	CO	HC	VOC
x1 gas floatation tank at the CPF	CBI Design CPF	10	0.76	75.0	0.20 kg/s	n/a	n/a	n/a	n/a	200
x1 north water injection tank at the CPF	CBI Design CPF	10	0.76	75.0	1.52 kg/s	n/a	n/a	n/a	n/a	1,520
x1 south water injection tank at the CPF	CBI Design CPF	10	0.76	75.0	1.53 kg/s	n/a	n/a	n/a	n/a	1,530

kg/s – kilograms per second, g/s – grams per second, m^3/s – cubic metres per second
[1] Two options modelled, assuming the Horizontal Directional Drilling (HDD) is undertaken at different locations on the banks of the Nile. Worst case impacts reported at each receptor.
[2] Two options modelled, assuming the Ferry is moored on either the north or south bank. Worst case impacts reported at each receptor.
[3] Four steam boilers in total, with one in reserve.
[4] Six gas-fired turbines, with one in reserve.
[5] Nine gas-fired fire heaters, with one in reserve.
[6] Peak emission rates given are averaged to represent emissions parameters for the duration of venting events from this sources (Export Oil Tank – 24 hours)
[7] Peak emission rates given are averaged to represent emissions parameters for the duration of venting events from this sources (Off-Spec Tank – 8 hours)
[8] Stack diameters estimated where appropriate to give a realistic exit velocity of gas from each plant.
[9] Low sulphur content in both gas and oil fuel options. Trace emissions only.
[10] VOC emissions rate used to represent HC emission rate also

Table 6-26: Model Input Data for Non-Point sources

Source	Estimated Daily 2-Way Trips[1]	Emission Temp.	Vehicle Emissions[2] (g/km/s)			
			NO_X	PM_{10}	$PM_{2.5}$	CO
Site Preparation and Enabling Works and Construction and Pre-commissioning						
Construction traffic route north of the Nile (Road C1 between JBR-09 and Tangi Construction Camp / Support Base)	116	Ambient	0.0115	0.0002	0.0002	0.0021
Construction traffic route on approach to the Central Processing Facility (Road L2)	125	Ambient	0.0124	0.0002	0.0002	0.0023
Construction traffic route south of the Nile (Road R1 at Buliisa)	221	Ambient	0.0218	0.0003	0.0003	0.0040

[1] Based on information provided in the ***Chapter 4: Project Description and Alternatives***
[2] Based on Ugandan Emissions Standards for Heavy Duty diesel powered vehicles (NO_X: 7.0 g/kWh, PM_{10}: 0.36 g/kWh and CO 4.5 g/kWh) and converted to grams per kilometre per second (g/km/s) using the UK's Department for Environment, Food & Rural Affairs Emissions Factor Toolkit (Ref.6-29)

6.7.1.7.1 Meteorological Data

The dispersion modelling assessment requires specific meteorological data parameters in order to predict the dispersion of emissions. Some, but not all of these parameters have been gathered at local meteorological monitoring stations at Bugoma and Mbegu (temperature, wind speed and wind direction), for a period of six months in 2014. The remaining parameters (precipitation, temperature, humidity and cloud cover) as well as temperature, wind speed, and wind direction data for periods not covered by the local sites have been sourced from the meteorological station at Entebbe International Airport.

This assessment has used six years of hourly sequential meteorological data to model the dispersion of Project emissions, including five years of data from Entebbe International Airport (2012-2016) and a single year of data (2014) that is an amalgamation of data from Entebbe airport and the two local meteorological sites at Bugoma and Mbegu. Windroses for these meteorological data are provided in Figure 6-6. The use of multiple years of meteorological data accounts for any year on year variation in meteorological conditions. The main assessment uses the hybrid data for 2014. The prediction of pollutant concentrations using the other years of meteorological data are considered in a sensitivity analysis in Appendix H.

The windroses show that winds predominantly blow from the southerly sector, with some winds blown from the north and fewer winds blown from the east and west. The local data gathered at Bugoma and Mbegu suggests that conditions nearer to the site have winds blowing more from the southeast sector than the data gathered at Entebbe.

The interaction of the meteorology with the ground in the Study Area and at the sites where the meteorological data are gathered is known as the *Surface Roughness*. A higher level of surface roughness creates a greater level of disturbance at ground level, which affects the meteorological conditions at the surface, where air quality sensitive receptors are located. To account for the effect of the difference in surface roughness between the Study Area and the meteorological data gathering sites, the ADMS dispersion model allows to specify surface roughness factors at these locations. For this assessment, a surface roughness factor of 0.4 has been selected for the Study Area site and a surface roughness factor of 0.2 selected for the meteorological data site, thus indicating that the influence of trees and buildings on meteorological conditions at or near to ground level is greater within the Study Area, compared to the meteorological data gathering areas, which are usually located on open spaces at airports and airstrips.

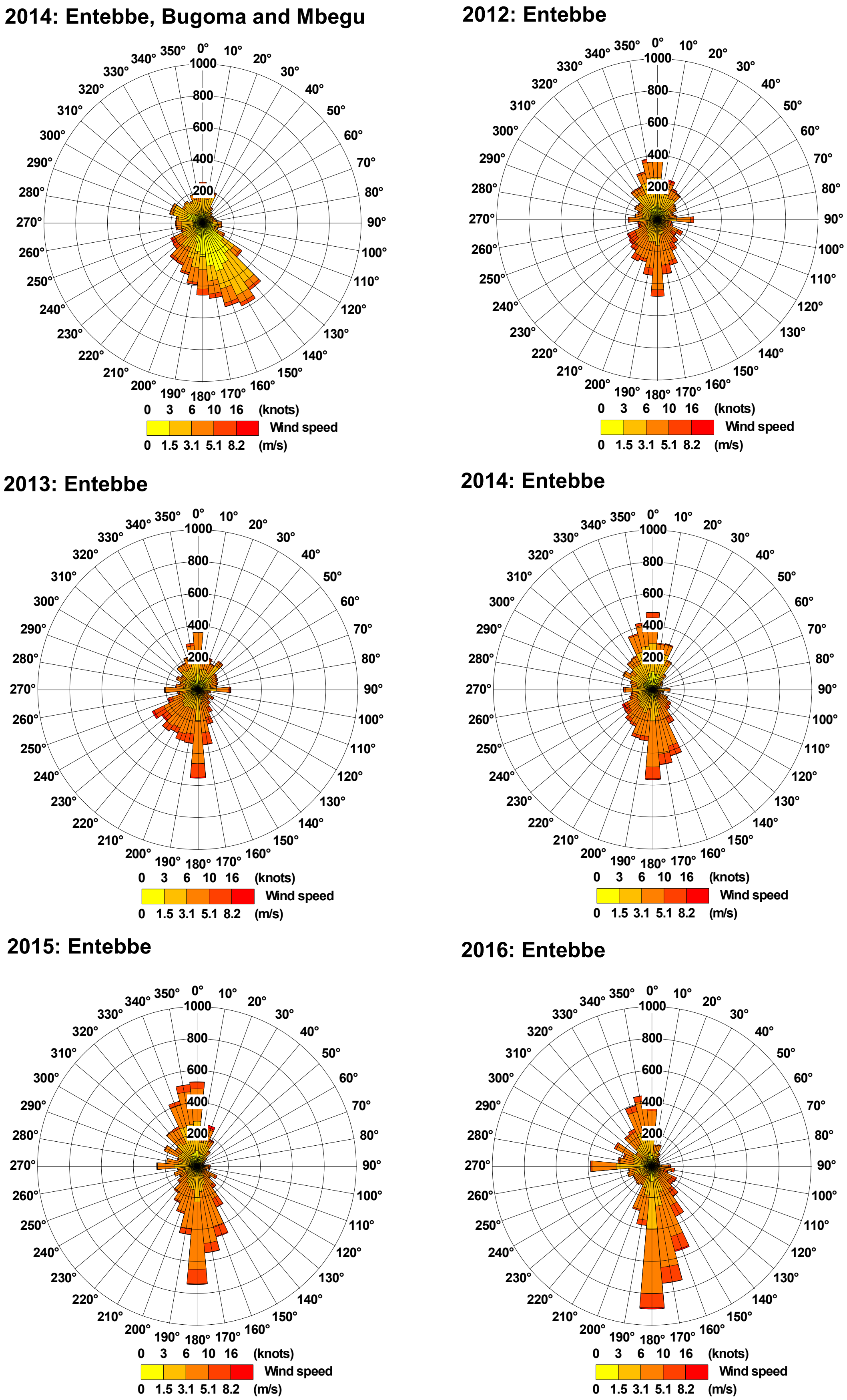

Figure 6-6: Wind Roses of Project Meteorological Data

6.7.1.7.2 Background / Ambient Pollutant Concentration Data

There is limited existing pollutant concentration data available in Uganda that can be considered representative of background/ambient conditions within the Study Area. As such, the results from baseline air quality survey (both 2014 and 2016/2017) were used to establish ambient concentrations of the pollutants that could be practically measured.

For the impact assessment, the background/ambient concentrations are added to the contribution of emissions from the Project, to calculate total pollutant concentrations, which can then be directly compared to the EALs. Where no background data for a pollutant is available, the assessment considered the Project contribution to total concentrations only. The background data used in this assessment is summarised in Table 6-27.

Table 6-27: Assessment Background / Ambient Pollutant Concentrations

Pollutant	Averaging Period	Background Conc. (µg/m^3)	EAL (µg/m^3)	Notes
NO_2	Annual mean	6.1	40	Average baseline NO_2 survey data gathered at various locations in the Study Area over a period that is representative of the annual mean.
	Hourly mean	12.2	200	Two times the representative annual mean NO_2 value, which is an industry-accepted approach for estimating daily mean concentrations.
NO_X	Annual mean	8.6	30	Average baseline NO_X survey data gathered at various locations in the Study Area over a period that is representative of the annual mean.
PM_{10}	Annual mean	34.1	20	Half of the average 1 hour mean value (68.3 µg/m^3) gathered at various locations in the Study Area over 27 days spread out over a nine month period, which is an industry-accepted approach for estimating annual mean concentrations from hourly mean data.
	Daily mean	51.2	50	Three quarters of the average 1 hour mean value (68.3 µg/m^3) gathered at various locations in the Study Area over a 27 days spread out over a nine month period, which is an industry-accepted approach for estimating daily mean concentrations from hourly mean data.
$PM_{2.5}$	Annual mean	7.5	10	Half of the average 1 hour mean value (14.5 µg/m^3) gathered at various locations in the Study Area over a 27 days spread out over a nine month period, which is an industry-accepted approach for estimating annual mean concentrations from hourly mean data
	Daily mean	11.2	25	Three quarters of the average 1 hour mean value (14.5 µg/m^3) gathered at various locations in the Study Area over a 27 days spread out over a nine month period, which is an industry-accepted approach for estimating daily mean concentrations from hourly mean data.

Pollutant	Averaging Period	Background Conc. (μg/m³)	EAL (μg/m³)	Notes
CO	8 Hour mean	292.2	10,000	Average baseline CO data gathered over a six month Phase 1 survey at various multiple locations across the Study Area.
	Hourly mean	465.7	23,000	Average baseline CO data gathered over a six month Phase 1 survey at various multiple locations across the Study Area.
	30 minute mean	1397.1	60,000	Average baseline CO data gathered over a six month Phase 1 survey at various multiple locations across the Study Area.
	15 minute mean	4191.3	100,000	Average baseline CO data gathered over a six month Phase 1 survey at various multiple locations across the Study Area.
VOCs / HCs	Daily mean	2.2	5,000/6,000	2 times the representative annual mean VOC value, which is an industry-accepted approach for estimating daily mean concentrations.
TSP	Daily Mean	81.2	300	Three quarters of the average 1 hour mean value (121.8 μg/m³) gathered at various locations in the Study Area over 27 days spread out over a nine month period, which is the standard approach for estimating daily mean concentrations from hourly mean data.

6.7.1.7.3 Terrain Data

Terrain data can be used in the dispersion modelling of emissions to account for the influence of geographical features within the Study Area, including hills, valleys and plateaux, on meteorological conditions.

The Study Area, which is located within the flood plain of the Victoria Nile and is in close proximity to Lake Albert, is characterised by flat plain land with occasional and very gentle undulations. It is considered that the limited variation in terrain height within the study area will not have a great effect on the dispersion of pollutants to the extent that modelling will require the input of terrain data. The assessment therefore assumes that the Study Area is flat.

6.7.1.7.4 Building Downwash

Buildings and structures that make up the Project can have the potential to affect the dispersion of emissions from Project point sources, if they are located close enough and high enough to the modelled sources to interact with meteorological conditions there. As the wind blows over and around these buildings and structures, the air flow can be disrupted and pollutants may become entrained within the eddy (cavity) near to the buildings and structures, or within the associated zone of turbulent air (wake).

A building or structure produces an area of wake influence directly downwind from the structure’s trailing edge, to a distance of around five times its height or width (whichever is the lesser). Buildings will only have an effect on emissions where the building height, plus 1.5 times the lesser of the building height and maximum length of the building, is greater than the stack height. In this instance, Project point sources are released from such heights that Project buildings or structures are unlikely to influence the dispersion of emissions from the stacks. Furthermore, the influence of buildings on the dispersion of emissions only has a marked effect on receptors located in close proximity to the source. In this instance, because of the scale of the site, the nearest receptors are nearly 200 m away from the closest source and would not be expected to notice a marked difference in predictions with the inclusion of buildings. Therefore, the influence of buildings and structures has not been included in this assessment.

6.7.1.7.5 NO_X to NO_2 Conversion

Emissions of NO_X from Project sources will consist mainly of nitric oxide (NO) at the point of release, oxidising within the atmosphere to form NO_2 as it moves downwind and away from the source. At the point of release, approximately 95% of the NO_X emission will be in the form of NO, with the other 5% consisting of NO_2. Following release from the stack, more of the NO is then converted to NO_2 at a rate that is dependent on a number of factors, including the availability of local ambient ozone (O_3).

For detailed assessments of NO_2 impacts, such as this, UK and US guidance (Ref.6-10) suggests the establishment of a site specific conversion rate, which will take into account local O_3 concentrations and typical hours of sunlight, to calculate site specific NO_X to NO_2 conversion rates for inclusion within a detailed dispersion modelling assessment.

For this detailed assessment, the hourly sequential NO_X, NO_2 and O_3 data gathered by the continuous monitoring devices during the 2014 survey have been used to calculate a site specific NO_X to NO_2 conversion rate within the Study Area, using the chemistry module in the ADMS 5 software. Using this data, the model calculates a separate NO_X to NO_2 conversion rate for each hour of the year, depending on the level of NO (NO_X – NO_2) and O_{3-} at that hour, as well as the number of hours of daylight at the Project latitude and the cloud cover information within the hourly sequential meteorological dataset used. The model also assumes that 5% of the NO_X emission from the stack is directly emitted as NO_2.

A diurnal profile of hourly average NO_X, NO_2 and O_3 data across the 2014 survey period is provided in Figure 6-7. The chart shows a typical relationship between NO_X, NO_2 and O_3 that is clearly influenced by the hours of daylight with near 100% conversion NO_X to NO_2 conversion from 9am to 4pm, when NO_X concentrations are at their lowest.

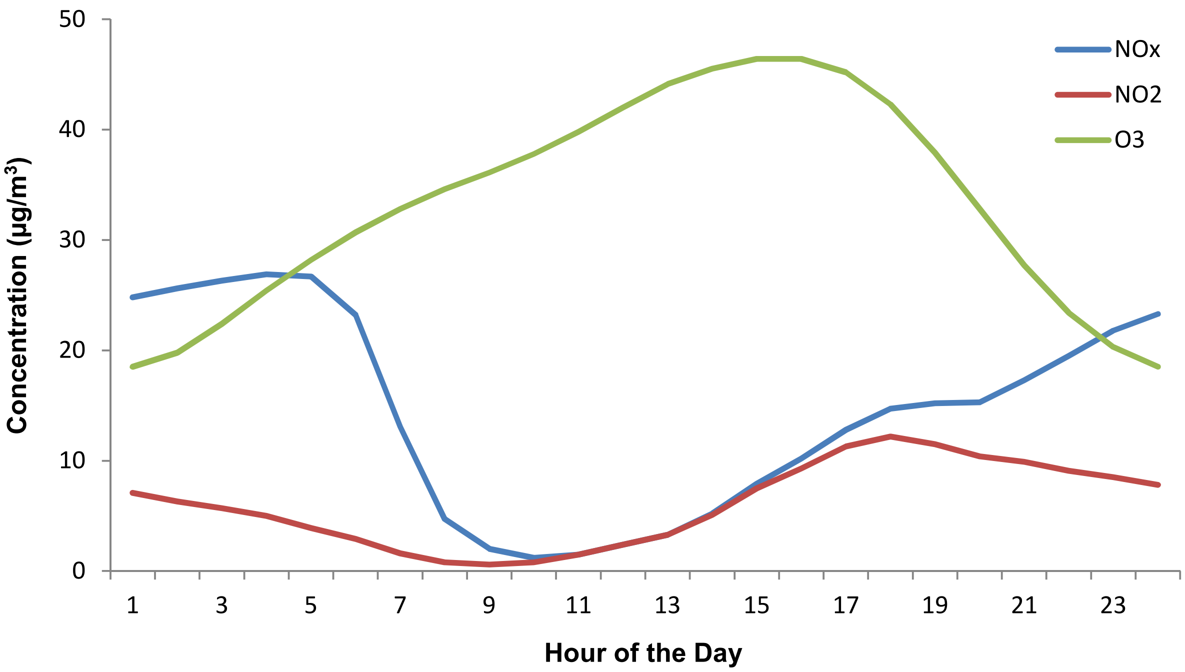

Figure 6-7: Diurnal Profile of Average Hourly NO_X, NO_2 and O_3 Concentrations (2014 Survey)

It is assumed that there is a 100% conversion of all other pollutants considered in this assessment. SO_X emissions have not been considered due to the low sulphur content of the fuel source proposed.

6.7.2 In-built Design Mitigation

A list of relevant embedded mitigation measures already built into the design of the Project are outlined within ***Chapter 4: Project Description and Alternatives***. The measures relevant to this assessment are summarised in Table 6-28 below and have been taken into account when predicting the significance of the potential impacts.

Table 6-28: Embedded Mitigation Measures

Embedded Mitigation Measures
Flow meters will be integrated on all refuelling points to monitor usage. Sampling points will also be established to enable spot sampling of fuel composition
During normal Operations, power will be provided by the CPF; there will be no back-up generators other than black-start and emergency generators
There will be no routine flaring during normal operations
A flow meter will be integrated into the flare design to monitor flow and a sample point will be integrated to monitor composition
A Vapour Recovery Unit (VRU) will be located at the CPF to process gases generated
A metering system will be integrated into the main power generation system package to enable the continuous monitoring of flow and composition. A sampling point will also be established to enable sampling of exhaust gas
Diesel generator(s) will be located in the Industrial Area for the provision of power and small diesel generator packages will be used for all other work sites to provide power for small items of equipment such as pumps/compressors
Implementation of a Dust Control Plan, which will include: • Measures to include the application of dust suppressants (including water), on potentially dust generating sources, including on site and off site roads used by Project vehicles and material stockpiles; • Water will be sprayed onto the roads and work sites to supress dust generation, where necessary. Water will be provided at the work sites and mobile water bowsers will be available to control dust generation, if required; • Activities likely to generate dust (e.g. drilling powders use and transfer) will be enclosed and dust catchers in place when practicable; • Trucks carrying potentially dusty material will be covered, to reduce fugitive dust emissions from the materials being transported; • Roads used by Project vehicles will be maintained, to the extent that this is possible, to reduce fugitive dust emissions associated with surface dust being disturbed by the passing of traffic; and • Concrete batching materials to be stored in sealed silos with the batching area regularly watered down to supress dust emissions.
For power generation, centralised diesel generator package including back up facilities will be located at the Industrial Area Construction Support Base to service the construction and pre-commissioning activities within the Industrial Area. Dedicated generator packages of varying sizes will also be mobilised to provide the power requirements for the construction and pre-commissioning of at discrete locations including the Lake Water Abstraction System, well pads and pipeline installation sites. Separate independent packages will be mobilised with the drilling rig to service the power requirements for the drilling activities
• Mud Products will comply with Uganda's Health, Safety and Environment Regulations. Only Chemicals ranked E or D in the OCNS (Oil Chemical National Scheme classification) will be allowed to be used; • All products for completion and drilling fluids will be free of chlorides; the upper limit will be 2% by weight; • All Products entering in the mixing of drilling, completion and cementing will be free of aromatic Hydrocarbon, the upper limit is fixed at 300 parts per million (ppm); and • No asphalt, no gilsonite, nor equivalent so called "black" products will be permitted in the drilling fluids and cementing formulations.
All transportation will be compliant with applicable road transport regulations. In the Project Area, routine transportation operations will normally only occur in day light. Deliveries of equipment and the movement of people will be scheduled in convoys, where practicable
A review of relevant studies, if necessary, will be undertaken during the Commissioning and Operations Phase to confirm that the planned decommissioning activities utilise good industry practices and are the most appropriate to the prevailing circumstances and future land use

Embedded Mitigation Measures
During the Decommissioning Phase the following assumptions are applicable regarding supporting facilities: • Localised effluent collection facilities will be provided for chemical storage, hazardous materials storage, liquid waste storage, tanks, and fuelling facilities. Such containment will include impermeable areas, kerbing, bunding and drip trays as appropriate; • Sewage will be treated by existing wastewater treatment plants (WWTPs) and discharged in accordance with wastewater treatment standards as presented in Chapter 10: Surface Water or collected and transferred to suitably licensed treatment facilities for processing and disposal; • For power generation, a centralised diesel generator package including back up facilities will be located at the Construction Support Base to service the decommissioning activities within the Industrial Area. Dedicated generator packages of varying sizes will also be mobilised to provide the power at discrete locations including the Lake Water Abstraction System, well pads and pipeline decommissioning sites; and • Waste will be segregated and managed in accordance with a Waste Management Plan.
A Waste Management Plan will be developed and maintained to cover the duration of the Project; and will address the anticipated waste streams, likely quantities and any special handling requirements. The Project Proponent's will implement a waste tracking system to ensure traceability of all wastes removed off site.
Prior to transfer offsite to a licensed waste treatment facility, waste materials will be segregated and stored in appropriate containers to prevent: • Accidental spillage or leakage; • Contamination of soils and groundwater; • Corrosion or wear of containers; • Loss of integrity from accidental collisions or weathering; • Theft; and • Odour and scavenging by animals.
The existing camps have operating WWTPs. Sewage produced from the camps will be treated at the WWTPs in compliance with regulatory requirements (refer to Chapter 10: Surface Water). Sewage from other Project Areas (e.g. road work sites) will be collected and transferred to WWTPs and/or suitably licensed treatment facilities for processing and disposal. All sewage sludge will be removed periodically from WWTPs and transferred off site for disposal
Sewage produced from the camps and other Project Areas will be treated at the WWTPs located at the camps in compliance with regulatory requirements (refer to Chapter 10: Surface Water). Wastewater from the well pads will be collected and transferred by tanker to the nearest WWTPs
For the Masindi Vehicle Check Point, sewage will either be treated by a wastewater treatment plant on site and discharged in accordance with the wastewater treatment standards presented in Chapter 10: Surface Water or transferred to the Masindi sewage treatment plant for processing (depending on capacity and approval)
During the Commissioning and Operations Phase waste will be stored and processed at the Integrated Waste Management Area located south of Victoria Nile. There will be no waste management facility located north of the Victoria Nile within the MFNP
For the well pads, Victoria Nile Ferry Crossing Facility and the Lake Water Abstraction System, sewage will be collected and transferred to suitably licensed treatment facilities for processing and disposal

6.7.3 Assessment of Impacts: Site Preparation and Enabling Works and Construction and Pre-commissioning

6.7.3.1 Introduction

The following section presents the identified potential impacts associated with the Site Preparation and Enabling Works; and Construction and Pre-commissioning phases. As detailed in section 6.7.1.6, potential fugitive impacts have been assessed qualitatively, which takes into account the associated in-built design mitigation measures, as listed in section 6.7.2, and any additional mitigation measures required to reduce those potential impacts to as low as reasonably practicable are also suggested as part of the assessment.

The controlled emissions impacts, including point sources, have been assessed quantitatively. Emissions from these sources have been modelled to include the corresponding embedded mitigation, as listed in section 6.7.2, and any additional mitigation measures required to reduce impacts to as low as reasonably practicable, outlined within this chapter.

During these phases of the works, potential air quality impacts are considered in relation to the list of Project activities listed in Table 6-19.

Works associated with the Site Preparation and Enabling Works of the Project are envisaged to last for around 60 months (5 years). From month 13 this will run concurrently with the Construction and Pre-commissioning phase of the Project, which is expected to require around 84 months (7 years).

6.7.3.2 Potential Impacts (pre additional mitigation) - Site Preparation and Enabling Works and Construction and Pre-commissioning

6.7.3.2.1 Fugitive Dust and PM_{10} Emissions

Project worksites where the majority of activity undertaken during these phases will occur are primarily open, undeveloped areas that will need to be cleared of all structures and unnecessary vegetation prior to the construction of the Project elements. During the Site Preparation and Enabling Works phase, works will typically involve excavations and earthworks, temporary stockpiling of potentially dusty materials, and the use of unsurfaced haul roads, which are often the principal sources of dust. Following the site clearance of each worksite, Project infrastructure will be erected during the Construction and Pre-commissioning phase, during which the principal sources of emissions are likely to be from the cutting and grinding of materials, and the movement of construction related road vehicles on paved an unpaved roads. The latter stages of this phase, when the majority of the buildings and infrastructure are complete, will involve restoration, landscaping, and finishing works. During these works, the principal sources of dust will include the storage, handling, and movement of materials generated.

Fugitive particulate emissions generated during these phases will be predominantly made up of coarse materials (>PM_{10}), which, under certain meteorological conditions, have the potential to be carried by the wind and deposited beyond the worksite boundaries, where they could soil or damage property and disrupt the amenity of members of the public. Whilst the majority of particulate emissions generated by construction activity will be coarse, there is the potential for some generation of finer particulate emissions, including PM_{10}. Again, under certain meteorological conditions, this could have potential impact at locations beyond the construction site boundaries, where there are dust sensitive receptors nearby.

Worst case potential impacts are likely to occur at receptors located closest to the worksite boundaries. Construction and demolition specific guidance in the UK (Ref.6-24) suggests that fugitive emissions of dust are most likely to impact on amenity at receptors located within 350 m of a construction site boundary, with the highest risk of impacts occurring at receptors located within 50 m. The majority of Project worksites, with the exception of the well pads to the north of the Nile, well pads KGG-06, KGG-09 and NGR-05, to the south of the Nile, and the Water Abstraction System, have dust and PM_{10} sensitive receptors located within 350 m. Several worksites, including the Industrial Area, have dust and PM_{10} sensitive receptors located within 50 m (see Figure 6-4). There is therefore the potential for fugitive emissions of dust and PM_{10} generated by activities undertaken during these phases to harm the amenity characteristics of these locations and/or the health of sensitive receptors.

The majority of dust sensitive receptors within 350 m of the worksite boundaries are residential dwellings. These receptors already experience elevated levels of particulate matter (dust and PM_{10}), as observed during baseline monitoring in the dry season, which is typical of a country that sometimes experiences arid conditions. Project related dust deposition could soil or damage personal property beyond levels typically experienced under baseline conditions, and an increase in PM_{10} concentrations could put the Project EAL for that pollutant at risk of being exceeded. The majority of sites are also surrounded by arable agricultural land.

However, potential impacts are only likely to occur at individual receptors when they are located downwind of a dust generating activity. In such instances, the magnitude of dust soiling and PM_{10} impact will be variable and dependent on the quantity of emissions generated by the activity/activities being undertaken at the time and the strength and direction of the wind. The area within which the Project is located is arid for a large proportion of the year and the inhabitants of the area and surrounding land uses are already tolerant of elevated dust and PM_{10} conditions, as identified during the baseline survey.

Due to the intermittent and variable nature of dust and PM_{10} impacts at individual sensitive receptors, coupled with the existing tolerance of elevated dust and PM_{10} conditions, as a result of the natural aridness of the Project Study Area, the sensitivity of receptors to fugitive emissions of dust and PM_{10} is considered to be moderate. Following the application of the dust and PM_{10} mitigation measures set out in ***Chapter 4: Project Description and Alternatives*** (and summarised in Section 6.7.2), which are in line with those listed in IFC EHS guidance (Ref.6-4), emissions should be controlled to the extent that the magnitude of impact will be no worse than low. A low potential impact magnitude and moderate receptor sensitivity represents a potential impact of **Low** to **Moderate Adverse** significance for fugitive dust and PM_{10} emissions.

6.7.3.2.2 Fugitive NRMM Emissions

These phases of the Project will require the use of NRMM, including excavators, dozers, graders, tippers and cranes. The NRMM will be diesel fuelled and will therefore be a source of combustion emissions that could impact on sensitive receptors located closest to the worksite boundaries.

The sensitivity of receptors to combustion emissions is considered to be low, due the existing good standard of air quality in the Project Area, with the exception of PM_{10} and $PM_{2.5}$, which are both elevated due to the arid conditions often experienced in the area, rather than any existing urban or industrial sources.

The risk of NRMM emissions impacts at individual sensitive receptors is limited by the intermittent nature of their use and the variability of their location, in that they will only be operational for specific tasks, as and when they are required, and those tasks will be spatially distributed across each worksite. Furthermore, the worksites are designed so that the actual works undertaken within them are not adjacent to the worksite boundaries. Therefore, there will be a buffer between the nearest receptors and the NRMM emission sources. In light of this, and the relevant embedded design mitigation measured for NRMM emissions listed in section 6.7.2, the magnitude of potential impact associated with NRMM emissions is considered to be low. A low impact magnitude and low receptor sensitivity represents a potential impact of **Low Adverse** significance for fugitive NRMM emissions, which is considered not significant.

6.7.3.2.3 Fugitive Emissions of VOCs

During this phase, fugitive emissions of VOCs are limited to those associated with the paints used for welding (pickling passivation), painting/coating activities and fuel transfer activities, most of which will be done within Industrial Area in dedicated facilities at the Construction Support Base. Such emissions could have an impact on local air quality, should the safeguarding measures described in ***Chapter 4: Project Description and Alternatives*** ever fail to mitigate this risk (as summarised in section 6.7.2). Emissions could increase the exposure of sensitive receptors located closest to emissions sources (predominantly the Industrial Area) to daily mean concentrations of VOCs.

Due to the existing low levels of VOC concentrations established during the baseline survey within the Project Area, the sensitivity of receptors to fugitive VOC emissions is considered to be low. The risk of fugitive emissions of VOCs occurring to the extent that the EALs would be at risk of being exceeded is exceptionally low, in that the high standards of work set by the Project Proponents and their contractors is such that leaks will be rare, and in the unlikely event a leak does occur, it will be contained and managed as soon as practically possible. Given the intermittent nature of such occurrences, the magnitude of potential impact for fugitive emissions of VOCs during these phases is considered to be low. A low impact magnitude and low receptor sensitivity represents a potential impact of **Low Adverse** significance for fugitive VOC emissions, which is considered not significant.

6.7.3.2.4 Fugitive Odour Emissions

Odour emissions associated with these phases are related to the use of paint and coating activities undertaken at the Construction Support Base, and the storage of potentially odorous waste at designated locations, prior to collection by a third party and removal from the Project Area. Should any emissions occur, they are most likely to be as a result of spillages of drilling muds and fluids, and the storage of food waste from the various camps utilised during these phases.

Fugitive odour emissions impacts are most likely to impact on odour sensitive receptors located closest to the source. For the temporary storage of waste at the accommodation camps, the odour sensitive receptors would principally be the Project contractors living on site, but would also include existing sensitive receptors located close to the camp boundaries. At the waste holding facilities away from the camps, the odour sensitive receptors would be the nearest residential properties to those facilities.

Like dust impacts, fugitive odour impacts are very much dependent on meteorological conditions, with impacts likely to affect individual receptors that are downwind of a potential odorous emission source. Unlike dust impacts, odour impacts are likely to be worse during periods of calmer winds, which only minimise odour dispersion. The sensitivity of receptors to odour impacts is subjective, in that the offensiveness of an odour will vary from person to person. However, it is generally accepted that odour associated with food waste can be offensive, if the waste is not managed correctly. Therefore, the sensitivity of odour sensitive receptors in the Project Areas is considered to be moderate.

A Project **Waste Management Plan** will be developed and shall describe how waste will be stored at the camps and waste storage sites, and how it will be disposed of from the Project Area. Standard best practice measures to reduce odours from any waste storage will be implanted as port of normal operations, including the sealing of waste storage vessels and the removal of waste from site as quickly and as frequently as practically possible (see section 6.7.2 and ***Chapter 4: Project Description and Alternatives***). Such measures are common practice on all well managed sites. The magnitude of impact for fugitive emissions of odour during these phases is considered to be low. A potential low impact magnitude and moderate receptor sensitivity represents a potential impact of low-moderate significance. Given the implementation of the **Waste Management Plan** and the effectiveness of standard best practice procedures on site this is considered to represent a **Low Adverse** significance, which is considered not significant.

6.7.3.2.5 Controlled Vehicle Emissions

During these phases of the Project, the number of Project-related vehicle movements will be highest, as construction materials and site contractors are driven to and from each worksite. The emissions from these vehicles, primarily NO_2, PM_{10}, $PM_{2.5}$ and CO have the potential to increase the exposure of human health sensitive receptors located adjacent to the roads used by construction traffic to total concentrations of these pollutants. Emissions of NO_X also have the potential to increase the exposure of roadside ecology to annual mean concentrations of NO_X, nutrient nitrogen deposition, and acid deposition.

The baseline surveys undertaken in the Study Area have identified that existing conditions regarding most of the pollutants considered are of a good standard, including annual mean and daily mean concentrations of NO_2 which are well below the relevant EALs. Existing conditions for PM_{10} and $PM_{2.5}$ are both elevated, due to the arid conditions often experienced in the area, rather than any existing urban or industrial sources.

The potential impact (referred to as the Process Contribution) of road traffic emissions on sensitive receptors has been predicted at representative roadside locations adjacent to the main construction route to the well pads north of the Nile, the main construction route on the approach to the Industrial Area, and the main construction route to the well pads south of the Nile. The assessment assumes that all proposed daily trips, as defined in ***Chapter 4: Project Description and Alternative***, will occur at the same time. In reality, this will not be the case, with Project activities being undertaken at different times within these phases of the works.

It is noted that potential road traffic emissions impacts associated with the Site Preparation and Enabling Works and Construction and Pre-commissioning phases are temporary and will last for the duration of these phases only. The contribution of Project-related vehicle movement emissions to total pollutant concentrations and deposition rates (Referred to as the Predicted Environmental Concentration (PEC)) at the representative sensitive receptors is presented in Table 6-29 and Table 6-30.

Human Health Sensitive Receptors

Nitrogen Dioxide (NO_2)

Potential impacts account for between 10% and 25% of the EAL for annual mean NO_2 at the worst affected receptors closest to the construction routes, which relates to potential low impact magnitude. Existing annual mean NO_2 conditions are well below the EAL for this pollutant and averaging period (<50% of the EAL), which suggests that receptor sensitivity is low, resulting in a potential impact of **Low Adverse** significance for annual mean NO_2.

Potential impacts account for between 25% and 50% of the EAL for hourly mean NO_2 at receptor locations closest to the road. The maximum impact on hourly mean NO_2 equates to a moderate impact magnitude. Ambient concentrations of hourly mean NO_2 accounts for less than 50% of the EAL, which means that the sensitive receptors are considered to be of low sensitivity to this pollutant and averaging period. A moderate impact magnitude and low receptor sensitivity represents a potential impact of **Low** to **Moderate Adverse** significance for annual and hourly mean NO_2.

Particulate Matter (PM_{10} and $PM_{2.5}$)

Table 6-29 shows that impacts at roadside human health sensitive receptors account for less than 10% of the EALs for annual mean and daily mean concentrations of PM_{10} and $PM_{2.5}$, which equates to a Insignificant impact significance.

Carbon Monoxide (CO)

Table 6-29 shows that impacts at roadside human health sensitive receptors account for less than 1% of the EALs for 8 hour mean, hourly mean, 30 minute mean and 15 minute mean concentrations of CO, which equates to an **Insignificant** impact significance.

Ecologically Sensitive Receptors

Nitrogen Oxides (NO_X)

Table 6-30 shows that potential impacts at roadside ecologically sensitive receptors account for more than 50% of the EAL for annual mean concentrations of NO_X immediately adjacent to the road, between 25% and 50% of the EAL at locations 50 m back from the road, and less than 10% of the EAL at locations 100 m away from the road. There is therefore a high impact magnitude for annual mean NO_X concentrations immediately adjacent to the roads used by Project vehicles, impacts quickly reduce with increasing distance away from the road, to the extent that the potential impact magnitude is moderate at 50 m and low at 100 m from the roadside.

Due to the large area covered by the ecological habitat considered in this assessment and the relatively small area of those habitats that could be impacted upon by Project vehicle emissions (the area within 100 m of the construction routes which equates to <1% of the habitat area), the magnitude of impact is therefore deemed to be low adverse overall. Construction route C1, along with construction route C2 and C3, passes through the MFNP, which is a nationally designated conservation area and home to priority species. Whilst these species (or the species that they rely on) adjacent to the existing road may or may not be sensitive to airborne concentrations of NO_X, this natural habitat is still defined as a receptor with moderate to high sensitivity (see Table 6-20). A low impact magnitude and moderate to high receptor sensitivity represents a potential impact of **Low** to **Moderate Adverse** significance for annual mean NO_X. The construction route L2 is not located within the MFNP or any other designated habitat, but is home to arable farmland (predominantly modified habitat), which has a low sensitivity to potential air quality impacts.

Nutrient Nitrogen Deposition

The potential impact to annual mean nutrient nitrogen deposition rates is less than 10% of the relevant EAL at locations immediately adjacent to the construction route roads, which equates to an **Insignificant** impact significance.

Acid Deposition

The impact to annual mean acid deposition rates is between 10% and 25% of the relevant EAL at locations immediately adjacent to the road, falling to less than 10% of the EAL at a distance of 100 m from the road. There is therefore a low impact magnitude for annual mean NO_X concentrations immediately adjacent to the roads used by Project vehicles, with impacts quickly reducing with increasing distance away from the road, to the extent that the impact magnitude is low at locations 100 m from the roadside. A low impact magnitude and moderate to high receptor sensitivity represents a potential impact of **Low** to **Moderate Adverse** significance for annual mean acid deposition.

Summary

For human health sensitive receptors, potential impacts of insignificant or low to moderate significance could occur at the worst affected locations nearest to the construction routes. In this instance, the low to moderate impact significance reported is deemed to represent a potential impact of **Low Adverse** significance overall, as the PEC (i.e. the ambient conditions plus Project contribution) remains well below the EAL for this pollutant, and is therefore not significant.

For ecologically sensitive receptors, insignificant or low to moderate impact significance is predicted to occur at the worst affected locations nearest to the construction routes. In this instance, the low to moderate impact significance reported is deemed to represent a potential impact of **Low Adverse** significance overall, as the PEC (i.e. the ambient conditions plus Project contribution) remains below the EAL for these pollutants, and potentially impacts on only a small proportion of the sensitive habitat area, and is therefore not significant.

Table 6-29: Road Traffic Emissions Impacts – Human Health Sensitive Receptors

Location	Annual Mean Conc. (µg/m³)			Daily Mean Conc. (µg/m³)		8 Hour mean Conc. (µg/m³)	Hourly Mean Conc. (µg/m³)		30 Minute Mean Conc. (µg/m³)	15 Minute Mean Conc. (µg/m³)
	NO_2	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	CO	NO_2	CO	CO	CO
Process Contribution (Proportion of EAL given in Parenthesis (%))										
Construction traffic route on approach to the CPF (Road L2)	5.9 14.8%	0.1 0.5%	0.1 0.7%	0.2 0.5%	0.2 0.6%	6.8 0.1%	64.5 32.3%	7.0 <0.1%	12.4 <0.1%	12.6 <0.1%
Construction traffic route south of the Nile (Road R1 at Buliisa)	9.3 23.3%	0.2 0.9%	0.1 1.2%	0.4 0.9%	0.3 1.1%	11.5 0.1%	86.4 43.2%	11.9 0.1%	12.4 <0.1%	12.6 <0.1%
Predicted Environmental Concentration (Proportion of EAL given in Parenthesis (%))										
Construction traffic route on approach to the CPF (Road L2)	12.0 30.0%	**34.2** **171.0%**	7.6 75.7%	**51.4** **102.9%**	11.4 45.4%	299.0 3.0%	76.7 38.4%	472.7 2.1%	1404.3 2.3%	4198.7 4.2%
Construction traffic route south of the Nile (Road R1 at Buliisa)	15.4 38.6%	**34.3** **171.4%**	7.6 76.2%	**51.6** **103.3%**	11.5 45.9%	303.7 3.0%	98.4 49.3%	477.6 2.1%	1409.5 2.3%	4203.9 4.2%
EALs	**40**	**20**	**10**	**50**	**25**	**10000**	**200**	**23000**	**60000**	**10000**

Table 6-30: Road Traffic Emissions Impacts – Ecologically Sensitive Receptors

Location	Annual Mean Concentration	Annual Mean Deposition Rate	
	NO_X (µg/m³)	Nutrient Nitrogen (kg N/ha/yr)	Acid (eq/ha/yr)
Process Contribution (Proportion of EAL given in Parenthesis (%))[1]			
Construction traffic route north of the Nile (Road C1 between JBR-09 and Tangi Construction Camp / Support Base)	18.9 – 8.7 – 62.8% – 28.9%	1.3 – 0.9 8.5% – 5.9%	91.6 – 63.1 18.3% – 12.6%
Construction traffic route on approach to the CPF (L2)	15.2 – 9.4 50.8% – 31.4%	1.0 – 0.9 6.6% – 5.7%	70.8 – 61.3 14.2% – 12.3%
Predicted Environmental Contribution (Proportion of EAL given in Parenthesis (%))[1]			
Construction traffic route north of the Nile (Road C1 between JBR-09 and Tangi Construction Camp / Support Base)	27.5 – 17.3 91.5% – 57.5%	2.2 – 1.8 14.4% – 11.7%	154.3 – 125.8 30.9% – 25.2%
Construction traffic route on approach to the CPF (L2)	23.8 – 18.0 79.5% – 60.1%	1.9 – 1.7 12.5% – 11.6%	133.6 – 124.1 26.7% – 24.8%
EALs	**30**	**15 – 35**	**500**
[1] Range of Process Contribution given, from a roadside location to a location that is 50m back from roadside			

6.7.3.2.6 Controlled Energy Generation Plant Emissions

During these phases of the Project, the energy demand will be met by a series of diesel-fired generators of a range of sizes at a multitude of locations across the Project Area (as listed in Table 6-25). The combustion emissions from the generators have the potential to increase sensitive exposure to the pollutants NO_2, PM_{10}, $PM_{2.5}$, CO, and hydrocarbons (HCs) at sensitive receptors near to each worksite.

For this assessment, the quantification of the diesel generator emissions has assumed that all generators across the Project will be operational at the same time. In reality, due to the phasing of works, this is unlikely to be the case, and the potential impacts reported below are likely to be conservative. It is also noted that potential energy generation plant emissions impacts associated with the Site Preparation and Enabling Works and Construction and Pre-commissioning phases are temporary and will last for the duration of these phases only.

Human Health Sensitive Receptors

The contribution of diesel generator emissions to total pollutant concentrations at the worst affected representative sensitive receptor for each pollutant and averaging period is presented in Table 6-31. The potential impact of energy generation plant emissions during Site Preparation and Enabling Works and the Construction and Pre-commissioning phases at other discrete air quality sensitive receptors is shown in Figure 6-8 and Figure 6-9. The contours depicted on the figures represent the contribution to hourly mean and annual mean NO_2 concentrations from Project emissions sources during these phases (see Table 6-25). Contour plots are provided for the worst-case scenario for this pollutant and averaging periods (i.e. the scenario where the worst maximum offsite impact is experienced).

Carbon Monoxide (CO) and Hydrocarbons (HCs)

For the averaging periods for CO and HC, the contribution of energy generation plant emissions has a negligible impact magnitude at the worst affected offsite receptor for all scenarios considered. The sensitivity of receptors to the averaging periods for CO and HC is considered to be low, due to ambient concentrations being less than 50% of the EAL for these pollutants. A low impact magnitude at a location that has low sensitivity equates to a potential impact of **Low Adverse** significance.

Nitrogen Dioxide (NO_2)

A low magnitude impact is predicted for the contribution to annual mean and hourly mean concentrations of NO_2. The sensitivity of receptors to the averaging periods for NO_2 is considered to be low, due to ambient concentrations being less than 50% of the EAL for this pollutant. A low impact magnitude at a location that has low sensitivity equates to a potential impact of **Low Adverse** impact significance.

Particulate Matter (PM_{10} and $PM_{2.5}$)

For the averaging periods for PM_{10} and $PM_{2.5}$, the contribution of energy generation plant emissions has a negligible impact magnitude and **Insignificant** impact significance at the worst affected offsite receptor. The PEC for annual mean and hourly mean PM_{10} does exceed the EALs for this pollutant, due to the elevated existing conditions within the Study Area.

Ecologically Sensitive Receptors

Figure 6-10 to Figure 6-12 show the distribution of potential impacts of annual mean NO_X, nutrient nitrogen deposition, and acid deposition on ecological habitat within the Study Area during these phases. The contours depicted on the figures represent the contribution to annual mean NO_X, nutrient nitrogen deposition, and acid deposition from Project emissions sources during these phases (see Table 6-25). Contour plots are provided for the worst-case scenario for each pollutant (i.e. the scenario where the worst maximum offsite impact is experienced).

Oxides of Nitrogen (NO_X)

Annual mean NO_X impacts are predicted to be around 10% of the EAL, representing a potential impact of low magnitude for that pollutant at the worst affected locations of the high to moderate sensitive MFNP receptor. Impacts at the other designated ecological sites considered are less than 1% of the

EAL. At the worst affected part of the MFNP, this constitutes a potential impact of **Moderate Adverse** significance and a **Low** to **Moderate Adverse** significance elsewhere.

Nutrient Nitrogen Deposition

Nutrient nitrogen deposition rate impacts account for around 7% of the EAL within the MFNP, the Critical Load for which is 15 – 35 kg N/ha/yr, therefore having a negligible magnitude of impact. Nitrogen deposition impacts at the other high sensitivity ecologically designated sites are less than 1% of the relevant EALs (15 – 35 kg N/ha/yr for species rich grassland and 5 – 10 for humid forests). In the low sensitivity areas nearer to the Industrial Area, to the south of the Nile, worst case nutrient nitrogen impacts account for around 20% of the EAL within 100 m of the worksite, which still represents a low magnitude impact. Deposition rates quickly drop off with increasing distance from Project sources. At the worst affected part of the MFNP, this constitutes a potential impact of **Low to Moderate Adverse** significance and a **Low Adverse** significance elsewhere.

Acid Deposition

Acid nitrogen impacts are predicted to be around 10% of the EAL, representing a low impact magnitude for that pollutant at the worst affected locations of the high to moderate sensitive MFNP receptor. Impacts at the other designated ecological sites considered are less than 5% of the EAL. In the low sensitivity areas nearer to the Industrial Area, to the south of the Nile, worst case acid deposition impacts account for around 20% of the EAL. At the worst affected part of the MFNP, this constitutes a potential impact of **Moderate Adverse** significance and a potential impact of **Low** to **Moderate Adverse** significance elsewhere.

Summary

For the human health sensitive receptors, the overall potential impact significance from controlled energy plant during these phases is considered to be **Low Adverse**, and is therefore not significant.

For the ecological receptors a low to negligible impact magnitude is predicted for annual mean NO_X, nitrogen deposition and acid deposition (and consequently no contour plots have been included). The low magnitude of impact predicted at the location of moderate to high sensitivity represents a moderate / low to moderate adverse impact significance for airborne NO_X concentrations and acid deposition. The worst case NO_X and acid deposition impacts affect a small proportion of the moderate to highly sensitive ecological receptor (<0.1% of the total area), with the majority of the ecological site experiencing a low impact significance. As such, the overall potential impact significance is considered to be **Low Adverse** and therefore not significant.

Table 6-31: Potential Energy Generation Plant Impacts – Human Health Sensitive Receptors

Receptor Description	NO_2 (Conc. µg/m^3)		PM_{10} (Conc. µg/m^3)		$PM_{2.5}$ (Conc. µg/m^3)		CO (Conc. µg/m^3)				HCs
	Annual mean	Daily Mean	Annual mean	Daily Mean	Annual mean	Daily Mean	8 Hr Mean	Hourly Mean	30 Min Mean	15 Min Mean	Daily Mean
Process Contribution (µg/m^3)											
Maximum offsite potential impact	8.6 21.5%	35.1 17.5%	0.1 0.6%	0.5 1.0%	0.1 1.3%	0.5 1.9%	13.5 0.1%	23.0 0.1%	25.9 <0.1%	27.7 <0.1%	1.9 <0.1%
Predicted Environmental Concentration (µg/m^3)											
Maximum offsite potential impact	16.1 40.3%	76.9 38.4%	**34.2** **171.1%**	**51.7** **103.4%**	7.6 76.3%	11.7 46.7%	305.7 3.1%	488.7 2.1%	1423.0 2.4%	4219.0 4.2%	3.0 0.1%
EAL	**40**	**200**	**20**	**50**	**10**	**25**	**10,000**	**23,000**	**60,000**	**100,000**	**5,000**

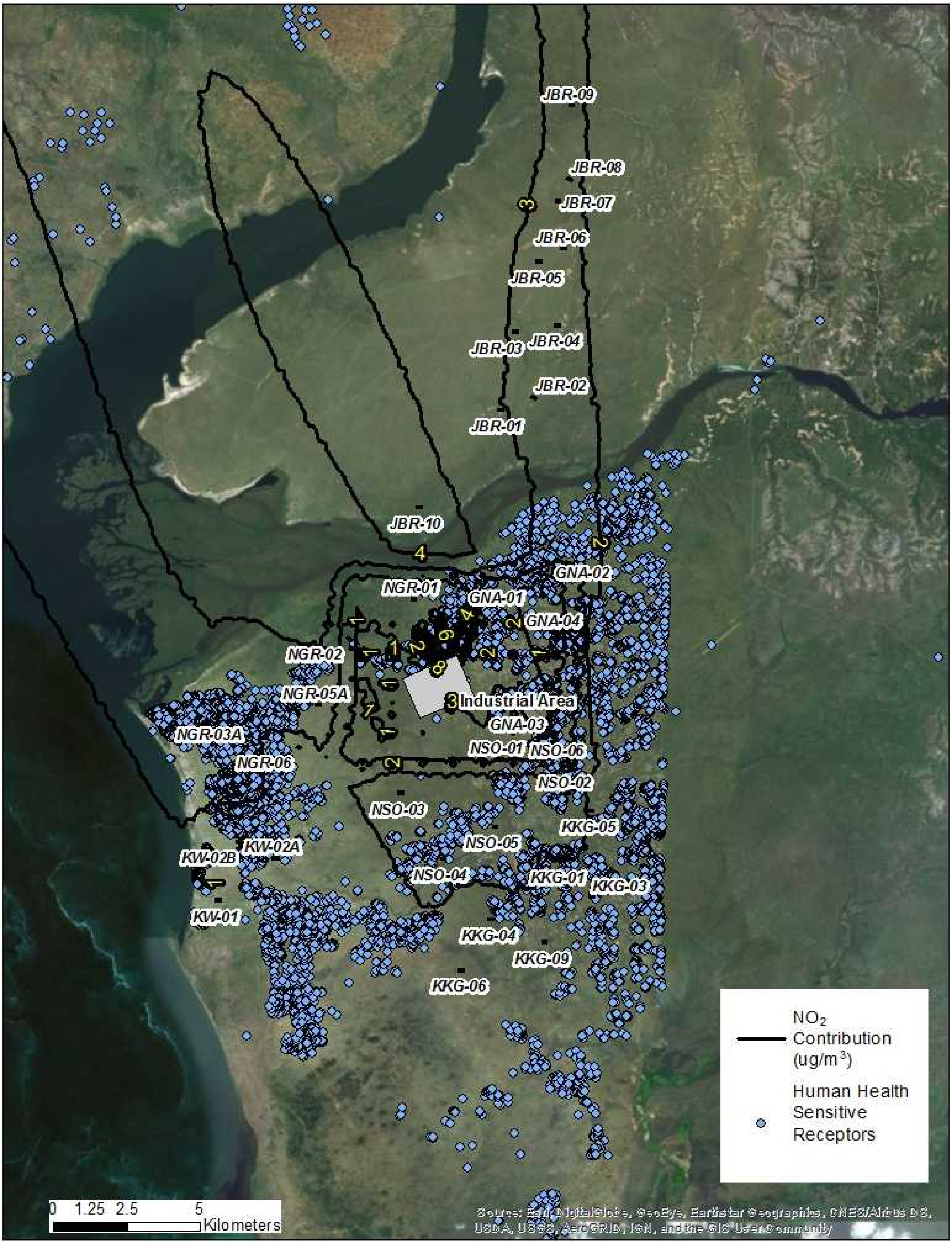

Figure 6-8: Construction Phases Hourly NO_2 Impacts (Contribution from Project Sources) – Human Health Sensitive Receptors

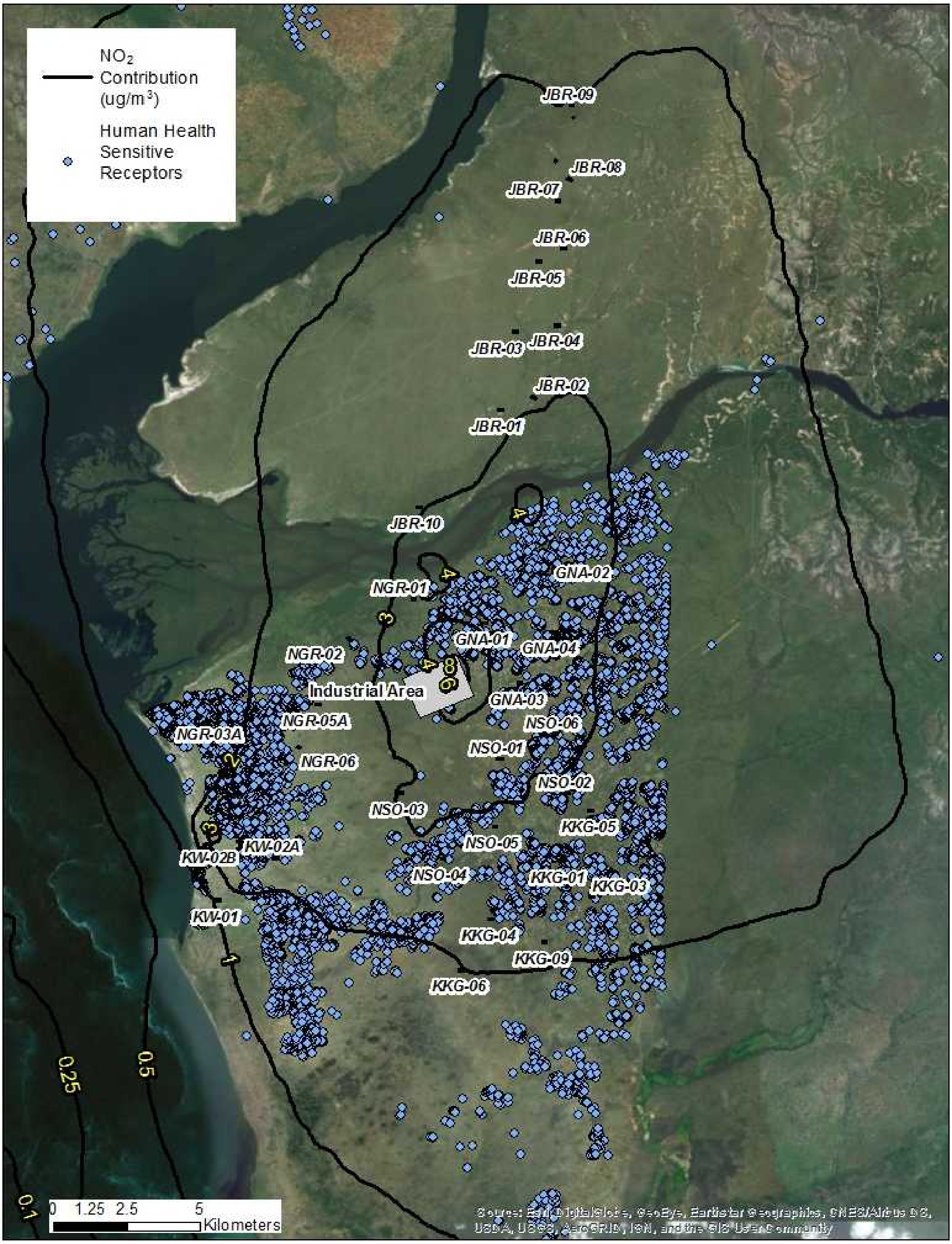

Figure 6-9: Construction Phases Annual Mean NO_2 Impacts (Contribution from Project Sources) – Human Health Sensitive Receptors

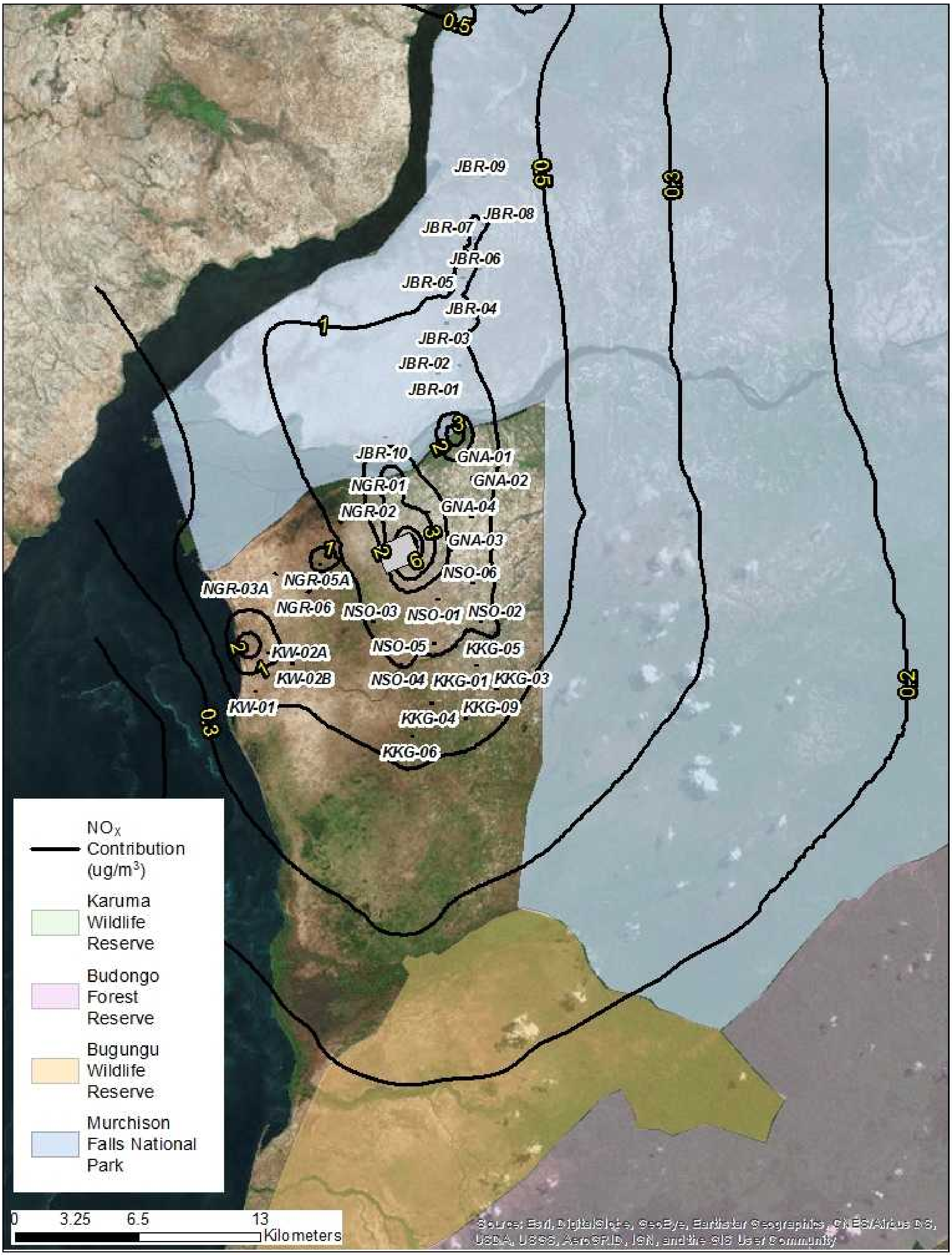

Figure 6-10: Construction Phases Annual Mean NO_X Impacts (Contribution from Project Sources) – Ecologically Sensitive Receptors

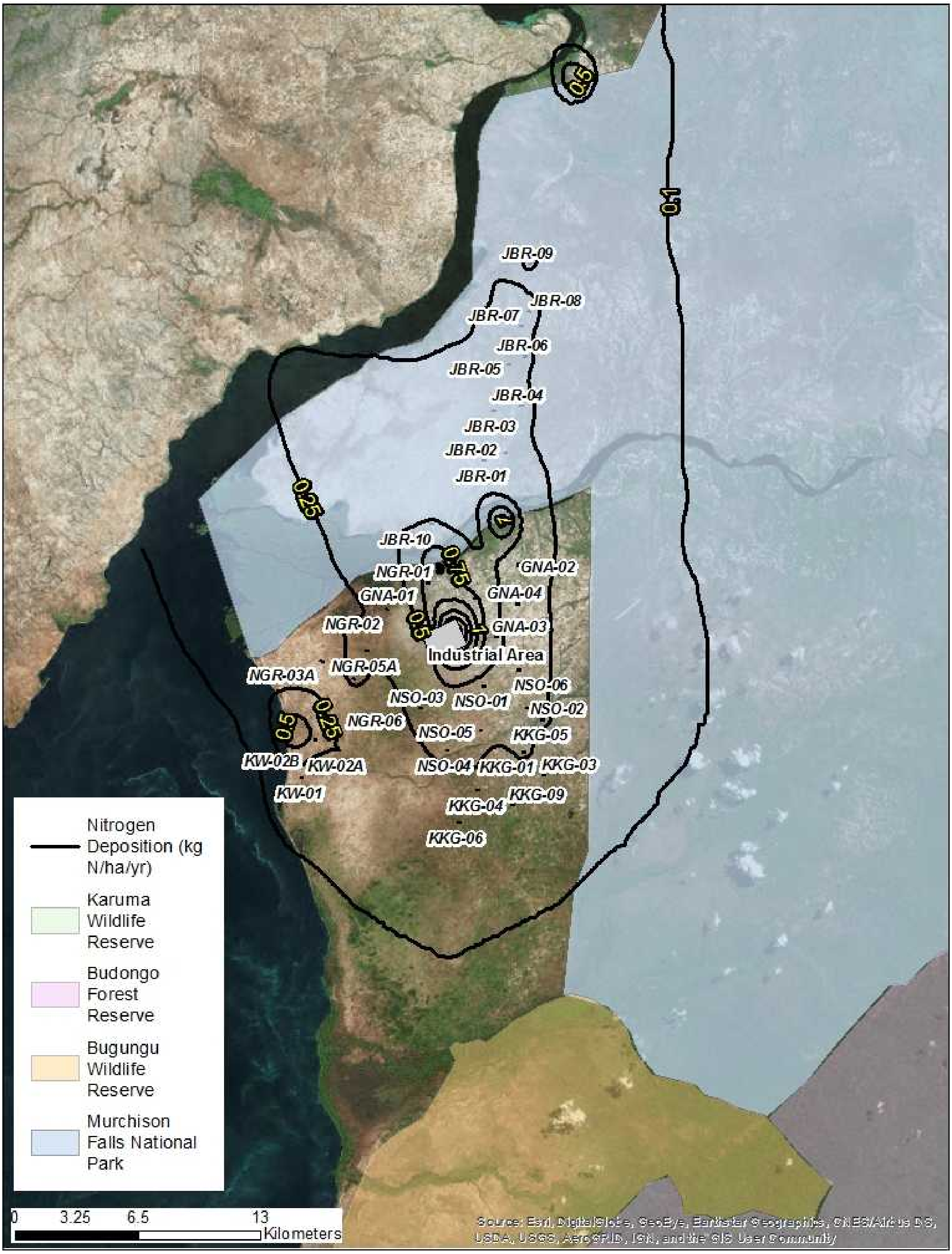

Figure 6-11: Construction Phases Annual Mean Nitrogen Deposition Impacts (Contribution from Project Sources) – Ecologically Sensitive Receptors

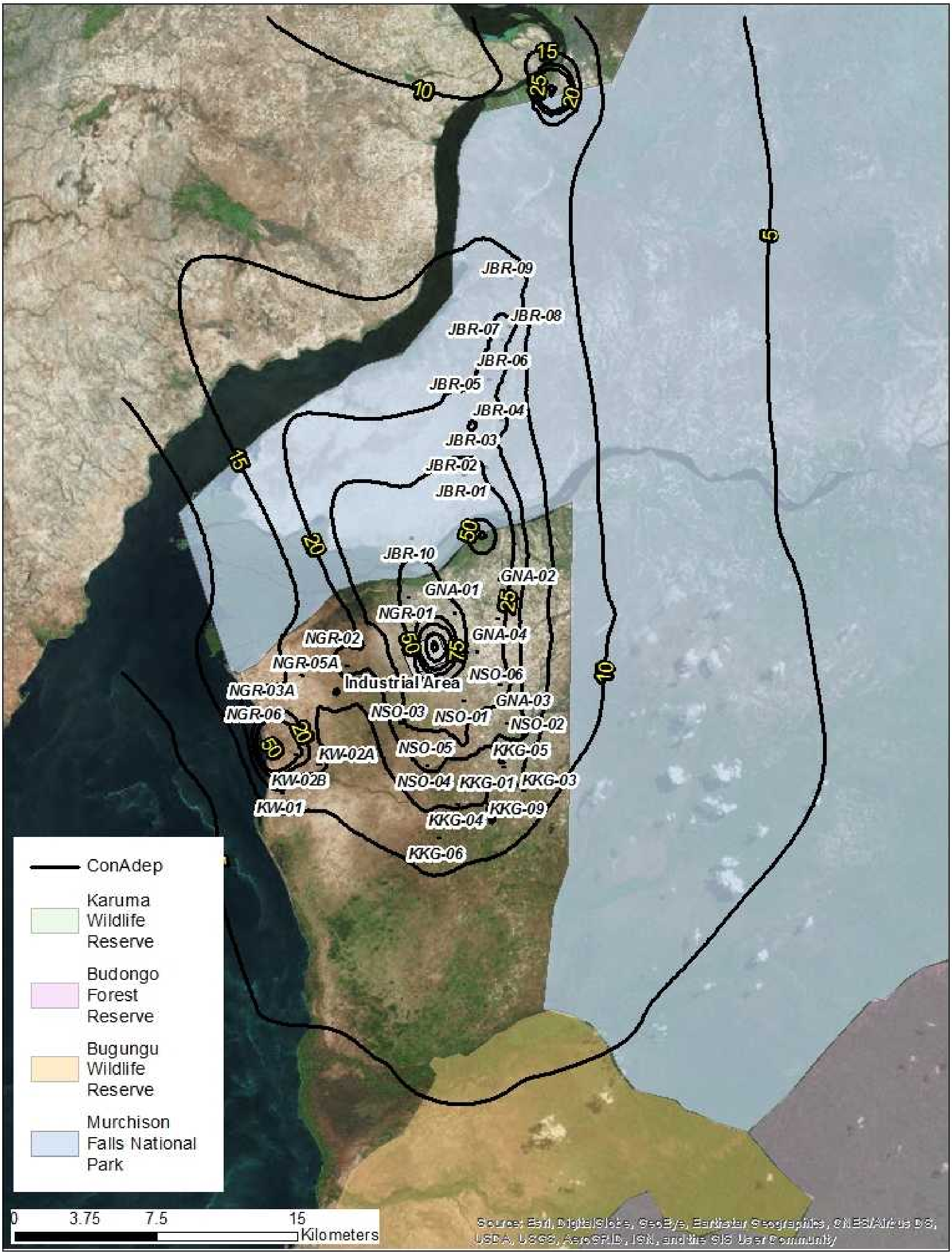

Figure 6-12: Construction Phases Annual Mean Acid Deposition Impacts (Contribution from Project Sources) – Ecologically Sensitive Receptors

6.7.3.3 Additional Mitigation and Enhancement

In addition to the in-built design mitigation measures described in ***Chapter 4: Project Description and Alternatives*** and presented in Table 6-28, additional mitigation measures should also be implemented to further reduce the risk of impacts to air quality. These measures are summarised in Table 6-32 below.

Table 6-32: Additional Mitigation Measures

No.	Additional Mitigation Measures	Relevant Phase: Site Preparation and Enabling Works	Relevant Phase: Construction and Pre-Commissioning	Relevant Phase: Commissioning and Operations	Relevant Phase: Decommissioning
Fugitive Dust and PM_{10} Emissions					
AQ.1	For work activities located close to dust sensitive receptors, mitigations will be considered to minimize the dust emissions. A range of specific dust suppression measures shall be implemented to minimise potential impacts. Such measures shall be implemented on a case by case basis and may include the use screens covers and/or barriers.	X	X		X
AQ.2	Use enclosed chutes and conveyors and covered skips, where practicable	X	X		X
AQ.3	Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate	X	X		X
AQ.4	Ensure equipment is readily available on site to clean any dry spillages, and clean up spillages as soon as reasonably practicable after the event using wet cleaning methods	X	X	X	X
AQ.5	Re-vegetate exposed areas/soil stockpiles to stabilise surfaces as soon as practicable	X	X		X
AQ.6	Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place	X	X		X
AQ.7	Use water-assisted dust sweeper(s) on the tarmacked access roads, to remove, as necessary any material tracked out of the site as required	X	X		X
AQ.8	Vehicle access points to be sited at suitable locations and where possible, away from receptors to limit impacts from dust generation	X	X		X
Fugitive NRMM Emissions					
AQ.9	Prohibit the unnecessary idling of plant	X	X		X
AQ.10	Enforcement of a low speed limit for NRMM, such as 10 kilometres per hour (kph) within working areas	X	X		X
AQ.11	Regular servicing and maintenance of NRMM plant to ensure they are operating as per manufacturer's specification	X	X		X
AQ.12	Allowing only trained and accredited (as required) personnel in the use of NRMM	X	X		X
AQ.13	Phased planning of construction activities on the worksites so that NRMM plant are not regularly located in close proximity to nearby sensitive receptors	X	X		X

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
Fugitive Emissions of VOCs					
AQ.14	Majority of coating and painting activities shall be done at the Construction Support Base in dedicated buildings	X	X		
AQ.15	On site painting and coating shall be limited to touch up and roller application	X	X		
AQ.16	All spray applications will normally be carried out in the enclosed blast and paint shop, which will be fitted with the necessary air filters to prevent fugitive emissions to air and will use non-toxic paint, where available, and containment practices to stop overspray	X	X		
AQ.17	Implementation of a fugitive emissions measurement program and leak detection system			X	
Fugitive Odour Emissions					
AQ.18	The opening of waste storage vessels for limited periods of filling and emptying	X	X	X	X
AQ.19	Ensure spill response equipment (including sampling and personal protective equipment) is readily available on site to contain and clean any spillages as soon as reasonably practicable after the event	X	X	X	X
AQ.20	The positioning of potentially odorous waste storage vessels at locations as far away from odour sensitive receptors as practically possible	X	X	X	X
AQ.21	The removal of potentially odorous waste from the Project Area at appropriate time and frequency	X	X	X	X
AQ.22	Implementing a Grievance Management Procedure, to allow recording and follow up of any odour complaints related to Project activities, in a timely manner	X	X	X	X
AQ.23	Undertake regular observation and recording of site odour conditions	X	X	X	X
Controlled Vehicle Emissions					
AQ.24	Prohibit the unnecessary idling of Project vehicles	X	X	X	X
AQ.25	Regular servicing and maintenance of Project vehicles to ensure they are operating as per manufacture's specification	X	X	X	X
AQ.26	Allowing only trained personnel to drive Project vehicles	X	X	X	X
AQ.27	As far as possible, sourcing material from locations close to the Project Area to reduce haulage distances, and therefore the exposure to noise and emissions from traffic	X	X		X

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
AQ.28	Optimising the logistics to maximise use of available vehicles, reduce number of trips and reduce movements on more sensitive routes where possible; using convoys when appropriate (e.g. via using one shared logistics service provider who can ensure appropriate planning across all parts of the Project and ensure efficiencies are made)	X	X	X	X
AQ.29	Developing and implementing a Road Safety and Transport Management Plan that will outline speed limits and setting and enforcing traffic management measures (e.g. 40 km/hr), and indicating vehicles should be driven at steady speeds observing the speed limit and not making unnecessary noise, such as sounding horns, etc.	X	X	X	X
Controlled Energy Generation Plant Emissions					
AQ.30	Operating the energy generation plant as and when required, and at the load required to meet the energy demand of the worksite/activity at that time	X	X		X
AQ.31	Ensuring the energy generation plant is well maintained and used in accordance with manufacturer's specification	X	X	X	X
AQ.32	The use of centralised power generation will be implemented on the Construction Support Base to minimise the number of discrete diesel generators required to support construction activities at the Industrial Area	X	X		

6.7.3.4 Residual Impacts - Site Preparation and Enabling Works and Construction and Pre-commissioning

6.7.3.4.1 Fugitive Dust and PM_{10} Emissions

Following the application of embedded design mitigation and the additional dust and PM_{10} mitigation measures listed, which are considered to be GIIP for construction sites across the world, the impact magnitude is considered to be low. An impact of this magnitude at receptors that are considered to have a moderate sensitivity to dust and PM_{10} equates to an impact significance that is Low to Moderate adverse. Providing that the dust and PM_{10} control measures are implemented correctly throughout the works, and that any complaints are fully investigated and corrective measures applied to the mitigation plan when and where necessary, the potential effect of fugitive dust and PM_{10} emissions is considered to be of a **Low Adverse** significance and therefore classed as being not significant.

6.7.3.4.2 Fugitive NRMM Emissions

The embedded design and additional mitigation measures relevant to NRMM emissions are considered to be appropriate for reducing impacts to the extent that the impact magnitude is low. The sensitivity of receptors to NRMM emissions is also considered to be low, due to the quality of existing air with the Study Area. This equates to a **Low Adverse** impact significance, which is considered not significant.

6.7.3.4.3 Fugitive Emissions of VOCs

Fugitive emissions of VOCs during this phase are extremely rare in occurrence, due to the nature of work expected during the phase. Given the rare, low volume and intermittent nature of potential emissions, the magnitude of impact for fugitive emissions of VOCs during these phases is considered to be low. As existing low levels of VOC concentrations were established during the baseline survey within the Project Area, the sensitivity of receptors to fugitive VOC emissions is also considered to be low. A low impact magnitude at locations of low sensitivity equates to a **Low Adverse** residual impact significance. The effect of fugitive emissions of VOCs during this phase will be insignificant.

6.7.3.4.4 Fugitive Odour Emissions

The Project **Waste Management Plan** will describe how waste will be stored at the camps and waste storage sites, and how it will be disposed of from the Project Area. Standard best practice measures to reduce odours from any waste storage will be implemented as part of normal operations, including the immediate clean-up of spillages, sealing of waste storage vessels and the removal of waste from site as quickly and as frequently as practically possible. Such measures are considered GIIP on all well managed sites. Odours associated with use of paint and coating activities will be minimised by undertaking the vast majority of works at a designated area within the Construction Support Base and the appropriate handling and storage of potentially odorous materials.

Given the implementation of the Project **Waste Management Plan** and the effectiveness of standard best practice odour management procedures on site, the magnitude of impact for fugitive emissions of odour during these phases is considered to be low. The effect of fugitive emissions of odour during this phase is Moderate/Low. Providing that the measures described within the Project **Waste Management Plan** are implemented correctly throughout the works, and that any complaints are fully investigated and corrective measures applied to the mitigation plan when and where necessary, the residual effect of fugitive odour emissions is considered to be of a **Low Adverse** residual impact significance and therefore classed as being not significant.

6.7.3.4.5 Controlled Vehicle Emissions

A worst case moderate impact magnitude has been determined for hourly mean NO_2 impacts at human health receptors located immediately adjacent to the Project vehicle routes. A moderate impact magnitude at a location that has a low sensitivity to hourly mean NO_2 impacts represents a moderate to low impact significance. In this instance, because the PEC is less than 50% of the EAL, the residual effect is considered to be of a **Low Adverse** impact significance and therefore classed as being not significant.

A low impact magnitude has been determined for annual mean NO_X concentrations at ecological receptors adjacent to construction routes within the MFNP, due to the limited area of the habitat that is likely to be affected by emissions from the road. Such an impact at a receptor that is deemed to be of moderate to high sensitivity equates to an impact significance that is considered to be moderate to low significance. However, in this instance, the residual impact significance is considered to be **Low Adverse** and thus not significant, due to the limited sensitivity of species within the habitat to airborne NO_X and nutrient nitrogen and acid deposition, as well as the phasing of the works undertaken and the temporary nature of the works. During the Commissioning and Operations phase of the Project, vehicle movement emissions will be limited to those associated with maintenance and impacts, and will therefore be negligible and are not discussed further in the Commissioning and Operations phase impact assessment (Section 6.7.4).

6.7.3.4.6 Controlled Energy Generation Plant Emissions

A low to negligible impact magnitude has been determined for all pollutants and averaging periods at human health sensitive locations. At the receptors that have a low sensitivity to the majority of pollutants considered and a high sensitivity to PM_{10}, these impacts equate to a **Low Adverse** residual significance, which is considered to be not significant.

A low to negligible impact magnitude has been determined for all pollutants at the ecologically sensitive locations considered. Low impacts are restricted to a small area (<0.1% of the MFPA) with vast majority of the ecological area experiencing a negligible impact. The residual impact significance is therefore determined to be **Low Adverse** and classed as not significant.

6.7.4 Assessment of Impacts: Commissioning and Operations

6.7.4.1 Introduction

During the Commissioning and Operations phase of the Project, the potential emissions to air are considered in relation to the Project Activities outlined in Table 6-19.

The Commissioning and Operations phase is expected to commence approximately 36 months after effective date of the main construction contract award. The lifetime of the Project is anticipated to be 25 years.

The flare located at the CPF will be a source of emissions to air during this phase. The flare is predominantly for emergency purposes, but some intermittent flaring is expected to occur during start up, plant stabilisation and maintenance (which would involve one gas compression train non-operational for two six hour periods per month). Such flaring events are expected to be limited to 48 hours in duration up to the maximum design flowrate. Reducing the frequency of flaring events will require a high plant reliability (>93%) and is therefore the main design focus. The potential impacts of the flare in operation is considered within Section 6.10 Unplanned Events. The results reported and discussed in that section are also representative of flaring in the Commissioning and Operations phase.

6.7.4.2 Potential Impacts (pre additional mitigation) - Commissioning and Operations

6.7.4.2.1 Fugitive Emissions of VOCs

During the Commissioning and Operations phase there will be a risk of fugitive emissions of VOCs associated with well pads for maintenance and annulus gas management if required, and the storage and handling of materials such as chemicals, oils, paints and solvents. There will also be the potential for intermittent fugitive VOC emissions from oily pigging wastes (once every two weeks at pads), as well as from the sludge treatment undertaken at the CPF. During this phase, the majority of VOC emissions will be controlled through the embedded mitigation as described in ***Chapter 4: Project Description and Alternatives*** (and as listed in section 6.7.2), including the use of an onsite VRU located at the CPF.

Should the in-built design mitigation fail, operations could potentially generate emissions of VOC that could increase the exposure of sensitive receptors located closest to the well pads and Industrial Area to daily mean concentrations of VOCs.

Due to the existing low levels of VOC concentrations established during the baseline survey within the Study Area, the sensitivity of receptors to fugitive VOC emissions is considered to be low. The risk of fugitive emissions of VOCs occurring to the extent that the EALs would be at risk of being exceeded is exceptionally low, in that the high standards of work set by the Proponents and their contractors is such that leaks will be rare and in the unlikely event a leak does occur, it will be identified, contained and managed as soon as practically possible. Furthermore, any emissions from well pads associated with their maintenance and annulus gas management will be done for low level, low frequency events (<100 standard cubic metre per hour (sm^3/h)). In event that annulus gas management will generate emissions at a rate of >100sm^3/hr, a compressor and pipework shall be installed to direct annulus gas flow into the production line.

The potential impact of emissions associated with maintenance and annulus gas management has been quantified separately to the assessment described in this chapter, to inform the design of the Project. That assessment used the dispersion modelling software AERMOD to predict the max 24 hour mean VOC concentrations at site boundary locations of a number of well pad sites, assuming VOC emissions concentrations of 100 sm^3/hr and 200 sm^3/hr. Even with the higher of the emissions concentrations considered, that dispersion modelling assessment predicted concentrations at well pad site boundary locations that accounted for just 1.5% of the EAL for that pollutant.

Given the intermittent nature of such occurrences, the potential impact significance for fugitive emissions of VOCs during the Commissioning and Operations phase is considered to be **Low Adverse**.

6.7.4.2.2 Fugitive Odour Emissions

Potential odour emissions during this phase are associated with the regular pigging campaigns at the well pads, sludge treatment at the CPF and the storage and handling general waste at the Operational Camp. Due to the in-built design mitigation described in ***Chapter 4: Project Description and Alternatives*** (as listed in section 6.7.2), the magnitude of potential impact for fugitive emissions of odour during this phase is considered to be low and the sensitivity of odour sensitive receptors in the Project Areas considered to be moderate. A low impact magnitude and moderate receptor sensitivity represents a low-moderate impact significance. Given the implementation of the Waste Management Plan and the effectiveness of standard best practice procedures on site this is considered to represent a **Low Adverse** significance which is not significant.

6.7.4.2.3 Controlled Energy Generation Plant Emissions

During initial start-up and plant stabilisation, the power generation plant at the CPF will be temporarily fuelled by diesel. Once stabilised, the power generation plant will then be run on fuel gas produced from Project reservoirs, referred to as the 'excess gas phase'. During field life, the amount of gas produced from the reservoir will gradually decrease and eventually become insufficient to meet the power and heat generation demand. This phase is referred to as the 'gas deficient phase'. During the gas deficient phase, the base case will be to import electricity to meet the Project power demand (subject to availability). The heat demand, however, will be supplemented with the combustion of crude oil produced from the reservoirs.

The assessment considers two power generation plant design configurations (Op1 and Op2 (refer to Table 6-24 for details)). Both configurations are modelled for the excess gas phase (gas fuelled) and the gas deficient phase (crude oil fuelled) (a and b). The modelled Process Contribution and PEC are reported in Table 6-33. A summary of potential impact magnitude, receptor sensitivity and potential impact significance for the pollutants considered in each scenario is provided in Table 6-34. The implication of the potential impacts are provided below for each pollutant considered for human health and ecologically sensitive receptors.

Human Health Sensitive Receptors

Carbon Monoxide (CO),Hydrocarbons (HC) and Volatile Organic Compounds (VOC)

For the averaging periods for CO, HC and VOC, the contribution of power and heat generation plant emissions has a negligible impact magnitude at the worst affected offsite receptor for all scenarios considered. The sensitivity of receptors to the averaging periods for CO, HC and VOC is considered to be low, due to ambient concentrations being less than 50% of the EAL for these pollutants. A low impact magnitude at a location that has low sensitivity equates to a potential impact of **Low Adverse** significance.

Nitrogen Dioxide (NO_2)

A low magnitude impact is predicted for the contribution to annual mean and hourly mean concentrations of NO_2 for both options considered and for both fuel types. The sensitivity of receptors to the averaging periods for NO_2 is considered to be low, due to ambient concentrations being less than 50% of the EAL for this pollutant. A low impact magnitude at a location that has low sensitivity equates to a potential impact of **Low Adverse** significance.

Particulate Matter (PM_{10} and $PM_{2.5}$)

Particulate emissions are only associated with the power and heat generation plant during the gas deficient phase. For annual mean concentrations of PM_{10}, a negligible impact magnitude is predicted for scenario Op1b and a low impact magnitude predicted for scenario Op2b, at the worst affected receptor. Due to existing PM_{10} conditions, relative to the WHO guideline values for that pollutant, the sensitivity of receptors to PM_{10} emissions is considered to be high. The potential impact significance to annual mean PM_{10} is therefore considered to be **Low Adverse** in scenario Op1b and **Moderate Adverse** in scenario Op2b.

For daily mean concentrations of PM_{10}, a low impact magnitude is predicted for both Op1b and Op2b scenarios, at the worst affected receptor. Again, due to existing PM_{10} conditions, relative to the WHO guideline values for that pollutant, the sensitivity of receptors to PM_{10} emissions is considered to be high. The potential impact significance to daily mean PM_{10} is therefore considered to be **Moderate Adverse** in both scenarios.

For annual mean concentrations of $PM_{2.5}$, a negligible impact magnitude is predicted for scenario Op1b and a low impact magnitude predicted for scenario Op2b, at the worst affected receptor. Due to existing $PM_{2.5}$ conditions, relative to the WHO guideline values for that pollutant, the sensitivity of receptors to $PM_{2.5}$ emissions is considered to be moderate. The potential impact significance to annual mean $PM_{2.5}$ is therefore considered to be **Low Adverse** in scenario Op1b and Low to **Moderate Adverse** in scenario Op2b.

For daily mean concentrations of $PM_{2.5}$, a moderate impact magnitude is predicted for both Op1b and Op2b scenarios, at the worst affected receptor. Existing $PM_{2.5}$ conditions, relative to the WHO guideline values for that pollutant, are considered to be low. The potential impact significance to daily mean $PM_{2.5}$ is therefore considered to be **Low** to **Moderate Adverse** in both scenarios.

Summary

The process contributions predicted at the human health sensitive receptors for the worst case scenario for NO_2 and daily mean PM_{10} impacts are represented in Figure 6-13 to Figure 6-15. The contours depicted on the figures represent the contribution of the pollutants listed to concentrations from Project emissions sources during this phase (see Table 6-25). Contour plots are provided for the worst-case scenario for each the pollutants and averaging periods mentioned above (i.e. the scenario where the worst maximum offsite potential impact is experienced).

The low impact significance identified for the majority of receptors and the majority of pollutants (NO_2, CO, HC and VOC) is considered to be not significant, as is the low impact significance identified for annual mean PM_{10} and $PM_{2.5}$ in scenario Op1b.

The low to moderate and moderate adverse impact significance identified for annual and daily mean $PM_{2.5}$ and annual and daily mean PM_{10}, in scenarios Op1b and Op2b respectively, could typically be considered to represent a significant effect following the impact assessment process. However, in this instance this is not considered to be the case and the potential impact significance for these pollutants are also considered to be not significant. This is because the receptor sensitivity to PM_{10} and $PM_{2.5}$, and the magnitude of potential impact, is relative to the Environmental Assessment Level (EAL) for these pollutants, which is based on the WHO guidelines. The baseline surveys have established that existing PM_{10} conditions (and, to a lesser extent $PM_{2.5}$ conditions) are already elevated above or near to the EAL for these pollutants and averaging periods. However, this is as a result of natural sources from the often arid environment, rather than toxic particles associated with any exiting industrial or urban pollutant sources. The low to moderate / moderate potential impact significance reported is only predicted for these pollutants at the worst affected receptor locations (i.e. those located closest to the northern boundary of the CPF), and only during the gas deficient phase (Op1b and Op2b). The majority of receptors, located away from the northern boundary, are likely to experience a lower impact significance. Furthermore, During the gas deficient phase, some site energy requirements will be met by an imported source, thereby reducing the load and emissions associated with the oil-fired energy generation plant on site.

In summary, the potential impact significance from the power and heat generation plant at the CPF at human health sensitive receptors ranges from **Low** to **Moderate Adverse** at the worst affected locations, which are those situated immediately to the north of the CPF boundary. For the reasons given above, the potential impact significance is considered to be not significant.

Ecologically Sensitive Receptors

Oxides of Nitrogen (NO_X)

The greatest NO_X impact could occur in scenario Op2b, where the contribution to annual mean concentrations are between 3% and 6% of the EAL, representing a negligible impact magnitude for that pollutant at the worst affected locations of the high to moderate sensitive MFNP receptor. Impacts at the other designated ecological sites considered are less than 0.5% of the EAL. The potential impact significance at all locations is therefore considered to be **Low Adverse** and not significant.

Nutrient Nitrogen Deposition

In the same scenario (Op2b), the greatest nutrient nitrogen deposition rate impacts account for around 5% of the EAL within the MFPA, the Critical Load for which is 15 – 35 kg N/ha/yr, therefore having a negligible magnitude of impact. Nitrogen deposition impacts at the other high sensitivity ecologically designated sites are less than 1% of the relevant EALs (15 – 35 kg N/ha/yr for species rich grassland and 5 – 10 kg N/ha/yr for humid forests). In the low sensitivity areas nearer to the Industrial Area, to the south of the Nile, worst case nutrient nitrogen impacts account for around 7% of the EAL within 100 m of the worksite, which still represents a negligible magnitude impact. The potential impact significance at all locations is therefore considered to be **Low Adverse** and not significant.

Acid Deposition

Acid deposition rate impacts account for around 5% of the EAL within the worst affected area of the MFPA, representing a negligible magnitude impact at this high to moderate sensitive receptor. Impacts at the other high sensitivity designated ecological sites in the study area are less than 1% of the EAL. In the low sensitivity areas nearer to the Industrial Area, to the south of the Nile, worst case acid deposition impacts account for around 15% of the EAL, which constitutes a low magnitude of impact. The potential impact significance at all locations is therefore considered to be **Low Adverse** and not significant.

Summary

The process contribution predicted at the ecologically sensitive habitats considered are shown in Figure 6-16 to Figure 6-18. The contours depicted on the figures represent the contribution of the pollutants listed to concentrations from Project emissions sources during this phase (see Table 6-25). Contour plots are provided for the worst-case scenario for each pollutant considered for ecological receptors (i.e. the scenario where the worst maximum offsite impact is experienced). They show that airborne NO_X concentrations and deposition rates quickly drop off with increasing distance from Project sources. Worst case potential impact significance has been identified as **Low Adverse** and therefore not significant.

Table 6-33: Potential Energy Generation Plant Impacts – Human Health Sensitive Receptors

Scenario / Receptor Description	NO_2 (Conc. µg/m^3)		PM_{10} (Conc. µg/m^3)		$PM_{2.5}$ (Conc. µg/m^3)		CO (Conc. µg/m^3)				HCs	VOCs
	Annual mean	Hourly Mean	Annual mean	Daily Mean	Annual mean	Daily Mean	8 Hr Mean	Hourly Mean	30 Min Mean	15 Min Mean	Daily Mean	Daily Mean
Process Contribution (µg/m^3)												
Op1a – Maximum offsite potential impact	4.3 10.7%	22.6 11.3%	n/a	n/a	n/a	n/a	1.3 <0.1%	64.8 0.3%	67.3 0.1%	68.7 0.1%	3.4 0.1%	3.4 0.1%
Op1b – Maximum offsite potential impact	4.9 12.2	29.3 14.7%	0.8 4.2%	7.3 14.5%	0.8 8.5%	7.3 29.1%	49.6 0.5%	86.3 0.4%	89.5 0.1%	91.3 0.1%	3.4 0.1%	3.4 0.1%
Op2a – Maximum offsite potential impact	4.5 11.4	21.9 10.9%	n/a	n/a	n/a	n/a	5.9 0.1%%	218.5 0.9	223.1 0.4%	225.6 0.2%	10.0 0.2%	10.0 0.2%
Op2b – Maximum offsite potential impact	5.1 12.8%	26.1 13.0%	1.3 6.3%	9.1 18.1%	1.3 12.5%	9.1 36.2%	63.9 0.6%	157.6 0. %7	161.1 0.3%	162.9 0.2%	10.0 0.2%	10.0 0.2%
Predicted Environmental Concentration (µg/m^3)												
Op1a – Maximum offsite potential impact	11.7 29.1%	66.4 33.2%	n/a	n/a	n/a	n/a	293.5 2.9%	530.5 2.3%	1464.4 2.4%	4260.0 4.3%	4.5 0.1%	4.5 0.1%
Op1b – Maximum offsite potential impact	12.3 30.7	73.3 36.6%	**34.9** **174.7%**	**58.5** **116.9%**	8.3 83.5%	18.5 73.9%	341.8 3.4%	552.0 2.4%	1486.6 2.5%	4282.6 4.3%	4.5 0.1%	4.5 0.1%
Op2a – Maximum offsite potential impact	11.9 29.7%	65.7 32.8%	n/a	n/a	n/a	n/a	298.1 3.0%	684.2 3.0%	1620.2 2.7%	4416.9 4.4%	11.1 0.2%	11.1 0.2%

Scenario / Receptor Description	NO_2 (Conc. µg/m³)		PM_{10} (Conc. µg/m³)		$PM_{2.5}$ (Conc. µg/m³)		CO (Conc. µg/m³)				HCs	VOCs
	Annual mean	Hourly Mean	Annual mean	Daily Mean	Annual mean	Daily Mean	8 Hr Mean	Hourly Mean	30 Min Mean	15 Min Mean	Daily Mean	Daily Mean
Op2b – Maximum offsite potential impact	12.5 31.2%	69.9 34.9%	**35.4** **176.8%**	**60.3** **120.5%**	8.8 87.5%	20.3 81.0%	356.1 3.6%	623.3 2.7%	1558.2 2.6%	4354.2 4.4%	11.1 0.2%	11.1 0.2%
EAL	**40**	**200**	**20**	**50**	**10**	**25**	**10,000**	**23,000**	**60,000**	**100,000**	**5,000**	**6,000**

Table 6-34: Summary of Energy Generation Plant Impacts – Human Health Sensitive Receptors

Pollutant	Averaging Period	Impact Magnitude				Receptor Sensitivity	Impact Significance			
		Op1a[1]	Op1b[2]	Op2a[3]	Op2b[4]		Op1a[1]	Op1b[2]	Op2a[3]	Op2b[4]
NO_2	Annual Mean	Low	Low	Low	Low	Low	Low	Low	Low	Low
	Hourly Mean	Low	Low	Low	Low	Low	Low	Low	Low	Low
PM_{10}	Annual Mean	n/a	Negligible	n/a	Low	High[5]	n/a	Low	n/a	Moderate (Low)[6]
	Daily Mean	n/a	Low	n/a	Low	High[5]	n/a	Moderate (Low)[6]	n/a	Moderate (Low)[6]
$PM_{2.5}$	Annual Mean	n/a	Negligible	n/a	Low	Moderate[5]	n/a	Low	n/a	low to moderate
	Daily Mean	n/a	Moderate	n/a	Moderate	Low	n/a	low to moderate (Low)[6]	n/a	low to moderate (Low)[6]

Pollutant	Averaging Period	Impact Magnitude				Receptor Sensitivity	Impact Significance			
		Op1a[1]	Op1b[2]	Op2a[3]	Op2b[4]		Op1a[1]	Op1b[2]	Op2a[3]	Op2b[4]
CO	Daily Mean	Negligible	Negligible	Negligible	Negligible	Low	Negligible	Negligible	Negligible	Negligible
	Hourly Mean	Negligible	Negligible	Negligible	Negligible	Low	Negligible	Negligible	Negligible	Negligible
	30 Min Mean	Negligible	Negligible	Negligible	Negligible	Low	Negligible	Negligible	Negligible	Negligible
	15 Min Mean	Negligible	Negligible	Negligible	Negligible	Low	Negligible	Negligible	Negligible	Negligible
HC	Daily Mean	Negligible	Negligible	Negligible	Negligible	Low	Negligible	Negligible	Negligible	Negligible
VOC	Daily Mean	Negligible	Negligible	Negligible	Negligible	Low	Negligible	Negligible	Negligible	Negligible

[1] Fluor design – excess gas phase
[2] Fluor design – gas deficient phase
[3] CBI design – excess gas phase
[4] CBI design – gas deficient phase
[5] Receptor sensitivity determined by existing air quality established during the baseline surveys, relative to the Project EALs. Baseline survey established that PM_{10} and $PM_{2.5}$. conditions in the Study Area are already elevated beyond or close to the Project EALs for these pollutants, mainly due to natural sources, rather than existing industrial or urban pollution sources.
[6] Impact significance reduced to reflect the fact that existing PM_{10} and $PM_{2.5}$ concentrations are elevated due to natural sources, rather than existing industrial or urban pollution sources.

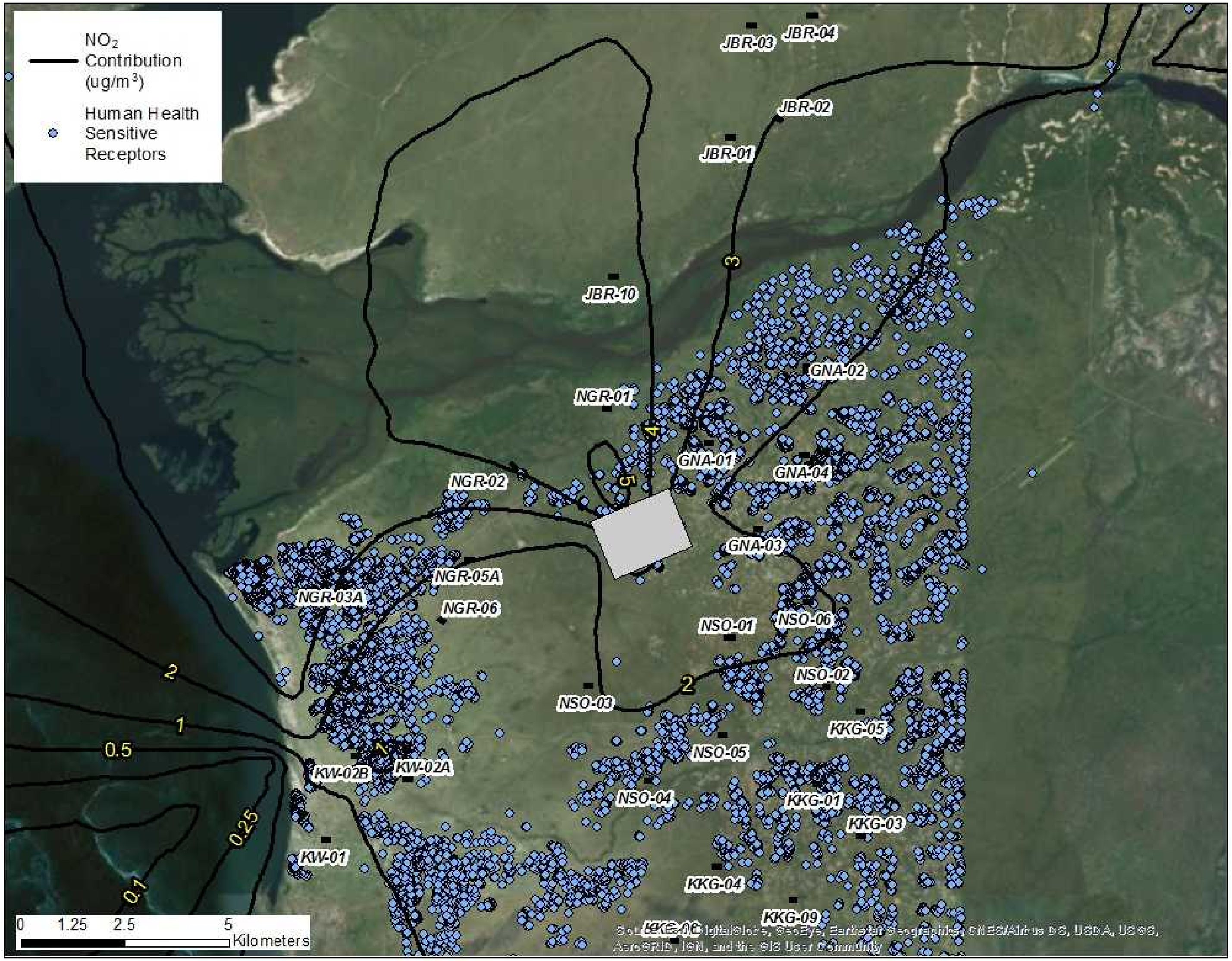

Figure 6-13: Operational Phase Annual Mean NO_2 Impacts (Scenario Op2b) (Contribution from Project Sources) – Human Health Sensitive Receptors

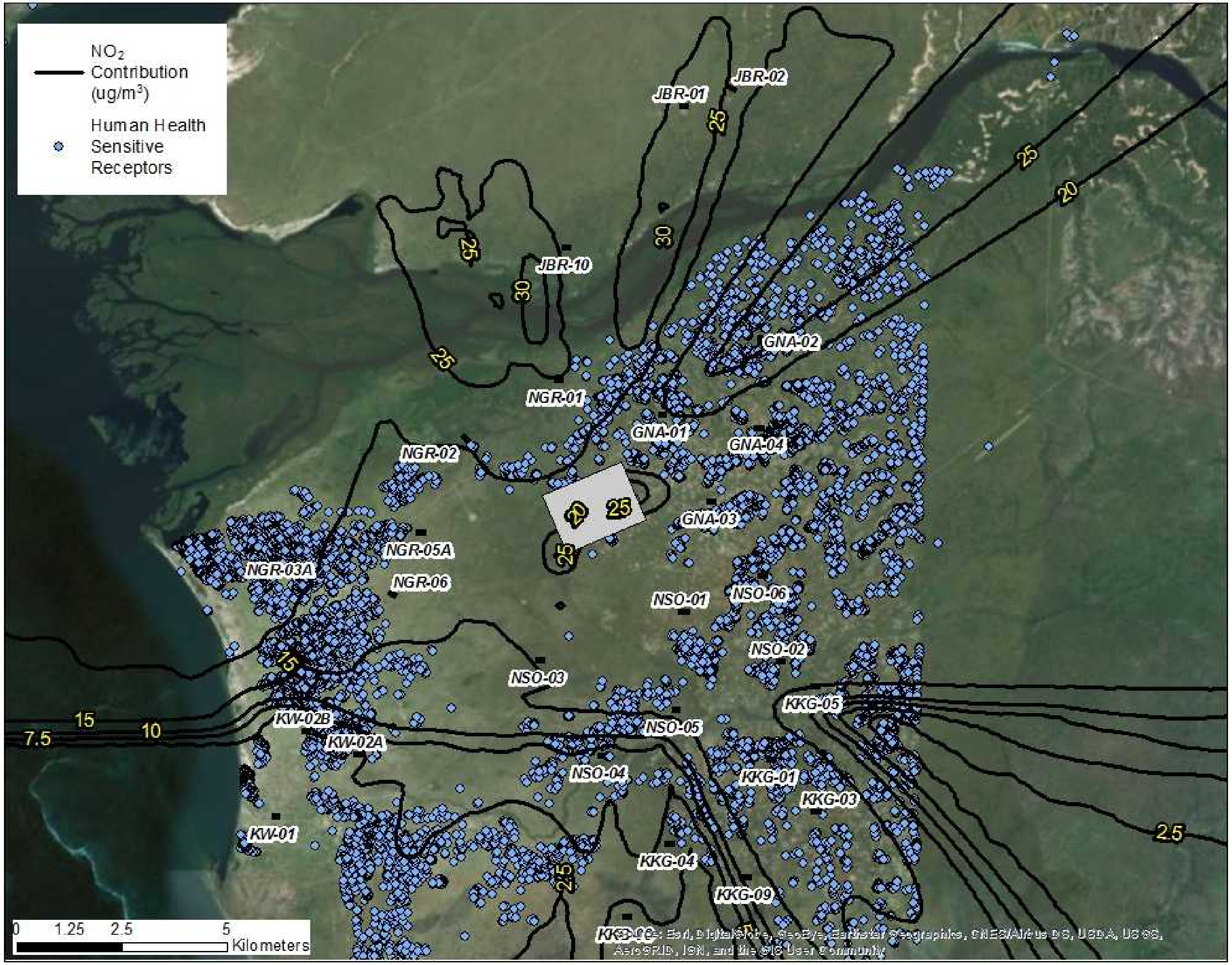

Figure 6-14: Operational Phase Hourly Mean NO_2 Impacts (Scenario Op1b) (Contribution from Project Sources) – Human Health Sensitive Receptors

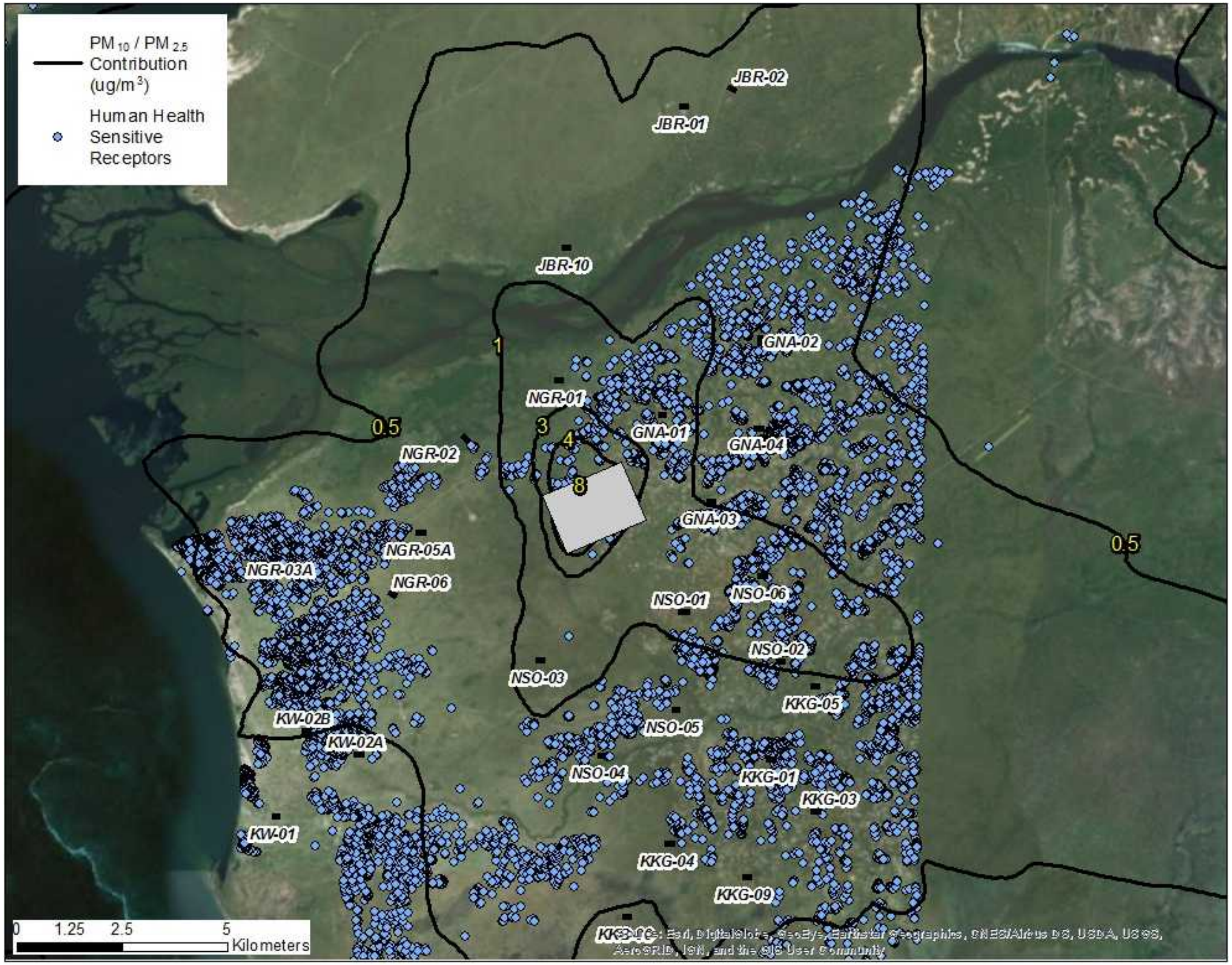

Figure 6-15: Operational Phase Daily Mean PM_{10} Impacts (Scenario Op2b) (Contribution from Project Sources) – Human Health Sensitive Receptors

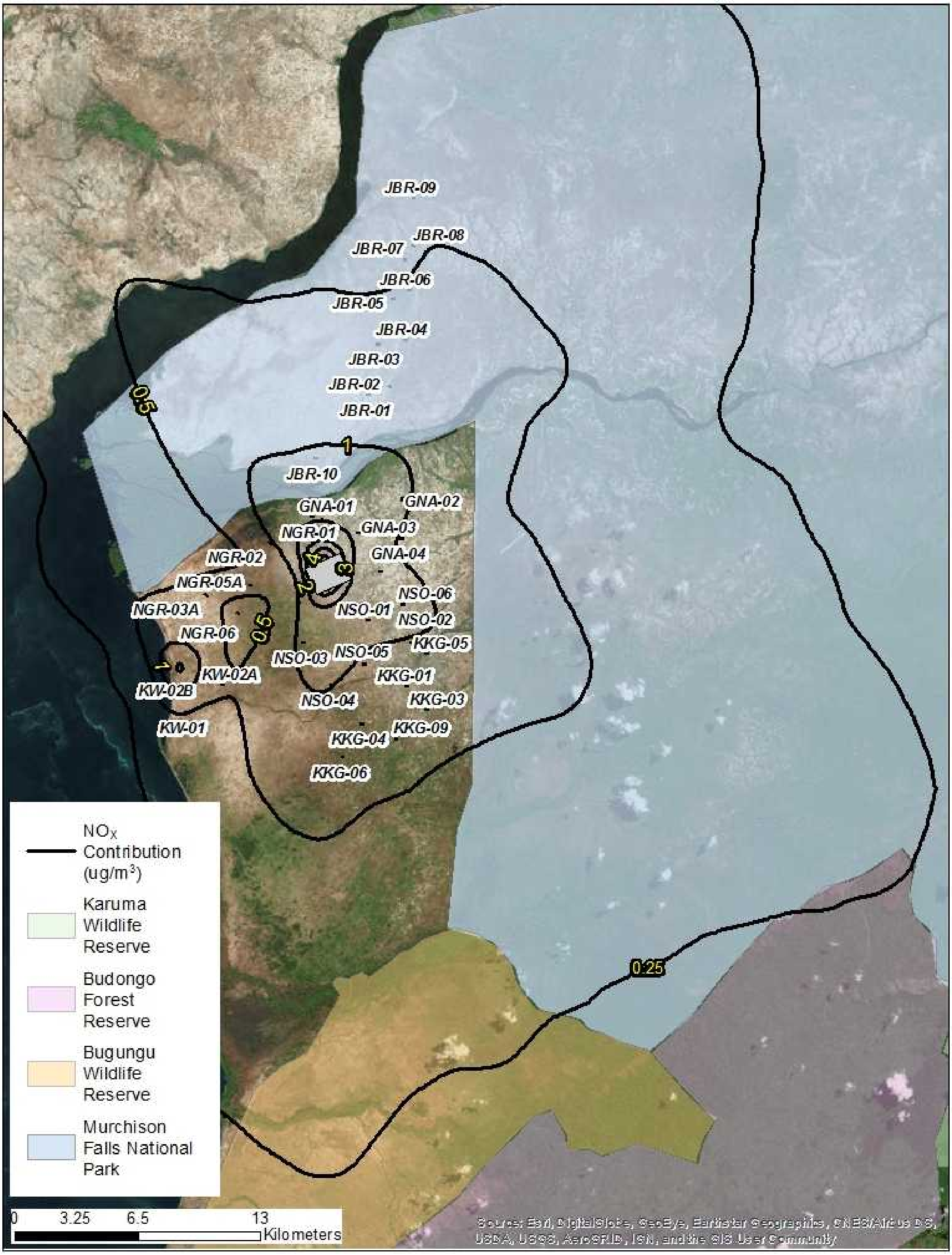

Figure 6-16: Operational Phase Annual Mean NO_X Impacts (Scenario Op2b) (Contribution from Project Sources) – Ecologically Sensitive Receptors

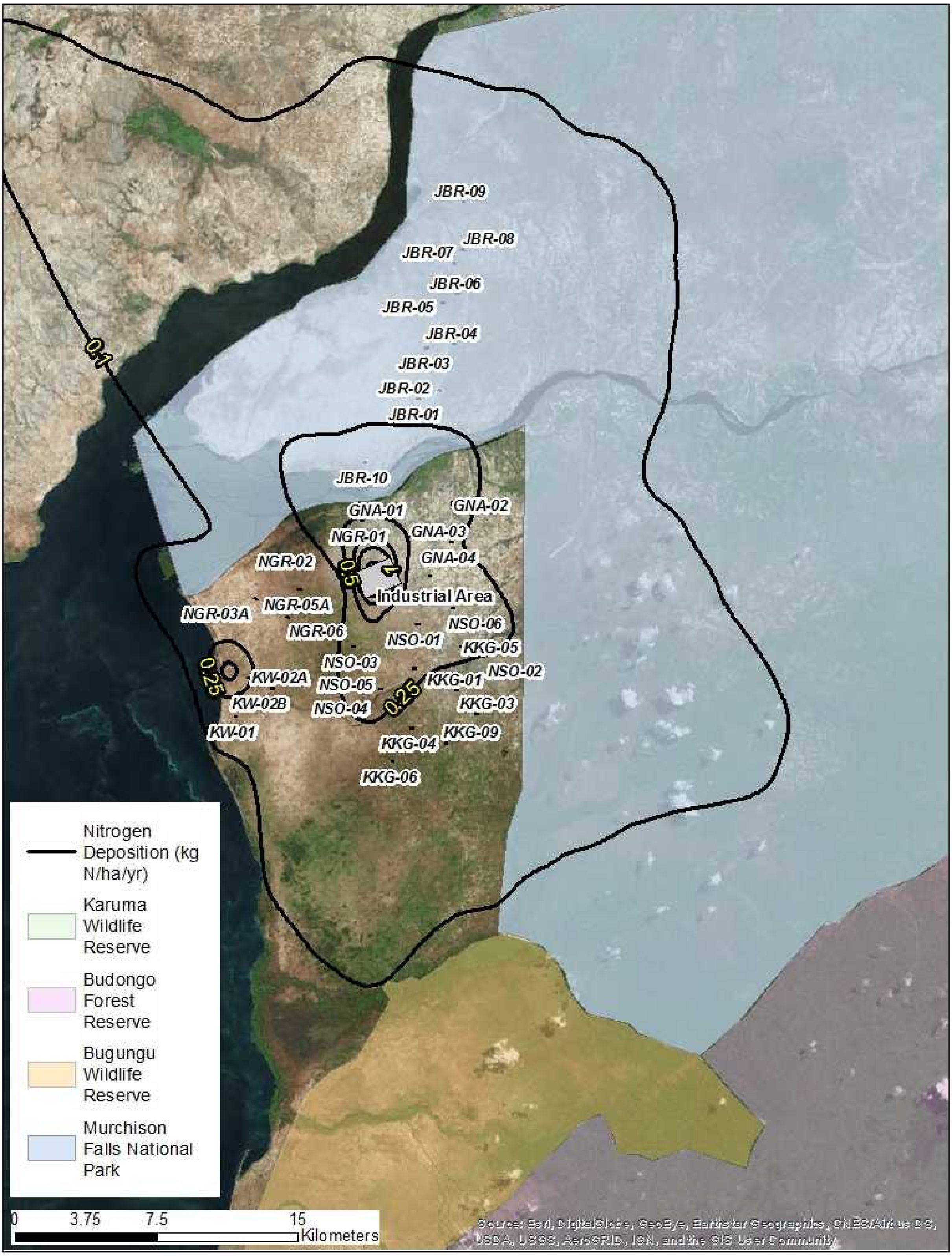

Figure 6-17: Operational Phase Nitrogen Deposition Impacts (Scenario Op2b) (Contribution from Project Sources) – Ecologically Sensitive Receptors

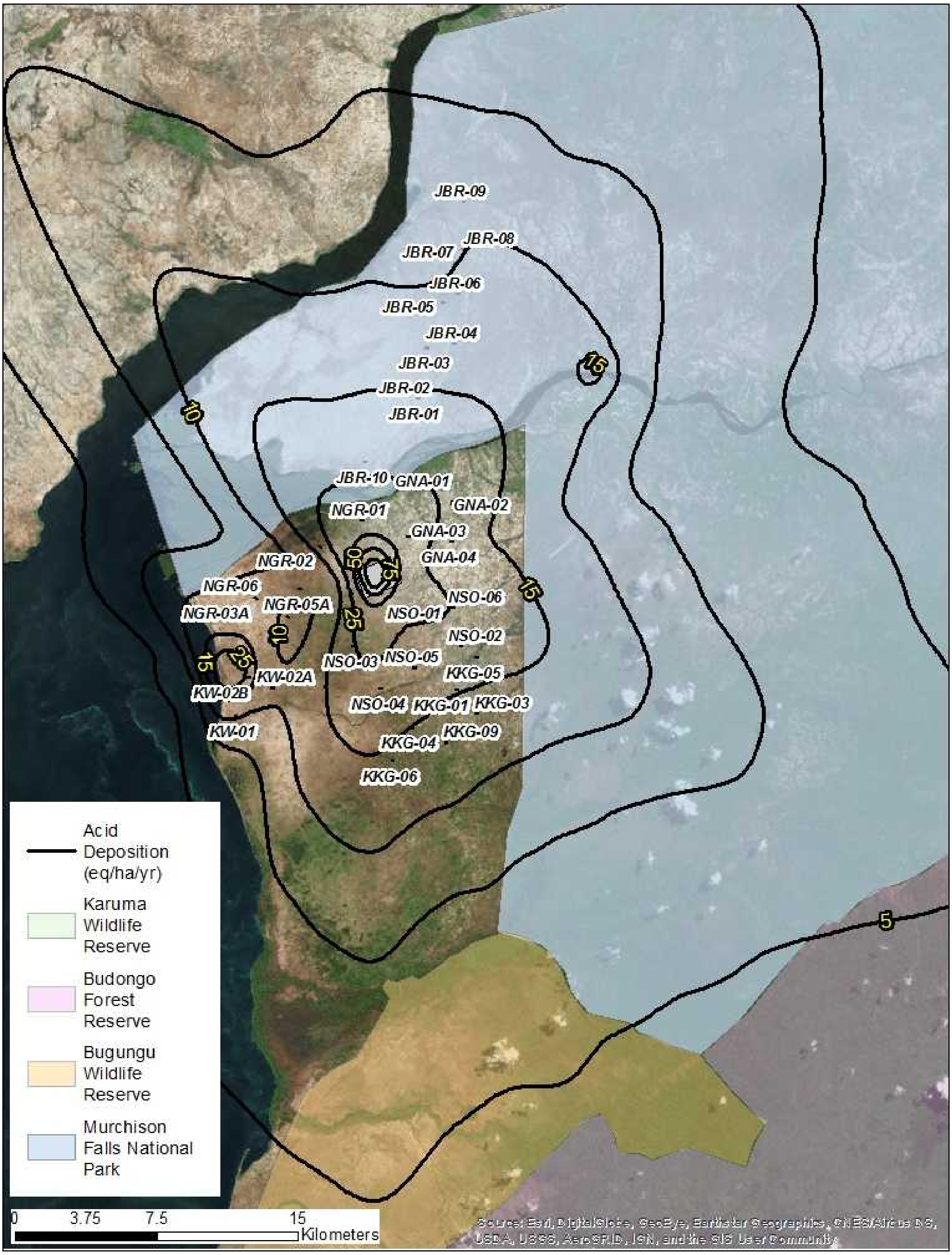

Figure 6-18: Operational Phase Acid Deposition Impacts (Scenario Op2b) (Contribution from Project Sources) – Ecologically Sensitive Receptors

6.7.4.3 Additional Mitigation and Enhancement

Mitigation measures to control and reduce potential impacts to air quality during the Commissioning and Operations phase are summarised in Table 6-32.

6.7.4.4 Residual Impacts – Commissioning and Operations

6.7.4.4.1 Fugitive Emissions of VOCs

Fugitive emissions of VOCs at the CPF during this phase should be few and far between, due to the operation of the VRU and regular planned maintenance on valves, flanges and pipework, and only limited fugitive emissions will occur at the well pads during periodic maintenance and annulus gas management. Given the intermittent nature of any emissions, the magnitude of impact for fugitive VOCs during these phases is considered to be low.

Due to the existing low levels of VOC concentrations established during the baseline survey within the Project Area, there is little to no risk of an exceedance of the EAL for this pollutant under normal operations. The sensitivity of receptors to fugitive VOC emissions is therefore considered to be low. A low impact magnitude in locations of low sensitivity has a **Low Adverse** impact significance. The effect of fugitive emissions of VOCs during this phase will therefore be classed as being not significant.

6.7.4.4.2 Fugitive Odour Emissions

It is generally accepted that odour associated with food waste can often be offensive if the waste is not managed correctly, as is odour associated with oily waste from pigging and sludge treatment. Therefore, the sensitivity of odour sensitive receptors in the Project Area is considered to be moderate as a minimum. The Project **Waste Management Plan** will describe how waste will be stored at the camps and waste storage sites, and how it will be disposed of from the Project Area. Standard best practice measures to reduce odours from any waste storage will be implemented as standard procedure on site, including the sealing of waste storage vessels and the removal of waste from site as quickly and as frequently as practically possible. Such measures are common practice on all well managed sites.

Odours associated with maintenance and annulus gas management will be limited to small volume releases that will be infrequent and occur over short periods of time. Any larger volumes of annulus gas management will be controlled by directing it to the product flow line and not released at source.

Given the implementation of the **Waste Management Plan** and the effectiveness of standard best practice procedures on site, and the removal of anything other than smaller volume release of well gas at the well pads, the magnitude of impact for fugitive emissions of odour during these phases is considered to be low. The effect of fugitive emissions of odour during this phase is therefore considered to be of a **Low Adverse** significance, which is considered not significant, in light of the waste management measures proposed.

6.7.4.4.3 Controlled Energy Generation Plant Emissions

Worst case off site impacts were predicted for daily mean concentrations of $PM_{2.5}$, where the process contribution of the energy generation plant would have a moderate impact magnitude. The sensitivity of the receptors to these pollutants is low, as ambient concentrations are less than 50% of the relevant EAL. In this instance, the moderate impact magnitude and low receptor sensitivity equates to a **Low Adverse** impact significance, due to the nature of existing $PM_{2.5}$ conditions within the study area, and is therefore not significant. For annual mean $PM_{2.5}$, the same conclusion is drawn where a low magnitude impact is predicted at a limited number of receptors with moderate sensitivity to that pollutant and averaging period. Again, this is because the elevated ambient conditions in the Study Area are due to naturally occurring sources common in often arid environments, rather than particulate generated by urban centres or industry.

The assessment has also identified that there are exceedances of the annual mean and daily mean EALs for PM_{10} at the worst affected receptor location. For this pollutant and averaging periods, the contribution of Project emissions to annual and hourly mean concentrations peak at 6% (negligible impact magnitude) and 18% (low impact magnitude) of the EALs respectively. A low impact magnitude at highly sensitive receptors would typically result in a moderate adverse impact significance. However, the remaining contribution to the total concentrations reported is from existing sources, which are predominantly naturally occurring particles generated by the often arid conditions experienced within the Study Area, rather than as a result of toxic emissions from existing industrial or urban pollution sources. Therefore, the impacts associated with this pollutant and the averaging periods at the highly sensitive receptors result in a **Low Adverse** impact significance that is not significant.

Along with the worst case impact significance for the other pollutants (NO_2, CO, VOC, HC) and averaging periods, which ranged from Low Adverse to Insignificant, the overall residual impact significance at human health sensitive receptors is considered to be **Low Adverse** and therefore not significant. This is due to a combination of limited impact magnitude and the exaggerated sensitivity of receptors to particulate matter as a result of natural sources.

A low to negligible impact magnitude has been determined for all pollutants at the ecologically sensitive locations considered. Low impacts are restricted to a small area (<0.1% of the MFPA) with vast majority of the ecological area experiencing a negligible impact magnitude. The residual impact significance is therefore determined to be **Low Adverse** and classed as not significant.

6.7.5 Assessment of Impacts: Decommissioning

6.7.5.1 Introduction

Emissions to air associated with the Decommissioning phase of the Project regarding combustion emissions (NO_2, PM_{10} and $PM_{2.5}$ from vehicles and NRMM) and demolition dust are likely to be very similar to (or less than) those reported for the Site Preparation and Enabling Works and the Construction and Pre-Commissioning phases of the Project. There will also be HC and VOC emissions associated with the depressurisation of plant and pipework, as well as potential odour emissions associated with chemicals for the purging of pipe work.

6.7.5.2 Additional Mitigation and Enhancement

Mitigation measures to control and reduce potential impacts to air quality during the Decommissioning phase are summarised in Table 6-32. By the Decommissioning phase, dust control measures may have become more efficient with advancements in technology and therefore, mitigation measures may be more efficient. To reduce potential emissions associated with the depressurisation of plant and pipework, they will be made empty prior to decommissioning and works will be undertaken as efficiently as possible, by appropriately trained contractors with the best practice mitigation measures available at that time.

6.7.5.3 Residual Impacts - Decommissioning

Following the application of embedded design mitigation and the additional mitigation measures listed in Table 6-32, the impact magnitude is considered low. An impact of this magnitude at sensitive receptors that are considered to be moderate equates to an impact significance in this case of a **Low Adverse** significance.

6.7.6 Assessment of Impacts: Summary

Table 6-35 provides a summary of the predicted impacts and their significance, as reported in this chapter.

Table 6-35: Impact Summary

Description of potential impact	Receptor Type	Sensitivity	Magnitude of Potential Impact	Potential Impact Significance	Sensitivity	Magnitude of Residual Impact	Residual Impact Significance
Site Preparation and Enabling Works and Construction and Pre-commissioning							
Fugitive emissions of dust and PM_{10} associated with the storage, handling, and manipulation of potentially dusty materials and movement of construction vehicles on public roads	Human health and amenity	Moderate	Low	Low to Moderate	Moderate	Low	**Low Adverse**[8]
Fugitive combustion emissions from the operation of NRMM	Human health	Low	Low	Low	Low	Low	**Low Adverse**
Fugitive emissions of VOCs during well pad construction and commissioning activities	Human health	Low	Low	Low	Low	Low	**Low Adverse**
Fugitive emissions of odour from the paint and coating activities and the storage of waste material prior to removal for the Project Area	Amenity	Moderate	Low	Low to Moderate	Moderate	Low	**Low Adverse** [9]
Controlled emissions of NO_2, PM_{10} and $PM_{2.5}$ from construction-related vehicle movements	Human health	Low[1]	Moderate[1]	Low to Moderate[1]	Low[1]	Moderate[1]	**Low Adverse** [1,10]
	Ecology	Moderate to High[2]	Low[6]	Low to Moderate[2,6]	Moderate to High[2]	Low[6]	**Low Adverse** [2,6,11]
Controlled construction energy generation plant exhaust emissions located at the Construction Support Base and well pad generators	Human health	Low[3]	Low[3]	Low[3]	Low[3]	Low[7]	**Low Adverse** [3]
	Ecology	Moderate to High[2]	Low[7]	Low to Moderate[2,7]	Moderate to High[2]	Low[7]	**Low Adverse** [2,8,12]

Description of potential impact	Receptor Type	Sensitivity	Magnitude of Potential Impact	Potential Impact Significance	Sensitivity	Magnitude of Residual Impact	Residual Impact Significance
Commissioning and Operations							
Fugitive emissions of VOCs during from operational well pads and the Central Processing Facility, and the potential for harm to human health	Human health	Low	Low	Low	Low	Low	**Low Adverse**
Fugitive emissions of odour from the storage of waste material prior to removal for the Project Area	Amenity	Moderate	Low	Low to Moderate	Moderate	Low	**Low Adverse**
Controlled energy generation plant exhaust emissions (as listed in Table 6-25) located at the Central Processing Facility	Human health	High[4]	Low[4]	Moderate[4]	High[4]	Low[4]	**Low Adverse** [4,13]
	Ecology	Low[5]	Low[7]	Low[5,7]	Low[5]	Low[7,7]	**Low Adverse** [5,7]
Decommissioning							
Fugitive emissions of dust and PM_{10} associated with the storage, handling, and manipulation of potentially dusty materials and movement of decommissioning vehicles on public roads	Human health and amenity	Moderate	Low	Low to Moderate	Moderate	Low	**Low Adverse** [8]
Fugitive combustion emissions from the operation of NRMM	Human health	Low	Low	Low	Low	Low	**Low Adverse**
Fugitive emissions of VOCs during the depressurisation of plant and pipework	Human health	Low	Low	Low	Low	Low	**Low Adverse**
Fugitive emissions of odour associated with chemicals and the purging of pipework prior to removal	Amenity	Moderate	Low	Low to Moderate	Moderate	Low	**Low Adverse** [9]

Description of potential impact	Receptor Type	Sensitivity	Magnitude of Potential Impact	Potential Impact Significance	Sensitivity	Magnitude of Residual Impact	Residual Impact Significance
Controlled emissions of NO_2, PM_{10} and $PM_{2.5}$ from decommissioning-related vehicle movements	Human health	Human health	Low[1]	Moderate[1]	Low to Moderate[1]	Low[1]	**Low Adverse** [1,10]
	Ecology	Moderate to High[2]	Low[6]	Low to Moderate[2,6]	Moderate to High[2]	Low[6]	**Low Adverse** [2,6,11]

[1] Hourly mean NO_2, the pollutant and averaging period with the worst case impact significance is listed for this source. Where receptors have a higher sensitivity to other pollutants (PM_{10} and $PM_{2.5}$) the impact magnitude is negligible.
[2] Moderate to high sensitivity because of the varying conditions across the study area and the transient nature of potentially sensitive species.
[3] Annual and hourly mean NO_2, the pollutant and averaging periods with the worst case impact significance is listed for this source. Where receptors have a higher sensitivity to other pollutants (PM_{10} and $PM_{2.5}$) the impact magnitude is negligible.
[4] Annual and daily mean concentrations of PM_{10} and $PM_{2.5}$, the pollutant and averaging periods with the worst case impact significance is listed for this source.
[5] Negligible impacts are predicted at the moderate to high sensitivity receptors from this source, the worst case impact significance is listed for the low sensitivity receptor.
[6] Annual mean NO_X, the pollutant and averaging period with the worst case impact significance is listed for this source.
[7] Annual mean NO_X and acid deposition, the pollutants and averaging periods with the worst case impact significance is listed for this source.
[8] Residual impact significance is Low, because of the published efficiency of dust and PM_{10} control measures and the fact that receptors are already tolerant of elevated ambient conditions to dust soiling.
[9] Residual impact significance is Low, because in-built design mitigation and any additional mitigation measures described in the assessment should be sufficient to control emissions to the extent that any effect will not be significant.
[10] Residual impact significance is Low, because the Predicted Environmental Concentration (ambient conditions plus Project contribution) is still well below the EAL for the Hourly mean NO_2.
[11] There are limited control measures available for reducing vehicle emissions, beyond changing proposed traffic routes or committing to the use of vehicles with better emissions technology. However, the residual impact magnitude is considered to be low, because of the limited areas where impacts are likely across the Study Area (i.e. restricted to locations adjacent to the roads used by Proposed Development traffic).
[12] There are limited control measures available for reducing generator emissions, beyond committing to the use of generators with better emissions technology, or increasing stack heights. However, the residual impact magnitude is considered to be low, because of the limited areas where impacts are likely across the Study Area (i.e. restricted to locations where the generator emission plumes ground) and the fact that total concentrations and deposition rates are well below the respective EALs.
[13] The residual impact significance is low adverse, rather than moderate adverse, and is considered to be not significant in this instance. The sensitivity of receptors to ambient PM_{10} and $PM_{2.5}$ conditions is exaggerated relative to the WHO air quality guidelines, which appear elevated due to natural sources, rather than potentially toxic industrial or urban particles from existing sources.

6.8 Greenhouse Gas Emissions/Climate Change

The GHG emissions calculation has been carried out in accordance with the Greenhouse Gas Protocol (Ref. 6-30, Ref. 6-31) and therefore considers carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

Emissions are reported as tonnes carbon dioxide equivalent (tCO_2e) or mega tonnes CO_2e (MtCO2e).

6.8.1 Emissions Sources

Table 6-36 presents the Project activities that are considered to have the potential to change the baseline GHG emissions in Uganda.

Table 6-36: Project Activities with the Potential to affect Baseline GHG Emissions

Phase	Activity
Site Preparation and Enabling Works	• **Change in carbon stocks:** Loss of carbon stocks due to clearance of vegetation and stripping of soils. • **Fuel consumption:** GHG emissions from the combustion of diesel in vehicles, mobile and static plant, and generators for the construction base and camp, as well as other ancillary uses. Includes transportation of purchased materials and goods. • **Construction materials:** GHG emissions (embodied carbon) resulting from energy used to extract, process and/ or manufacture materials used during enabling works. • **Waste management:** GHG emissions resulting from the transportation and treatment of waste from enabling works. • **Transportation of purchased materials and goods:** GHG emissions from the combustion of fuels associated with the distance and type of transportation of purchased materials and goods to the Project site.
Construction and Pre-Commissioning	• **Fuel consumption:** GHG emissions from combustion of diesel in road vehicles, ferry movements, mobile and static plant, and generators for the operation base and camp, as well as other ancillary uses. • **Waste management:** GHG emissions resulting from the transportation and treatment of construction waste. • **Construction materials:** GHG emissions (embodied carbon) resulting from energy used to extract, process and/ or manufacture materials used during construction.
Commissioning and Operations	• **Energy consumption in power generation:** GHG emissions from operation of the CPF, operational support base, operation camp, well pads, flowlines, water abstraction system, and other plant and equipment. Energy generated by on site power generation unit. • **Diesel consumption:** GHG emissions from the combustion of diesel in vehicles, mobile and static plant, and generators for the operation base and camp, as well as other ancillary uses. • **Flaring and venting emissions:** GHG emissions released to atmosphere during flare emissions during normal CPF operations and venting at well pads. • **Waste management:** GHG emissions resulting from the transportation and treatment of operational waste (e.g. contaminated cartridges, spent lube oil, sand sludge etc.).

Phase	Activity
Decommissioning	• This will be dependent upon the decommissioning strategy, but it is expected to be similar to those sources of GHG emissions that have been identified at the Construction and Pre-commissioning stage.

6.8.2 Standards and Guidance

The assessment of potential GHG emissions impacts arising from the Project has taken into consideration applicable IFC performance standards, European Investment Bank guidelines, Ugandan policy, and recognised international guidance regarding GHG emissions assessment. A summary is provided in Table 6-37.

Table 6-37: Summary of Applicable Standards and Guidance

Standard	Description	Criteria
Uganda's Intended Nationally Determined Contributions (INDC) 2015 (Ref. 6-32).	The INDC comprises the national climate action plan, as submitted to the UN Framework Convention on Climate Change (UNFCCC).	The INDC commits the Ugandan Government to a 22% reduction of national GHG emissions by 2030 compared to the business-as-usual emissions projection, which comprises a a target annual GHG emission limit for 2030 of 77.3 $MtCO_2e$ per year.
IFC Performance Standards (Ref. 6-33)	Performance Standard 3 provides guidance on practices and technologies that promote energy efficiency, sustainable use of resources, and reduction of greenhouse gas emissions.	Sets a reporting requirement threshold of 25,000 tCO_2e, with reporting guidance on emissions sources.
European Investment Bank (EIB) (Ref. 6-34)	Methodologies for the assessment of project GHG emissions, compiled by EIB from a 3-year pilot phase from 2009-2011 to measure the impact in GHG emissions from the projects it finances.	Identifies 100,000 tCO_2e as a significant threshold from a single project.

6.8.3 Greenhouse Gas Emissions/Climate Change

The GHG emissions baseline follows one of the three approaches recommended by the IPCC, in that it accounts for both:

- The GHGs emitted through current activity within the Study Area; and
- The carbon currently stored within vegetation and soils within the Study Area (i.e. 'carbon stocks' that serve to remove carbon dioxide from the atmosphere).

Table 6-38 below describes the factors that have been taken into account:

Table 6-38: Aspects of GHG

Aspect		Description	Comment
Sources of GHG emissions	Village activity	Local habitation (e.g. burning of fuel wood, use of diesel or other liquid fuels).	Assumed that these activities will remain even if displaced to outside the Project boundary.
	Local airfields	Light aircraft take offs and landings at the Bugungu Airstrip and Pakuba Airfield, which primarily serve tourists visiting the MFNP.	Assumed that these activities will remain even if displaced to outside the Project boundary
Category of carbon stocks	Soils	Stocks of carbon in the soil that are not part of the living biomass (i.e. all carbon apart from living roots).	We have calculated these as part of the existing soil types and have accounted for loss of soil stock for permanent and temporary structures within the GHG inventory associated with the site.
	Biomass	The above ground vegetation carbon stock comprises carbon within, for instance, stem, stump, bark, seeds and foliage. Below ground, carbon is present within live roots.	We have calculated these as part of the existing vegetation types and have accounted for loss of biomass stock within the GHG inventory associated with the site.

Notes:

- Road transportation is not included as a key GHG emissions source emissions as the most common modes of transport comprise walking, bicycles and motorcycle taxis.
- Agricultural activity is not included as a key GHG emissions source as; farming within the Study Area is assumed to comprise subsistence or small-scale farming.

6.8.4 GHG Calculations results

A summary of the sources of GHG emissions considered in this assessment are outlined in Table 6-39. These include planned and routine activities outlined in ***Chapter 4: Project Description and Alternatives***. Calculated emissions associated with emergency and unplanned events are discussed below.

Table 6-39: Sources of GHG Emissions considered in the assessment

Project Phase	GHG emissions source
Site Preparation and Enabling Works	Fuel consumption from vehicles, mobile and static plant, generators and other ancillary uses
	Treatment of waste
	Transportation of waste
	Construction materials (embodied carbon)
	Vegetation clearance and soil stripping (loss of carbon stock)
Construction and Pre-commissioning	Fuel consumption on site
	Treatment of waste
	Transportation of waste

Project Phase	GHG emissions source
	Embodied carbon in construction materials (partial only as only quantities of some materials available at this stage)
	Transportation of materials
Commissioning and Operations	Power generation
	Treatment of waste
	Transportation of waste
	Generator use
	Flaring emissions

The national Ugandan inventory is compiled on an annual basis, therefore it is considered appropriate to consider the average annual GHG emissions during the Project, as shown in Table 6-40. Some phases will overlap however (see ***Chapter 4: Project Description and Alternatives***), with Site Preparation and Enabling Works activities overlapping with Construction and Pre-Commissioning and Commissioning and Operations activities, meaning there is potential for the peak emissions to be up to an estimated 1.05 $MtCO_2e$ per annum.

Table 6-40: Annual Average GHG Emissions

Phase	GHG emissions ($MtCO_2e$)	Main contributor	Length of phase (years)	Average annual GHG emissions (tCO_2e.annum)
Site Preparation and Enabling Works	244,200	Fuel consumption (50%)	5	49,000
Construction and Pre-Commissioning	763,700	Transportation of materials (72%)	7	109,400
Commissioning and Operations	22,274,200	Power generation (97%)	25	891,200
Decommissioning*	763,700	Transportation of materials (72%)*	7*	109,400
Total	23,282,100	N/A	N/A	N/A

*Assumed to be the same as the Construction and Pre-Commissioning

The total GHG emissions for the Project are calculated to be about **23 $MtCO_2e$** up to the point when production ceases. The Commissioning and Operations phase comprises the majority of the GHG emissions due to the power generation emissions.

Decommissioning impacts are assumed to be of similar magnitude and significance to the Construction and Pre-commissioning phase, and therefore estimated to also be in the region of 0.8 $MtCO_2e$. This is likely to be an overestimate of actual emissions as it does not account for the planned reinstatement of the site to baseline conditions, which should reintroduce a carbon sink and offset some of the Project impacts.

Assuming that Decommissioning phase impacts will be similar to those of Construction and Pre-Commissioning phase, the total GHG emissions at the end of the Project is predicted to be a total of about **24 $MtCO_2e$**.

Only the Site Preparation and Enabling Works phase is predicted to generate less than the 25,000 tCO2e per annum threshold given in IFC PS 3 (see Table 6-37). Consequently only the first two years of the project will be beneath this threshold as the Construction and Pre-commissioning phase will overlap with the remainder of the Site Preparation and Enabling Works phase. So if lending was ultimately sought to help deliver the Project, all other phases would be subject to IFC annual reporting as indicated in Table 6-37. It is also the only Project phase that generates less than the 100,000 tCO2e per annum threshold for significance suggested by EIB and can therefore be considered negligible.

As outlined in Table 6-37, the Ugandan Government needs to achieve less than 77.3 MtCO_2e / year by 2030 (Ref. 6-32). It is expected that the Project will be operational by this date and emitting on average 891,200 tCO_2e per annum; or just over 1.1% of the national GHG emissions.

Applying the criteria outlined in ***Chapter 3: ESIA Methodology***, the Project is considered likely to generate a low magnitude of change during most years of the Project, with the first few years before the start of the Commissioning and Operations phase reducing to negligible. Taking a conservative assumption that the atmosphere and climate is of high sensitivity to change in GHG emissions, as suggested by the general scientific community, the residual effect is judged to range between **Insignificant** and **Moderate Adverse**.

6.9 In-Combination Effects

As described in ***Chapter 4: Project Description and Alternatives,*** the Project has a number of supporting and associated facilities that are being developed separately (i.e. they are subject to separate permitting processes and separate ESIAs or EIAs). These facilities include:

- Tilenga Feeder Pipeline;
- East Africa Crude Oil Export Pipeline (EACOP);
- Waste management storage and treatment facilities for the Project;
- 132 kV Transmission Line from Tilenga Central Processing Facility to Kabaale Industrial Park; and
- Critical oil roads.

As these facilities are directly linked to the Project and would not be constructed or expanded if the Project did not exist, there is a need to consider the in-combination impacts of the Project and the supporting and associated facilities. This is distinct from the Cumulative Impact Assessment which consider all defined major developments identified within the Project's Area of Influence (and not just the associated facilities) following a specific methodology which is focussed on priority Valued Environmental and Social Components (VECs) (see ***Chapter 21: Cumulative Impact Assessment***).

The in-combination impact assessment considers the joint impacts of both the Project and the supporting and associated facilities. The approach to the assessment of in-combination impacts is presented in ***Chapter 3: ESIA Methodology,*** Section 3.3.5.

The combined effect of emissions associated with these facilities has been considered qualitatively. The identified residual impacts of the Project listed in Table 6-41 below are predicted to have the potential to be exacerbated due to in-combination effects with supporting and associated facilities. Impacts likely to have an in-combination effect are those associated with the Site Preparation and Enabling Works, the Construction and Pre-commissioning, and the Decommissioning phase. It is not anticipated that Project emissions associated with the Commissioning and Operations phase will coincide with, or take place at a nearby location to any in-combination effect. A comment is provided on the potential in-combination impacts and the need for additional collaborative mitigation between project proponents to address these impacts.

Table 6-41: In-Combination Impacts to Air Quality

Description of Potential Impact of Project	Comment on potential in-combination effects with associated facilities
Site Preparation and Enabling Works, the Construction and Pre-commissioning, and Decommissioning phases – fugitive dust and PM_{10} impacts	Potential increase in dust deposition rates and short term concentrations of PM_{10}. Limited to sensitive locations within 350 m of a Project worksite and the Tilenga Feeder Pipeline worksite. Likely to only affect residential properties close to the south-western boundary of the Industrial Area.
Site Preparation and Enabling Works, the Construction and Pre-commissioning, and Decommissioning phases – fugitive odour emissions impacts	Potential increase in odour impacts experienced at sensitive locations close to temporary waste storage at a Project site and Tilenga Feeder Pipeline worksite, in the unlikely event that both sites have waste storage facilities in close proximity. This would only affect a limited number of receptors if occurring at all.
Site Preparation and Enabling Works and the Construction and Pre-commissioning phases - road traffic emissions impacts	Potential increase in concentrations of the pollutants associated with road traffic emissions at roadside receptors located adjacent to roads used by Project vehicles and vehicles on the Oil Critical Roads . This would only affect receptors located immediately adjacent to the roads.
Increased GHG emissions (and loss of carbon stock)	These projects will all in combination have an increased effect on the national GHG inventory and further affect the ability of Uganda to meet its INDC of 22% against a business as usual projection by 2030.

Key additional collaborative mitigation will include:

- Project Proponents will invite other developers to participate in joint planning initiatives with local government and other relevant stakeholders, and will continue to share best practices to allow other developers to learn from successful implementation of mitigation measures addressing odor and atmospheric emissions. Where feasible, other developers will be invited to invest expertise or resources in the joint implementation of initiatives addressing these impacts; and
- Project Proponents will invite other developers to participate in joint planning initiatives with local government and other relevant stakeholders to optimise traffic flows in consideration of required vehicle movements for all developments.

6.10 Unplanned Events

Unplanned events are incidents that are not expected to occur during the Project's normal activities, such as emergencies, accidents, and incidents. More information on the assessment of unplanned events is contained within ***Chapter 20: Unplanned Events***. For the purposes of the air quality assessment, impacts from the following emergency sources have been quantified in isolation:

- Diesel-fired emergency energy generation plant at the CPF;
- Diesel-fired fire water pumps at the CPF;
- Flare at the CPF;
- Storage vessel venting at the CPF; and
- Well blowout during drilling.

Each of the sources listed will only have emissions when an unplanned event affects that particular element of the Project in an emergency situation. The flare may or may not have a pilot burning at all times in readiness for an emergency. This is dependent on the flare type and ignition technology required to guarantees availability of the flare for each emergency scenario. Emissions associated with a pilot burn are negligible and do not influence the air quality predictions made for the normal scenarios considered in the air quality assessment.

A series of in-built design mitigation measures are included to reduce the impact of emissions associated with unplanned events, including the release of emissions from height, to encourage dispersion, the duration of emissions to be limited as much as practical, to reduce total emissions, and for the flare to have a high level of efficiency.

Two different scenarios have been modelled to quantify potential unplanned event impacts. The first scenario (Em1) considers the operation of two 6 MW diesel-fired generators, two 2000 kVA fire water pumps, an elevated open flare, and the venting of storage tanks at specific locations at the CPF. The second Scenario (Em2) considers the operation of three 2 MW diesel-fired generators, three 2000 kVA fire water pumps, an enclosed ground flare and the venting of storage tanks at different locations at the CPF. In both scenarios, the venting of storage tanks has focused on the worst-case scenario where the export oil tank and off-spec tank vent together for a period of 24 hours and 8 hours respectively, within the same 24 hour period. The other storage tanks listed in Table 6-25 are less likely to be required to vent and have therefore not been quantified in the assessment. The modelled Process Contributions from these sources are reported in Table 6-42.

The results indicate that the individual operation of the emergency generators, fire pumps, elevated open flare and storage tanks would not cause an exceedance of the EALs in Scenario Em1, nor would the individual operation of the emergency generators, fire pumps and storage tanks in Scenario Em2. However, the operation of the enclosed ground flare in scenario Em2 could cause an exceedance of the EAL for daily mean PM_{10} and $PM_{2.5}$.

Where exceedances of an EAL are predicted, it should be noted that the modelling of air quality impacts associated with intermittent sources is inherently conservative. This is because the impact over such periods is highly dependent on the meteorological conditions at the time. Because the exact period of operation of intermittent sources is unknown, along with the fact that previous years of met data can only be indicative of conditions during operation, the assumption has to be made that intermittent emissions could occur over any period of the year and for the duration of the pollutant averaging period being considered (i.e. in this instance daily means). This is inherently conservative in that it is therefore assumed that intermittent emissions will last for the duration of the averaging period considered and coincide with the worst meteorological conditions experienced at each receptor. In reality, the duration of such emissions is more likely to occur over a period of hours and the risk of emissions coinciding with the worst meteorological conditions experienced at each receptor is considered to be highly unlikely.

For example, flaring will be limited to unplanned events (with the exception of some limited operation during start up, plant stabilisation and maintenance). The EALs for daily mean PM_{10} and $PM_{2.5}$ could be exceeded at sensitive locations close to the Industrial area, should flaring occur continuously for a period of 24 hours or more from an enclosed ground flare (which is in line with the EALs for daily mean PM_{10} and $PM_{2.5}$, which are based on a maximum 24 hour averaging period). In reality, flaring at the rates modelled (as shown in Table 6-25) are likely to occur over a much shorter duration than the period modelled, and actual impacts are likely to be lower than the daily mean PM_{10} and $PM_{2.5}$ impacts reported in Table 6-42.The air quality standards that are relevant to ecological sensitivity are all based on annual mean conditions. The unplanned events considered in this assessment are expected to be operational for hours or days at most and will therefore have very little impact on annual mean conditions at the ecological sensitive areas.

The residual effect of Greenhouse Gas (GHG) emissions on the atmosphere and climate is judged to range between insignificant to moderate adverse throughout the project lifetime, with higher emissions associated with the Commissioning and Operations phase. However, the Project Proponents are committed to adhering to BAT and will seek design controls to help minimise emissions. Additionally, the future planned restoration of the affected land within the Project Area would help to partially offset adverse impacts through reintroduction of vegetation (which will act as a future carbon stock source).

Air quality impacts associated with well pad blowout during drilling have not been quantified, due to the variables that cannot be accounted for within the dispersion model (e.g. the volume of gas released, the rate of VOC emissions within the gas and the duration of emissions). Measures will be implemented to reduce the risk of well blowout. Further details on unplanned events relevant to the Project, including measures to mitigate impacts, are detailed in ***Chapter 20: Unplanned Events***.

With respect to greenhouse gas emissions, considering emergency flaring it is anticipated that overall flaring results in 591,400 tonnes per annum of additional CO2e.

Table 6-42: Potential Unplanned Events Impacts – Human Health Sensitive Receptors

Scenario / Receptor Description	NO_2 (Conc. µg/m^3)		PM_{10} (Conc. µg/m^3)		$PM_{2.5}$ (Conc. µg/m^3)		CO (Conc. µg/m^3)				HCs	VOCs
	Annual mean	Daily Mean	Annual mean	Daily Mean	Annual mean	Daily Mean	8 Hr Mean	Hourly Mean	30 Min Mean	15 Min Mean	Daily Mean	Daily Mean
Scenario Em1												
Emergency diesel-fired generators	n/a	59.0 29.5%	n/a	2.1 4.2%	n/a	2.1 8.4%	32.7 0.3%	43.52 0.2%	44.8 0.1%	45.6 <0.1%	3.9 0.1%	1.2 <0.1%
Diesel-fired fire water pumps	n/a	54.4 27.2%	n/a	0.3 0.6%	n/a	0.3 1.3%	19.8 0.2%	24.9 0.1%	26.3 <0.1%	27.2 <0.1%	1.1 <0.1%	1.2 <0.1%
Elevated open flare	n/a	54.3 27.1%	n/a	20.5 41.1%	n/a	20.5 82.1%	384.2 3.8%	737.65 3.2%	790.7 1.3%	861.8 0.9%	<0.1 <01.%	394.3 6.6%
Storage tank venting	n/a	<0.1 <0.1%	n/a	<0.1 <0.1%	n/a	<0.1 <0.1%	<0.1 <0.1%	<0.1 <0.1%	<0.1 <0.1%	<0.1 <0.1%	3919.9 78.4%	3919.9 65.3%
Scenario Em2												
Emergency diesel-fired generators	n/a	59.4 29.7%	n/a	0.4 0.7%	n/a	0.4 1.5%	20.4 0.2%	27.75 0.1%	30.1 0.1%	31.6 <0.1%	1.6 <0.1%	1.2 <0.1%
Diesel-fired fire water pumps	n/a	58.7 29.4%	n/a	0.3 0.7%	n/a	0.3 1.4%	19.9 0.2%	27.72 0.1%	30.3 0.1%	31.9 <0.1%	1.6 <0.1%	1.2 <0.1%
Enclosed ground flare	n/a	66.2	n/a	**51.4**	n/a	**51.4**	901.6	2686.27	2726.3	2751.9	117.4	394.3
		33.1%		**102.8%**		**205.6**	9.0%	11.7%	4.5%	2.8%	2.3%	6.6%

Scenario / Receptor Description	NO_2 (Conc. µg/m^3)		PM_{10} (Conc. µg/m^3)		$PM_{2.5}$ (Conc. µg/m^3)		CO (Conc. µg/m^3)				HCs	VOCs
	Annual mean	Daily Mean	Annual mean	Daily Mean	Annual mean	Daily Mean	8 Hr Mean	Hourly Mean	30 Min Mean	15 Min Mean	Daily Mean	Daily Mean
Storage tank venting	n/a	<0.1 <0.1%	n/a	<0.1 <0.1%	n/a	<0.1 <0.1%	<0.1 <0.1%	<0.1 <0.1%	<0.1 <0.1%	<0.1 <0.1%	2513.2 50.3%	2513.2 41.9%
EAL	**40**	**200**	**20**	**50**	**10**	**25**	**10,000**	**23,000**	**60,000**	**100,000**	**5,000**	**6,000**

6.11 Cumulative Impact Assessment

Chapter 21: Cumulative Impact Assessment (CIA) provides an assessment of the potential cumulative effects of the Project together with other defined developments in the Project AoI. The CIA focussed on VECs that were selected on the basis of set criteria including the significance of the effects of the Project, the relationship between the Project and other developments, stakeholder opinions and the status of the VEC (with priority given to those which are of regional concern because they are poor or declining condition). On the basis of the selection process, Local Air Quality was not considered to be a priority VEC and is not considered further in the CIA.

Due to the spatial extent of the Study Area, it is considered unlikely that emissions associated with other major developments in the region would have a cumulative impact that could result in a significant adverse effect. For a potential cumulative impact to occur, emissions from this Project and cumulative developments nearby would need to be generated in sufficient quantities and dispersed by specific meteorological conditions that would cause the receptors to be affected at the same time. Whilst the presence of any emissions associated with other committed developments within the Study Area will gradually increase ambient pollutant concentration over time, the extent to which this is likely to occur is unlikely to affect the conclusions of this assessment.

As GHG emissions are assessed at the national level, all major projects in combination have an increased effect on the national GHG inventory and further affect the potential ability of Uganda to meets is INDC of 22% against a business as usual projection by 2030. Further information is included within ***Chapter 21: Cumulative Impact Assessment***.

6.12 Conclusions

This assessment of potential air quality impacts considers emissions associated with Site Preparation and Enabling Works, Construction and Pre-commissioning, Commissioning and Operations, and Decommissioning phases associated with the Project.

Baseline conditions have been assessed by analysis of data gathered during baseline surveys undertaken within the Study Area. The baseline surveys identified that ambient air quality in the Study Area is generally of a good standard. The survey did identify, however, that ambient concentrations of PM_{10} were already elevated above the relevant EALs for annual and daily mean averaging periods. This is due to the often arid nature of the Study Area (outside of the wetter months), rather than existing sources of urban or industrial emissions.

Fugitive emissions during all phases of the Project have been considered qualitatively in this chapter. Such emissions include dust and PM_{10} generated by construction activities, combustion emissions associated with NRMM, VOC emissions associated with maintenance and annulus management at the well pads and odour associated with Project waste. Such emissions should be adequately controlled through the implementation of best practice procedures and the management of emissions through the mitigation measures described in this chapter and ***Chapter 4: Project Description and Alternatives***.

The emissions associated with the activities relating to the main Project components (energy generation plant) have been modelled using dispersion modelling software to predict the impact of the main pollutants emitted at discrete receptor locations. During the Site Preparation and Enabling Works and the Construction and Pre-Commissioning phases, diesel-fired energy generation plant will have a low to negligible impact magnitude for human health sensitive receptors. Coupled with the sensitivity of the receptors to each pollutant, determined by the existing conditions within the Study Area, the residual impact significance was **Low Adverse** to **Insignificant**. At ecological receptors considered, impacts ranged from negligible to moderate. However, moderate impacts were restricted to just a small area of the MFPA, adjacent to existing roads. The vast majority of the Park will experience an **Insignificant** residual impact significance.

During the Commissioning and Operations phase, the impact magnitude of Project emissions during normal operation ranged from low to negligible for all pollutants and averaging periods for the excess gas scenarios considered. For the gas deficient scenarios, impact magnitude ranged from low to negligible for all pollutants considered, with the exception of daily mean $PM_{2.5}$. The moderate impact magnitude for daily mean $PM_{2.5}$ was considered to constitute a **Low Adverse** residual impact significance, and is not significant. The low impact magnitude predicted for annual mean and daily mean

PM_{10} during the gas deficient phase would constitute a moderate adverse effect, due to the existing conditions that are already in excess of the EALs, and the implications on receptor sensitivity. However, because the largest contribution to the total annual and daily mean PM_{10} concentrations is from the existing background sources, which is predominantly from natural sources due to the arid environment, rather than toxic particles associated with industrial or urban pollution sources, these impacts are not considered to constitute an impact that is significant. Instead, the residual impact significance is considered to be **Low Adverse** which is not significant.

The decommissioning of the Project will have impacts similar to those modelled and reported for the Site Preparation and Enabling Works and Construction and Pre-commissioning activities and are therefore not predicted to have a significant effect. There will also be HC and VOC emissions associated with the depressurisation of plant and pipework, as well as potential odour emissions associated with chemicals for the purging of pipe work. Such emissions should be adequately controlled through the implementation of best practice procedures and the management of emissions through the mitigation measures described in this chapter and ***Chapter 4: Project Description and Alternatives***.

The impact of emissions from unplanned events has also been quantified for short term air quality impacts. This has identified that there could be an exceedance of the relevant air quality standards for daily mean PM_{10} and $PM_{2.5}$ should an enclosed ground flare operate for up to 24 hours consecutively for PM_{10}, and 12 hours within a 24 hour period for $PM_{2.5}$. By their very nature unplanned events are often significant and the focus is therefore on prevention measures. This is discussed in ***Chapter 20: Unplanned Events***.

Average annual GHG emissions are anticipated to be highest during the Commissioning and Operations phase emitting around 891,200 tCO_2e per annum; or just over 1.1% of the national GHG emissions, with the main contributor relating to the power generation. The Project Proponents will seek safe and energy efficient ways to operate the Project wherever possible, with the aim of continuously trying to reduce its emissions.

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07 – Noise and Vibration

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7 Noise and Vibration

7.1 Introduction

This Environmental and Social Impact Assessment (ESIA) chapter presents an assessment of noise and vibration impacts associated with the development during Site Preparation and Enabling Works; Construction and Pre-Commissioning; Commissioning and Operations; and Decommissioning phases of the Project.

Noise from the Project has the potential to affect the health and amenity of human receptors in the area and to affect the integrity of the environment. Similarly, vibration produced by the development has the potential to cause annoyance to human receptors, to disturb wildlife receptors, and to cause damage to building structures. Consequently, noise and vibration are an important consideration in the ESIA process.

This ESIA Chapter approaches the assessment in the context of the relevant legislation and policy framework. The noise and vibration assessment methodology is presented, including details of baseline surveys undertaken. Baseline conditions captured during the surveys are included in the chapter and form the basis of the impact assessment. Mitigation measures that may be required in order to avoid or minimise any significant adverse impacts are proposed, and the likely residual impacts after these measures have been employed are also considered. Cumulative impacts, considering other schemes in the area, are also discussed.

7.2 Scoping

The Scoping process was undertaken in 2015 and the results summarised in the Scoping Report. The process identified potential noise and vibration impacts that may occur as a result of Project activities as summarised in Table 7-1. However, it should be noted that the Project phasing and identified list of potential impacts have evolved during the completion of this ESIA Chapter and consequently build and expand on those originally identified in Table 7-1 during the Scoping phase.

Table 7-1: Potential Noise and Vibration Impacts

Potential Impact	Potential Cause	Potential Sensitivity	Phase
Potential for increased noise generation, as a result of construction / decommissioning phase activities (e.g. drilling).	All construction activities undertaken at CPF, Well pads, Water Abstraction facility, pipeline routes and Waste Storage areas.	Residential areas, protected areas including MFNP, and other sensitive ecological areas within close proximity to the construction works associated with the well pad sites, CPF/ Industrial area, Water Abstraction facility, and flowlines.	Construction / Decommissioning
Potential for increased noise generation, associated with vehicle movements.	Vehicle movements both during construction / decommissioning (e.g. delivering equipment, and transporting construction personnel).	Residential areas and receptors located close to access roads, sensitive ecological areas close to access roads.	Construction Operation Decommissioning

Potential Impact	Potential Cause	Potential Sensitivity	Phase
Potential for Project activities to cause vibration (e.g. from piling works).	All construction / decommissioning activities undertaken at CPF, Well pads (especially during periods of drilling), Water Abstraction Point, pipeline routes and Waste Storage areas.	Residential areas, protected areas including Murchison Falls National Park (MFNP), and other sensitive ecological areas within close proximity to the construction works associated with the well pad sites, CPF/Industrial area, Water Abstraction Point, and pipeline routes.	Construction / Decommissioning
Potential for increased noise generation, as a result of operational activities (e.g. at well pad sites).	CPF operations and Well pad site operations including well testing; emergency flaring; Generators,	Residential areas, protected areas including MFNP, and other sensitive ecological areas within close proximity to the construction works, well pad sites, CPF/Industrial area, and Water Abstraction Point.	Operation

7.3 Legislative Framework

7.3.1 National Standards

The National Environment (Noise Standards and Control) Regulations, 2003 (Under sections 28 and 107 of the National Environment Act Cap 153) (Ref. 7-1) prescribe the maximum permissible noise levels from a facility or activity to which a person or building may be exposed, and set provisions for control of noise.

The object of these Regulations is to:

- Prescribe the maximum permissible noise levels (First Schedule) from a facility or activity to which a person may be exposed;
- Provide for the control of noise and for mitigating measures for the reduction of noise; and
- Generally to give effect for the provisions of section 29 of the National Environment Statute.

The National Environment (Noise and Vibration Standards and Control) Regulations, Draft 2013 are also indicated in this part when they differ to the ones of 2003. They provide for maximum permissible vibration levels and control and mitigation measures for the reduction of vibration which were not present in the regulations from 2003. Some permissible levels are also revisited in the Draft regulations.

The noise criteria relevant to the project are reproduced in Table 7-2 to Table 7-6. The timeframe takes into consideration human activity and is defined as:

- Day:06:00 – 22:00; and
- Night: 22:00 - 06:00.

Table 7-2: Maximum Permissible Noise Levels for General Environment

Facility	Noise Limits dB(A) (L_{eq})	
	Day	Night
A. Any building used as hospital, convalescence home, home for the aged, sanatorium and institutes of higher learning, conference rooms, public library, environmental or recreational sites.	45	35
B. Residential buildings	50	35
C. Mixed residential (with some commercial and entertainment)	55	45
D. Residential + industry or small-scale production + commerce	60	50
E. Industrial	70	60

Table 7-3: Maximum Permissible Noise Levels for Construction Site (on Surrounding Environment)

Regulations	Noise Control Zone/ Facility	Maximum noise level permitted (L_{eq}) in dB(A)	Maximum noise level permitted (L_{eq}) in dB(A))
		DAY	NIGHT
2003	Residential	60	40
	Commercial	75	50
	Industrial	85	65
2013 (Draft)	1. Hospitals, schools, institutions of higher learning, homes for the disabled etc.	50	60
	Buildings other than those prescribed in paragraph (1)	75	65

Table 7-4: Maximum Permissible Noise Levels for Construction Site (on workers)

Activity	Maximum Noise Level Permitted (L_{eq}) in dB(A)
1. Work requiring a large amount of mental concentration	55
2. Work requiring verbal communication or great accuracy and attention	85*
3. Any noise work setting	85*

Notes:
* No matter how short a time, a worker exposed to noise levels greater than 85 dBA should wear hearing protectors with an attenuation of at least 6 dB A and no worker should enter an area where noise levels exceeds 140 dBA.

This is only prescribed in the Draft (2013) regulations.

Schedule 1 Part II of the 2003 regulations and Schedule 2 of 2013 (draft) regulations also specified that noise Levels shall not exceed a L_{eq} of:

(i) Factory/Workshops 85 dB(A);
(ii) Offices 50 dB(A); and
(iii) Factory/Workshop Compound 75 dB(A).

Table 7-5: Maximum Permissible Noise Levels for Mines and Quarries

Facility	Limit Value in dB(C)
1 For any building used as a hospital, school, convalescent home, old age home or residential building	109dB (C)
2 For any building in an area used for residential and one or more of the following purposes: Commerce, small-scale production, entertainment, or any residential apartment in an area that is used for purposes of industry, commerce or small-scale production, or any building used for the purpose of industry, commerce or small-scale production.	114dB (C)

Table 7-6: Maximum Permissible Noise Levels for Road and Road Construction

Days & Times	L_{eq} dBA	L_{eq} Max slow dBA
Monday to Friday 07:00 to 19:00hrs	70	80
Monday to Friday 19:00 to 22:00hrs	60	65
Saturday 08:00 to 16:30hrs	65	75
Sundays and Public Holidays 08:00 to 16:30hrs	60	52
This is only prescribed in the Draft (2013) regulations.		

Vibration limits are also specifically set for the construction of roads where buildings may be at risk of damage. These limits are prescribed in Schedule 12 of 2013 (draft) regulations and presented in Table 7-7.

Table 7-7: Permissible Vibration Limits for Road Construction in order to Minimise the Risk of Building Damage

Permissible Vibration Velocity (Peak Particle Velocity) at the Closest Part of any Property to the Source of Vibration at a frequency of		
Less than 10 Hz	10 – 50 Hz	50 – 100 Hz
8 mm/s	12.5 mm/s	20 mm/s

The Project Proponents are required to implement appropriate measures to keep construction and operational noise and vibration within the prescribed limits, and, where excessive noise or vibration is deemed unavoidable to obtain a licence to permit noise or vibration in excess of permissible limits.

7.3.2 International Standards

7.3.2.1 WHO Guidelines for Community Noise (1999)

The World Health Organization’s (WHO) ‘Community Noise Guidelines’ (Ref. 7-2) recommend external (outdoor) daytime and evening environmental noise limits, and internal (indoor) night-time limits to avoid sleep disturbance. The guidelines generally prescribe two noise levels within bedrooms to avoid sleep disturbance:

- 30 dB(A) for continuous noise during night (23:00—7:00); and
- 45 dB(A) for single events (maximums).
- At night, sound pressure levels at the outside façades of the living spaces should not exceed 45 dB L_{Aeq} and 60 dB L_{Amax}, so that people may sleep with bedroom windows open. These values have been obtained by assuming that the noise reduction from outside to inside with the window partly open is 15 dB. The WHO Guidelines also recommend the following day period noise levels in outdoor amenity spaces:

- 55 dB(A) L_{eq} to protect the majority of people from being seriously annoyed;
- 50 dB(A) L_{eq} to protect the majority of people from being moderately annoyed; and
- 70 dB(A) L_{eq} for Industrial, commercial, shopping and traffic areas, to prevent hearing impairment.

7.3.2.2 International Finance Corporation (IFC) Environmental Health and Safety Guidelines (2007)

Table 17.1 of the 2007 IFC General EHS Guidelines (Ref. 7-3) for management of environmental noise prescribe limits for the day and night periods. It is stated that *"Noise impacts should not exceed the levels presented in Table 1.7.1, or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site."* These noise levels are reproduced in Table 7-8.

Table 7-8: IFC Noise Level Guidance

Receptor	One Hour L_{Aeq} (dB)	
	Daytime (07:00 – 22:00)	Night-time (22:00-07:00)
Residential, institutional, educational	55	45
Industrial, commercial	70	70

The noise levels in Table 7-6 correspond to the outdoor noise levels in the WHO Guidelines. Should measured background noise levels exceed the IFC criteria in Table 7-8, noise impacts should not result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.

Section 1.7 of the 2007 IFC Guidelines recognise that methods for prevention and control of sources of noise emissions depend on the source and proximity of receptors, and provide list of noise reduction options that should be considered. Also contained within the IFC Guidelines are requirements for monitoring, including parameters that good monitoring practice should adhere to and specifications for types of equipment that should be used.

The EHS guidelines (2007) Onshore Oil and Gas development recommend that noise dispersion model is undertaken for significant noise sources such as flare stacks and permanent processing facilities.

The EHS guideline (2007) Construction Materials extraction recommends specific noise and vibration minimization and control techniques.

7.3.2.3 IFC Performance Standard (PS)

The Performance Standard (PS) 3 (Ref. 7-4) Pollution Prevention and Abatement recognises that increased industrial activity and urbanization often generate increased levels of pollution to air, water, and land that may threaten people and the environment at the local, regional, and global level. The term "pollution" is intended to include forms such as noise and Vibration. One of the objectives of the PS3 is to '*avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities*'.

IFC PS 2 noise requirements associated with Labour working conditions are incorporated in ***Chapter 18: Health and Safety***.

7.3.2.4 British Standard (BS) 5228: 2009+A1:2014

British Standard BS 5228-1 *'Code of practice for noise and vibration control on construction and open sites. Noise'* (Ref. 7-5) provides a 'best practice' guide for noise control, and includes Sound Power Level (Lw) data for individual plant as well as a calculation method for noise from construction activities. BS 5228-2 '*Code of practice for noise and vibration control on construction and open sites. Vibration'* (Ref. 7-6), provides comparable 'best practice' for vibration control, including guidance on the human response to vibration.

7.3.2.5 Summary of Applicable Standards and Guidance

A summary of applicable standards and guidance is provided here. The relevant applicable standard to each project phase is defined in 7.6.1.3.

Table 7-9: Summary of Applicable Standards and Guidance

Standard	Criteria
International Guidance	
IFC General Environmental, Health and Safety (EHS) Guidelines: Environmental – Section 1.7 noise (Ref. 7.3)	*Residential; institutional and educational receptors:* Daytime (07:00 – 22:00): $L_{Aeq,15h}$[1] 55 dB Night-time (22:00 – 07:00): $L_{Aeq,9h}$ 45 dB *Industrial and commercial receptors:* Daytime (07:00 – 22:00): $L_{Aeq,15h}$ 70 dB Night-time (22:00 – 07:00): $L_{Aeq,9h}$ 70 dB
WHO Guidelines for Community Noise (Ref. 7.2)	*Inside dwellings:* Speech intelligibility, and moderate annoyance, day time and evening: $L_{Aeq,16h}$ 35 dB Sleep disturbance: $L_{Aeq,8h}$ 30 dB Effective communication in office and schools: $L_{Aeq,1h}$ 35 dB *Outside dwellings:* To prevent serious annoyance during the daytime and evening: $L_{Aeq,16h}$ 55 dB. To prevent sleep disturbance during the night-time period for occupants sleeping with an open bedroom window: $L_{Aeq,8h}$ 45 dB.
Ugandan Regulations	
The National Environment (Noise and Vibration Standards and Control) Regulations, 2013 (Ref 7.1)	**Maximum Permissible Noise Levels for General Environment** *Any building used as hospital, convalescence home, home for the aged, sanatorium and institutes of higher learning, conference rooms, public library, environmental or recreational sites:* Daytime: $L_{Aeq,}$ 45 dB; Night: L_{Aeq} 35 dB *Residential buildings:* Daytime: $L_{Aeq,}$ 50 dB; Night: L_{Aeq} 35 dB *Mixed residential (with some commercial and entertainment):* Daytime: $L_{Aeq,}$ 55 dB; Night: L_{Aeq} 45 dB *Residential + industry or small-scale production + commerce*: Daytime: $L_{Aeq,}$ 60 dB; Night: L_{Aeq} 50 dB *Industrial:* Daytime: $L_{Aeq,}$ 70 dB; Night: L_{Aeq} 60 dB

[1] $L_{Aeq,T}$ is defined as the equivalent continuous sound level. It is the steady sound level which would produce the same energy over a given reference time period T (in this case, 15 hours).

Standard	Criteria
	Maximum Permissible Noise Levels for Construction Site (on surrounding environment) *Hospitals, schools, institutions of higher learning, homes for the disabled etc.*: Daytime: $L_{Aeq,}$ 50 dB; Night: L_{Aeq} 60 dB. *Buildings other than those prescribed in paragraph (1):* Daytime: $L_{Aeq,}$ 75 dB; Night: L_{Aeq} 65 dB *Mine and Quarry Noise:* Hospital, school, residential: 109 dB(C) Mixed residential and commercial: 114 dB(C)

There is no national and international guidance for determining criteria for construction vibration impacts on human receptors. Vibration impacts associated with Project activities are based on information within the industry recognised British Standard (BS) 5228-2 (Ref. 7-6), which is considered a suitable best practice document.

There are no national or international guidance relating to noise and vibration impacts on ecological receptors. Consequently, noise and vibration impacts on ecological receptors are not considered within this chapter. National and international guidance on impacts experienced by ecological receptors are presented in ***Chapter 14: Terrestrial Wildlife*** and ***Chapter 15: Aquatic Life***.

7.4 Spatial and Temporal Boundaries

The Project Area is defined by the boundaries of the Blocks EA-1A, CA-1 and LA-2 North, whilst the extent of the Project Area of influence (AoI) is explained in ***Chapter 1: Introduction***. The Project has the potential to cause noise and vibration disturbance to both human and ecological receptors. The Study Area relevant to Noise and Vibration is considered equivalent to the extent of the Project Area boundaries and includes sensitive receptors that have the potential to be affected by noise and vibration during Project activities.

The proposed timescales for the different phases of the Project are set out in ***Chapter 4: Project Description and Alternatives***. A brief summary of the timescales are provided below:

- Site Preparation and Enabling Works Phase expected to take approximately 5 years;
- Construction and Pre-Commissioning is expected to take up to 7 years;
- Commissioning and Operations is expected to commence approximately 36 months after effective date of the main construction contract award. The lifetime of the Project is 25 years; and
- Decommissioning is planned for the end of the 25 year operation.

The duration of activities which may lead to potential noise and vibration impacts differ between short and long term episodes, all of which are included within the assessment.

7.5 Baseline

7.5.1 Introduction

This section of the Noise and Vibration Chapter presents details regarding the collection of baseline noise data. Baseline noise conditions have been established through a number of sources:

- Desktop review of secondary data presented in previous studies in the Project Area;
- Baseline noise surveys undertaken through previous campaigns in 2011-2014;
- Baseline surveys carried out in November and December 2016 specifically for the ESIA, undertaken to supplement data collected during 2011-2014 and to further establish baseline conditions during

day and night periods at the proposed locations of Project components and potentially affected receptors; and

- Noise surveys associated with the Early Works Project Brief undertaken by AWE in 2017.

The desktop review of the previous studies indicated that there were no existing sources that were considered to generate significant levels of vibration within the Project Area. Furthermore, no perceivable level of ambient vibration was observed during attendance at site. Assessment of vibration impacts is undertaken through the consideration of the specific level of vibration from a source associated with the Project at which annoyance or structural damage become an issue. Consequently, the assessment of vibration impacts is not dependent on the baseline ambient level of vibration and, subsequently, vibration measurements were scoped out of the surveys.

7.5.2 Data Gap Analysis

Previous noise studies undertaken within and in the vicinity of the Study Area have included baseline measurements across Blocks CA-1 and LA-2 North. The known noise monitoring locations are shown in Figure 7-1. A gap analysis was completed during the Scoping phase of the Project to review available information to help characterise the baseline ambient noise environment and identify data gaps. The findings of the gap analysis are summarised below:

- On the whole, ambient noise records were available to characterise the acoustic landscape across Blocks CA-1, EA-1A and LA-2 North during the daytime;
- The available data included consistently measured daytime noise levels from previous AECOM survey campaigns, detailed in the Environmental Baseline Study (EBS) for Block 1 in Uganda Report Volume 1 (Ref. 7-7); and
- Daytime noise measurements carried out within 2 km radius of exploration/appraisal wells across the Study Area were available from ESIA Reports completed by other consultants. Further details on these studies are presented in Appendix I. However, results were not always reported using the same parameters and indices (dB(A); L_{Aeq}, etc.) making the comparison with the national and international criteria for environmental noise inconsistent.

On the basis of these findings, it was considered that additional noise measurements were necessary to further establish baseline noise conditions. For this purpose, an ambient noise survey was undertaken by Tilenga ESIA team in November and December 2016 at identified sensitive receptors and locations of Project components within the Study Area (see Figure 7-2).

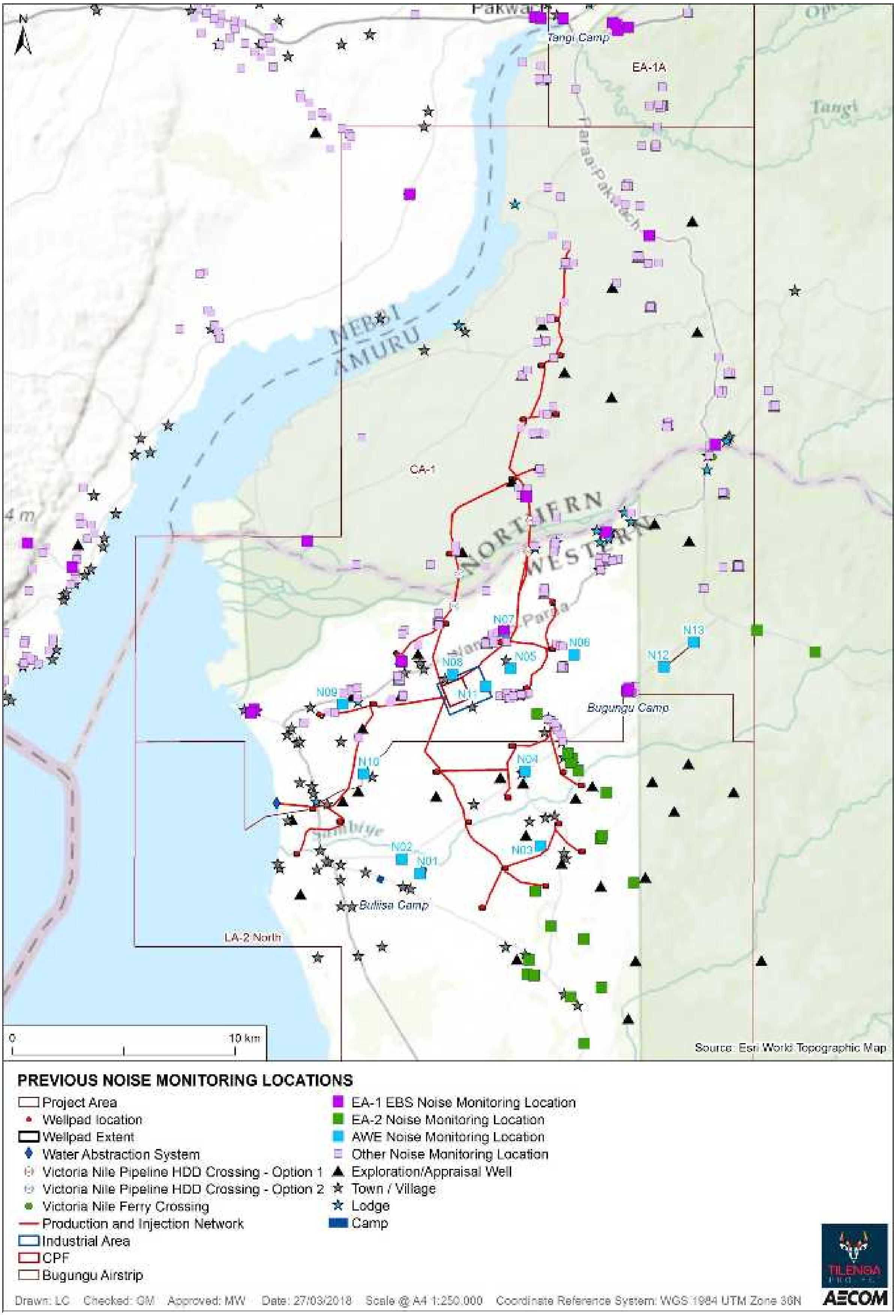

Figure 7-1: Known Noise Monitoring Locations

7.5.3 Baseline Data Collection

7.5.3.1 Primary Data – 2014 Baseline Surveys – Method Overview

The EBS (Block CA-1 EBS for Block 1 in Uganda Report Volume 1 (Ref. 7-7) contains details of four AECOM baseline noise survey campaigns in Block 1 during 2014. Noise measurement locations for these campaigns were identified as follows:

- 12 measurement locations across area north of the Victoria Nile;
- 8 measurement locations across area south of the Victoria Nile; and
- 7 measurement locations across area west of the Victoria Nile.

The identified locations for daytime measurements of background noise level were located in areas identified as having sensitive receptors (i.e. residential areas, tourist facilities, schools), natural areas (e.g. MFNP and Ramsar site), areas with existing petroleum activities (field camps, storage areas) and locations for potential Project activities. Short term monitoring data at the identified locations was gathered over four monitoring campaigns that were undertaken as follows:

- Campaign 1: 05/02/14-13/02/14 (dry season);
- Campaign 2: 08/05/14-17/05/14 (wet season);
- Campaign 3: 03/07/14-10/07/14 (dry season); and
- Campaign 4: 16/09/14-26/09/14 (wet season).

7.5.3.2 Primary Data – 2016 Baseline Surveys – Method overview

In order to supplement the existing data, an ambient noise survey was undertaken by Tilenga ESIA team in November and December 2016 at identified sensitive receptors within the Study Area, including measurements in both day and night periods. Daytime measurements were undertaken at locations associated with key Project components, with additional night time measurements undertaken at those monitoring locations where residential or ecological sensitive receptors were identified. Observation notes of dominant noise sources and other characteristics of the ambient climate were made during the measurements in order to provide context for the noise environment at each measurement location. The noise measurements were undertaken following the principles and guidance of ISO1996-1:2003 ‘Acoustics - Description and measurement of environmental noise — Part 1: Basic quantities and assessment procedures’ and noise monitoring methodology set out in International Finance Corporation (IFC) Environmental, Health and Safety (EHS) Guidelines.

The selection of the survey locations was informed by the findings of the data gap analysis and consideration of previous studies in the Study Area. The following locations were ultimately identified and included in the November and December 2016 baseline noise monitoring exercise: The locations of the 2016 survey points are presented in Table 7-10 below and presented in Figure 7-2.

It was decided to undertake the survey during one season only as the measurement results of EBS EA-1 in 2014 did not present definitive trend in terms of noise level between the dry and wet season. Baseline information contained in the majority of EIA/ESIA documents relevant to project did not differentiate dry and wet season.

Table 7-10: Noise Monitoring Locations

Block	Survey Point ID	Reference Location	Survey type (Day/Night)	Rationale and Intended Receptor
LA-2	N1	Original Water Abstraction System location.	Daytime only	Nearby residential receptors that could be affected by noise from Water Abstraction System construction and operation
CA-1	N2	Near known residential receptors and Wanseko Pier.	Day & Night time	To be representative of nearby residential receptors and Wanseko Pier.
CA-1	N3	North west corner of CPF	Day & Night time	Residential receptors that could be affected by noise from the CPF
CA-1	N4	North east corner of CPF	Day & Night time	Residential receptors that could be affected by noise from the CPF
CA-1	N5	South east corner of CPF	Day & Night time	Residential receptors that could be affected by noise from the CPF
CA-1	N6	South west corner of CPF	Day & Night time	Residential receptors that could be affected by noise from the CPF
LA-2	N7	KGG 01 - well pad: near known residential land users	Daytime only	Nearby residential land users that could be affected by noise from KGG 01
LA-2	N8	NGA 01 - Well pad: Southernmost well in Block LA-2	Daytime only	Nearby residential land users that could be affected by noise from NGA 01
LA-2	N9	Original KW 02- Well pad location, near KW02A and KW 02B near known residential land users	Daytime only	Nearby residential land users that could be affected by noise from KW02
CA-1	N10	NSO 06 - Well pad: near known residential land users	Daytime only	Nearby residential land users that could be affected by noise from NSO 06
CA-1	N11	JBR 06 – Well Pad: Located in the MFNP (also close to previous monitoring location in the EBS)	Day & Night time	Noise at nearby area in MFNP to corroborate and add to existing data
LA-2	N12	NSO 03 -Well Pad: Representative locations within LA-2	Daytime only	Noise representative of a well pad area within LA-2
CA-1	N13	On roadside at road within the MFNP	Day & Night time	Noise associated with existing roads within the Park and within the project area
CA-1	MRL	Adjacent to Murchison River Lodge and other accommodation within the MFNP	Day & Night time	Murchison River Lodge guesthouse and other lodges/accommodation in that area (i.e. Nile River Lodge, Yebo Lodge, Kabalega Lodge)

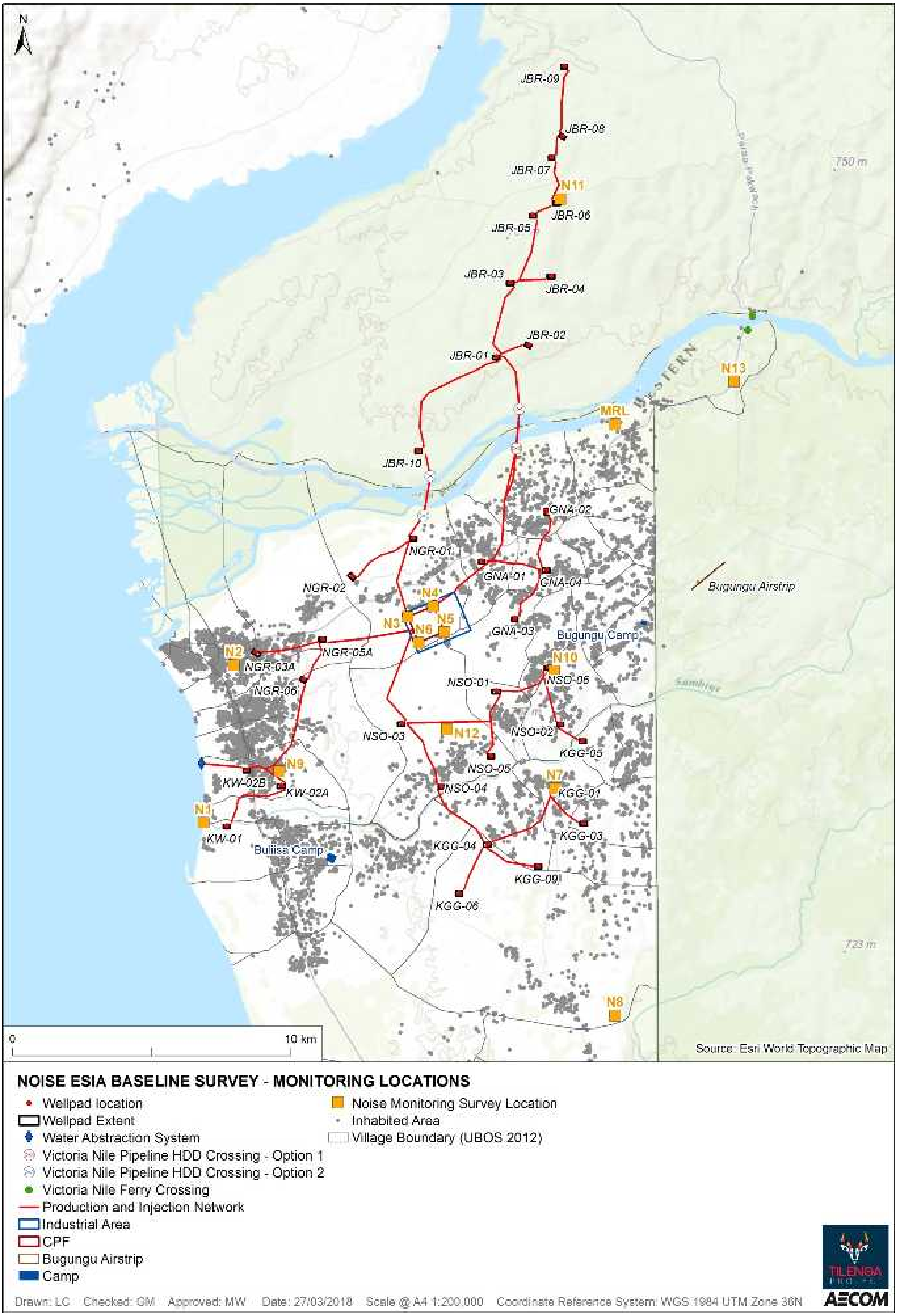

Figure 7-2: Baseline ESIA Survey – Monitoring and Receptor Locations

The purpose of the noise survey was to quantify the prevailing daytime and night-time background noise at key receptor locations that may be affected by Project activities. This enables the assessment of construction and operational noise impacts to any identified sensitive receptors, applying the national and international criteria presented in this Chapter, which take into account the prevailing ambient noise levels.

Noise monitoring was undertaken using a Rion NL52 Type 1 sound level meter and a Casella CEL-62X sound level meter. Calibration of the sound level meter was undertaken prior to and after completion of each noise measurement using a Rion NC74 handheld acoustical calibrator and a Casella CEL-110/2. No variation in calibration levels was noted. Calibration certificates are available on request.

Weather conditions including temperature, wind speed, wind direction and rain were recorded during each monitoring period. All measurements were undertaken during periods when weather conditions were suitable for measuring ambient noise levels.

7.5.3.3 Secondary Data - 2017 Early Works Baseline Survey – Method Overview

Ambient noise surveys were undertaken by AWE in June 2017 as part of the Early Works Project Brief. Noise measurements were taken using a Casella CEL-62X -Digital integrated sound level meter for which calibration certificates are available on request.

Measurements of background noise level were performed at 13 locations across the survey area, selected to include residential areas, Murchison Falls National Park, existing roads, proposed project locations, and potentially sensitive receptors. The locations can be grouped as follows:

- One location in proximity to the Industrial Area to target potentially sensitive receptors near to the Industrial Area fence line;
- Seven locations within the southern part of CA-1, of which:
  - Two locations were selected to target potentially sensitive receptors in proximity to a potential borrow pit location;
  - Three locations were selected to target potentially sensitive receptors in the vicinity of the proposed A1 and A4 upgrade road works, and
  - Two locations were selected to assess potential impact to wildlife in the vicinity of the proposed Bugungu airstrip upgrade within MFNP.
- Five locations in the northern part of LA-2 (to target potentially sensitive receptors in the vicinity of the proposed B1, B2, A2, A3, and A4 upgrade road works).

All the measurements were Fast and Impulse time weighted. Percentile parameters such as L_{AF10} (the noise level exceeded for 10% of the measurement period, A-weighted), L_{AF90} (the noise level exceeded for 90% of the measurement period, A-weighted), L_{AF95} (the noise level exceeded for 95% of the measurement period, A-weighted) and L_{Aeq} (A-weighted, equivalent sound level - with the same Energy content as the varying acoustic signal measured) were recorded. Measurements of background noise level and assessment were performed according to ISO 1996 standard methodology. All measurements were taken during day time and each noise measurement session lasted 20 minutes. Further information is provided in Appendix C.

7.5.3.4 Other Secondary Data

In addition to the studies undertaken for the baseline survey in 2014, 2016 and primary data from AWE in 2017, the existing ambient noise records from previous studies undertaken by other consultants provide some level of general understanding of the noise environment across the Project Area.

The following studies containing information about baseline acoustic conditions in the Study Area have been considered:

- Noise Measurements Report for Bugungu Camp, 2013 (Ref. 7-8);
- Noise Monitoring Report for Gunya-2 Well Testing, 2013 (Ref. 7-9);

- Noise Monitoring Report for Gunya-3 Well Testing, 2013 (Ref. 7-10);
- Noise Monitoring Report for Jobi -East-I Drill Pad, 2013 (Ref. 7-11);
- Noise Monitoring Report for Jobi East-7 well site, 2013 (Ref. 7-12);
- Noise Monitoring Report for Mpyo-5 Well site, 2013 (Ref. 7-13); and
- Noise Monitoring Report for Mpyo-F well during wireline testing, 2013 (Ref. 7-14).

The main purpose of the noise monitoring was to obtain environmental noise levels at sensitive receptors around each well site during well testing, and to establish compliance with national noise standards. Consequently, the monitored noise levels are largely affected by drilling, testing and other activities.

7.5.3.5 Baseline Data

The following tables present the results of the baseline noise monitoring undertaken for the Project.

Table 7-11 presents the Primary Data collected during AECOM survey campaigns in 2014, as detailed in the EBS document.

Table 7-12 and Table 7-13 present the Primary Data collected during the Tilenga ESIA survey campaign in November/December 2016, as detailed in Section 7.5.3.2 of this Chapter.

The Secondary Data collected during previous studies in the area by other consultants is summarised in Appendix I. Noise data from 2017 AWE surveys are summarised in Appendix C.

Table 7-11: Primary Data (2014) – Daytime Baseline Noise Results in North, South and West Nile Areas during CA-1 EBS 2014

Measurement Location	Measurement point ID	Description of the Measurement Location	First Campaign (February 2014) Dry Season		Second Campaign (May 2014) Wet Season		Third Campaign (July 2014) Dry Season		Fourth Campaign (September 2014) Wet Season	
			Noise Results		Noise Results		Noise Results		Noise Results	
			L_{Aeq} (dB)	L_{90} (dBA)	L_{Aeq} (dB)	L_{90} (dBA)	L_{Aeq} (dB)	L_{90} (dBA)	L_{Aeq} (dB)	L_{90} (dBA)
Noise measurement locations within area north of the Victoria Nile										
N01	N01-A	Tangi camp - camp entrance.	56.7	45.4	65.4	57.2	59.5	35.5	61.7	33.6
	N01-B	Tangi camp - access road to Fort Murchison Nature Lodge.	52.7	31.8	50.9	36.4	54.2	30.2	47.9	34.2
	N01-C	Tangi camp - Northwest corner, sparse community houses outside the camp fence.	35.5	32.4	43.8	38.8	41.1	34.0	48.9	40.9
	N01-D	Tangi camp - Northeast corner, Uganda People's Defence Force (UPDF) houses.	56.9	55.7	58.5	56.1	56.1	51.2	46	32.4
N02		Crossroad to Pakwach road, close to Jobi-East-6 (I) well pad (completely restored).	57.5	35.7	49.1	29.0	52.9	24.5	37.7	29.8
N03		Paraa river crossing. Residential houses (UWA rangers' living quarters) near ferry landing.	53.3	45.0	49.1	42.1	50.4	40.9	48.3	38.2
N04		Virgin area within the Ramsar Site and a potential project area. The area is South of Rii-1 well pad.	33.9	26.8	41.5	34.3	40.9	29.2	49.4	45.9
N05	N05-A	Virgin area inside MFNP, around Pandera (rangers' post). In proximity to access road to rangers' post.	42.4	36.2	39.4	36.3	33.4	26.1	38.1	30.8
	N05-B	Virgin area inside MFNP, around Pandera (rangers' post). Isolated area Southwest to rangers' post.	40.7	28.0	44.5	40.5	31.4	24.7	34.2	27.9

Measurement Location	Measurement point ID	Description of the Measurement Location	First Campaign (February 2014) Dry Season Noise Results		Second Campaign (May 2014) Wet Season Noise Results		Third Campaign (July 2014) Dry Season Noise Results		Fourth Campaign (September 2014) Wet Season Noise Results	
			L_{Aeq} (dB)	L_{90} (dBA)	L_{Aeq} (dB)	L_{90} (dBA)	L_{Aeq} (dB)	L_{90} (dBA)	L_{Aeq} (dB)	L_{90} (dBA)
N06		Virgin area inside Ramsar Site, close to Victoria Nile river. Evidence of wildlife in the area, especially hippos and birds.	32.6	23.0	41.5	29.6	41.5	29.6	35	27.4
N18	N18-A	Virgin area along the MFNP northern boundary. Hill along Gulu-Arua Road at about 300 m from the road.	30.3	22.4	49.7	39.0	34.9	27.8	33.5	25.3
	N18-B	Virgin area along the MFNP northern boundary. Hill along Gulu-Arua Road.	58.8	37.9	58.9	35.6	69.2	28.8	57.9	24.5
Noise measurement locations within the area south of the Victoria Nile										
N07		Murchison River Lodge.	56.9	53.3	40.0	35.1	39.8	30.3	42.7	36.8
N08	N08-A	Bugungu camp. Southwest corner at camp entrance road.	53.3	48.4	57.5	47.7	51.2	48.3	47.9	45.1
	N08-B	Bugungu camp. Northwest corner.	50.1	42.2	49.1	47.0	47.1	42.8	49.8	46.3
N09		Ngiri-2 well pad currently used as storage yard.	44.1	34.5	51.0	43.8	48.7	42.7	43.9	33.9
N10	N10-A	Wanseko Town Council at the water tank close to Wanseko Primary School.	48.4	40.6	50.8	42.6	52.3	41.0	54.6	42.1
	N10-B	Wanseko Town Council crossroad the main road.	60.0	59.1	59.1	50.5	69.9	50.6	65.4	49.5
N11		Virgin area inside MFNP.	35.5	25.5	53.7	50.0	39.0	28.2	33.2	26.5
N12		Kisomere village, town centre.	59.6	49.1	57.5	50.7	58.3	47.8	56.8	52.7
Noise measurement locations within the area west of the Victoria Nile										
N13		Hill above Panyimur Sub county.	37.9	26.8	40.5	29.7				
N14		Panyimur Sub county, settlement centre.	44.1	38.1	55.3	44.1				

Measurement Location	Measurement point ID	Description of the Measurement Location	First Campaign (February 2014) Dry Season		Second Campaign (May 2014) Wet Season		Third Campaign (July 2014) Dry Season		Fourth Campaign (September 2014) Wet Season	
			Noise Results		Noise Results		Noise Results		Noise Results	
			L_{Aeq} (dB)	L_{90} (dBA)	L_{Aeq} (dB)	L_{90} (dBA)	L_{Aeq} (dB)	L_{90} (dBA)	L_{Aeq} (dB)	L_{90} (dBA)
N15	N15-A	Pakwach Town Council along Gulu–Arua road, at crossroad to Pacego village road.	60.2	52.2	68.4	53.1				
	N15-B	Pakwach Town Council, along Gulu–Arua road, on the main road in town centre.	-	-	67.6	59.6				
	N15-C	Pakwach Town Council, Albert Nile Bridge (west bridge side).	47.2	42.1	49.9	43.5				
N16		Panyigoro village. Main road.	53.2	36.3	55.7	43.3				
N17		Kiroli village along Gulu–Arua Road, from Pakwach to Nebbi.	34.9	25.8	41.0	34.4				

Table 7-12: Primary Data (2016) Daytime Noise Survey Results

Survey Point ID on Map	Start Date, Time	Duration, T (mm:ss)	Noise Parameters				Observations on Noise Sources
			$L_{Aeq,T}$ dB	$L_{AFMax,T}$ dB	$L_{A10,T}$ dB	$L_{A90,T}$ dB	
N1	05/11/2016, 09:47:06	60:00	43.6	68.6	45.5	34.2	Dominant noise source: crickets and birdsong. Also some noise from residents' chickens.
N2	05/11/2016, 13:01:26	60:00	40.6	69.1	42.2	35.0	Dominant noise source: crickets. Also some noise from activity in local village: children playing, rooster calling.
N3	06/11/2016, 09:06:54	60:00	38.5	62.9	40.2	28.5	Dominant noise source: birdsong and crickets. Also some noise from local livestock (chickens and cattle).
N4	06/11/2016, 11:31:49	60:00	38.9	65.9	38.5	33.2	Dominant noise source: birdsong crickets and flies. Livestock audible in distance.
N5	06/11/2016, 12:45:59	60:00	35.8	61.0	36.3	25.1	Dominant noise source: birdsong and insects.

Survey Point ID on Map	Start Date, Time	Duration, T (mm:ss)	Noise Parameters				Observations on Noise Sources
			$L_{Aeq, T}$ dB	$L_{AFMax, T}$ dB	$L_{A10, T}$ dB	$L_{A90, T}$ dB	
N6	06/11/2016, 14:00:12	60:00	34.5	66.1	35.9	24.8	Dominant noise source: birdsong and insects.
N7	07/11/2016, 15:15:37	60:00	35.6	62.4	37.0	30.3	Dominant noise source: crops rustling in light breeze, birdsong and distant noise from vehicles using roads. Some noise also audible from activity in nearby village.
N8	07/11/2016, 11:05:16	60:00	39.0	68.4	39.8	29.6	Dominant noise source: insects and birdsong. Also some noise from activity in local village: babies crying and children playing.
N9	05/11/2016, 11:30:25	60:00	42.7	60.1	44.7	36.4	Dominant noise source: crickets and birdsong, some noise from activity in nearby village: children playing and some just audible amplified music.
N10	07/11/2016, 13:47:22	60:00	36.0	64.8	35.5	26.8	Dominant noise source: birdsong and insects.
N11	08/11/2016, 10:22:31	60:00	31.3	56.2	32.6	25.3	Dominant noise source: insects and long grass rustling in light breeze. Measurement was near Pakuba Airstrip but no movements were observed from there during the measurement period.
N12	05/11/2016, 14:59:35	60:00	37.9	62.6	39.4	32.6	Dominant noise source: birdsong and crickets. Some noise audible from activity in nearby village.
N13	08/11/2016, 12:28:37	60:00	47.8	79.5	40.7	29.0	Dominant noise source: birdsong. Also noise from occasional vehicles (4x4s and mopeds) using nearby road, causing the highest noise levels.

Table 7-13: Primary Data (2016) Night Noise Survey Results

Survey Point ID	Start Date, Time	Duration, T (mm:ss)	Noise Parameters				Observations on Noise Sources
			$L_{Aeq, T}$ dB	$L_{AFMax, T}$ dB	$L_{A10, T}$ dB	$L_{A90, T}$ dB	
N2	08/11/2016, 21:45:08	30:00	49.0	65.3	51.5	43.5	Dominant noise source: crickets (louder than in day) and frogs.
N3	06/11/2016, 21:51:59	30:00	38.0	54.7	39.7	35.6	Dominant noise source: crickets and some wind rustling vegetation.
N4	06/11/2016, 22:30:38	30:00	48.0	62.0	52.3	39.5	Dominant noise source: crickets and some wind rustling vegetation.
N5	07/11/2016, 21:24:33	30:00	41.6	65.6	43.0	39.1	Dominant noise source: crickets and some wind rustling vegetation.
N6	07/11/2016, 21:58:21	30:00	42.5	55.0	43.4	40.2	Dominant noise source: crickets, frogs and some wind rustling vegetation.
N11*	06/12/2016, 22:28:46	30:00	33.1	51.2	-	-	Dominant noise source: wind rustling vegetation, birdsong and crickets
N13*	07/12/2016, 23:42:11	30:00	38.1	55.8	-	-	Dominant noise source: wind rustling vegetation, birdsong and crickets.
Murchison River Lodge*	08/12/2016, 23:02:22	30:00	38.0	58.8	-	-	Dominant noise source: wind rustling vegetation, birdsong and crickets. Some noise from activity in nearby Lodge and occasional vehicle movements.

*due to the limitations of noise monitoring equipment, only $L_{Aeq,T}$ and L_{Amax} data was logged.

7.5.3.6 Baseline Data Assumptions and Limitations

The primary survey data was collected under the local environmental conditions at the time of the baseline survey and may evolve during the lifetime of the Project. As the baseline year has been defined to include the period during which noise monitoring took place, it is considered that noise measurements are suitably representative of baseline conditions where Project activities will take place or where sensitive receptors are located.

Measurement of existing ambient or background sound levels are subject to a degree of uncertainty. Environmental sound levels vary between days, weeks, and throughout the year due to variations in source levels and conditions, meteorological effects on sound propagation and other factors. Every effort is made to ensure that measurements are undertaken in such a way as to provide a representative sample of conditions, such as avoiding periods of adverse weather conditions, and events that may result in atypical sound levels. Consequently, noise monitoring is considered to provide data that can be considered representative of the typical noise levels at the location during a specific time period. However, a small degree of uncertainty will always remain in the values taken from such a measurement survey.

The secondary data are based on previous studies and available information gathered by other consultants. No validations were undertaken by Tilenga ESIA team from data obtained from other consultants.

7.5.4 Baseline Characteristics

Table 7-14 presents a summary of baseline noise levels at the sites of Project components, based on the monitoring data obtained during the November 2016 survey (presented in Table 7-12 and Table 7-13), EBS data (presented in Table 7-11) and AWE data (presented in Appendix C).

Table 7-14: Summary of Baseline Noise Levels at Representative Project Component Sites

Project Component	Representative Survey Point ID	Measured Daytime Noise Levels dB(A) L_{eq}	Measured Night-time Noise Levels dB(A) L_{eq}
Industrial Area	N3, N4, N5, N6	35 – 39	38 - 48
Water Abstraction System location (location moved since the survey)	N1	44	-
Well pad NRG-04 (removed from Project)	N2	44	49
Well pad KGG-01	N7	36	-
Well pad NGA-01	N8	39	-
Well pad KW-02 (location moved since the survey and split onto two nearby locations KW-02A and KW-02B)	N9	43	-
Well pad NSO-06	N10	36	-
Well pad NSO-03	N12	38	-
Well pad JBR-06	N11	31	33
On roadside at road within the MFNP	N13	48	38
HDD Option 1 North Clearance Site	EBS N04	34 – 49	-
HDD Option 1 South Clearance Site	EBS N07	40 – 43	-
HDD Option 2 South Clearance Site	EBS N12	57 – 60	-
Victoria Nile Ferry Crossing	EBS N03	48 – 53	-
Bugungu Airstrip SW Edge	AWE N12	39	-
Bugungu Airstrip NW Edge	AWE N13	40	-
Sites on south side of Victoria Nile	MRL	-	38

The results of the primary data from the 2016 survey campaign show, in general, similar daytime baseline noise levels of 35 to 40 dB(A) L_{eq} at different project component sites, with increased background noise levels of 40 to 45 dB(A) L_{eq} at measurement positions located close to towns. Noise levels at measurement location N13 in proximity of a road were measured at 48 dB(A) L_{eq}. Noise survey locations in remote areas (i.e. N11) away from the road within the MFNP were measured at 31 dB(A) L_{eq}.

Noise levels are below the maximum permissible noise levels for general environment under the National Environment (Noise and Vibration Standards and Control) Regulations, (as presented in Table 7-2), which can be attributed to the overall absence of significant anthropogenic noise sources (e.g. road, air, rail traffic) across the Study Area. While noise from residents of homesteads and villages was audible at most positions, the dominant noise source at most locations was from insects, birds and wind rustling through vegetation.

Night-time levels are shown to be higher than daytime noise levels (ranging from 33 to 49 dB(A) L_{eq}). Based on site observations, this was due to the increased noise from insects during night periods.

The measured night time noise levels for locations other than Well pad JBR-06 were above the maximum permissible noise levels for general environment under the National Environment (Noise and Vibration Standards and Control) Regulations.

It is noted that the most recent AWE 2017 noise survey results confirmed the same trend as discussed above. Noise levels measured at the primary schools, church and the village centres were above the regulatory noise criteria.

The secondary noise data presented in Appendix I shows similar noise levels across the study area to data obtained during the primary surveys. Levels in the range of 30 to 45 dB(A) L_{eq} were measured in isolated areas (e.g. within the MFNP or inside the Ramsar Site) and influenced mainly by natural sources (i.e. wildlife, wind). Higher noise levels (typically in the range of 50 to 70 dB(A) L_{eq}) were detected in the vicinity of more built-up areas and along main roads, and attributed to the operation of diesel generators, human presence and vehicle traffic.

7.6 Impact Assessment and Mitigation

7.6.1 Impact Assessment Methodology

This assessment considers the significance of potential noise and vibration impacts on human receptors, relative to baseline conditions, for the Site Preparation and Enabling Works, Construction and Pre-Commissioning, Commissioning and Operations; and Decommissioning phases of the Project.

The impact of occupational noise and vibration on employees in the Project team during all phases of the Project is discussed in ***Chapter 18: Health and Safety***. Where the noise and vibration assessment identifies the potential for impacts on ecologically sensitive areas, this is considered in ***Chapter 14: Terrestrial Wildlife*** and ***Chapter 15: Aquatic Life***.

The methodology applied follows the standard practice approach for assessing noise and vibration impacts taking into account Ugandan national and international noise and vibration standards, TEP Uganda company standards and recognised Good International Industry Practice (GIIP) regarding the assessment and control of noise and vibration, as detailed in section 7.3.

The closest human receptors to the Project activities have been identified and used to define the spatial scope of the assessment as outlined in section 7.4. The sensitivities of individual receptors have been categorised by their nature using the criteria in Table 7-16 to help determine the potential significance of impacts.

The assessment of impacts has been undertaken by identifying and evaluating a range of activities and scenarios that are likely to occur throughout the phases of the Project. The key activities likely to generate noise and vibration during each of the Project phases are included below in Table 7-15.

Table 7-15: Key Project Activities Likely to Result in Noise and Vibration

Phase	Key Noise and Vibration Activities
Site Preparation and Enabling Works	Vehicle movements: • Mobilisation of plant and vehicles to the Project Site. • Transportation of personnel to and from the Project Site. • Deliveries of materials and supplies to the Project Site. • Increased vehicle movements on the local and national road network. • Physical movement of vehicles and plant (Industrial Area, well pads, Water Abstraction System (onshore facilities option only)[2], Masindi Vehicle Check Point, Bugungu Airstrip and Victoria Nile Ferry Crossing Facilities)
	Drilling of boreholes for water abstraction (Buliisa camp, Bugungu camp, Tangi Camp, well pads and Industrial Area).
	Use of power generation plant (e.g. diesel generators).
	Clearance of vegetation and soils (Industrial Area, well pads, Water Abstraction System, Masindi Vehicle Check Point, Bugungu Airstrip and Victoria Nile Ferry Crossing Facilities).
	Demolition of existing buildings at the Industrial Area, well pads, Water Abstraction System (onshore facilities option only), if present.
	Construction of Camp (temporary facility) within Industrial Area.
	Installation of structure around well pads in the north of the Victoria Nile.
	Civil works activities at well pads and Water Abstraction System sites.

[2] The Project comprises two options for the Water Abstraction System as presented in Section 4.3.7 of Chapter 4: Project Description and Alternatives.

Phase	Key Noise and Vibration Activities
	Installation of facilities at Victoria Nile Ferry Crossing (i.e. containers)
	Installation of temporary facilities at the Masindi Vehicle Check Point (i.e. containers).
	Construction of Victoria Nile Ferry Crossing Facility, including piling for the jetties.
	Construction of new access roads (W1, C1, C2, N1, N2, N3, inter field access roads south of the Victoria Nile) and upgrade works of existing roads (A1, A2, A3, A4, B1 and B2) including the installation of drainage.
	Excavation from borrow pits and quarries and the movement of excavated materials
	Upgrade of runway at Bugungu Airstrip.
Construction and Pre-Commissioning	Vehicle movements: • Mobilisation of plant and vehicles to the Project Site. • Transportation of personnel to and from the Project Site. • Deliveries of materials and supplies to the Project Site. Increased vehicle movements on the local and national road network. • Physical movement of vehicles and plant (Industrial Area, well pads, Water Abstraction System, Masindi Vehicle Check Point, Bugungu Airstrip and Victoria Nile Ferry Crossing Facilities). • Transportation of materials and supplies including hazardous substances (i.e. drill cuttings) within the Project Site. • Movement of construction vehicles for Production and Injection Network RoW, Water Abstraction System pipeline RoW and Horizontal Directional Drilling (HDD) Construction Area
	Installation of structures around all key Project components
	Use of temporary power generation plant (e.g. diesel generators)
	Construction activities at the Industrial Area and Water Abstraction System (both on-shore and off-shore options)
	Excavation of construction material from quarries and movement of excavated materials
	Drilling of wells (on a 24 hour basis) at well pads
	Construction of well pad surface facilities
	Clearance of vegetation and soils for Production and Injection Network RoW, Water Abstraction System pipeline RoW and HDD Construction Area
	Construction of Production and Injection Network (i.e. pipelines and flowlines) and Water Abstraction System pipeline RoW including trenching, welding, storage of material, backfilling etc.
	HDD activities at the Victoria Nile Crossing Points (on a 24 hour basis) – Options 1 and Option 2[3].
	Aircraft movements to/from Bugungu Airstrip
	Pre-commissioning of Production and Injection Network, valves at the well pads, Water Abstraction System and CPF

[3] The Project comprises two location options for the HDD Victoria Nile Crossing as presented in Section 4.3.8.1 of Chapter 4: Project Description and Alternatives.

Phase	Key Noise and Vibration Activities
Commissioning and Operations	Vehicle movements: • Transportation of operational personnel to and from the Project Site • Delivery of materials and supplies (including fuel and other hazardous substances) to the Project Site Physical movement of vehicles and plant within the Project Site
	Operation of CPF plant and equipment. Operation of power generation facility at the CPF.
	Operation of plant and equipment at well pads and Water Abstraction System
	Operation and maintenance of the Victoria Nile Ferry including barge movements across the Victoria Nile.
	Operation of flare (either elevated or enclosed option)
Decommissioning	Demolition of project components and infrastructure
	Vehicle movements.

Perceivable levels of vibration at nearby sensitive receptors are unlikely to be produced (due to the low levels of vibration produced from plant that do not have a direct vibration generating interaction with the ground and attenuation provided through the transmission of vibration through the ground from source to receiver) with the exception of the following:

- Site Preparation and Enabling Works:
  - Drilling of boreholes for water abstraction (Buliisa camp, Bugungu camp, Tangi Camp, well pads and Industrial Area);
  - Piling during landing structure construction at Victoria Nile Ferry Crossing;
  - Construction of new roads (N1, N2, N3, C1, C2, C3, inter field access roads south of the Victoria Nile (D roads) inter field access roads north of the Victoria Nile constructed within the Production and Injection Network);
  - Upgrade of runway at Bugungu Airstrip; and
  - Construction of temporary facilities at the Masindi Vehicle Check Point (including the M1 road).
- Construction and Pre-Commissioning:
  - Drilling of wells at well pad sites (on a 24 hour basis); and
  - HDD activities at the Victoria Nile Crossing Points (on a 24 hour basis) – Option 1 and Option 2.

As such, vibration impacts from all other activities have been scoped out of the assessment.

7.6.1.1 Impact Assessment Criteria

Criteria have been developed for assessing the potential noise and vibration impacts from all phases of the Project, and include impact magnitude and receptor sensitivity. The impact significance matrix in ***Chapter 3: ESIA Methodology*** is used to determine the significance of each impact.

7.6.1.2 Receptor Sensitivity

Potential sensitive receptors have been taken into consideration when assessing the impacts associated with noise and vibration levels from Project activities. Receptors considered include buildings where human occupants may be disturbed by adverse noise and vibration levels and or buildings whose structures may be sensitive to vibration. The sensitivity of receptors has been determined taking into consideration their use and subsequent sensitivity to noise and vibration based on the criteria presented in Table 7-16.

Table 7-16: Noise and Vibration Receptor Sensitivity

Sensitivity	Description
High	Any building used as hospital, convalescence home, home for the aged, sanatorium and institutes of higher learning, conference rooms, public library, environmental or recreational sites.
Moderate	Residential areas or other areas where members of the public will be regularly resting/ sleeping such as tourist lodges/hotels/field camps. Any healthcare, educational, or worship buildings sensitive to changes in noise and/or vibration levels.
Low	Office areas or other areas where members of the public will be undertaking work requiring concentration.
Negligible	Industrial/ construction areas or other areas members of the public will be present but not working in noise sensitive conditions.

It should be noted that, when assessing potential noise and vibration impacts at night, only residential properties and hospitals are considered occupied and thus sensitive to impacts. Receptors are considered to be permanent buildings or field workers who are permanently located around sites. Temporary receptors such as tourists have not been considered in the assessment of noise and vibration impacts as they do not have a fixed location so impacts cannot be determined.

7.6.1.3 Impact Magnitude

7.6.1.3.1 Site Preparation and Enabling Works, Construction and Pre-Commissioning and Decommissioning Noise Criteria

Ugandan regulations contain details of noise threshold for construction noise; however, EHS Guidelines state:

'When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent'.

Consequently, although IFC criteria may not be considered ideal for defining construction noise limits, it is considered, in line with EHS Guidelines, that it is the most stringent criteria to apply when assessing potential construction noise impacts. Consequently, reference has been made to IFC criteria when defining the magnitude of construction noise impact on sensitive receptors.

Construction noise (including during the Site Preparation and Enabling Works, Construction and Pre-Commissioning and Decommissioning Phases) is temporary and reversible and so exceedances of the IFC Guidelines noise criteria (considered more stringent than Ugandan standards and based on permanent noise in the general environment) are likely to be tolerable. As such, the magnitude of noise impact criteria is more lenient for construction noise than has been applied to the longer-term noise sources. Consequently, the upper limits of 55 dB $L_{Aeq,10h}$ (where a typical working day on a construction site lasts from 08:00 to 18:00) are considered to be the onset of impacts. For drilling activities that are undertaken continuously, night-time impacts have been assessed considering a threshold of 35 dB LAeq,1h, which defines the onset of adverse levels of noise.

WHO Guidelines state that a significant increase in noise is typically equivalent to a greater than 5 dB increase. As such, subsequent magnitude of impact categories are defined in 5 dB increments.

7.6.1.3.2 Operational Site Activity Noise Criteria

Noise generated by operational site activities is considered to represent a long-term impact due to the 25-year project lifespan. As the well pads and Industrial Area (including the CPF) will introduce new noise sources into the areas, the assessment defines the magnitude of impact in terms of residual noise in comparison to Ugandan/ IFC noise criteria (which are based on WHO Guidelines noise criteria) and the increase in noise levels at sensitive receptors should criteria be exceeded.

Noise criteria for outdoor living areas are stated in both Ugandan and WHO Guidelines with a guideline level of 50 dB $L_{Aeq,16h}$ for residential properties. In addition to this lower guideline value, WHO Guidelines sets an upper guideline value of 55 dB $L_{Aeq,16h}$, which is equivalent to IFC daytime (i.e. 07:00 to 22:00) noise criteria and Ugandan regulations criteria for a mixed residential area. When determining the magnitude of impact in outdoor living areas, it is considered a Negligible impact is equivalent to a daytime noise level below 50 dB $L_{Aeq,15h}$ and a Low impact equivalent to daytime noise levels between 50 dB and 55 dB $L_{Aeq,15h}$. Subsequent magnitude of impact categories are defined in 5 dB incremental increases.

Night-time noise criteria in Ugandan regulations for noise in the general environment of residential properties is set as 35 dB $L_{Aeq,9h}$. WHO Guidelines and IFC set an equivalent criterion at level of 45 dB $L_{Aeq,9h}$. Consequently, an exceedance of the Ugandan regulations criterion is considered equivalent to a Low impact, and an exceedance of the WHO/ IFC criterion is considered equivalent to a Moderate impact. As with daytime assessment criteria, subsequent magnitude of impact categories are defined in 5 dB incremental increases.

Should the criteria be exceeded, the magnitude of impact will also depend on the level that the background noise (the measured L_{Aeq} dB at a sensitive receptor) is exceeded by the residual noise (the combined background noise and predicted operational noise). IFC Guidelines state that noise should not increase by more than 3 dB at a sensitive receptor, so an exceedance of the upper limit or an increase of greater than 3 dB is considered to represent the criterion for determining the onset of a significant impact (i.e. a Moderate or High impact at a Moderate sensitivity receptor).

7.6.1.3.3 Road Traffic Noise Criteria

Construction traffic movements associated with both the Site Preparation and Enabling Works Phase and Construction and Pre-Commissioning Phase has the potential to affect existing road traffic noise. Furthermore, during the Operational and Pre-Commissioning Phase there is also the potential for increased traffic on the existing road network to result in increased noise levels.

Human receptors are less sensitive to changes in noise level of an existing source than they are to the introduction of a new noise source. Given that the nature of noise remains consistent, a change in noise level of 1 dB is considered equivalent to the lowest perceivable change in noise level to the most sensitive human and a change in noise of 3 dB is considered the lowest change in noise perceivable to the average human. Consequently, as road traffic is an existing source of noise, it is considered appropriate that the criteria for determining the magnitude of impact is more lenient than criteria used for the assessment of site activities that introduce a new noise source into the general environment.

Should the Ugandan regulations criteria be exceeded at a sensitive receptor, the magnitude of change of road traffic noise is assessed based on IFC Guidelines stating that noise should not increase by 3 dB at the nearest receptor. WHO Guidelines state that a significant increase in noise is typically equivalent to a greater than 5 dB increase. Consequently, significant impacts are identified if the IFC noise criteria are exceeded and road traffic noise increases by more than 5 dB at the nearest receptor and a subsequent increase in impact magnitude (High impact) is considered equivalent to a 10 dB increase in noise.

7.6.1.3.4 Vibration Criteria

Table 7-17 provides Peak Particle Velocity (PPV) vibration levels and provides a semantic scale for the description of construction vibration impacts on human receptors based on guidance contained in BS 5228-2 (Ref. 7-7).

Table 7-17: Vibration Impact Magnitude Criteria

PPV Level	Description	Magnitude of Impact
>= 10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level.	High
1.0 to < 10.0 mm/s	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.	Moderate
0.3 to < 1.0 mm/s	Vibration might be just perceptible in residential environments.	Low
< 0.3 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.	Negligible

In addition to human annoyance, building structures may be damaged by high levels of vibration. The levels of vibration that may cause building damage are far in excess of those that may cause annoyance. Cosmetic damage to residential buildings is unlikely at levels below 8 mm/s at frequencies of less than 10 Hz, 12.5 mm/s at frequencies ranging from 10 to 50 Hz and 20 mm/s at frequencies ranging from 50 to 100 Hz. Consequently, if vibration levels are controlled to those specified by significant human annoyance then it is unlikely that buildings will be damaged by construction related vibration.

In comparison to the prediction of the noise, calculation of vibration levels is more complex. This is primarily due to the propagation through non-uniform ground plus the coupling between the vibration source and the ground, and between the ground and the affected buildings. In addition, the magnitude of vibration that is likely to be experienced at nearby sensitive receptors is dependent on a number of factors:

- Ground conditions;
- Type of plant;
- Drilling depth; and
- Distance from source to receptor.

Because of these factors, vibration results are generally less accurate than these obtained when predicting noise. Due to uncertainties in vibration calculations, a qualitative assessment of potential vibration impacts has been undertaken based on representative source data.

7.6.1.3.5 Noise and Vibration Criteria Summary

A summary of the magnitude of impact criteria for each assessed component of the Project is presented in Table 7-18.

Table 7-18: Noise and Vibration Impact Magnitude Criteria

Magnitude	Description
High	Construction noise levels exceed 55 dB $L_{Aeq,10h}$ (daytime) or 45 dB $L_{Aeq,9h}$ (nigh-time) by more than 10 dB at any receptor. The daytime residual noise level at any receptor resulting from operational Project components exceeds 60 dB $L_{Aeq,15h}$, or exceeds the measured background noise level by greater than 5 dB. The night-time residual noise level at any receptor resulting from drilling activities or operational Project components exceeds 50 dB $L_{Aeq,9h}$, or exceeds the measured background noise level by greater than 5 dB. Road traffic noise level at any receptor exceeds 60 dB $L_{Aeq,15h}$, or increase road traffic noise by more than 10 dB. Construction PPV level of 10 mm/s of more at any receptor.

Magnitude	Description
Moderate	Construction noise levels exceed 55 dB $L_{Aeq,10h}$ (daytime) or 45 dB $L_{Aeq,9h}$ (nigh-time) by greater than 5 dB but not exceeding 10 dB at any receptor. The daytime residual noise level at any receptor resulting from operational Project components exceeds 55 dB $L_{Aeq,15h}$ but does not exceed 60 dB $L_{Aeq,15h}$, or exceeds the measured background noise level by greater than 3 dB but no greater 5 dB. The night-time residual noise level at any receptor resulting from drilling activities or operational Project components exceeds 45 dB $L_{Aeq,9h}$ but does not exceed 50 dB $L_{Aeq,9h}$, or exceeds the measured background noise level by greater than 3 dB but no greater 5 dB.. Road traffic noise level at any receptor exceeds 55 dB $L_{Aeq,15h}$ but does not exceed 60 dB $L_{Aeq,15h}$, or increase road traffic noise by more than 5 dB but no greater than 10 dB. Construction PPV level at any receptor from 1.0 to 10.0 mm/s.
Low	Construction noise levels at any receptor exceeds 55 dB $L_{Aeq,10h}$ (daytime) or 45 dB $L_{Aeq,9h}$ (nigh-time) by no more than 5 dB at any receptor. The daytime residual noise level at any receptor resulting from operational Project components exceeds 50 dB $L_{Aeq,15h}$ but does not exceed 55 dB $L_{Aeq,15h}$, or does not exceed the measured background noise level by greater than 3 dB. The night-time residual noise level at any receptor resulting from drilling activities or operational Project components exceeds 35 dB $L_{Aeq,9h}$ but does not exceed 45 dB $L_{Aeq,9h}$, or does not exceed the measured background noise level by greater than 3 dB. Road traffic noise level at any receptor exceeds 50 dB $L_{Aeq,15h}$ but does not exceed 55 dB $L_{Aeq,15h}$, or do not result in an increase in road traffic noise of greater than 5 dB. Construction PPV level from 0.3 to 1.0 mm/s at any receptor.
Negligible	Construction noise levels do not exceed 55 dB $L_{Aeq,10h}$ (daytime) or 45 dB $L_{Aeq,9h}$ (nigh-time) at any receptor. The daytime residual noise level at any receptor resulting from operational Project components does not exceed 50 dB $L_{Aeq,15h}$, or does not exceed the measured background noise level. The night-time residual noise level at any receptor does not exceed 35 dB $L_{Aeq,9h}$, or does not exceed the measured background noise level. Road traffic noise levels at any receptor do not exceed 50 dB $L_{Aeq,15h}$, or do not result in an increase in road traffic noise of greater than 3 dB. Construction PPV level of less than 0.3 mm/s at any receptor.

7.6.1.3.6 Significance of Impact Criteria

Table 3-1 of the ***Chapter 3: ESIA Methodology*** provides a matrix showing the significance of impacts depending on the sensitivity of receptors and magnitude of impact.

Impacts classed from Insignificant to Low significance are considered to be **not significant**, whereas impacts classed from Moderate to High are considered to be significant for the purposes of this ESIA. However, final determination of whether impacts are likely to be significant is made following the classification of impacts and using professional judgement. These include consideration of the duration, frequency and likelihood of impacts and whether they are temporary or permanent and the area and number of receptors affected.

7.6.1.3.7 Comparison of Criteria with Baseline Conditions

This section provides a discussion of measured noise data (as summarised in Table 7-14) at different Project component areas in comparison to noise impact criteria in presented in Table 7-18.

Industrial Area

Baseline daytime noise levels in the proximity of the Industrial Area have been measured at 35 to 39 dB $L_{Aeq,T}$. Baseline noise measurements indicate that existing daytime noise levels do not exceed the IFC daytime noise level criteria (07:00 – 22:00 $L_{Aeq,15h}$ 55 dB) or Ugandan Regulations maximum permissible noise level for residential areas (06:00 – 22:00 $L_{Aeq,8h}$ 45 dB). Therefore, the thresholds for daytime impact magnitude presented in this section have been based on the criteria of absolute levels presented in Table 7-18, rather than on the criteria of exceeding measured background noise levels.

Baseline night-time noise levels in the proximity of the Industrial Area have been measured at 38 to 48 dB $L_{Aeq,T}$. At the majority of locations (N3, N5, N6) around the Industrial Area, baseline noise measurements indicate that existing night time noise levels do not exceed the IFC night noise level criteria (22:00 – 07:00 $L_{Aeq,9h}$ 45 dB). However, the night-time noise levels exceed the Ugandan Regulations maximum permissible noise level for residential areas (22:00 – 06:00 $L_{Aeq,8h}$ 35 dB), which is considered to be the threshold for a Low impact due to noise during the Operational and Pre-Commissioning Phase. Therefore, the threshold for a Low night-time impact magnitude during the Operational and Pre-Commissioning Phase for receptors near the Industrial Area has been set at 38 dB $L_{Aeq,T}$. This is the lowest measured night-time noise level and is considered to be a robust methodology to apply.

Well Pad Sites

Baseline daytime noise levels in the proximity of well pads have been measured at 31 to 48 dB $L_{Aeq,T}$. Baseline noise measurements indicate that existing daytime noise levels do not exceed the IFC daytime noise level criteria (07:00 – 22:00 $L_{Aeq,15h}$ 55 dB) and the highest measured levels are equivalent to Ugandan Regulations maximum permissible noise level for residential areas (06:00 – 22:00 $L_{Aeq,8h}$ 45 dB). Therefore, the thresholds for daytime impact magnitude presented in this section have been based on the criteria of absolute levels presented in Table 7-18, rather than on the criteria of exceeding measured background noise levels.

Baseline night-time noise levels in the proximity of well pads have been measured at 33 to 38 dB $L_{Aeq,T}$. Baseline noise measurements indicate that existing night-time noise levels do not exceed the IFC night-time noise level criteria (22:00 – 07:00 $L_{Aeq,9h}$ 45 dB) and is equivalent to Ugandan Regulations maximum permissible noise level for residential areas (22:00 – 06:00 $L_{Aeq,8h}$ 35 dB). Therefore, the thresholds for night-time impact magnitude presented in this section have been based on the criteria of absolute levels presented in Table 7-18, rather than on the criteria of exceeding measured background noise levels.

Bugungu Airstrip

Baseline daytime noise levels in the proximity of Bugungu Airstrip have been measured at 39 to 40 dB $L_{Aeq,T}$. Baseline noise measurements indicate that existing daytime noise levels do not exceed the IFC daytime noise level criteria (07:00 – 22:00 $L_{Aeq,15h}$ 55 dB) or Ugandan Regulations maximum permissible noise level for residential areas (06:00 – 22:00 $L_{Aeq,8h}$ 45 dB). Therefore, the thresholds for daytime impact magnitude presented in this section have been based on the criteria of absolute levels presented in Table 7-18, rather than on the criteria of exceeding measured background noise levels. No activities will be taking place during the night-time at Bugungu Airstrip.

Lake Albert Water Abstraction Station

Although the proposed location of the Lake Albert Water Abstraction Station has moved since the noise survey was undertaken, location N1 is considered representative of typical noise levels on the banks of Lake Albert. Representative baseline daytime noise levels for the Lake Albert Water Abstraction Station have been measured at 44 dB $L_{Aeq,T}$. Baseline noise measurements indicate that existing daytime noise levels do not exceed the IFC daytime noise level criteria (07:00 – 22:00 $L_{Aeq,15h}$ 55 dB) or Ugandan Regulations maximum permissible noise level for residential areas (06:00 – 22:00 $L_{Aeq,8h}$ 45 dB). Therefore, the thresholds for daytime impact magnitude presented in this section have been based on the criteria of absolute levels presented in Table 7-18, rather than on the criteria of exceeding measured background noise levels. No activities will be taking place at during night-time at the Lake Albert Water Abstraction Station.

Victoria Nile Ferry Crossing

Baseline daytime noise levels in the proximity of the Victoria Nile Ferry Crossing have been measured at 48 – 53 dB $L_{Aeq,T}$. Baseline noise measurements indicate that existing daytime noise levels do not exceed the IFC daytime noise level criteria (07:00 – 22:00 $L_{Aeq,15h}$ 55 dB). However, the daytime noise levels exceed the Ugandan Regulations maximum permissible noise level for residential areas (06:00 – 22:00 $L_{Aeq,8h}$ 45 dB), which is considered to be the threshold for a Low impact due to noise during the

Operational and Pre-Commissioning Phase. Therefore, the threshold for a Low daytime impact magnitude during the Operational and Pre-Commissioning Phase for receptors near the Victoria Nile Ferry Crossing has been set at 48 dB $L_{Aeq,T}$. This is the lowest measured daytime noise level and is considered to be a robust methodology to apply. No activities will be taking place at during night-time at the Victoria Nile Ferry Crossing.

HDD Crossing Options

Baseline daytime noise levels in the proximity of HDD crossing options 1 and 2 vary from 34 dB $L_{Aeq,T}$ at the north side of Option 1 in an uninhabited area of the MFNP to 60 dB $L_{Aeq,T}$ at the south side of Option 2. However, it is noted that the measurements in the proximity of the HDD Crossing with the higher levels were influenced by their proximity to roads. Daytime noise levels in the proximity of the HDD crossing option sites on the north and south of the Victoria Nile were otherwise generally in the region 40 – 43 dB $L_{Aeq,T}$ and also generally lower than the IFC daytime noise level criteria (07:00 – 22:00 $L_{Aeq,15h}$ 55 dB) or Ugandan Regulations maximum permissible noise level for residential areas (06:00 – 22:00 $L_{Aeq,8h}$ 45 dB). Therefore, the thresholds for daytime impact magnitude presented in this section have been based on the criteria of absolute levels presented in Table 7-18, rather than on the criteria of exceeding measured background noise levels.

HDD activities on the south bank of the Victoria Nile will be 24-hour. There is no measurement data for baseline night time noise levels in the proximity of the HDD Crossing Options. However, night time measurements at MRL are considered to represent a comparable noise environment to the HDD crossing sites south of the Victoria Nile given the common proximity of all sites to the Victoria Nile and absence of factors such as road traffic noise during the night. It is therefore considered that night time levels at the HDD crossing sites will be in the region of 38 dB $L_{Aeq,15h}$ and will not exceed the IFC night noise level criteria (22:00 – 07:00 $L_{Aeq,9h}$ 45 dB). However, the night-time noise levels exceed the Ugandan Regulations maximum permissible noise level for residential areas (22:00 – 06:00 $L_{Aeq,8h}$ 35 dB), which is considered to be the threshold for a Low impact due to noise during the Operational and Pre-Commissioning Phase. Therefore, the threshold for a Low night-time impact magnitude during the Operational and Pre-Commissioning Phase for receptors near the HDD crossing sites has been set at 38 dB $L_{Aeq,T}$.

7.6.1.4 Noise Modelling Methodology

Noise models have been prepared using the CadnaA digital noise modelling software package. CadnaA is an internationally recognised model that predicts noise levels based on the appropriate input data (e.g. location and orientation of noise sources, sound power data and operating times etc.).

CadnaA uses the methodologies described within ISO 9613:1996 '*Acoustics - Attenuation of Sound during propagation outdoors' Part 1 – 'Calculation of the absorption of sound by the atmosphere*' and Part 2 – 'Attenuation of sound during propagation outdoors' (Ref. 7-15). This methodology is accepted as an industry standard for the prediction of industrial noise propagation. Noise contour maps were generated using 10 m x 10 m grid spacing. The model outputs comprised noise contour plots illustrating predicted noise emission levels experienced at a height of 1.5 m above ground level.

The modelling includes the following assumptions:

- ***Noise Sources*** - The proposed plant items have been modelled as point sources located at appropriate positions and heights. Positioning of plant items for noise from the CPF and well pads during the Commissioning and Operations Phase is based on layout drawings where available. Layout drawings were not available for positions of construction plant during the Site Preparation and Enabling Works Construction and Pre-Commissioning phases and as such position of the mobile plant used for works has been modelled close to the site boundary in order to represent a reasonable worst case. Regarding plant orientation, all plant items are modelled as point noise sources assuming omni-directional propagation of sound –allowing for a worst-case assessment whereby sound is equally distributed in all directions. All plant has been assumed with noise emitting at a height of 1 m, with the exception of some operational plant items for which more specific heights were available;

- ***Ground Conditions***[4] - The land on site and at site boundaries is made up of mostly unused vegetated land / farmland. Accordingly, attenuation due to ground acoustic absorption effects has assumed a Ground Factor of 0.6. For the Commissioning and Operations Phase models, ground conditions for built areas within the Industrial Area assume a Ground Factor of 0.1 for hard ground. Flat ground has been assumed across the sites, in line with observation made during site visits;
- ***Atmospheric Absorption*** - Atmospheric absorption coefficients corresponding to a temperature of 10ºC as a worst case as atmospheric absorption increases as temperature increases (as per Table 2 of ISO 9613-2) and a relative humidity of 70% have been used;
- ***Building Massing*** – For the purpose of this assessment, a 2.4m high wall has been modelled at the north part of the Industrial Area for the Commissioning and Operations phase according to site layout plans. This wall has been included in the model as a solid continuous noise barrier. No other building massing or structures have been included in this or any other model. The finalised layouts of the Industrial Area and well pads will contain buildings and structures that have the potential to screen receptors from noise emissions. Consequently, noise model predictions can be considered representative of a worst case scenario with no on-site screening applied;
- ***Well Pad Perimeter Structures*** – Vegetation clearance around each well pad will be limited to 15 m wide buffer from perimeter security structure. Within the MFNP, the perimeter security structure will be designed to withstand the ingress of animals entering the well pads. However, no consideration of noise attenuation from permitted structure (e.g. bund wall) has been considered as a "worst case" scenario that is relevant to both North and South Nile pads has been assessed; and
- ***Noise source 'On' times*** - Plant items are modelled as being continuously working (i.e. 100% on time) during the relevant hours of each modelled scenario which also constitutes a worst case scenario. Modelling has been undertaken to predict noise levels over a 1 hour period.

7.6.1.4.1 Site Preparation and Enabling Works Models

Noise models have been produced to predict noise levels arising from activities during the Site Preparation and Enabling Works phase of the Project.

As the exact location of noise generating equipment used during the Site Preparation and Enabling Works Phase will not be fixed, predictions have been made based on distances of receptors from site boundaries in order to represent reasonable worst case scenarios. The plant items that have been included in the Site Preparation and Enabling Works noise propagation models have been based on the equipment lists presented in ***Chapter 4: Project Description and Alternatives***. Noise levels modelled for these plant items have been based on library data obtained from British Standard 5228-1 (Ref. 7-6), which contains a database of noise levels for a range of construction equipment. The source terms presented in Table 7-19 have been used for the plant items listed in ***Chapter 4: Project Description and Alternatives.***

Table 7-19: Noise Source Levels used for Site Preparation and Enabling Works Models

Plant Item	Sound Power Level (SWL) used (dB)	BS5228 Reference
Excavator	102	Table C.6 Item 12
Dumper	109	Table C.4 Item 7
Roller	103	Table C.5 Item 20
Grader	103	Table D.3 Item 74
Tipper	105	Table C.8 Item 20

[4] These assumptions have been defined in accordance with the Project Proponents ESIA Framework Document.

Plant Item	Sound Power Level (SWL) used (dB)	BS5228 Reference
Loader	99	Table C.2 Item 8
Dozer	112	Table C.8 Item 17
Water Tanker	110	Table C.4 Item 89
Asphalt Paver	108	Table C.5 Item 31
Crawler Crane	110	Table D.7 Item 115

7.6.1.4.2 Construction and Pre-Commissioning Noise Models

Noise models have been produced to predict noise levels arising from activities during the Construction and Pre-Commissioning phase of the Project.

Noise models have been produced for works at the Industrial Area and well pads during the Construction and Pre-Commissioning phase. The same plant items as presented in Table 7-19 for works during the Site Preparation and Enabling Works phase have been modelled where they are included in the list of plant used for these works presented in ***Chapter 4: Project Description and Alternatives.***

Noise models have also been produced for the construction and laying of pipelines using plant items from Table 7-19 and additional plant referenced from BS 5228-1 (Ref. 7-5). Table 7-20 presents the plant items modelled for pipeline construction, which have not previously been presented.

Table 7-20: Pipeline Construction Noise Sources

Plant Item	Sound Power Level (SWL) used (dB)	BS5228 Reference
Fuel Bowser	110	Table C.6 Item 36
Compressor	106	Table D.3 Item 99
Generator	95	Table D.7 Item 53
Tractor	101	Table C.4 Item 74
Water Bowser	113	Table D.11 Item 51
HIABs, cranes and sidebooms	110	Table D.7 Item 115
JCB and Link Belt 300	102	Table C.6 Item 12

Plant list in the Project Description for the Construction and Pre-Commissioning phase are roughly equivalent to the plant listed for the Site Preparation and Enabling Works phase. As detailed methodologies are not available for Site Preparation and Enabling Works and Construction and Pre-Commissioning phases the aim of noise predictions aims to consider a worst case where a number of plant are operating simultaneously in an area near a site boundary. As such, the total number of plant is not a significant factor and noise predictions are more affected by the type of plant employed. Consequently, for works during the Construction and Pre-Commissioning phase, it is considered that noise is likely to be equivalent to, but no higher than, noise generated at these sites during the Site Preparation and Enabling Works. Consequently, the noise modelling procedure covered in section 7.6.1.4.1 has been applied for construction activities during the Construction and Pre-Commissioning phase.

Well drilling activities will be undertaken continuously at each of the well pad sites. The methodology applied for modelling noise from well drilling activities has been referenced from 'The Influence of Prospecting Unconventional Hydrocarbon Reservoirs on the Acoustic Climate' (Re. 7-19). The main source of noise from drilling activities originates from the generator, water pumps and the top drive. The top drive will move up and down the derrick depending on the depth of the drill. The derrick will be approximately 43 m high so, for the purposes of noise predictions, it is assumed that the top drive is at a height of 30 m. Noise sources included in well drilling predictions are presented in Table 7-21.

Table 7-21: Well Pad Drilling Noise Sources

Plant Item	Sound Power Level (SWL) dB	Number of plant
Generator	102	3
Mud pump	90	3
Top drive	90	1

7.6.1.4.3 HDD Drilling for Victoria Nile Crossing

The Victoria Nile crossing will require two HDD construction areas; one north of the Victoria Nile and the other to the. The HDD rig will be located on the south site and the north site will be used as the pipe stringing area. Noise modelling of HDD drilling activities has been undertaken based on the site layouts presented in ***Chapter 4: Project Description and Alternatives***. The sound power levels for HDD plant are presented in Table 7-22.

Table 7-22: HDD Drilling Noise Sources

Plant Item	Sound Power Level (SWL) dB	Number of plant – North Site	Number of plant – South Site
Generator	102	1	2
Drilling rig	107	0	1
Mud pump	90	1	2
Mud recycler	102	1	2
Mud mixer	108	1	2

7.6.1.4.4 Construction Traffic

Based on the estimated peak vehicle trips per month presented in ***Chapter 4: Project Description and Alternatives***, hourly average vehicle flows have been derived. The derived hourly flows assume 30 working days per month and 12 working hours per day, and also assume one bus movement per hour per site to transport workers. The calculated hourly flows used for each phase are presented in Table 7-23.

Table 7-23: Hourly Haulage Route Flows

Site	Estimated Monthly Trips	Estimated Hourly HGV Haulage Flows (including one bus movement per hour)
Construction traffic movements north of the Victoria Nile	583	3
Construction traffic movements south of the Victoria Nile	1,210	5
CPF construction traffic movements	1,904	6
Inter-field access roads south of the Victoria Nile (D roads)	2,400	8
Inter field access road from JBR-01 to Victoria Nile ferry crossing	1,400	5
Inter field access road from JBR-01 to JBR-02	2,800	9
Inter field access road from JBR-02 to JBR-04	1,400	5
Inter field access road from JBR-01 to JBR-03	5,600	17
Inter field access road from JBR-03 to JBR-05	7,000	20
Inter field access road from JBR-05 to JBR-06	8,400	24
Inter field access road from JBR-06 to JBR-07	9,800	28
Inter field access road from JBR-07 to JBR-08	11,200	32
Inter field access road from JBR-08 to JBR-09	12,600	36
Inter field access road from JBR-01 to JBR-10	1,400	5

The impact due to changes in traffic relates to a change in baseline road traffic noise so accounting for the impact for construction traffic in isolation is likely to over-estimate potential impacts. Additionally, impacts may be over-estimated when taking into consideration the beneficial change in baseline road traffic noise due to resurfacing of existing roads proposed for haul routes. Consequently, a qualitative assessment of potential construction traffic noise impacts has been undertaken which conservatively estimates potential noise impacts. Figure 7-1 shows the inhabitable areas and their relative locations to the access routes. A count of actual receptors has not been undertaken for each phase as the adopted qualitative assessment approach deems this unnecessary.

7.6.1.4.5 Operational Plant Noise Models

Noise models have been produced to predict noise levels arising from operation of plant during the Commissioning and Operations Phase of the Project. Predictions have been made for noise for two different potential example designs of the CPF and from a single typical well pad configuration.

Site layout drawings for the two industrial area options and a typical well pad, as presented in ***Chapter 4: Project Description and Alternatives*** have been reviewed by Tilenga ESIA team and noise generating plant items have been positioned in representative site locations based on the layouts. The noise input data for plant items to be used in the modelling of the CPF have been based on the levels provided by the Project Proponents. All plant in noise generating areas of the CPF (i.e. power generation, water treatment, export pumps, water injection system etc.) have been modelled on the basis that they will meet the normally accepted industry standard of 85 dBA $L_{eq,T}$ at 1 m. It has been assumed that all plant will be operating at their maximum acceptable noise limit as specified.

As there are two current design options for the CPF, models have been produced for each option. The layouts will be referred to in this chapter as CPF Option One and CPF Option Two. CPF Option One is based on the layout presented in the Project Description. CPF Option Two represents a worst case scenario with high noise generating plant located in the north-east of the CPF site, which is in close proximity to the nearest noise sensitive receptors.

It should be noted that, as the design of the CPF and well pads is still at an early stage, building massing, walls and large plant items that will provide some screening of propagation of noise have not been accounted for in noise models. However, a 2.4 m high wall has been modelled in the north of the Industrial Area to attenuate the propagation of noise to receptors north of the site.

7.6.1.4.6 Flare Noise Modelling

The elevated flare has been modelled at a location defined by the indicative CPF site layout presented in the Project Description. The elevated flare was modelled to produce a noise output of 115 dB at 1 m in accordance with information provided by the Project Proponents. Additionally, information received stated that the enclosed flare will be designed in line with other plant at the CPF to achieve a noise output of no more than 85 dB at 1 m and thus this option has not been modelled.

7.6.1.4.7 Aircraft Noise Modelling

The USA Federal Aviation Authority produces the Integrated Noise Model (INM), which is the most commonly used airport noise model in the industry. The INM is a computer model that generates data on aircraft noise levels in the vicinity of airports. It is developed from the algorithms and frameworks outlined in the SAE-AIR-1845 document (Ref. 7-16), which complies with the calculation method set out in ECAC Doc 29, 3rd Edition (Ref. 7-17) and ICAO Doc 9911 (Ref. 7-18). The INM uses Noise-Power-Distance (aircraft noise level at ground height as a function of distance) data to estimate noise levels, accounting for the typical operational mode, engine thrust setting, source-to-receiver geometry, acoustic directivity and other environmental factors.

Due to the low levels of baseline operations (approximately two Cessna 208 Caravan flights per week), it is considered that, as there are at least five days per week where no activity takes place, future aircraft activity should be compared against a baseline of no daily movements. The estimated daily aircraft movements at the Bugungu Airstrip associated with the Construction and Pre-Commissioning Phase have been modelled to take into account a worst case of six Beechcraft 1900 movements per day (three approaches and three departures). Noise modelling has been undertaken to account for aircraft movements in both runway directions.

7.6.1.4.8 Decommissioning

Activities during the Decommissioning phase will be generally similar to those during the Construction and Pre-Commissioning phase. As such, no models have been produced specifically for Decommissioning activities and impacts identified through the Construction and Pre-Commissioning models are considered to apply also to the Decommissioning phase.

7.6.2 Embedded In-built Design Mitigation

A list of relevant embedded design mitigation measures already built into the design of the Project is presented within ***Chapter 4: Project Description and Alternatives***. Additionally, a number of noise specific measures are highlighted in Table 7-24 below.

Table 7-24: Embedded Mitigation Measures

Embedded Mitigation Measures to Reduce Noise Impacts
During normal Operations, power will be provided by the CPF; there will be no back-up generators other than black-start and emergency generators
There will be no routine flaring during normal operations
For the CPF, equipment will be designed to achieve occupational noise level compliance of 85dBA at 1 metre (which is an industry accepted standard) where practicable

Embedded Mitigation Measures to Reduce Noise Impacts
Diesel generator(s) will be located in the Industrial Area for the provision of power and small diesel generator packages will be used for all other work sites to provide power for small items of equipment such as pumps/compressors
As per base case, there will be no routine nightshift activities associated with the Site Preparation and Enabling Works Phase
For power generation, centralised diesel generator package including back up facilities will be located at the Industrial Area Construction Support Base to service the construction and pre-commissioning activities within the Industrial Area. Dedicated generator packages of varying sizes will also be mobilised to provide the power requirements for the construction and pre-commissioning of at discrete locations including the Lake Water Abstraction System, well pads and pipeline installation sites. Separate independent packages will be mobilised with the drilling rig to service the power requirements for the drilling activities
With the exception of drilling and HDD construction activities there will be no permanent night time working in the MFNP
Construction activities for the Production and Injection Network will be contained within the permanent Right of Way (RoW) which will have a width of 30 m and is designed to accommodate the pipeline trench(s), stockpile areas, laydown, welding, and the movement of construction equipment alongside the trench(s)
All transportation will be compliant with applicable road transport regulations. In the Project Area, routine transportation operations will normally only occur in day light. Deliveries of equipment and the movement of people will be scheduled in convoys, where practicable
The base case for Tilenga is that there will be no night driving. However, night driving may be permitted in exceptional circumstances and with internal derogation where it is deemed safe and practicable to do so
The ferry will operate for 8 hours a day and will be dedicated to Project use only. There will be no ferry movements during night time hours except in exceptional circumstances and with internal derogation
During the Decommissioning Phase the following assumptions are applicable regarding supporting facilities: • For power generation, a centralised diesel generator package including back up facilities will be located at the Construction Support Base to service the decommissioning activities within the Industrial Area. Dedicated generator packages of varying sizes will also be mobilised to provide the power at discrete locations including the Lake Water Abstraction System, well pads and pipeline decommissioning sites

7.6.3 Assessment of Impacts: Site Preparation and Enabling Works Phase

7.6.3.1 Introduction

The use of construction plant and vehicles within the Project Area has the potential to produce temporary increases in existing noise levels. Such impacts are direct and, due to the dynamic nature of works, are considered to be of intermittent short-term duration. The potential noise impacts during the Site Preparation and Enabling Works Phase are anticipated to only affect local receptors. The potential for noise impacts has been assessed for the activities listed in Table 7-12. In addition to noise impacts, the potential for vibration impacts has also been assessed for the activities that have the potential to generate significant levels of vibration.

7.6.3.2 Potential Impacts (Pre-Additional Mitigation) – Site Preparation and Enabling Works

7.6.3.2.1 Industrial Area Site Preparation and Enabling Works Noise

The noise modelling methodology presented in Section 7.6.1.4.1 has been used to predict noise generated by Site Preparation and Enabling Works at the Industrial Area. A noise contour plot detailing the results of Site Preparation and Enabling Works noise predictions at the Industrial Area is presented in Figure I2-1 of Appendix I. The noise contour plot is considered representative of high intensity activities.

As the layout of the CPF has not been finalised (optimisation is still ongoing with FEED contractors), the location of works on-site cannot be accurately determined, so there is potential for high intensity activities to be undertaken at any site boundary. Consequently, the analysis to identify sensitive receptors that may be affected by noise takes into consideration buffers around the entire site defined by the largest distance from each contour band (representing magnitude of impacts) to the site boundary. Sensitive receptors located within each buffer were identified by Tilenga ESIA GIS experts using data gathered during both AECOM EBS and Tilenga ESIA baseline surveys, plus those of Artelia Eau and Environment (as detailed in ***Chapter 16: Social***). A figure detailing the analysis undertaken to identify sensitive receptors is presented in Figure I2-2 of Appendix I. Detailed results of analysis identifying affected sensitive receptors are presented in Table 7-25.

Table 7-25: Potential Industrial Area Site Preparation and Enabling Works Impacts

Magnitude of potential Impact	Predicted Distance of Noise Propagation from Site Boundary	Potentially Affected Receptors	Sensitivity of Receptors	Significance of Impact
High	0 to 50 m	Approximately 11 residential (10 to north of Industrial Area, 1 to south) in villages of Uduk II, and Kasinyi.	Moderate	**Moderate Adverse**
High	0 to 50 m	Workers in fields	Low	**Low Adverse**
Moderate	50 to 125 m	Approximately 23 residential receptors (13 to north, 10 to south). Villages of Uduk II, and Kasinyi.	Moderate	**Low Adverse**
Low	125 to 250 m	Approximately 11 residential receptors (10 to north, 1 to south). Villages of Uduk II, and Kasinyi.	Moderate	**Insignificant**

Analysis of receptors within noise impact contour bands indicates that up to 45 receptors are predicted to experience potential impacts ranging from Low to High magnitude. Of the 45 receptors identified, 11 receptors are predicted to experience High and 23 receptors are predicted to experience Moderate magnitude of impacts.

It should be noted that, as a detailed methodology for Site Preparation and Enabling Works activities is not available at this stage of the assessment, noise predictions are worst case and representative of intense periods activity where, over the course of a working day, all plant are operational. In reality, it is likely that the worst case noise levels predicted will only occur for limited periods of time when plant are operational in close proximity to sensitive receptors. Consequently, noise at nearby receptors is likely to be lower than the predicted levels for the majority of the Industrial Area Site Preparation and Enabling Work phase.

When taking into consideration that the predicted noise levels are worst case and only likely to be temporary and last for limited durations, it is considered that, based on professional experience, the identified significance of potential impact can be reduced by one order of magnitude at off-site receptors. A reduction in order of magnitude has been applied when potential significant impacts (representing a worst case scenario) are likely to be limited. In the cases of the Industrial Area (and well pads), the size of the sites means that plant are unlikely to be based in the same locations for extended periods of time so the likelihood of worst case noise predictions occurring is considered to be low. Where potential significant impacts occur, these can be reduced by limiting the duration of the daily event that generates high noise levels. This has the repercussion of high noise generating events occurring for short daily durations over longer periods when they could be completed in a shorter period with higher daily noise levels. For example, an activity that may be completed in a week may be required to be extended to 6 weeks if activities are required to be limited to 2 hours a day. It is often preferable to stakeholders for work to be completed in shorter periods so higher noise levels are likely to be more tolerable with the understanding that the work can be completed in a shorter timescale

As the affected receptors identified are all of Moderate sensitivity, the significance of potential impacts will be **Moderate Adverse** Significance for 11 receptors, which is considered to be a potential significant impact. All other receptors will experience a potential impact significance ranging from **Insignificant** to **Low Adverse**, which are not considered to be significant.

In addition to Moderate sensitivity receptors, workers on land adjacent to the Industrial Area site may be affected by Site Preparation and Enabling Works activities. These workers are considered to be of Low sensitivity to noise so the potential impact significance is identified as **Low Adverse** and not significant.

7.6.3.2.2 Well Pad Site Preparation Noise

A noise contour plot detailing the results of Site Preparation and Enabling Works noise predictions at the well pad sites is presented in Figure I2-3 of Appendix I. The noise contour plot is considered representative of high intensity activities.

As the layout of the well pad sites has not been finalised, the location of works on-site cannot be accurately determined, so there is potential for high intensity activities to be undertaken at any site boundary. Consequently, the analysis to identify sensitive receptors that may be affected by noise takes into consideration buffers around the entire site defined by the largest distance from each contour band (representing magnitude of impacts) to the site boundary. The sensitive receptors were identified by Tilenga ESIA GIS experts using data gathered during both AECOM EBS and Tilenga ESIA baseline surveys, plus those of Artelia Eau and Environment (as detailed in ***Chapter 16: Social***).

Figures detailing the analysis undertaken to identify sensitive receptors are presented in Figure I2-4 to Figure I2-37 of Appendix I. Analysis of the noise modelling results for the well pad sites identify that 15 of the 34 well pads are predicted to result in a Negligible impact magnitude at nearby human receptors during Site Preparation and Enabling Works. These well pad sites are summarised below:

- JBR-01, 02, 03, 04, 05, 06, 07, 08, 09 & 10;
- KW-01;
- NGR-06;
- KGG-06; and
- NSO-01 & 03.

Noise generated at the remaining 19 well pads has the potential to result impacts ranging from Low to High at nearby receptors. Detailed results of analysis identifying affected sensitive receptors are presented in Table 7-26.

Table 7-26: Potential Well Pad Site Preparation and Enabling Works Impacts

Magnitude of potential Impact	Predicted Distance of Noise Propagation from Site Boundary	Potential Affected Receptors	Sensitivity of Receptors	Potential Significance of Impact
High	0 to 40 m	**GNA-02** - 6 residential properties to south in village of Kilyango. **GNA-04** - 7 residential properties in the village of Avogera. **KGG-01** - 5 residential properties surrounding the site in the village of Oriibo. **KGG-04** - 1 residential property to the north in the village of Kichoke Bugana. **KGG-03** - 2 residential properties to the east and north in the village of Beroya. **KW-02B** - 7 residential properties in the village of Kisiomo. **NGR-01** - 1 homestead in the village of Kisinyi to south. **NGR-03A** - 20 residential properties in the village of Kiyer, Kirama and Kichoke. **NSO-04** - 1 residential property to east in the village of Kibambura.	Moderate	Moderate Adverse
High	0 to 40 m	Workers in fields	Low	Low Adverse
Moderate	40 to 90 m	**GNA-01** - 2 residential properties in village of Kisomere. **GNA-02** - 5 residential properties to south in village of Kilyango. **GNA-04** - 1 residential property in the village of Avogera. **KGG-01** - 7 residential properties to the north in the village of Oriibo. Oriibo Primary School. **KGG-03** - 3 residential properties to the north east in the village of Beroya. **KGG-04** - 1 residential property to the north in the village of Kichoke Bugana. **KGG-09** - 3 residential property to the north in the village of Kijumbya. **KW-02A** - 1 residential property in the village of Kakindo. **KW-02B** - 2 residential properties to the north and south in the village of Kisiomo. **NGR-02** - 1 residential properties to south east in the village of Kasinyi. **NGR-03A** - 17 residential properties in the village of Kiyer, Kirama and Kichoke. **NSO-02** - 3 residential properties in the village of Ngwedo farm.	Moderate	Low Adverse

Magnitude of potential Impact	Predicted Distance of Noise Propagation from Site Boundary	Potential Affected Receptors	Sensitivity of Receptors	Potential Significance of Impact
		NSO-04 - 1 residential property to east in the village of Kibambura. **NSO-06** - 6 residential properties to north in the village of Uduk II. 1 residential property to east in the village of Ngwedo farm.		
Low	90 to 180 m	**GNA-01** - 42 residential properties to north east and west. Village of Kisomere. **GNA-02** - 32 residential properties to north and south. Village of Kilyango. **GNA-03** - 9 residential properties to the south in village of Uduk II. Uduk II Church. **GNA-04** - 54 residential properties in the village of Avogera. **NGR-02** - 5 residential properties to south east in the village of Kasinyi. **NGR-03A** - 63 residential properties to south east in the village of Kiyer, Kirama and Kichoke. **NGR-05A** - 3 settlements in village of Kirama **KGG-01** - 15 residential properties, to the north, east and west in the village of Oriibo. Pentecostal Church of God. Charismatic Episcopal Church. **KGG-03** - 2 residential properties to the north east in the village of Beroya. **KGG-04** - 5 residential properties to the north east and east in the village of Kijumbya. **KGG-05** - 1 residential properties to the north east and east in the village of Gotlyech. **KGG-09** - 3 residential properties in the village of Kichoke Bugana.1 residential property in the village of Kijumbya. **KW-02A** - 3 residential properties in the village of Kakindo. **KW0-2B** - 16 residential properties to the north and south in the village of Kisiomo. 20 residential properties to the east in the village of Kakindo. **NSO-02** - 13 residential properties to the north and south in the village of Ngwedo farm. **NSO-04 -** 11 residential properties to north in the village of Kibambura. **NSO-05** – 2 residential properties in the village of Ngwedo. **NSO-06** - 45 residential properties in the village of Uduk II.	Moderate	Insignificant

Up to 448 receptors are predicted to experience potential impacts ranging from Low to High, of which 50 are predicted to experience a High magnitude of impact and 54 are predicted to experience a Moderate magnitude of impact.

As discussed in Section 7.6.3.2.1, noise predictions are considered to be worst case and represent periods of intense activity when plant are operational in close proximity to sensitive receptors. Due to the temporary nature of works and the likely limited duration of exposure of receptors to worst case noise levels, it is considered that, based on professional judgement, the significance of potential impact can be reduced by one order of magnitude at off-site receptors. As the receptors identified are all of Moderate sensitivity, the significance of potential impacts is **Moderate Adverse** (significant) for 50 receptors. All other receptors will experience a potential impact significance ranging from **Insignificant** to **Low Adverse** i.e. not significant.

In addition to Moderate sensitivity receptors, workers on land adjacent to well pad sites may be affected by Site Preparation and Enabling Works activities. These workers are considered to be of Low sensitivity to noise so the potential impact significance is identified as **Low Adverse** i.e. not significant.

7.6.3.2.3 Victoria Nile Ferry Crossing Clearance and Infrastructure Construction Noise

Analysis of nearby receptors undertaken by Tilenga ESIA GIS experts showed that the closest human receptors to the Victoria Nile Ferry Crossing are located approximately 250 m away. However, analysis of aerial imagery indicates buildings located approximately 60 m from the site that are identified of either temporary lodge staff or UWA rangers accommodation. Predictions of Site Clearance activities (as summarised in Table 7-26 for well pad sites) indicates that receptors at a distance of 60 m are likely to experience a Moderate impact. This is equivalent to a potential impact of **Moderate Adverse** significance at Moderate sensitivity receptors.

For all other receptors, it is considered that, due to the separation distance between site and receptors, noise will be suitably atmospherically attenuated and receptors will experience a Negligible noise impact. Consequently, the resultant potential impact significance will be **Insignificant**.

7.6.3.2.4 Lake Albert Water Abstraction System Site (Onshore Option Only) Clearance Noise

Analysis of nearby receptors undertaken by Tilenga ESIA GIS experts showed that the closest human receptors to the Water Abstraction System onshore facility are located approximately 570 m away. It is considered that, due to the separation distance between site and receptors, noise will be suitably atmospherically attenuated and receptors will experience potential impacts of Negligible magnitude. Consequently, the resultant significance of impact will be **Insignificant**.

7.6.3.2.5 Bugungu Airstrip Upgrade Noise

Analysis of nearby receptors undertaken by Tilenga ESIA GIS experts showed that the closest human receptors to the Bugungu Airstrip are located 1.3 km away. It has been identified that impacts from upgrade works at Bugungu Airstrip at this distance will not result in a noise impact of a magnitude greater than Negligible. Consequently, the resultant potential impact significance will be **Insignificant**.

7.6.3.2.6 Masindi Vehicle Check Point Construction Noise

It has been identified using aerial photography that the nearest building to the location of Masindi Vehicle Check Point is approximately 100 m away. Based on the noise impact contours generated for Site Preparation and Enabling Works of proposed well pad location, which will use the same plant items as works at the Masindi Vehicle Check Point, it is considered that no receptors will be close enough to experience a magnitude of impact greater than Low. This is equivalent to a **Low Adverse** potential impact significance at Moderate sensitivity receptors.

As noise predictions are worst case and based on plant being operational at the closest location to sensitive receptors, significant impacts of airstrip activities will be temporary and limited in duration. Consequently, based on professional judgement, a reduction of one order of magnitude is considered reasonable to apply to the potential impact significance, which is identified as being **Insignificant**.

7.6.3.2.7 Road Construction/ Upgrade Noise

A noise contour plot detailing the results of road construction/ upgrade works noise predictions is presented in Figure I2-3 of Appendix I. The noise contour plot is considered representative of high intensity activities at a typical work site. The noise contours have been analysed to identify sensitive receptors that may be affected by noise through consideration of buffers around the entire road works network defined by the largest distance from each contour band (representing magnitude of impacts) to the work site boundaries. The sensitive receptors were identified by Tilenga ESIA GIS experts using data gathered during both AECOM EBS and Tilenga ESIA baseline surveys, plus those of Artelia Eau and Environment (as detailed in ***Chapter 16: Social***). Figures detailing the analysis undertaken to identify sensitive receptors are presented in Figure I2-38 to Figure I2-80 of Appendix I. The detailed results of analysis identifying affected sensitive receptors are presented in Table 7-27.

Table 7-27: Potential Road Construction/ Upgrade Noise Impacts

Potential impact Magnitude	Predicted Distance of Noise Propagation from Site Boundary	Potentially Affected Receptors				Sensitivity of Receptors	Potential Significance of Impact
		Settlements	Healthcare	Worship	Education		
High	0 to 50 m	Approximately 650 receptors in the following villages: Ajigo, Avogera, Bukongolo, Kamandindi, Kasinyi, Kibambura, Kichoke Bugana, Kigwera NE, Kigwera NW, Kigwera SE, Kijangi, Kijumbya, Kirama, Kisansya E, Kisomere, Kitahura, Kiyere, Kizikya, Masaka, Mvule I, Ngwedo, Oriibo, Paraa, Uduk I, Uduk II	Avogera Health Centre II (28m) Kiyere Kigwera Health Centre II (49m)	Uduk II Church of God (21m) Uduk II Pentecostal Church (22m) Akichira Catholic Church (7m) Avogera Open Heaven Church (13m) Avogera Church of Uganda (25m) Ntembiro Church (36m) Kijumbya Catholic Church (25m) Ngwedo Catholic Church (32m) Ngwedo Church (49m) Ngwedo Mosque (30m)	Ngwedo School (9m) Kijangi Primary School (35m) Kijumbya Primary School (38m)	Moderate	**Moderate Adverse**
Moderate	50 to 125 m	Approximately 900 receptors in the following villages: Ajigo, Avogera, Bukongolo, Kamandindi, Kasinyi, Kibambura, Kichoke Bugana, Kigwera NE, Kigwera NW, Kigwera SE, Kijangi, Kijumbya, Kirama, Kisansya E, Kisomere,	None	Avogera Miracle Church (51m) Pentecostal Church of God (120m) Charismatic Episcopal Church (95m) Uriibo Catholic Church (110m) Kiyere St Mary Ndandamire Catholic Church (105m)	Kirama Primary School (100m) Kigwera Nursery and Primary School (95m) Uduk II Ngwedo Secondary School (60m) Ngwedo School (85m)	Moderate	**Low Adverse**

Potential impact Magnitude	Predicted Distance of Noise Propagation from Site Boundary	Potentially Affected Receptors				Sensitivity of Receptors	Potential Significance of Impact
		Settlements	Healthcare	Worship	Education		
		Kitahura, Kiyere, Kizikya, Masaka, Mvule I, Ngwedo, Oriibo, Paraa, Uduk I, Uduk II		Ngwedo Church. Church of Uganda (60m)			
Low	125 to 225 m	Approximately 800 receptors in the following villages: Ajigo, Avogera, Bukongolo, Kamandindi, Kasinyi, Kibambura, Kichoke Bugana, Kigwera NE, Kigwera NW, Kigwera SE, Kijangi, Kijumbya, Kirama, Kisansya E, Kisomere, Kitahura, Kiyere, Kizikya, Masaka, Mvule I, Ngwedo, Oriibo, Paraa, Uduk I, Uduk II	Ngwedo Drug shop (130m)	Uriibo Church of Uganda (165m) Uriibo Church of God (160m) Kijumbya Church Of Uganda (130m) Kirama Catholic Church (210m) Uduk I Shongambe Church Of Uganda (150m)	Uribo Primary School (160m) Nyapea Primary School (160m)	Moderate	**Insignificant**

A large number of receptors are located in close proximity to locations where road upgrade works activities are proposed. Consequently, there is potential for significant impacts to occur; however, it should be noted that activities will be temporary and limited in duration. Based on professional experience of road upgrade works, it is possible that work on sections of road affecting sensitive receptors can be completed in a matter of days. Additionally, noise predictions are considered to be worst case and represent periods of intense activity when plant are operational in close proximity to sensitive receptors. Consequently, when accounting for conservative prediction methodology, the temporary nature and limited duration of impacts, a reduction of one order of magnitude (based on professional judgement) is considered reasonable to apply to the significance of impact. As a result, approximately 650 Moderate sensitivity receptors may experience a potential impact of **Moderate Adverse** significance. All other receptors will experience potential impacts ranging from Insignificant to Low Adverse i.e. not significant.

7.6.3.2.8 Excavation from Borrow Pits and Quarries Noise

An assessment of excavation from borrow pits and quarries has not been undertaken as the locations of borrow pits and quarries has not been finalised. Consequently, it is not possible to identify receptors that may be subject to significant noise impacts. In order to carry out an assessment of the likely level of noise emissions from borrow pits and quarries, it has been considered that activities in borrow pits and quarries are likely to result in noise levels that may be considered equivalent to those generated by Site Preparation and Enabling Works activities.

The results of noise predictions for Site Preparation and Enabling Works at well pad sites are presented in Table 7-25. The distances at which impacts occur in Table 7-25 are considered equivalent to the likely distance at which potential impacts may occur around borrow pit and quarry sites. The potential impact significance at Moderate sensitivity receptors around borrow pits and quarries is predicted to occur at the following distances from the site boundary:

- Moderate Adverse – 0 to 40 m; and
- Low Adverse – 40 to 90 m.

Potential significant impacts may be experienced by receptors within 40 m of a quarry or borrow pit location. Consequently, the potential for significant noise impacts should be considered when finalising the locations for quarries and borrow pits.

7.6.3.2.9 Victoria Nile Ferry Crossing Construction Piling Vibration

As described in ***Chapter 4: Project Description and Alternatives***, a piling rig and ancillary equipment i.e. crawler crane and a vibratory hammer will be used to install the three walls of sheet piles and the two mooring dolphins required on both the southern and northern banks of the river banks.

BS 5228-2 (Ref. 7-6) provides historic example data on vibration levels at varying distances during vibratory hammer piling works, whereby it is unlikely that vibratory hammer piling will generate levels of vibration exceeding 0.3 mm/s at a distance of greater than 20 m.

It is noted in the assessment of site clearance and construction noise at the Victoria Nile Ferry Crossing sites north and south of the Victoria Nile that the nearest sensitive receptor is approximately 250 m away. However, analysis of aerial imagery indicates buildings located approximately 60 m from the site that are identified of either temporary lodge staff or UWA rangers accommodation. At these separation distances, potential vibration impacts from vibratory hammer piling will be limited to a Negligible magnitude. Consequently, the resultant potential impact significance will be **Insignificant**.

7.6.3.2.10 Borehole Drilling Vibration

Borehole drilling has the potential to generate vibration that may impact on nearby receptors. The level of vibration generated is likely to be lower than during well drilling (see section 7.6.4.2.12) and thus comparing to impact piling is likely to result in a significant over-prediction of vibration. Consequently, it is considered more appropriate to compare borehole drilling with vibration levels generated by bored piling. Based on experience of undertaking assessments of bored piling, it is unlikely that borehole drilling will generate levels of vibration exceeding 0.3 mm/s at a distance of greater than 20 m. Given that there will be a suitable buffer round the Industrial Area and a 15 m buffer around well pads, potential vibration impacts due to borehole drilling are unlikely to exceed a Negligible magnitude. Consequently, the potential impact significance due to vibration at Moderate sensitivity receptors is likely to be **Insignificant**.

7.6.3.2.11 Road Construction/ Upgrade Vibration

The potential for vibration impacts to occur during the runway upgrade and road construction activities are most likely during the operation of vibratory compactors. Depending on the plant adopted for vibratory compaction, PPV levels may range from approximately 1 to 5 mm/s at a distance of approximately 10 m. Consequently, when accounting for a worst case vibratory compactor, there is potential for Moderate vibration magnitude of impact at nearby sensitive receptors at sites with receptors within approximately 50 m of proposed runways and road sites.

Due to the potential for vibration affecting Moderate sensitivity receptors, a potential impact significance of High is applicable according to Project criteria. However, it should be considered that the duration of potential vibration impacts are likely to be short in duration i.e. no longer than a day at individual receptors. Consequently, when accounting for the limited duration of potential impacts, the potential impact significance is considered to be no worse than **Moderate Adverse**.

7.6.3.2.12 Bugungu Airstrip Runway Upgrades Vibration

Bugungu Airstrip does not have any human receptors in close proximity (closest being over 1.3 km away) to result in a potential impact magnitude due to vibration that is greater than Negligible. Consequently, the potential impact significance due to Bugungu Airstrip upgrades is **Insignificant**.

7.6.3.2.13 Masindi Vehicle Check Point Construction Vibration

As detailed in Section 7.6.3.2.6, the nearest identified building to the existing grass airstrip at Masindi is approximately 100 m away. It is considered that attenuation of vibration over this distance is likely to reduce levels the magnitude of impact to no greater than Low. The potential impact significance for Moderate sensitivity receptors is Low; however, when accounting for the limited duration of exposure to vibration and the temporary nature of works, the potential impact significance due to runway upgrade works at Masindi airstrip is, based on professional judgement, considered to be **Insignificant**.

7.6.3.3 Additional Mitigation and Enhancement

Where potential significant impacts have been identified, additional measures have been proposed to limit the extent of the predicted noise impacts. The additional mitigation and monitoring measures that are recommended are presented in Table 7-28 below. Additional mitigation measures relevant to ground-borne vibration have also been proposed.

Table 7-28: Additional Mitigation Measures

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
NV.1	Operating the energy generation plant as and when required, and at the load required to meet the energy demand of the worksite/activity at that time	X	X		X
NV.2	The use of centralised power generation will be implemented on the Construction Support Base to minimise the number of discrete diesel generators required to support construction activities at the Industrial Area	X	X		
NV.3	Implementing a **Grievance Mechanism Procedure**, to allow recording and follow up of any complaints related to Project activities, in a timely manner	X	X	X	X
NV.4	Regular servicing and maintenance of vehicles and plant to ensure they are operating as per manufacture's specification	X	X	X	X
NV.5	Prohibit the unnecessary idling of vehicles and plant	X	X	X	X
NV.6	An **Environmental Monitoring Programme** to be established. This will include monitoring noise levels at nearby sensitive receptors	X	X	X	X
NV.7	For work activities located close to noise sensitive receptors, mitigation measures will be implemented to minimise the impact. A range of specific noise mitigation measures shall be implemented to minimise impacts. Such measures shall be implemented on a case by case basis and may include the use of temporary abatement such as dampening and shielding techniques, noise barriers, and mufflers. Specific noise regulations and thresholds will be specified in the Noise and Vibration Management Plan	X	X		X
NV.8	Where possible, selection of low-noise rated machinery and generators	X	X	X	X

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
NV.9	Community engagement before work commences and after on a regular basis according to the **Stakeholder Engagement Plan**	X	X	X	X
NV.10	During detailed engineering phase the present noise study will be refined by the selected engineering company and drilling contractor(s) and based on selected vendor data and mitigations will be addressed accordingly to minimise the noise impact at receptors at acceptable noise levels	X	X	X	X
NV.11	As far as possible, sourcing material from locations close to the Project Area to reduce haulage distances, and therefore the exposure to noise and emissions from traffic	X	X		X
NV.12	Optimising the logistics to maximise use of available vehicles, reduce number of trips and reduce movements on more sensitive routes where possible; using convoys when appropriate (e.g. via using one shared logistics service provider who can ensure appropriate planning across all parts of the Project and ensure efficiencies are made)	X	X	X	X
NV.13	Developing and implementing a Road Safety and Transport Management Plan that will outline speed limits and setting and enforcing traffic management measures (e.g. 40 km/hr), and indicating vehicles should be driven at steady speeds observing the speed limit and not making unnecessary noise, such as sounding horns, etc.	X	X	X	X
NV.14	Construction and upgrading of roads used as haul routes should be undertaken using best practice to ensure that there are no surface irregularities that may result in increased noise emissions from tyre/ road interactions	X			
NV.15	Roads will be well maintained to minimise noise generated from surface irregularities	X	X	X	X
NV.16	Loud music is not to be played	X	X	X	X
NV.17	Avoiding activities which generate high noise levels during night-time work during construction (except for some drilling activities which due to the technical requirements have to be continuous until the well is developed)		X		
NV.18	To avoid nuisance and potential damage to nearby structures from drilling activities, an assessment of potential vibration levels will be undertaken to determine impacts (if any) to nearby receptors. Investigations will be based well locations, manufacturers vibration data for equipment and vibration risk criteria as per industry guidance. Should at risk receptors be identified from the assessment, further vibration mitigation measures will be developed and applied on a case by case basis		X		
NV.19	An additional detailed review of the noise generated by various Project activities at each key Project component will be undertaken when the construction and drilling contractors are defined. Should potential significant impacts be identified, appropriate mitigation measures will be undertaken		X		

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
NV.20	Noise abatement of drilling equipment, for example by use of mufflers, or noise barriers and enclosures where appropriate, especially during night time operations		X		
NV.21	Multiple drilling activities close to identified sensitive receptors should be avoided where practicable		X		
NV.22	Additional noise modelling should be undertaken during detailed engineering. Noise modelling will include finalised locations of plant items and detailed Sound Power Levels based on manufacturer's data. A mitigation strategy will be developed to minimise the impact upon nearby sensitive receptors.			X	
NV.23	In principle, during ramp up power will be provided from power generation sources (within the Industrial Area and at each well pad); there will be no additional generators used during this activity			X	
NV.24	Before decommissioning, a **Decommissioning Management Plan** will be prepared and agreed with NEMA and other relevant agencies prior to the commencement of any on-site works. It will include details on the methods and activities associated with the decommissioning of the infrastructure, including the transportation and final disposal or re-use strategy for Project components and wastes. Completion criteria will be detailed in the management plans				X
NV.25	Where generation of noise or vibration in excess of regulatory limits is deemed unavoidable, the Project Proponents will obtain a licence to permit noise or vibration in excess of permissible limits	X	X	X	X

7.6.3.4 Residual Impacts – Site Preparation and Enabling Works Phase

The additional mitigation measures are commitments that will be adopted in the proposed Site Preparation and Enabling Works methodology to minimise noise and vibration emissions. However, the level of mitigation achieved through the implementation of additional mitigation measures will be dependent on the specific methodology adopted by the Contractor. Consequently, a qualitative estimation on the potential reduction in impacts at nearby sensitive receptors has been undertaken to account for the implementation of additional mitigation measures to identify residual impacts.

A summary of the residual noise and vibration impacts during the Site Preparation and Enabling works Phase which take into account additional mitigation are presented in Table 7-29 and Table 7-30. It is considered that implementation of the additional mitigation measures is likely to result in a reduction in noise equivalent to a reduction of an order of impact magnitude at affected sensitive receptors.

Table 7-29: Site Preparation and Enabling Works Residual Impacts - Noise

Source of Impact	Magnitude of Potential Impact	Sensitivity of Receptors	Significance of Potential Impact	Significance of Residual Impact
Industrial Area Site Preparation and Enabling Works Noise	Negligible to High	Moderate	Low to Moderate Adverse	**Low Adverse**
Well Pad Site Preparation and Enabling Works Noise – South of Victoria Nile	Negligible to High	Moderate	Moderate Adverse	**Low Adverse**
Well Pad Site Preparation and Enabling Works Noise – North of Victoria Nile	Negligible	Moderate	Insignificant	**Insignificant**
Victoria Nile Ferry Crossing Clearance and Infrastructure Construction Noise	Negligible to Moderate	Moderate	Moderate Adverse	**Low Adverse**
Lake Albert Water Abstraction System Onshore Facility Noise	Negligible	Moderate	Insignificant	**Insignificant**
Bugungu Airstrip Upgrade Noise	Negligible	Moderate	Insignificant	**Insignificant**
Masindi Vehicle Check Point Construction Noise	Negligible to Low	Moderate	Insignificant	**Insignificant**
Road Construction/ Upgrade Noise	Negligible to High	Moderate	Moderate Adverse	**Low Adverse**
Excavation from Borrow Pits and Quarries Noise	-	-	-	**Low Adverse**

Table 7-30: Site Preparation and Enabling Works Residual Impacts - Vibration

Activity	Receptors Sensitivity	Magnitude of Potential Impact	Potential impact significance	Residual impact significance
Victoria Nile Ferry Crossing Piling Vibration	Negligible	Moderate	Insignificant	**Insignificant**
Borehole Drilling Vibration	Negligible	Moderate	Insignificant	**Insignificant**
Road Construction/Upgrade Vibration	Negligible to High	Moderate	Moderate Adverse	**Low Adverse**
Masindi Vehicle Check Point Vibration	Negligible to Low	Moderate	Insignificant	**Insignificant**
Bugungu Airstrip Upgrade Vibration	Negligible	Moderate	Insignificant	**Insignificant**

7.6.4 Assessment of Impacts: Construction and Pre-Commissioning Phase

7.6.4.1 Introduction

The activities taking place during the Construction and Pre-Commissioning Phase that have the potential to result in noise impacts are listed in Table 7-15. The potential for noise impacts are considered throughout the Construction and Pre-commissioning Phase along with the potential for vibration impacts during drilling of the wells at the well pads. In addition, potential vibration impacts are considered due to HDD activities at the Victoria Nile pipeline Crossing.

In addition to noise impacts due to Construction and Pre-Commissioning activities, potential noise impacts are also considered due to construction traffic movements (including bus movements for construction personnel) on the Project road network, ferry movements at the designated river crossing and aircraft movements to move personnel to and from the Study Area.

Pre-commissioning of the Production and Injection Network, valves at the well pads, Water Abstraction System and CPF involves pumping of water through completed infrastructure. For the Water Abstraction System, the potential impacts during pre-commissioning are considered equivalent to those identified during the Commissioning and Operational phase and, as such, residual impacts due to pre-commissioning activities are covered in the Commissioning and Operational phase impact assessment.

7.6.4.2 Potential Impacts (pre-additional mitigation) – Construction and Pre-Commissioning Phase

7.6.4.2.1 Industrial Area Construction Noise

The modelling methodology presented in Section 7.6.1.4.1 has been used to predict noise impacts at human sensitive receptors produced during the Construction and Pre-Commissioning Phase. As discussed in Section 7.6.1.4.2, it is considered that the methodology applied for Site Preparation and Enabling Works is likely to generate to levels that are considered equivalent to, but no higher than, noise generated during Construction and Pre-Commissioning activities.

It is considered that noise predictions are worst case and representative of intense periods of activity where, over the course of a working day, all plant are operational. In reality, it is likely that the worst case noise levels predicted will only occur for limited periods of time when plant are operational in close proximity to sensitive receptors. Consequently, through the course of the Industrial Area Construction and Pre-Commissioning phase, noise at nearby receptors is likely to be lower than the predicted levels. As the worst case noise levels for Construction and Pre-Commissioning are considered equivalent to those generated by Site Preparation and Enabling Works, the detailed results of analysis identifying affected sensitive receptors are referenced from Table 7-25.

As identified in Section 7.6.3.2.1, 45 receptors may experience potential impacts ranging from Low to High. Of the 45 receptors identified, 11 are predicted to experience a High significance impact and 23 are predicted to experience a Moderate Adverse significance impact.

When taking into consideration that the predicted noise levels are worst case and only likely to be temporary and last for limited durations, it is considered that, the identified significance of potential impact levels can be reduced by one order of magnitude at off-site receptors. As the identified receptors are all of Moderate sensitivity, the significance of potential impacts will be of a **Moderate Adverse** Significance for 11 receptors, which is considered to be a potential significant impact. All other receptors will experience a potential impact significance ranging from **Insignificant** to **Low Adverse**, which are not considered to be significant.

In addition to Moderate sensitivity receptors, workers present on land adjacent to the Industrial Area site may be affected by Construction and Pre-Commissioning activities. These workers are considered to be of Low sensitivity to noise so the significance of potential impact is identified as **Low Adverse** and not significant.

7.6.4.2.2 Well Pad Construction Noise

As discussed in Section 7.6.4.2.1, Site Preparation and Enabling Works noise is likely to be equivalent to, but no higher than, noise generated during Construction and Pre-Commissioning activities. As the worst case noise levels for Construction and Pre-Commissioning Site Preparation are considered equivalent to those generated by Site Preparation and Enabling Works, the detailed results of analysis identifying affected sensitive receptors are referenced from Table 7-26.

As identified in Section 7.6.3.2.2, construction activities at well pad sites has the potential to result in potential impacts magnitude ranging from Low to High at nearby receptors. Up to 448 receptors are predicted to experience potential impacts ranging from Low to High magnitude, of which 50 are predicted to experience a High magnitude of potential impact and 54 are predicted to experience a Moderate magnitude of potential impact.

Noise predictions are considered to be worst case and represent periods of intense activity when plant are operational in close proximity to sensitive receptors. When taking into consideration that the predicted noise levels are worst case and only likely to be temporary and last for limited durations, it is considered that, based on professional experience, the identified significance of impact levels can be reduced by one order of magnitude at off-site receptors. As the identified receptors are all of Moderate sensitivity, the significance of potential impacts will be **Moderate Adverse** (significant) for 50 receptors. All other receptors will experience a potential impact significance ranging from **Insignificant** to **Low Adverse** i.e. not significant.

In addition to Moderate sensitivity receptors, workers on land adjacent to well pad sites may be affected by noise generating activities. These workers are considered to be of Low sensitivity to noise so the potential impact significance is identified as **Low Adverse** i.e. not significant.

7.6.4.2.3 Well Drilling Noise

Drilling activities will be continuous and last for approximately 11 days at each well location with up to 22 wells located at a well pad site. It has been assumed when undertaking noise predictions of drilling activities that there will be no drilling within 40 m of the site boundary, including the 15 m buffer around well pad sites. As drilling will be continuous, impacts have been derived based on night-time assessment criteria, which is when receptors are most sensitive to noise.

A noise contour plot detailing the results of well drilling noise predictions is presented in Figure I3-1 of Appendix I. The noise contours have been analysed to identify sensitive receptors that may be affected by noise through consideration buffers defined by the largest distance from each contour band (representing magnitude of impacts) to the site boundaries. The sensitive receptors were identified by Tilenga ESIA GIS experts using data gathered during both AECOM EBS and Tilenga ESIA baseline surveys, plus those of Artelia Eau and Environment (as detailed in ***Chapter 16: Social***).

Figures detailing the analysis undertaken to identify sensitive receptors due to drilling activities at well pads are presented in Figure I3-2 to Figure I3-36 of Appendix I. Analysis of the noise modelling results for the well sites identify that 12 of the 34 well pads are predicted to result in a Negligible impact magnitude at nearby human receptors during the Construction and Pre-Commissioning phase. These well pad sites are summarised below:

- JBR-01, 02, 03, 04, 05, 06, 07, 08, 09 & 10;
- KGG-06; and
- NSO-03.

Detailed results of analysis identifying affected sensitive receptors are presented in Table 7-31.

Table 7-31: Potential Well Drilling Night-time Noise Impacts

Potential Impact Magnitude	Predicted Distance of Noise Propagation from Site Boundary	Potentially Affected Receptors		Sensitivity of Receptors	Potential Significance of Impact
		Settlements	Healthcare		
High	0 to 60 m	**GNA-02 -** 6 settlements to south in village of Kilyango. **GNA-04** - 8 settlements in village of Avogera. **KGG-01** - 6 settlements in village of Oriibo. **KGG-03** - 3 settlements to east in village of Beroya. **KGG-04** - 2 settlements in village of Kijumbya and Kichoke Bugana. **KW-02A** - 1 settlement in village of Kakindo. **KW-02B** - 7 settlements to east in village of Kisiomo and Kakindo. **NGR-01** - 1 settlement 10m to south in village of Kasinyi. **NGR02 -** 1 settlement in village of Kasinyi. **NGR-03A -** 30 settlements in village of Kirama. **NSO-02** - 3 settlements in village of Ngwedo farm. **NSO-04 -** 1 settlement in village of Kibambura. **NSO-05** - 2 settlements in village of Kibambura. **NSO-06** - 3 settlements in village of Uduk I.	-	Moderate	**High Adverse**
Moderate	60 to 130 m	**GNA-01 -** 7 settlement surrounding the site in village of Kisomere. **GNA-02** - 21 settlement Kilyango.	-	Moderate	**Moderate Adverse**

Potential Impact Magnitude	Predicted Distance of Noise Propagation from Site Boundary	Potentially Affected Receptors		Sensitivity of Receptors	Potential Significance of Impact
		Settlements	Healthcare		
		GNA-03 - 5 settlements in village of Uduk II. **GNA-02 -** 25 settlements surrounding in village of Kilyango. **GNA-04 -** 27 settlements in village of Avogera. **KGG-01** - 9 settlements in village of Oriibo. **KGG-03** - 3 settlements to north in village of Beroya. **KGG-04** - 3 settlements in village of Kijumbya. **KGG-09** - 5 settlements in village of Kijumbya, Kichoke Bugana, and Kikoora. **KW-02A** - 2 settlements in village of Kakindo. **KW-02B** - 7 settlements in village of Kisiomo and Kakindo. **NGR-02** - 5 settlement to south east in village of Kasinyi. **NGR-03A** - 38 settlements in villages of Kiyer, Kirama and Kichoke. **NSO-02** - 4 settlements in village of Ngwedo farm. **NSO-04** - 4 settlements in village of Kibambura. **NSO-05** - 2 settlements in village of Kibambura. **NSO-06** - 23 settlements in village of Uduk I and Ngwedo farm.			

Potential Impact Magnitude	Predicted Distance of Noise Propagation from Site Boundary	Potentially Affected Receptors		Sensitivity of Receptors	Potential Significance of Impact
		Settlements	Healthcare		
Low	130 to 450 m	**GNA-01** - 266 settlements to north east and south in village of Kisomere. **GNA-02** - 260 settlements in village of Kilyango. **GNA-03** - 86 settlements in village of Uduk II. **GNA-04** - 290 settlements in village of Avogera. **KGG-01** - 175 settlements in village of Oriibo. Majority to north. **KGG-03** - 9 settlements village of Beroya. **KGG-04** - 26 settlements in village of Kijumbya. **KGG-05** - 44 settlements in village of Gotlytech and Ngwedo farm. **KGG-09** - 17 settlements in village of Kijumbya, Kichoke Bugana, and Kikoora. **KW-01** - 3 settlements to north east in village of Kizongi. **KW0-2A** - 44 settlements in village of Kakindo. **KW0-2B** - 110 settlements in village of Kisiomo and Kakindo. **NGR-01** - 1 settlement 320m to north east in village of Kasinyi. **NGR-02** - 3 settlements to south in village. **NGR-03A** - 360 settlements in villages	**GNA-02 -** God's mercy clinic - 330m south west	Moderate	**Low Adverse**

Potential Impact Magnitude	Predicted Distance of Noise Propagation from Site Boundary	Potentially Affected Receptors		Sensitivity of Receptors	Potential Significance of Impact
		Settlements	Healthcare		
		of Kiyer, Kirama and Kichoke. **NGR-05A** - 20 settlements in village of Kirama. **NGR-06** - 7 settlements in village of Kigwera NE and E. **NSO-01** - 6 settlement in village of Ngwedo. **NSO-02** - 66 settlements in village of Ngwedo farm. **NSO-04** - 46 settlements in village of Kibambura. **NSO-05** - 11 settlements in village of Kibambura. **NSO-06** - 250 settlements in village of Uduk I and Ngwedo farm.			

Analysis of noise contours indicates that up to 2,376 receptors may experience impacts ranging from Low to High due to well drilling activities. Approximately 74 receptors are predicted to experience a High magnitude of impact. As all receptors identified are of Moderate sensitivity, these receptors are identified as experiencing a High Adverse significance of impact. Approximately 190 receptors are predicted to experience Moderate magnitude of impact. As all receptors identified are of Moderate sensitivity, these receptors are identified as experiencing a potential impact of **Moderate Adverse** significance. In total, 264 receptors are predicted to experience significant impacts due to night-time drilling works.

All other receptors affected by well drilling noise will experience, at worst, a Low magnitude of impact, which is equivalent to a **Low Adverse** potential impact for Moderate sensitivity receptors and not considered to be significant.

7.6.4.2.4 Construction of Water Abstraction Noise

Onshore Facility Option

It is noted that the magnitude of impact of noise due to site clearance activities at the Water Abstraction System site was Negligible. It is considered that construction activities undertaken for the onshore option are equivalent in terms of noise generated so it can be concluded that the significance of potential impact due to noise from construction activities is **Insignificant** at Moderate sensitivity receptors.

Floating Platform Option

There is an offshore option for the location of the Water Abstraction System. The offshore option will be a floating platform housing submersible pumps and coarse filter equipment, and will be positioned approximately 1.5 km from the shoreline. If an offshore floating platform is selected it will be delivered to site in modular units and assembled onshore prior to towing it to the selected position in the lake using a barge. Barge movements will be the main source of noise.

It is noted that the magnitude of impact of noise due to site clearance activities at the Water Abstraction System site was Negligible. Considering the offshore location (which is further away from the onshore receptors) and the short duration of the installation process, it can be concluded that the significance of potential impact due to noise from construction activities is **Insignificant** at Moderate sensitivity receptors.

7.6.4.2.5 Production and Injection Network Construction Noise

A noise contour plot detailing the results of Production and Injection Network construction works noise predictions is presented in Figure I3-37 of Appendix I. The noise contour plot is considered representative of high intensity activities at a typical work site. The noise contours have been analysed to identify sensitive receptors that may be affected by noise through consideration of buffers around the entire network defined by the largest distance from each contour band (representing magnitude of impacts) to the work site boundaries. The sensitive receptors were identified by Tilenga ESIA GIS experts using data gathered during both AECOM EBS and Tilenga ESIA baseline surveys, plus those of Artelia Eau and Environment (as detailed in ***Chapter 16: Social***).

Figures detailing the analysis undertaken to identify sensitive receptors are presented in Figure I3-38 to Figure I3-77 of Appendix I. Detailed results of analysis identifying affected sensitive receptors are presented in Table 7-32.

Table 7-32: Potential Production and Injection Network Construction Noise Impacts

Potential Impact Magnitude	Predicted Distance of Noise Propagation from Site Boundary	Potentially Affected Receptors			Sensitivity of Receptors	Potential Significance of Impact
		Settlements	Worship	Education		
High	0 to 40 m	Approximately 54 receptors at the following villages: Avogera, Beroya, Bukongolo, Gotlyech, Kakindo, Kakoora, Kasinyi, Kibambura, Kichoke Bugana, Kigwera NE, Kigwera SE, Kijangi, Kijumbya, Kilyango, Kirama, Kisansya E, Kisiomo, Kisomere, Kityanga, Kiyere, Kizongi, Ngwedo Farm, Ngwedo, Oriibo, Uduk I, Uduk II	None	None	Moderate	**High Adverse**
Moderate	40 to 90 m	Approximately 250 receptors at the following villages: Avogera, Beroya, Bukongolo, Gotlyech, Kakindo, Kakoora, Kasinyi, Kibambura, Kichoke Bugana, Kigwera NE, Kigwera SE, Kijangi, Kijumbya, Kilyango, Kirama, Kisansya E, Kisiomo, Kisomere, Kityanga,	Kisomere Lamtekwaro church (50m) Bukindwa Church of God (70m)	None	Moderate	**Moderate Adverse**

Potential Impact Magnitude	Predicted Distance of Noise Propagation from Site Boundary	Potentially Affected Receptors			Sensitivity of Receptors	Potential Significance of Impact
		Settlements	Worship	Education		
		Kiyere, Kizongi, Ngwedo Farm, Ngwedo, Oriibo, Uduk I, Uduk II				
Low	90 to 180 m	Approximately 500 receptors at the following villages: Avogera, Beroya, Bukongolo, Gotlyech, Kakindo, Kakoora, Kasinyi, Kibambura, Kichoke Bugana, Kigwera NE, Kigwera SE, Kijangi, Kijumbya, Kilyango, Kirama, Kisansya E, Kisiomo, Kisomere, Kityanga, Kiyere, Kizongi, Ngwedo Farm, Ngwedo, Oriibo, Uduk I, Uduk II	None	Kirama Community School (100m)	Moderate	**Low Adverse**

A number of receptors are located in close proximity to Production and Injection Network construction locations. Although Production and Injection Network construction activities will be temporary and limited in duration, the extent of activities involved (i.e. clearing, trenching, laying, reinstating etc.) means there is potential for the duration of activities to extend to a period of weeks at any one location. Consequently, in this case, a reduction of one order of magnitude is not considered applicable to account for a potential worst case scenario.

As a result, approximately 54 Moderate sensitivity receptors may experience a **High Adverse** potential impact significance and 250 receptors may experience a **Moderate Adverse** potential impact significance. All other receptors will experience potential impacts ranging from **Insignificant** to **Low Adverse** i.e. not significant.

7.6.4.2.6 Construction Traffic Noise on Access Routes

Construction traffic impact magnitudes have been estimated based on vehicle movement numbers presented in Table 7-23. These figures account for all traffic associated with work sites during the Construction and Pre-Commissioning Phase. It is considered that only receptors within 15 m of haulage routes will experience potential impacts of greater than Negligible magnitude. At inhabited areas south of the Victoria Nile, it is considered that receptors in close proximity to haul routes are likely to experience potential impacts of Moderate magnitude. Consequently, moderate sensitivity receptors located in close proximity to haul routes are likely to experience potential impacts of **Moderate Adverse** significance.

7.6.4.2.7 Bugungu Airstrip Noise

A noise contour plot presenting daytime aircraft noise predictions for runway 05 operations is presented in Figure I3-78 of Appendix I.

Due to the proposed aircraft (Beechcraft 1900) being a small turboprop, on departure it has the ability to take-off without use of excessive thrust and can climb rapidly. Consequently, when accounting for three departures a day, the 50 dB $L_{Aeq,15h}$ noise contours on departure routes extend approximately to the boundaries of the airfield.

On approach, aircraft typically descend at an angle of 3°. Consequently, aircraft on final approach are likely to be considerably closer to the ground than at a comparative distance on departure. As a result, the 50 dB $L_{Aeq,15h}$ noise contour is predicted to extend approximately 1 km from the runway threshold. However, the 55 dB $L_{Aeq,15h}$ on approach paths is unlikely to extend beyond the airfield boundaries.

As no human sensitive receptors are located on alignment runways at Bugungu Airstrip within a distance of 1 km from the runway thresholds, the magnitude of impact of aircraft movements is identified as Negligible and the subsequent potential impact significance on Moderate sensitivity receptors is **Insignificant**.

7.6.4.2.8 Masindi Vehicle Check Point Noise

The Masindi Vehicle Check Point will be used as a truck transit point for vehicles prior to onward travel to the Industrial Area. The exception to this is vehicles travelling to Tangi that will not use the Masindi Vehicle Check Point. In addition to noise generated by traffic, the facility will contain the following sources of noise:

- Gas Fuelling facilities located within a bunded area;
- Wastewater treatment plant; and
- 800 KVA diesel generator.

Based on conservative estimation using Google Earth aerial mapping, gas fuelling facilities will be located approximately 250 m from the nearest sensitive receptors. The facilities will be contained within in a bunded area that will provide partial screening of noise propagation to nearby sensitive receptors. It is considered that, due to the partial screening from the bund and attenuation over distance, noise impacts are likely to be **Insignificant.**

The locations of the wastewater treatment plant and the diesel generator have not been finalised at this stage, it is assumed that, as a worst case, they could be located approximately 100 m away from the nearest sensitive receptor. Given that the pumps associated with the wastewater treatment plant will be located in buildings, it is likely that the significant source of noise will originate from the generator. An indicative sound power level for a generator has been identified as approximately 102 dB(A). This equates to an $L_{Aeq,T}$ of 52 dB a 100 m and, assuming that the generator will be operating continuously, is equivalent to a High magnitude of impact at night. This is equivalent to a potential impact of **High Adverse** significance at Moderate sensitivity receptors.

Noise from vehicle movements at the Masindi Vehicle Check Point, as per Section 7.6.4.2.6, is unlikely to result in significant impacts due to the distance from the site to sensitive receptors.

7.6.4.2.9 Site Clearance of HDD Construction Area for the Victoria Nile Crossing

It is stated in section 7.6.1.4.2 that noise models have been produced using same plant schedule for Site Clearance Works and for Construction Works, which is based on plant schedule presented in Table 4-25 of ***Chapter 4: Project Description and Alternatives***. Consequently, noise levels for site clearance and construction activities are considered approximately equivalent.

Option 1

The nearest human receptors (residential settlements of moderate sensitivity) are located approximately 70 m to the south of the south bank site, and 1.4 km to the south of the north bank site on the opposite side of the Victoria Nile. At these separation distances, potential noise impacts from site clearance and construction activities at HDD areas will be limited to a Negligible magnitude. Consequently, the resultant significance of potential impact on Moderate sensitivity receptors will be **Insignificant**.

Option 2

For the north bank site, the nearest human receptors (residential settlements of moderate sensitivity) are located approximately 1.3 km to the south on the opposite side of the Victoria Nile. At these separation distances, construction noise impacts from site clearance of the HDD areas will be limited to a Negligible magnitude. Consequently, the resultant significance of potential impact will be **Insignificant**.

For the south bank site, approximately 6 residential receptors of moderate sensitivity are located approximately 200 m to the south. As identified for well pad site preparation noise levels in Table 7-26, noise emissions at 200 m will experience a potential impact of Negligible magnitude. Consequently, the resultant potential impact on Moderate sensitivity receptors will be **Insignificant**.

7.6.4.2.10 Victoria Nile HDD Crossing Drilling Activity Noise

The noise modelling methodology presented in Section 7.6.1.4.3 has been used to predict noise generated by HDD drilling activities. Noise contour plots detailing the results of HDD drilling noise predictions at the north and south sides of the Victoria Nile are presented in Figure I3-79 and Figure I3-80 of Appendix I. The noise contours for two site options have been analysed to identify sensitive receptors that may be affected by noise through consideration buffers around the entire road network defined by the largest distance from each contour band (representing magnitude of impacts) to the work site boundaries. The sensitive receptors were identified by Tilenga ESIA GIS experts using data gathered during both AECOM EBS and Tilenga ESIA baseline surveys, plus those of Artelia Eau and Environment (as detailed in ***Chapter 16: Social***).

Option 1

Figures detailing the analysis undertaken to identify sensitive receptors for north and south sites for Option 1 are presented in Figure I3-81 and Figure I3-82 of Appendix I. Detailed results of analysis identifying affected sensitive receptors are presented in Table 7-33. It should be noted that, as no receptors are located in proximity of the north site, identified receptors are those affected by noise emissions from the south site.

Table 7-33: Potential HDD Night-time Noise Impacts – Option 1

Potential Impact Magnitude	Predicted Distance of Noise Propagation from Site Boundary	Potentially Affected Receptors	Sensitivity of Receptors	Potential Significance of Impact
		Settlements		
High	0 to 170 m	Approximately 2 settlements to east	Moderate	High Adverse
Moderate	170 to 320 m	Approximately 1 settlement to south	Moderate	Moderate Adverse
Low	320 to 980 m	Approximately 27 settlements to south east and 1 safari lodge to north east	Moderate	Low Adverse

Analysis of Option 1 noise contours indicates that up to 31 receptors may experience impacts ranging from Low to High due to well drilling activities. Two receptors are predicted to experience a High magnitude of impact. As all receptors identified are of Moderate sensitivity, these receptors are identified as experiencing a potential impact of **High Adverse** significance. One Moderate sensitivity receptor is predicted to experience a potential impact of **Moderate Adverse** significance.

All other receptors affected by well drilling noise will experience, at worst, a Low magnitude of potential impact, which is equivalent to a **Low Adverse** potential impact for Moderate sensitivity receptors and not considered to be significant.

Option 2

Figures detailing the analysis undertaken to identify sensitive receptors for north and south sites for Option 1 are presented in Figure I3-83 and Figure I3-84 of Appendix I. Detailed results of analysis identifying affected sensitive receptors are presented in Table 7-34. It should be noted that, as no receptors are located in proximity of the north site, identified receptors are those affected by noise emissions from the south site.

Table 7-34: Potential HDD Night-time Noise Impacts – Option 2

Potential Impact Magnitude	Predicted Distance of Noise Propagation from Site Boundary	Potentially Affected Receptors Settlements	Sensitivity of Receptors	Potential Significance of Impact
High	0 to 170 m	None	Moderate	High Adverse
Moderate	170 to 320 m	Approximately 7 settlements to south	Moderate	Moderate Adverse
Low	320 to 980 m	Approximately 21 settlements to south and south east	Moderate	Low Adverse

Analysis of Option 2 noise contours indicates that up to 28 receptors may experience impacts ranging from Low to High due to well drilling activities. No receptors are predicted to experience a High magnitude of potential impact. 7 Moderate sensitivity receptors are predicted to experience a potential impact of **Moderate Adverse** significance.

All other receptors affected by well drilling noise will experience, at worst, a Low magnitude of potential impact, which is equivalent to a potential impact of **Low Adverse** significance for Moderate sensitivity receptors and not considered to be significant.

7.6.4.2.11 Victoria Nile Ferry Crossing Noise

Between six and eight Ferry movements over an 8-hour day are forecast across the river. It is considered that noise generated by barge movements will be lower than noise generated by activities during the Site Preparation and Enabling Works phase. It should be noted that the Site Preparation and Enabling Works phase assessment of river crossing construction works identified potential impacts up to Moderate Adverse significance. It is expected that changes in river traffic during this phase would result in a lower magnitude. Consequently, potential noise impacts are identified as **Low Adverse.**

7.6.4.2.12 Well Drilling Vibration

An assessment of vibration generated by well drilling activities at well pads been based on representative levels of piling vibration. It should be noted that drilling is likely to result in lower vibration levels than piling and so this approach is considered to represent a conservative worst case scenario.

Drilling activities will be undertaken continuously during day and night. As the assessment is based on the human response to vibration, the sensitivity of receptors to vibration is considered to be the same during day and night periods. Consequently, potential vibration impacts identified are applicable to both day and night periods.

Based on potential impact piling levels, any receptor within approximately 40 m of a drilling rig may experience a Moderate potential impact. The receptors identified as experiencing a High noise potential impact in Table 7-26 represent receptors within 40 m of well pads so 50 receptors may potentially be impacted by drilling vibration. It should be noted that there is a 15 m buffer around the well pads so it considered that no receptor will be close enough to result in a potential High impact.

There are 50 receptors of Moderate sensitivity identified within approximately 40 m of well drilling sites and may experience a potential impact of **Moderate Adverse** significance due to drilling activities. All other receptors will experience potential impacts ranging from Insignificant to **Low Adverse** i.e. not significant.

7.6.4.2.13 Victoria Nile HDD Crossing Drilling Activity Vibration

The potential for vibration impacts from the Victoria Nile Pipeline Crossing using HDD (as discussed in section 4.5.2.8 of ***Chapter 4: Project Description and Alternatives***) has been reviewed and, as per well drilling, vibration generated has been considered equivalent to impact piling to ensure a robust assessment methodology.

Option 1

The nearest human receptors (residential settlements of moderate sensitivity) are located approximately 70 m to the south of the south bank site of the Victoria Nile. At this separation distance, vibration impacts from HDD drilling is likely to be no higher than 1.0 mm/s and therefore limited to a Low impact magnitude at two receptors. Consequently, the resultant significance of potential impact at Moderate sensitivity receptors will be **Low Adverse**. At all other receptors, the potential impact will be **Insignificant**.

Option 2

The nearest human receptors (residential settlements of moderate sensitivity) are located approximately 200 m to the south of the south bank site of the Victoria Nile. At this separation distance, vibration impacts from HDD drilling will be less than 0.3 mm/s and therefore limited to a Negligible magnitude. Consequently, the resultant significance of potential impact at Moderate sensitivity receptors will be **Insignificant**.

7.6.4.3 Additional Mitigation and Enhancement

Mitigation measures to control and reduce potential noise and vibration impacts during the Construction and Pre-Commissioning phase are summarised in Table 7-28.

7.6.4.4 Residual Impacts – Construction and Pre-Commissioning Phase

The additional mitigation measures are commitments that will be adopted in the proposed Construction and Pre-Commissioning Phase methodology to minimise noise and vibration emissions. However, the level of mitigation achieved through the implementation of additional mitigation measures will be dependent on the specific methodology adopted by the Contractor. Consequently, unless otherwise stated, a qualitative estimation on the potential reduction in impacts at nearby sensitive receptors has been undertaken to account for the implementation of additional mitigation measures to identify residual impacts.

The significance of potential impact is predicted to be up to High Adverse during well drilling activities. The additional mitigation recommended for drilling activities consists of silencers, mufflers, acoustic barriers and enclosures where appropriate. This mitigation may be applied to ground based plant i.e. generators and pumps. It has been estimated that the cumulative effect of additional mitigation is likely to provide at least 15 dB attenuation; however, higher levels of attenuation may be attainable depending on the plant manufacturer. Consequently, impacts may be further reduced if a bespoke approach to mitigation is undertaken. Additional mitigation is likely to reduce the range for **Moderate Adverse** impacts to approximately 15 m from the well pad boundary and **High Adverse** impacts confined to within the well pad boundaries.

The significance of potential impact is predicted to be up to High Adverse during HDD drilling. As with well drilling activities, additional mitigation recommended for HDD activities consists of silencers, mufflers, acoustic barriers and enclosures where appropriate. Assuming a cumulative reduction in noise of approximate 15 dB, significant impacts could be removed for Option 2 and High Adverse impacts reduced to **Moderate Adverse** for Option 1.

The significance of potential impact is predicted to be up to High Adverse during Production and Injection Network Construction. Given that an effective communication strategy is adopted, inhabitants of affected receptors are likely to be more tolerant of noise impacts given the understanding of the nature and duration of high noise generating activities. Consequently, the additional mitigation measures recommended are considered equivalent to a reduction in impact significance of one order. As a result, Moderate sensitivity receptors may experience temporary **Moderate Adverse** impact significance. All other receptors will experience impacts ranging from **Insignificant** to **Low Adverse** i.e. not significant.

The significance of potential impact is predicted to be High Adverse due to night-time generator noise emissions at the Masindi Vehicle Check Point. Given that screening (i.e. an enclosure) can be provided for residential receptors that may be affected, it is considered that significant impacts can be reduced and the residual impact will be, at worst, **Low Adverse**.

For all other Project components during the Construction and pre-Commissioning phase, it is considered that implementation of the additional mitigation measures is likely to result in a reduction in noise equivalent to a reduction of an order of impact magnitude at affected sensitive receptors.

A summary of the residual noise and vibration impacts taking into account additional mitigation is provided in Table 7-35 and Table 7-36.

Table 7-35: Construction and Pre-Commissioning Residual Impacts – Noise

Source of Impact	Magnitude of Potential Impact	Sensitivity of Receptors	Significance of Potential Impact	Significance of Residual Impact
Industrial Area Construction Noise	Negligible to High	Moderate	Moderate Adverse	**Low Adverse**
Well Pad Site Construction Noise – South of Victoria Nile	Negligible to High	Moderate	Moderate Adverse	**Low Adverse**
Well Pad Site Construction Noise – North of Victoria Nile	Negligible	Moderate	Insignificant	**Insignificant**
Night-time Well Drilling Noise – South of Victoria Nile	Negligible to High	Moderate	High Adverse	**Moderate Adverse**
Night-time Well Drilling Noise – North of Victoria Nile	Negligible	Moderate	Insignificant	**Insignificant**
Water Abstraction Station Construction Noise – On-shore Facility	Negligible	Moderate	Insignificant	**Insignificant**
Water Abstraction Station Construction Noise – Offshore Facility	Negligible	Moderate	Insignificant	**Insignificant**
Production and Injection Network Construction Noise	Negligible to High	Moderate	High Adverse	**Low Adverse**
Construction Traffic Noise	Negligible to Moderate	Moderate	Moderate Adverse	**Low Adverse**
Bugungu Airstrip Aircraft Noise	Negligible	Moderate	Insignificant	**Insignificant**
Masindi Vehicle Check Point Noise	Negligible to High	Moderate	High Adverse	**Low Adverse**
Option 1 Victoria Nile Crossing HDD Area Site Clearance and Construction Noise	Negligible	Moderate	Insignificant	**Insignificant**
Option 2 Victoria Nile Crossing HDD Area Site Clearance and Construction Noise	Negligible to Low	Moderate	Insignificant	**Insignificant**
Option 1 HDD Drilling Noise	Negligible to High	Moderate	High Adverse	**Moderate Adverse**
Option 2 HDD Drilling Noise	Negligible to Moderate	Moderate	Moderate Adverse	**Low Adverse**

Table 7-36: Construction and Pre-Commissioning Residual Impacts – Vibration

Activity	Magnitude of Potential Impact	Sensitivity of Receptors	Potential impact significance	Residual impact significance
Well Drilling – South of Victoria Nile	Negligible to Moderate	Moderate	Moderate Adverse	**Low Adverse**
Well Drilling – North of Victoria Nile	Negligible	Moderate	Insignificant	**Insignificant**
Option 1 Victoria Nile Crossing HDD Construction Vibration	Negligible to Low	Moderate	Low Adverse	**Low Adverse**
Option 2 Victoria Nile Crossing HDD Construction Vibration	Negligible	Moderate	Insignificant	**Insignificant**

7.6.5 Assessment of Impacts: Commissioning and Operations Phase

7.6.5.1 Introduction

Commissioning activities will be limited to testing the equipment and plant prior to first oil to ensure it operates correctly and any issues identified are addressed. Consequently, potential noise impacts identified in the operational noise assessment are considered equivalent to potential noise impacts that may be generated during commissioning activities. It should be noted that commissioning will include testing of the flare and has been considered in the Unplanned Events assessment (see Section 7.8).

The Operations phase of the project will involve the use of industrial plant such as compressors, pumps, turbines and generators. The operation of industrial plant at the Industrial Area (including CPF) and well pads have the potential to result in noise impacts at nearby receptors. Such impacts are direct and, due to the lifespan of the Project, are considered to be of permanent duration.

Well pads will be unmanned except for periods of well workovers, during which, well intervention activities will take place. Intervention activities will be undertaken using an electric powered rig. Due to the noise impact assessment accounting for a worst case scenario of noise emissions around the entire site boundary, it is considered unlikely that noise levels will be sufficiently elevated during workovers to affect the results of the operational well pad assessment. Consequently, the results of the assessment are considered representative of both normal well pad operations and workover periods.

Due to the proposed 24-hour operation of industrial processes at the Industrial Area (including CPF) and well pads, noise impacts have the potential to cause sleep disturbance during night-time operations and so night-time periods have also been considered in the noise assessment.

Extraction of water from Lake Albert and export to the CPF through pipelines will be powered through pumps at the Water Abstraction System using an onshore facility or a floating platform facility. These pumps have potential to generate noise that may impact on nearby sensitive receptors.

Potential noise impacts may also occur due to road traffic movements in the Project Area associated with the operation of Project components. Due to the Project lifespan, impacts from road traffic are considered to be permanent in nature and direct. Additional, permanent impacts will potentially be produced by movements of barge at the Victoria Nile Ferry Crossing.

7.6.5.2 Potential Impacts (pre-additional mitigation) – Commissioning and Operations Impacts

7.6.5.2.1 Industrial Area Noise

Noise modelling using the methodology presented in Section 7.6.1.4.5 has been used to predict noise levels at human sensitive receptors which have the potential to be affected by noise from operations at the Industrial Area. As there are two current design options for the layout of the CPF in the Industrial Area, predictions have been undertaken for both options, referred to in this chapter as CPF Option 1 and CPF Option 2.

Noise contour plots detailing the results of noise predictions of the operation CPF Option 1 and CPF Option 2 are presented in Figure I4-1 and Figure I4-2 of Appendix I. The noise contours have been analysed to identify sensitive receptors that may be affected by noise through consideration of buffers around the Industrial Area defined by the largest distance from each contour band (representing magnitude of impacts) to the site boundary. The sensitive receptors were identified by Tilenga ESIA GIS experts using data gathered during both AECOM EBS and Tilenga ESIA baseline surveys, plus those of Artelia Eau and Environment (as detailed in Chapter 16: Social).

A figure detailing the analysis undertaken to identify sensitive receptors is presented in Figure I4-3. Detailed results of analysis identifying affected sensitive receptors during the night-time period are presented in

No potential noise impacts above a magnitude of Negligible are predicted at receptors for either CPF Option 1 or CPF Option 2 during daytime periods.

Table 7-37 and Table 7-38 as this presents a worst case scenario.

No noise impacts above a magnitude of Negligible are predicted at receptors for either CPF Option 1 or CPF Option 2 during daytime periods.

Table 7-37: Potential Night-time Industrial Area – CPF Option 1

Magnitude of potential Impact	Predicted Distance of Noise Propagation from Site Boundary	Potential Affected Receptors	Sensitivity of Receptors	Potential Significance of Impact
High	Within site boundary	No receptors	-	-
Moderate	0 to 150 m	Approximately 12 settlements 30-150m to south in village of Uduk II. Approximately 24 settlements 10-150m to north in village of Kasinyi.	Moderate	**Moderate Adverse**
Low	150 to 950 m	Approximately 25 settlements 175-950m to south east in village of Uduk II. Approximately 1 settlement 260m to south in Kibambura. Approximately 20 settlements to 450-950m to east in Kisomere. Approximately 110 settlements 150-950m to north in village of Kasinyi.	Moderate	**Low Adverse**

Table 7-38: Potential Night-time Industrial Area – CPF Option 2

Magnitude of potential Impact	Predicted Distance of Noise Propagation from Site Boundary	Potential Affected Receptors	Sensitivity of Receptors	Potential Significance of Impact
High	0 to 40 m	Approximately 1 settlement 30m to south in village of Uduk II. Approximately 9 settlements 0-40m to north in village of Kasinyi	Moderate	**High Adverse**
Moderate	40 to 225 m	Approximately 15 settlements 75-180m to south in village of Uduk II. Approximately 30 settlements 40-225m to north in village of Kasinyi.	Moderate	**Moderate Adverse**

Magnitude of potential Impact	Predicted Distance of Noise Propagation from Site Boundary	Potential Affected Receptors	Sensitivity of Receptors	Potential Significance of Impact
Low	225 to 1050 m	Approximately 1 settlement 260m to south in Kibambura. Approximately 40 settlements 660-1050m in village of Uduk II. Approximately 40 settlements 480-1050m to east in village of Kisomere. Approximately 130 settlements 225-1050m to north in village of Kasinyi	Moderate	**Low Adverse**

During the night-time period, 192 receptors are predicted to experience a potential impact magnitude ranging from Low to High for CPF Option 1 (no High and 36 Moderate), and 266 receptors are predicted to experience magnitude of impacts ranging from Low to High for CPF Option 2 (10 High and 45 Moderate).

As the nearby receptors are all of Moderate sensitivity, the consequent significance of potential impacts during the worst case predicted scenario for CPF Option 1 will be **Moderate Adverse** for 36 receptors. All other receptors will experience a potential impact significance ranging from **Insignificant** to **Low Adverse** i.e. not significant.

The significance of potential impacts during the worst case predicted scenario for CPF Option 2 will be **High Adverse** for 10 receptors and **Moderate Adverse** for 45 receptors. All other receptors will experience a potential impact significance ranging from **Insignificant** to **Low Adverse** i.e. not significant.

The results show an increase in the potential impact significance for CPF Option 2 in comparison to CPF Option 1. This is expected as CPF Option 2 considers a scenario where noisy plant are located near the site boundary at the closest location to the nearest sensitive receptors. This highlights how considerate locating of noisy plant in relation to sensitive receptor locations can reduce potential noise impacts.

In addition, workers on land adjacent to the Industrial Area site may be affected by operational noise during the daytime. These workers are considered to be of Low sensitivity to noise so the potential impact significance is identified as **Insignificant** for both CPF Option 1 and CPF Option 2.

7.6.5.2.2 Well Pad Noise

A noise contour plot detailing the results of noise predictions of a representative well pad site is presented in Figure I4-4 of Appendix I. The noise contours have been analysed to identify sensitive receptors that may be affected by noise through consideration of buffers around the well pad sites defined by the largest distance from each contour band (representing magnitude of impacts) to the site boundary. The sensitive receptors were identified by Tilenga ESIA GIS experts using data gathered during both AECOM EBS and Tilenga ESIA baseline surveys, plus those of Artelia Eau and Environment (as detailed in ***Chapter 16: Social***).

Figures detailing the analysis undertaken to identify sensitive receptors are presented in Figure I4-5 to Figure I4-38 of Appendix I. Analysis of the noise modelling results for the well pad sites identifies that 15 of the 34 well pads are predicted to result in a Negligible impact magnitude at nearby human receptors due to the operational well pad sites. These well pad sites are summarised below:

- JBR-01, 02, 03, 04, 05, 06, 07, 08, 09 & 10;
- KGG 02 & 06;
- NSO-01 & 03; and
- KW-01.

The detailed results of analysis identifying affected sensitive receptors during the night-time period are presented in Table 7-39 for the daytime period and Table 7-40 for the night-time period.

Table 7-39: Potential Daytime Well Pad Impacts

Magnitude of Potential Impact	Predicted Distance of Noise Propagation from Site Boundary	Potential Affected Receptors	Sensitivity of Receptors	Potential Significance of Impact
High	Within site boundary	No receptors	-	-
Moderate	Within site boundary	No receptors	-	-
Low	0 to 30 m	**GNA-02** - 2 settlements in the village of Avogera to south in village of Kilyango. **GNA-04** - 6 settlements in the village of Avogera to the south. **NGR-01**- 1 settlement in village of Kasinyi. **NGR-03A** - 1 settlement to south east in the village of Kirama. **KGG-01** - 5 settlements to the south east in the village of Oriibo. **KGG-03** - 2 settlements to the east and north in the village of Beroya. **KGG-04** - 1 settlement in village of Kichoke Bugana. **KW-02B** - 1 settlement to the north in the village of Kisiomo. **NSO-04** - 1 settlement to east in the village of Kibambura.	Moderate	Low Adverse
Low	0 to 30 m	Workers in fields	Low	Insignificant

Table 7-40: Potential Night-time Well Pad Impacts

Magnitude of Potential Impact	Predicted Distance of Noise Propagation from Site Boundary	Potential Affected Receptors	Sensitivity of Receptors	Potential Significance of Impact
High	0 to 25 m	**GNA-02** - 1 settlement 20 m to south in village of Kilyango. **GNA-04** - Approximately 5 settlements 13–23 m to south west in village of Avogera. 13–23 m. **NGR-01** - Approximately 1 settlement 10m to south in village of Kasinyi. **NGR-03A** - Approximately 12 settlements 10-25m to the north and east in the village of Kirama.	Moderate	High Adverse

Magnitude of Potential Impact	Predicted Distance of Noise Propagation from Site Boundary	Potential Affected Receptors	Sensitivity of Receptors	Potential Significance of Impact
		KGG-01 - Approximately 5 settlements 10-30m in village of Oriibo. **KGG-03** - Approximately 2 settlements in village of Beroya, 5m east and 5m north. **KGG-04** - Approximately 1 settlement 5m to north in village of Kichoke Bugana. **KW-02B** - Approximately 4 settlements 15m to the east in village of Kisiomo. **NSO-04** - Approximately 1 settlement 18m to east in village of Kibambura.		
Moderate	25 to 85 m	**GNA-01** - Approximately 1 settlement 78m to west in the village of Kisomere. **GNA-02** - Approximately 9 settlements 30 - 75m to south. Village of Kilyango. **GNA-04** - Approximately 3 settlements 25m to south west, and 1 settlement 80m to south east, in village of Avogera. **NGR-02 -** Approximately 1 settlement 50m to south east in village of Kasinyi. **NGR-03A -** Approximately 30 settlements surround the site, 25-80m away in the village of Kirama. **NGR-05A** - Approximately 1 settlement in village of Kirama. **KGG-01** - Approximately 7 settlements 40-84m in village of Oriibo. **KGG-03** - Approximately 3 settlements 45-65m away in village of Beroya. **KGG-04** - Approximately 1 settlement 50m to north in village of Kichoke Bugana. **KGG-09 -** Approximately 1 settlement 80m to north in village of Kijumbya. Approximately 1 settlement 80m to south in village of Kichoke Bugana. **KW-02A -** Approximately 1 settlement 60m to west in village of Kakindo. **KW-02B -** Approximately 3 settlements 35m to north and 1 to south in the village of Kisiomo. **NSO-02 -** Approximately 3 settlements 45-60m to south in village of Ngwedo farm. **NSO-04 -** Approximately 2 settlements 75m north west and 70m east in village of Kibambura.	Moderate	Moderate Adverse

Magnitude of Potential Impact	Predicted Distance of Noise Propagation from Site Boundary	Potential Affected Receptors	Sensitivity of Receptors	Potential Significance of Impact
		NSO-06 - Approximately 7 settlements 50-75m to north and west in village of Uduk I. Approximately 1 settlement 50m to east in village of Ngwedo farm.		
Low	85 to 375 m	**GNA-01 -** Approximately 174 settlements 89-375m away. Majority to north east, east and west. Village of Kisomere. **GNA-02** - Approximately 240 settlements 88-375m away in village of Kilyango. Majority to south west. **GNA-03** - Approximately 74 settlements 95-375m away in village of Uduk II. Majority to south. **GNA-04** - Approximately 237 settlements 90-375m away. Majority to east and some to north west. in village of Avogera. **NGR-01** - Approximately 1 settlement 320m to north east in village of Kasinyi. **NGR-02** - Approximately 6 settlements 95-130m to south east. **NGR-03A -** Approximately 170 settlements to north east in village of Kichoke Approximately 160 settlements to east and west in village of Kirama. Approximately 60 settlements to south in village of Kiyere. **NGR-05A -** Approximately 18 settlements180-330m to west in village of Kirama. **NGR-06** - Approximately 3 settlements 300m to west in village of Kigwera SE. **KGG-01** - Approximately 150 settlements 100-375m away in village of Oriibo. **KGG-03** - Approximately 5 settlements 80-305m to north and one to east in village of Beroya. **KGG-04** - Approximately 20 settlements 110-315m to north east in village of Kijumbya. **KGG-05** - Approximately 40 settlements 175-375m to south east in village of Gotlyech. **KGG-09** - Approximately 18 settlements 85-375m away in villages of Kijumbya and Kichoke Bugana. Majority to south and north west.	Moderate	Low Adverse

Magnitude of Potential Impact	Predicted Distance of Noise Propagation from Site Boundary	Potential Affected Receptors	Sensitivity of Receptors	Potential Significance of Impact
		KW-01 - Approximately 1 settlement 315m north east in village of Kizongi. **KW-02B** - Approximately 89 settlements 85-375m to north east and south. **NSO-01** - Approximately 1 settlement 340m to south in village of Ngwedo. **NSO-02** - Approximately 60 settlements 100-375m away around the site in the village of Ngwedo farm. **NSO-04** - Approximately 34 settlements 95-370m to the north and west in the village of Kibambura. **NSO-05** - Approximately 10 settlements 105-350m to north west in village of Kibambura. **NSO-06** - Approximately 5 settlements 215-320m to south east in village of Ngwedo farm. Approximately 240 settlements 100-375m to north, west and south west in village of Uduk I. **KW-02A -** Approximately 27 settlements 120-350m to the west, north and east in the village of Kakindo.		

The magnitude of potential impact is no greater than Low during the daytime for all well pads where potential impacts have been identified. During the night-time period, noise predictions have identified 32 receptors as experiencing a High magnitude and 77 receptors experiencing a Moderate magnitude of potential impact.

As the receptors identified are all of Moderate sensitivity, the significance of potential impacts during the worst case predicted daytime scenario will be **Low Adverse** or **Insignificant**. The significance of potential impacts during the worst case night time scenario will be **High Adverse** for 32 receptors and **Moderate Adverse** for 77 receptors. All other receptors are predicted to experience a potential impact of **Low Adverse** or **Insignificant** significance.

In addition, workers on land adjacent to the well pad sites may be affected by operational noise during the daytime. These workers are considered to be of Low sensitivity to noise so the significance of potential impact is identified as **Insignificant**.

7.6.5.2.3 Lake Albert Water Abstraction Point Noise

Identification of nearby receptors undertaken by Tilenga ESIA GIS experts showed that the closest human receptors to the Water Abstraction System onshore facility are located approximately 570 m away. This distance is sufficient that atmospheric attenuation of noise will result in a Negligible magnitude due to plant operating at the site. Consequently, the resultant significance of potential impact will be **Insignificant**.

7.6.5.2.4 Road Traffic Noise

As traffic movements during the Commissioning and Operational phase of the Project are not expected to exceed 20 movements per month, the resultant significance of potential impact is considered to be **Insignificant.**

7.6.5.2.5 Victoria Nile Ferry Crossing Operational Noise

As discussed in section 7.6.3.2.3, due to the separation distance to the nearest human receptor, the magnitude of impact due to an intensifying of river traffic will result in a Low magnitude of potential impact at Moderate sensitivity receptors which is considered to be of a **Low Adverse** significance.

7.6.5.3 Additional Mitigation – Commissioning and Operations Phase

Mitigation measures to control and reduce potential noise impacts during the Commissioning and Operations phase are summarised in Table 7-28.

7.6.5.4 Residual Impacts

The additional mitigation measures are commitments that will be adopted in the Commissioning and Operations Phase to minimise noise emissions. However, the level of mitigation achieved through the implementation of additional mitigation measures will be dependent on the layout design of the Project elements and the implementation of mitigation on high risk noise generating items of plant. It is possible that through implementation of an appropriate mitigation strategy prior to finalising designs, there is potential for removing significant impacts at nearby receptors. As there is uncertainty over how the exact level of noise reduction, a qualitative estimation on the potential reduction in impacts at nearby sensitive receptors has been undertaken where implementation of additional mitigation is conservatively estimated as being equivalent to a reduction of one order of impact significance.

A summary of the residual noise impacts taking into account additional mitigation is provided in Table 7-41.

Table 7-41: Commissioning and Operations Residual Impacts - Noise

Source of Potential Impact	Magnitude of Potential Impact	Sensitivity of Receptors	Significance of Potential Impact	Significance of Residual Impact
CPF Option 1 Noise – Daytime	Negligible	Moderate	Insignificant	**Insignificant**
CPF Option 1 Noise – Night-time	Negligible to Moderate	Moderate	Moderate Adverse	**Low Adverse**
CPF Option 2 Noise – Daytime	Negligible	Moderate	Insignificant	**Insignificant**
CPF Option 2 Noise – Night-time	Negligible to High	Moderate	High Adverse	**Moderate Adverse**
Daytime Well Pad Noise – South of Victoria Nile	Negligible to Low	Moderate	Low Adverse	**Insignificant**
Daytime Well Pad Noise – North of Victoria Nile	Negligible	Moderate	Insignificant	**Insignificant**
Night-time Well Pad Noise – South of Victoria Nile	Negligible to High	Moderate	High Adverse	**Moderate Adverse**
Night-time Well Pad Noise – North of Victoria Nile	Negligible	Moderate	Insignificant	**Insignificant**
Lake Albert Water Abstraction Station Noise	Negligible	Moderate	Insignificant	**Insignificant**
Road Traffic Noise	Negligible	Moderate	Insignificant	**Insignificant**
Victoria Nile Ferry Crossing Noise	Low	Moderate	Low Adverse	**Insignificant**

7.6.6 Assessment of Impacts: Decommissioning

7.6.6.1 Introduction

This section considers the potential noise impacts that may occur during decommissioning, which is scheduled for 25 years after the Project has been completed. The following activities are considered during decommissioning:

- Vehicle movements;
- The demolition of facilities and infrastructure;
- Equipment and vehicle movements; and
- Earthworks.

7.6.6.2 Potential Impacts (pre mitigation) – Decommissioning

It is considered that these activities are similar to those considered during the Site Preparation and Enabling Works and Construction and Pre-Commissioning phases. Consequently, the potential for significant impacts during the Decommissioning phase is considered to be equivalent to those identified in those respective sections of this chapter to be comparable to a worst case.

7.6.6.3 Additional Mitigation

Mitigation measures to control and reduce potential noise impacts during the Decommissioning phase are summarised in Table 7-28.

7.6.6.4 Residual Impacts – Decommissioning

The residual impacts are considered equivalent to those identified during the Site Preparation and Enabling Works phase and the Construction and Pre-Commissioning phase.

7.7 In-Combination Effects

As described in ***Chapter 4: Project Description and Alternatives***, the Project has a number of supporting and associated facilities that are being developed separately (i.e. they are subject to separate permitting processes and separate ESIAs or EIAs). These facilities include:

- Tilenga Feeder Pipeline;
- East Africa Crude Oil Export Pipeline (EACOP);
- Waste management storage and treatment facilities for the Project;
- 132 Kilovolt (kV) Transmission Line from Tilenga CPF to Kabaale Industrial Park; and
- Critical oil roads.

As these facilities are directly linked to the Project and would not be constructed or expanded if the Project did not exist, there is a need to consider the in-combination impacts of the Project and the supporting and associated facilities. This is distinct from the Cumulative Impact Assessment which consider all defined major developments identified within the Project's Area of Influence (and not just the associated facilities) following a specific methodology which is focussed on priority Valued Environmental and Social Components (VECs) (see ***Chapter 21: Cumulative Impact Assessment***).

The in-combination impact assessment considers the joint impacts of both the Project and the supporting and associated facilities. The approach to the assessment of in-combination impacts is presented in ***Chapter 3: ESIA Methodology*****,** Section 3.3.5.

The identified residual impacts of the Project listed in Table 7-42 below are predicted to have the potential to be exacerbated due to in-combination effects with supporting and associated facilities. A comment is provided on the potential in-combination impacts and the need for additional collaborative mitigation between Project Proponents to address these impacts.

Table 7-42: In-Combination Impacts

Description of Potential Impact of Project	Comment on potential in-combination effects with associated facilities	Comment on the need for additional collaborative mitigation
Noise and vibration due to site clearance and construction activities	It is anticipated that site clearance and construction activities for associated facilities will be undertaken in a similar timeframe to the Project. Consequently, should works on Project facilities and associated facilities be undertaken in close proximity to each other, nearby receptors have the potential to experience in-combination effects.	Project Proponents will invite other developers to participate in joint planning initiatives with local government and other relevant stakeholders, and will continue to share best practices to allow other developers to learn from successful implementation of mitigation measures addressing noise. Where feasible, other developers will be invited to invest expertise or resources in the joint implementation of initiatives addressing these impacts. Project Proponents will invite other developers to participate in joint planning initiatives with local government and other relevant stakeholders to optimise traffic flows in consideration of required vehicle movements for all developments.
Operational noise from CPF and well pads	Noise generated by the operation of the waste management storage and treatment facilities has the potential to result in in-combination effects. The potential for in-combination effects is dependent on the location of the waste management storage and treatment facilities in relation to Project facilities and nearby sensitive receptors.	It is anticipated that sensible locating and design of waste management storage and treatment facilities can suitably reduce the potential for in-combination effects. Currently identified waste treatment facilities are not located within the project Area and thus no adverse in-combination effects are expected.

7.8 Unplanned Events

The assessment of Unplanned Events is covered in more detail in ***Chapter 20: Unplanned Events***. There are two options considered for emergency flaring; an enclosed option and an elevated option. Noise from emergency flaring operations has been assessed in line with Project criteria based on available information regarding maximum flaring noise during emergency situations (as described in section 7.6.1.4.6).

A noise contour plot detailing the results of noise predictions of emergency flaring events for the elevated flare option is presented in Figure I5-1 of Appendix I. The noise contours have been analysed to identify sensitive receptors that may be affected by noise through consideration of buffers around the Industrial Area defined by the largest distance from each contour band (representing magnitude of impacts) to the site boundary. The sensitive receptors were identified by Tilenga ESIA GIS experts using data gathered during both AECOM EBS and Tilenga ESIA baseline surveys, plus those of Artelia Eau and Environment (as detailed in ***Chapter 16: Social***).

A figure detailing the analysis undertaken to identify sensitive receptors is presented in Figure I5-2 of Appendix I. Detailed results of analysis identifying affected sensitive receptors during the night-time period are presented in Table 7-43 for the daytime period and Table 7-44 for the night-time period.

Table 7-43: Potential Daytime Flaring Event Impacts – Elevated Flare

Potential Impact Magnitude	Predicted Distance of Noise Propagation from Site Boundary	Potentially Affected Receptors	Sensitivity of Receptors	Significance of Impact
High	Within site boundary	None	-	-
Moderate	0 to 350 m	Approximately 15 settlements in Uduk II Approximately 28 settlements in Kasinyi	Moderate	**Moderate Adverse**
Low	350 to 825 m	Approximately 33 settlements in Kasinyi Approximately 1 settlement in Kibambura	Moderate	**Low Adverse**

Table 7-44: Potential Night-time Flaring Event Impacts – Elevated Flare

Potential Impact Magnitude	Predicted Distance of Noise Propagation from Site Boundary	Potentially Affected Receptors		Sensitivity of Receptors	Significance of Impact
		Settlements	Healthcare		
High	0 to 1,350 m	Approx. 150 settlements to north in village of Kasinyi Approx. 12 settlements to east in village of Kisomere Approx. 16 settlements to south in village of Uduk II Approx. 1 settlement to south in village of Kibambura	None	Moderate	**High Adverse**
Moderate	1,350 to 2,250 m	Approx. 135 settlements to north in village of Kasinyi Approx. 300 settlements to east in village of Kisomere Approx. 150 settlements to east in Uduk II	None	Moderate	**Moderate Adverse**
Low	2,250 to 3,300 m	Approx. 6 settlements to east in village of Kirama Approx. 45 settlements to north in village of Kasinyi Approx. 450 settlements to north east in village of Kisomere Approx. 80 settlements to east in village of Avogera Approx. 140 settlements to east in village of Uduk II Approx. 300 settlements to east in village of Uduk I Approx. 35 settlements to south in village of Ngwedo Approx. 1 settlement to south in village of Kibambura	None	Moderate	**Low Adverse**

During the day, 43 receptors are predicted to experience a Moderate magnitude of potential impact. This is equivalent to **Moderate Adverse** significance at Moderate sensitivity receptors.

Worst case potential impacts are predicted to occur during the night-time period with High magnitude of impact predicted at approximately 179 receptors. This is equivalent to **High Adverse** significance at Moderate sensitivity receptors. There are 585 receptors predicted to experience a Moderate magnitude of impact. This is equivalent to **Moderate Adverse** significance at Moderate sensitivity receptors.

Emergency flaring events would occur in the Commissioning and Operation phase of the Project, and the communication strategies outlined as additional mitigation measures during that phase should be adopted for emergency flaring i.e.:

- Where possible, informing stakeholders regarding timing of key activities associated with the Project on a regular basis, particularly when noise is expected to be generated;
- Implementing a Grievance Mechanism Procedure, to allow recording and follow up of any complaints related to Project activities, in a timely manner; and
- Monitoring of noise levels associated with Project activities to be undertaken by the Project contractor (as part of the Environmental Monitoring Programme). This will include monitoring noise levels at nearby sensitive receptors;

These procedures should be developed where appropriate with nearby settlements to ensure affected residents understand the need for unplanned flaring events and their duration (which would be for a maximum of 48 hrs at any one time, and expect to be for no more than 7% of the year). Prior warning should be provided to residents before any maintenance is undertaken. Consequently, the potential residual impact of flare maintenance and emergency flaring is considered to be **Moderate Adverse**.

The enclosed option is likely to result in a lower impact than the elevated emergency flaring option. As information provided indicates that the enclosed flare will be designed in line with noise requirements for all plant (85 dB $L_{Aeq,T}$ at 1 m), noise form the enclosed flare will not result in increased noise levels over the worst case assessment of CPF noise. Consequently, in the context of noise generated by CPF plant, the enclosed flare noise is considered to be a Negligible magnitude. This corresponds to an **Insignificant** impact at Moderate sensitivity receptors.

Table 7-45 provides a summary of the residual impacts during unplanned events.

Table 7-45: Summary of Unplanned Events Impacts

Source of Potential Impact	Magnitude of Potential Impact	Sensitivity of Receptors	Significance of Potential Impact	Significance of Residual Impact
Elevated Emergency Flaring – Daytime	Negligible to Moderate	Moderate	Moderate Adverse	**Low Adverse**
Elevated Emergency Flaring – Night-time	Negligible to High	Moderate	High Adverse	**Moderate Adverse**
Enclosed Emergency Flaring – Daytime	Negligible	Moderate	Insignificant	**Insignificant**
Enclosed Emergency Flaring – Night-time	Negligible	Moderate	Insignificant	**Insignificant**

7.9 Cumulative Impact Assessment

Chapter 21: Cumulative Impact Assessment (CIA) provides an assessment of the potential cumulative effects of the Project together with other defined developments in the Project AOI. The CIA focussed on VECs that were selected on the basis of set criteria including the significance of the potential effects of the Project, the relationship between the Project and other developments, stakeholder opinions and the status of the VEC (with priority given to those which are of regional concern because they are poor or declining condition). Whilst no specific priority VEC were selected directly as a result of noise and vibration considerations, a number were selected based on the potential impacts upon the local animal population and these are considered within ***Chapter 21: Cumulative Impact Assessment***.

Overall, potential noise impacts are in their nature localised and each cumulative scheme will put measures in place to reduce the occurrence of any adverse impacts associated with noisy activities. This factor, coupled with the unlikely event that noise generating activities will occur on different projects at the same time at a close location to each other, mean that no significant noise and vibration cumulative impacts are anticipated.

7.10 Conclusions

Impact assessment criteria were developed and utilised for assessing the potential noise and vibration impacts from the Site Preparation and Enabling Works, Construction and Pre-Commissioning, Commissioning and Operations; and Decommissioning phases of the Project, and include impact magnitude and receptor sensitivity. The assessment of potential impacts has been undertaken by identifying and evaluating a range of activities and scenarios that are likely to occur throughout the four phases of the Project.

The majority of residual impacts over each phase of the Project have been identified as being not significant. However, a small number of significant, Moderate Adverse significance impacts have been identified for the following activities:

- Construction and Pre-Commissioning Phase – Night-time Well Drilling Noise (South Nile) and Option 1 HDD Noise;
- Commissioning and Operations Phase – Night-time CPF Option 2 Noise;
- Commissioning and Operations Phase – Night-time Well Pad Noise (South Nile); and
- Unplanned Events – Night-time Emergency Flaring (Elevated Flare).

Well drilling will last for approximately 11 days at each well location with up to 22 wells located at a site. Additional mitigation measures will be implemented to help reduce the residual impacts to a Moderate Adverse significance. It is recommended that during the detailed engineering phase the present noise study is refined by the selected drilling contractor(s) and based on selected vendor data so that mitigations are addressed accordingly to minimize the noise impact at receptors at acceptable noise level.

CPF Option 2 represents a worst case CPF site layout with high noise generating plant located in the north-east of the site, which is the nearest location to receptors. Given that residual impacts for CPF Option 1 have been identified as Low Adverse and thus an acceptable option, consideration of the location of high noise generating plant in relation to nearby receptors should be taken in the final CPF layout design.

Should the elevated flaring option be chosen, significant noise impacts are predicted to occur during emergency flaring, which may last up to 48 hours. The frequency of flaring events will require high plant reliability and therefore performance in the event of an emergency is the focus of design ahead of noise mitigation. Consequently, education, awareness, and provision of information regarding Project activities, including unplanned flaring events, will be provided for the local population, particularly when noise is expected to be generated.

Based on information provided, noise from the enclosed flaring option is considered to be Insignificant; however, this is expected to be confirmed during further detailed design work, should this option be selected.

7.11 References

Ref. 7-1 Government of Uganda, (2013); The National Environment (Noise and Vibration Standards and Control) Regulations.

Ref. 7-2 World Health Organisation, *Guidelines for Community Noise,* (1999).

Ref. 7-3 IFC (2007a) Performance Standard 3, Resource Efficiency and Pollution Prevention.

Ref. 7-4 IFC (2012) Environmental, Health, and Safety Guidelines – General EHS Guidelines: Environmental – Noise Management.

Ref. 7-5 British Standards Institute (2014), BS 5228-1:2009+A1:2014 – Code of practice for noise and vibration control on construction and open sites. Part 1: Noise.

Ref. 7-6 British Standards Institute (2014); BS 5228-2 – Code of practice for Noise and Vibration control on construction and open sites. Part 2: Vibration.

Ref. 7-7 Total E&P Uganda/ AECOM, *Environmental Baseline Study for Block 1 in Uganda, Volume 1,* (2015).

Ref. 7-8 Air Water Earth ltd., *Noise Measurements Report for Bugungu Camp*, (2013).

Ref. 7-9 Air Water Earth ltd., *Noise Monitoring Report for Gunya-2 Well Testing*, (2013).

Ref. 7-10 Air Water Earth ltd., *Noise Monitoring Report for Gunya-3 Well Testing*, (2013).

Ref. 7-11 Air Water Earth ltd., *Noise Monitoring Report for Jobi East-1 Drill Pad*, (2013).

Ref. 7-12 Air Water Earth ltd., *Noise Monitoring Report for Jobi East-7 Well Site*, (2013).

Ref. 7-13 Air Water Earth ltd., *Noise Monitoring Report for Mpyo-5 Well Site*, (2013).

Ref. 7-14 Air Water Earth ltd., *Noise Monitoring Report for Mpyo-F Well Site during Wireline Testing with OGEC IRR-600 rig and Flow Testing with ZPEB 26 Rig*, (2013).

Ref. 7-15 International Standards Organisation, (1996); ISO 9613, Acoustics -- Attenuation of sound during propagation outdoors.

Ref. 7-16 Society of Automotive Engineers, (1995); Aerospace Information Report 1845, Procedure for the Calculation of Airplane Noise in the Vicinity of Airports.

Ref. 7-17 European Civil Aviation Conference, (2005); Doc 29, 3rd Edition, Report on Standard Method of Computing Noise Contours around Civil Airports.

Ref. 7-18 International Civil Aviation Organisation, (2008); Doc 9911 Recommended Method for Computing Noise Contours Around Airports Edition 1.

Ref. 7-19 Lukano & Macuba, The Influence of Prospecting Unconventional Hydrocarbon Reservoirs on the Acoustic Climate, AGH University of Science and Technology.

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08 – Geology and Soils

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8 Geology and Soils

8.1 Introduction

This Environmental and Social Impact Assessment (ESIA) Chapter presents an assessment of the potential impacts upon the existing soil and geology within the Project Area associated with the development. It also includes a detailed overview of the existing baseline conditions which are found within the Project Area and Project Area of Influence (AoI). Addressed in the assessment are the potential impacts associated with Site Preparation and Enabling Works, Construction and Pre-commissioning, Commissioning and Operations and Decommissioning phases of the Project.

8.1.1 Geology

The Albertine Graben is the principal prospective area for petroleum in Uganda and forms the northern part of the western arm of the East African Rift System (EARS), stretching over 500 kilometres (km) from the border with South Sudan in the north to Lake Edward in the south, covering an area of over 21,000 square kilometres (km²). The Albertine Graben is a Cenozoic rift basin, started during the late Oligocene/Early Miocene and developed on the Precambrian orogenic belts of the African Craton. The geological setting of the Albertine Graben consists of thick sequences of gneiss, schist derived sandstones and shales. The stratigraphy of the Albertine Graben is largely comprised of fluvial-deltaic and lacustrine deposits. The Albertine Graben has undergone several tectonic episodes of both extensional and compression regimes; evidence of these movements are seen through the fault systems defining the basins (Ref. 8-1).

8.1.2 Soils

Exploration Area 1A (EA-1A), Contract Area 1 (CA-1, formerly EA-1) and License Area 2 (LA-2 North, formerly EA-2 North) are located within the Pakwach Basin which is composed of rift sediments with a north-south trend. Soil is an unconsolidated material derived from rocks and organic materials. The major factors in the formation of soils are the parent rock material, climate and vegetation. Soils are formed by weathering which results in erosion due to rain and wind of the parent rock materials over time. The biological organisms in the soil contribute to the decomposition of organic materials providing nutrients for vegetation.

The old age and acidic nature of the rocks help to explain the relative nutrient poverty of the soils and relative flatness of the region (Ref. 8-2).

The Albertine Graben region is prone to soil erosion due to the combination of high intensity rainfall, sandy soils with high rates of water infiltration and a relatively impervious underlying clay layer. This, along with the high levels of herbivore grazing which affects the vegetation mat binding the soil, has resulted in serious gully erosion. One of the significant consequences of soil erosion is the increased sediment loading on lakes and rivers. Little is known about sediment loads and siltation in Uganda, as well as its relation to land-use practices. The national water quality monitoring programme measures sediment loads in rivers, but the data are insufficient to allow area-specific sediment loads to be determined (Ref. 8-3).

Previous soil surveys confirmed the presence of mainly fine acidic, loam sand-silty soils with variable permeability and, in some cases, severe signs of erosion in the EA-1A/CA-1 areas. Within LA-2 North soils are fairly similar, comprising mainly sands and clays. The sands are mostly unconsolidated, and are coarse to medium grained white clays, intercalated with sands, and are of varying composition. Ferralitic soils are known to cover a significant part of the South Nile area. Soils and sediments within river valleys comprise peaty sands and clays as well as reddish brown clay loams overlaying murram and ironstone.

8.2 Scoping

The Scoping process identified the potential impacts to geology and soils that could occur as a result of the construction, operation and decommissioning of the Project. These potential impacts are summarised in Table 8-1. It is worth noting that the Project phasing and identified list of potential impacts have evolved during the completion of this ESIA and consequently build and expand on those originally identified in Table 8-1 during the Scoping phase.

Table 8-1: Potential Geology and Soils Impacts

Potential Impact	Potential Cause	Potential Sensitivity	Phase
Potential impacts on soils physical, chemical and biological properties.	All construction/ decommissioning activities undertaken at Well Pads, central processing facility (CPF), Water Abstraction System, pipeline routes and Waste Storage areas.	Locations within the Project Area including agricultural areas and those within the Murchison Falls National Park (MFNP), and other sensitive ecological areas within close proximity to the construction / decommissioning works.	Construction Decommissioning
Potential for contamination.	All construction activities undertaken at Well Pads, CPF, Water Abstraction System, pipeline routes and Waste Storage areas. Operational activities including storage and use of fuels or other chemicals/ materials.	Locations within the Project Area including agricultural areas and those within the MFNP, and other sensitive ecological areas within close proximity to the construction / decommissioning works.	Construction Operation Decommissioning
Potential loss of top soil (i.e. soil erosion).	All construction / decommissioning activities undertaken at CPF, Well Pads, Water Abstraction System, pipeline routes and Waste Storage areas.	Locations within the Project Area including agricultural areas and those within the MFNP, and other sensitive ecological areas within close proximity to the construction works.	Construction Decommissioning

8.3 Legislative Framework

All relevant environmental standards prescribed in accordance with the National Environment Act Cap 153 (Ref. 8-4) and national regulations shall apply to the Project. Wherever applicable, the national standards shall take precedence over international standards unless such relevant standards do not exist.

8.3.1 National Legislative Framework

Chapter 2: Policy, Regulatory and Administrative Framework outlines the policies, laws, regulations, standards and international conventions that apply to the environmental, health, human rights and social aspects of the Project. The requirements stipulated within this framework encompass all phases of the Project. The framework includes both national legislation and international treaties and agreements to which Uganda is a signatory. The legislation and guidelines relevant to soils and geology are provided below:

- National Environment Management Policy;
- National Policy for the Conservation and Management of Wetland Resources;
- The National Environment Act, Cap. 153;
- The Environmental Impact Assessment Regulations, 1998;
- The National Environment (Minimum Standards for Management of Soil Quality) Regulations, 2001; and
- The National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations (1st Revised Draft), 2014.

8.3.1.1 National Standards Related to Soils and Geology

The potentially relevant national environmental standards related to soils and geology and applicable to the proposed Project and its environmental aspects, prescribed in accordance with the National Environment Act Cap 153 and national regulations, are the following:

- Soil Quality Parameters – First Schedule to the National Environment (Minimum Standards for Management of Soil Quality) Regulations, 2001 (Republic of Uganda, 1999) (Ref. 8-5); and
- National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations, S.I. No 5/1999, 1st Revised Draft, 2014 (Ref. 8-6).

Uganda does not have regulations or standards that establish safe levels of potential soil contaminants that could represent a potential threat to human health nor are there standards associated with land remediation. In the absence of Ugandan standards, international standards established for safe levels of contaminates would be used as surrogate standards for land remediation (Section 8.3.2). The National Environment (Minimum Standards for Management of Soil Quality) Regulations, 2001, set forth minimum soil quality standards for maintaining and restoring the productivity of soil. These standards apply to categories of agricultural practices including rain-fed agriculture, irrigated agriculture, irrigated rice systems, and natural flood rice systems. Minimum standards for rain-fed agriculture (the most common form practiced in the Project Area) are specified for bulk density, porosity, infiltration rate, permeability, slope, stoniness, soil depth, flooding/duration, and depth to water table. The Project Proponents will be required to ensure that any soils within the Project Area which will be used for agricultural purposes either during the lifetime of the Project (e.g. within the Pipeline and Injection Network Rights of Way) or following Decommissioning and site restoration, will comply with the agricultural standards for the relevant category.

Standards for Discharge of Effluent or Wastewater, 1999 include maximum permissible levels of various chemical and physical parameters including metals, semi-volatile organic compounds amongst others that can be present in liquid discharges to the environment (Ref. 8-6).

8.3.1.2 National Guidelines Related to Geology and Soils

In addition to national laws and regulations, further guidance on ESIA practice in Uganda related to soils and geology is provided through a number of general and sector-specific guidelines that include:

- Guidelines for Environmental Impact Assessment in Uganda (National Environment Management Authority (NEMA) 1997) (Ref. 8-7);
- Environmental Impact Assessment Guidelines for the Energy Sector, 2004 (Ref. 8-8); and
- Operational Waste Management Guidelines for Oil and Gas Operations (NEMA 2012) (Ref. 8-9).

The Guidelines for Environmental Impact Assessment describe the recommended approach to all aspects of the ESIA, including stakeholder engagement and public participation, report structure and presentation, baseline studies and mitigation measures. The Environmental Impact Assessment Guidelines for the Energy Sector provides mitigation measures which will be taken into consideration and included as appropriate during the impact assessment. The guidelines also address typical types of monitoring requirements during all phases of an energy project which will be considered in the Environmental and Social Management Plan (ESMP). Operational Waste Management Guidelines confirms the absence of Ugandan standards for solid (soil) waste disposal and provides direction that in the absence of Ugandan national standards the United Kingdom (UK) standards for solid disposal be adopted until the Ugandan Standards have been developed. It also provides methodologies and strategies for handling oil and gas exploration and production wastes including managing drilling wastes. The UK Guideline Values for soils are presented in Table 8-2.

8.3.2 International Standards and Guidelines

8.3.2.1 IFC Performance Standards and Guidelines

International Finance Corporation (IFC) Performance Standards (PSs) on Environment and Sustainability (Ref. 8-10) are directed towards project developers, providing guidance on how to identify risks and impacts, and are designed to help avoid, mitigate, and manage risks and impacts as a way of doing business in a sustainable way, including stakeholder engagement and disclosure obligations for the Project. IFC PSs that are applicable to geology and soil resources include:

- *IFC PS 1: Assessment and Management of Environmental and Social Risks and Impacts* - establishes requirements for social and environmental performance management throughout the life of a project; and

- *IFC PS 3: Resource Efficiency and Pollution Prevention* - defines an approach to pollution prevention and abatement in line with current internationally disseminated technologies and good practice.

IFC Environmental Health and Safety (EHS) Guidelines (IFC, 2007) (Ref. 8-11) are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). The General EHS Guidelines (IFC 2007) provide requirements associated with Wastewater, Hazardous Materials Management, Waste Management and Contaminated Land (Ref. 8-11).

The EHS Guidelines for Onshore Oil and Gas Development (IFC, 2007) (Ref. 8-12) and EHS Guidelines Onshore Oil and Gas Development (Draft) April 2017 (Ref. 8-13) include information relevant to exploration and production drilling; development and production activities; transportation activities including pipelines; other facilities including pump stations, metering stations, pigging stations, compressor stations and storage facilities; ancillary and support operations; and decommissioning.. These guidelines address management of the following EHS issues that are relevant to geology and soils: wastewater/effluent discharges, solid and liquid waste management, terrestrial impacts and project footprint, and spills. There are no specific soils standards that can be used for comparison to assess soil quality.

The EHS Guidelines for construction materials extraction (IFC, 2007) provide specific requirements associated with land conversion. It notably requires that affected land is rehabilitated to acceptable uses consistent with local or regional land use plans; and that land that is not restored for a specific community use should be seeded and revegetated with native species (Ref. 8-14).

When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. Furthermore, the IFC Performance Standards on Environmental and Social Sustainability (IFC, 2012.) suggest that, where none exist nationally, internationally recognised standards should be used. EHS guidelines related to discharge of effluents and project applicable standards are presented in ***Chapter 9: Hydrogeology***.

8.3.2.2 United Kingdom Soil Guideline Values

The NEMA Operational Guidelines for Oil and Gas Operations (Ref. 8-15) confirms the absence of Ugandan standards for solid (soil) waste disposal and provides direction that in the absence of Ugandan national standards the United Kingdom standards for solid disposal have been adopted until the Ugandan Standards have been developed. The UK Department for Environment, Food and Rural Affairs and the UK Environment Agency have published a series of Soil Guideline Values (SGVs) (Ref. 8-16).

A SGV is a contaminant concentration in soil, below which no harm will occur i.e. a ‘safe level’. If soil concentrations are above a SGV this indicates to a risk assessor that more assessment is required, or, intervention may be necessary to protect human health. SGVs have been derived using the Contaminated Land Exposure Assessment model produced by the Environment Agency. The primary purpose of an SGV is to assist risk assessors in determining unacceptable chronic risks (long-term) to human health from land contamination (Jeffries, J, 2009) (Ref. 8-17).

8.3.2.3 USEPA Soil Screening Levels

Ugandan standards for soil quality have been established, although they do not establish health-based regulatory limits that are applicable to contaminated land/soils. International guidelines such as United States Environmental Protection Agency (USEPA, 2017) Regional Screening Levels (RSLs) (Ref. 8-18) can be helpful in evaluating soil quality, and identifying the potential risk to human health posed by exposure to contaminated soil. RSLs were developed to assess the risk posed by contaminants at a site. They are risk-based concentrations derived from standardised equations combining exposure information assumptions with USEPA toxicity data. They do not constitute enforceable standards, but are useful to determine whether additional investigations at contaminated sites, and possibly response actions, are warranted (USEPA, 2017) (it is possible that some chemicals can occur naturally in soil at levels above RSLs, therefore an RSL exceedance does not always mean that contamination has occurred).

RSLs have been developed for chemical constituents commonly found in crude oil and refined petroleum products, including:

- Heavy metals, such as lead, cadmium, chromium, arsenic and selenium;
- Organic compounds, such as:
  - Polynuclear aromatic hydrocarbons (PAHs – organic compounds comprised of two or more benzene rings);
  - Mono-aromatic hydrocarbons (benzene, toluene, ethyl benzene, and xylenes (BTEX) – organic compounds derived from one benzene ring); and
  - Other petroleum hydrocarbons.

Soil quality data can be compared to USEPA RSLs to assess the presence of potentially toxic concentrations of soil constituents due to anthropogenic impacts (i.e. community activities, agricultural activities, oil exploration, waste management) or natural background conditions. The results of this comparison can be used to identify areas that have been contaminated due to human activities, and to establish background concentrations to assess the potential impact of future development.

Different sets of RSLs were developed for residential and industrial land use, taking into account potential receptors and exposure scenarios in each setting. Residential RSLs can be used as a conservative, preliminary tool for screening soil quality data to identify potential concerns. In some areas, it is possible that naturally occurring levels of some constituents can exceed one or more constituent-specific RSLs. In these cases, it is important to understand the background concentrations of potentially toxic constituents to determine whether or not they are present naturally, or if contamination has occurred. Establishing a baseline dataset of background soil quality prior to development will identify areas where constituent concentrations are naturally elevated and aid in evaluating the potential impact of future development. There are RSLs for soils for over 800 constituents. RSLs for Residential Soils for constituents that are commonly associated with oil and gas activities, including construction activities are presented in Table 8-2.

The UK Guideline values apply to soils that are intended for re-use or disposal. The RSLs for Residential Soils apply to the protection of human health (USEPA, 2017) (Ref. 8-19). Humans should not be exposed to soils with contaminant concentrations above the RSL limits.

Table 8-2: International Soils Standards

Soil Parameter	UK Soil Guideline Values[1]	USEPA Residential RSL[2]
BTEX (mg/kg)		
Benzene	0.33	1.2
Ethylbenzene	350	5.8
Toluene	610	4,900
m-Xylene	240	550
p- Xylene	230	560
o-Xylene	250	650
Xylenes, total	-	580
Petroleum Hydrocarbons: mg/kg		
C5-C8 Petroleum Hydrocarbons (aliphatic low)	-	520
C9-C18 Petroleum Hydrocarbons (aliphatic medium)	-	96
C19-C32 Petroleum Hydrocarbons (aliphatic high)	-	230,000
C21-C30 Petroleum Hydrocarbons	-	-
C30-C35 Petroleum Hydrocarbons	-	-
C35-C40 Petroleum Hydrocarbons	-	-
Total Petroleum Hydrocarbons	-	-

Soil Parameter	UK Soil Guideline Values[(1)]	USEPA Residential RSL[(2)]
Metals: mg/kg		
Antimony	-	31
Arsenic	32	0.68
Barium	-	15,000
Beryllium	-	160
Cadmium	10	71
Chromium	-	120,000
Cobalt	-	23
Copper	-	3,100
Lead	-	400
Mercury (elemental)	1	11
Mercury (Inorganic Hg2+)	170	-
Methyl Mercury (MeHg+)	11	7.8
Molybdenum	-	390
Nickel	130	1,500
Selenium	350	390
Strontium	-	47,000
Tin	-	47,000
Uranium	-	16
Vanadium	-	390
Zinc	-	23,000
Polynuclear Aromatic Hydrocarbons: mg/kg		
Acenaphthene	-	3,600
Acenaphthylene	-	-
Anthracene	-	18,000
Chrysene	-	110
Fluorene	-	2,400
Phenanthracene	-	-
Pyrene	-	1,800
General Chemistry: mg/kg		
Nitrate (NO_3)	-	130,000
Nitrate (as N)	-	-
Nitrite (NO_2)	-	7,800
Nitrite (as N)	-	-

Note: Sources: 1) UK Environment Agency 2010, *Soil Guideline Values*, May 2010, retrieved from http://www.esdat.net/Environmental_Standards.aspx July 2017 (Ref. 8-16) and 2) https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-june-2017 USEPA. 2017. *Regional Screening Levels (RSLs) - Resident Soil Table*. (Ref. 8-19).

8.4 Spatial and Temporal Boundaries

The Project is part of the oil and gas development being undertaken in the Lake Albert region. This ESIA Report relates specifically to the development of the EA-1A / CA-1 and LA-2 North fields (within Buliisa and Nwoya districts) referred to as the 'Project'. The Project Area covers approximately 110,000 hectares. The Project Area therefore includes the land located within the boundaries of EA-1A, CA-1 and LA-2 North areas. The Project AoI is defined as the area which covers the Project Area and a wider area over which the Project may have an influence and is discussed in more detail in ***Chapter 1: Introduction***.

Specifically, for soils and geology the Study Area is considered to encompass the key elements of the Project footprint and immediate surrounds having the potential to affect local soils and geology i.e. well pad locations, pipeline corridors, access roads, Industrial Area, camps and nearby sensitive receptors.

In the wider context, the Project is located at the northern end of the Albertine Graben, the principal prospective area for petroleum in Uganda, and forms the northern part of the western arm of the EARS, so the regional context for soils and geology is also important (e.g. including the regional structural; seismic and volcanic activity; physical and chemical properties and the distribution and characteristics of soils and bedrock) and has been considered. A regional context is provided as seismic and volcanic activity is not localised and can have an impact on the Project footprint. Soils and bedrock properties are provided as an indication of the characteristics that are anticipated within the Project Area.

The proposed timescales for the different phases of the Project are set out in ***Chapter 4: Project Description and Alternatives***. A brief summary of the timescales are provided below:

- Site Preparation and Enabling Works Phase expected to take approximately 5 years;
- Construction and Pre-Commissioning is expected to take up to 7 years;
- Commissioning and Operation is expected to commence approximately 36 months after effective date of the main construction contract award. The lifetime of the Project is 25 years; and
- Decommissioning is planned for the end of the 25 year operation.

The duration of activities which may lead to potential soil and geology impacts differ between short and long term episodes all of which are included within the assessment.

8.5 Baseline Data

8.5.1 Introduction

This section of the soils and geology chapter presents details regarding the collection of baseline data for the Study area.

The soils and geology topic covers geology and geomorphology, soil quality, soil erosion, natural oil seeps, seismicity and volcanism. The following types of data are relevant to the soils and geology baseline:

- Geological and geomorphological data to understand the structural context of the study area;
- Properties and distribution of soil types, and soil and bedrock characteristics to define the physical context of the study area;
- The presence of seismic and volcanic zones that could compromise the stability of structures and facilities;
- Soil quality/composition data to define background quality, potential use during Project activities, and appropriate corrective actions to prevent contamination and indirect impacts on other components (water and biodiversity);
- Naturally occurring and anthropogenic hydrocarbon occurrences in the study area to define existing background conditions prior to future development; and
- Physical and environmental characteristics affecting the risk of soil erosion from future development.

Baseline information was gathered from numerous sources - both secondary and primary, and used to identify the prevalent baseline conditions for soils and geology. Baseline soil surveys were undertaken through previous AECOM campaigns in 2014. These surveys were supplemented with a campaign undertaken in June 2017 to further establish baseline conditions.

Secondary sources included reports, Geographic Information System (GIS) data and raw data sets, such as:

- Total Exploration & Production (E&P) Uganda B.V (TEP Uganda) GIS datasets and reports;
- Tullow Uganda Operations Pty Ltd (TUOP) GIS datasets and reports;
- Other GIS data;
- Satellite images;
- Other readily available published books, reports and scientific literature;
- Ugandan government publications (referred to throughout the chapter); and
- Internet websites.

The TEP Uganda and TUOP reports include many Environmental Impact Assessments (EIAs) for the exploration phase activities in the Project Area as well as project briefs, interim reports and draft reports of ongoing studies as well as the scopes of work for planned studies not yet initiated. Furthermore, many of the reports held in the libraries of TEP Uganda and TUOP have been produced by a broad range of public and private organisations, institutions and government ministries and consulting firms.

Soils data from the previous surveys conducted within EA-1A/CA-1 and LA-2 North provide an indication of the overall status of soils characteristics and quality but do not cover all of the Project Area of Influence and thus does not adequately characterise soils characteristics and quality in the vicinity of all Project elements and sensitive receptors. Hence, additional soils field survey work was performed as part of the ESIA to ensure sufficient information is available to accurately characterise the existing baseline soils quality conditions within the Project Area and allow any potential impacts associated with the development plan to be assessed.

8.5.1.1 Data Gap Analysis

A data gap analysis was undertaken during the scoping phase of the Project which reviewed available information sources to identify any areas for which further data collection would be advantageous in the characterisation of baseline conditions.

The data and information gathered during the gap analysis was taken into consideration when planning for ESIA baseline data collection activities, which are discussed in more detail below. Since completion of the Scoping Report, additional geotechnical and geophysical studies for proposed Project infrastructure have been completed and used to inform the baseline characterisation of soils and geology.

8.5.2 Baseline Data Collection Methods

This section provides details of surveys undertaken within the Survey Area as well as providing details on data sourced from secondary sources. This information is then used to help identify the baseline conditions. Primary data are presented first followed by secondary data.

8.5.2.1 Primary Data and Baseline Surveys

Soils data from the previous surveys conducted within EA-1A/CA-1 and LA-2 North provides an indication of the overall status of soils characteristics and quality but does not cover all of the Study Area and does not adequately characterise soils characteristics and quality in the vicinity of all Project elements and sensitive receptors. Additional soils field survey work was performed as part of this ESIA to ensure sufficient information is available to accurately characterise the existing baseline soils quality conditions within the Project Area and allow any potential impacts associated with the development plan to be assessed. The key focus is the vicinity of the proposed Project footprint and sensitive receptors. Direct receptors include the soils and indirect receptors may include groundwater, surface water and arable land.

8.5.2.2 Primary Data – 2014 Baseline Surveys

8.5.2.2.1 Block EA-1 Environmental Baseline Study (EBS) for Block 1 in Uganda (Total E&P Uganda/ AECOM, 2015)

Soil samples were collected from selected locations within EA-1 (now known as CA-1) for chemical and parameter analysis as part of the Environmental Baseline Study (EBS) (Ref 8-2). Soil sampling locations were selected to include all three areas formally referred to as Block 1 (North Nile, South Nile and West Nile areas).

Locations were selected based on a review of aerial imagery, land use, topography, soil and vegetation types, and historical data including the findings of prior studies and oil exploration due diligence investigations. Soil samples were collected in undisturbed/virgin areas where there are no known anthropogenic/human activities in order to evaluate “background” conditions. Soil samples were also gathered in agricultural areas and on or near potentially polluted or impacted sites such as commercial tourist lodges, airfields, exploration drill pads, pits, waste storage areas, camps, and access roads. Specific locations included:

- Thirteen sampling locations in the North Nile area;
- Six in the South Nile area; and
- Four in the West Nile area.

EBS soil survey locations are identified in Figure 8-1.

8.5.2.3 Primary Data – 2017 Baseline Surveys

8.5.2.3.1 Baseline Soil Survey Campaign 2017

The ESIA soils survey consisted of one field campaign involving characterisation and sample collection at fifteen selected locations for chemical and parameter analysis. Only one campaign was undertaken as previous studies showed no seasonal differences in soil quality. The locations were selected to increase the spatial coverage of the existing soil quality dataset, and include areas potentially impacted by previous exploration drilling, areas where new Project elements are proposed for construction, areas of environmental sensitive receptors, and locations of reported natural oil seeps. The locations were selected based on a review of locations of proposed Project components, historical soil quality data, land resource use, and findings of prior studies.

The soils survey field campaign was completed in June 2017. Discrete survey locations include:

- Two locations (S1, S2) within CA-1 north and south of the Nile River at reported natural oil seeps;
- One location (S3) within CA-1 and Murchison Falls National Park north of the Nile River at a planned production well site;
- Four locations (S4, S10, S11, and S12) in the CPF/Industrial Area; and
- Eight locations (S5, S6, S7, S8, S9, S13, S14, and S15) in the northern part of LA-2 North at proposed production well and pipeline sites.

Table 8-3 provides an overview of the chosen sampling locations, including the coordinates, rationale and characteristics of each location. ESIA soil survey locations are identified in Figure 8-1.

Table 8-3: Soils Survey Locations and Description

Block	Survey Point	Location and Description	Rationale	Photograph
CA-1	S1	At natural oil seep location near Songe River north of Nile R in MFNP Elevation: 646 metres (m) Slope: 5% Soils: clay with vertic properties Drainage: Well drained Erosion: slight/nil Ground cover: 80% Thick grasses and shrubs Sampling point less than 100 m away from the temporary stream; wide gullies of more than 20 m deep and 30 m wide are within 1 km radius	Characterise soil quality impacted by natural oil seep	
CA-1	S2	At natural oil seep location in CA-1 south of Nile R Elevation 648 m Slope: 0-5% Soils: sandy soil, sandy/clay Drainage: Well drained Erosion: gullies Ground cover: 70-80% heavily vegetated thicket Sampling point is heavily vegetated thicket but dissected by gullies of approximately 2 m deep and about 4 m wide.	Characterise soil quality impacted by natural oil seep	

Block	Survey Point	Location and Description	Rationale	Photograph
CA-1	S3	Proposed location of JBR-02 in CA-1 north of Nile R Elevation 668 m, Slope to the south 8% Soils: sandy soil, arenic properties Drainage: well drained Erosion: slight/nil Ground cover: grass covered with low weeds, sparse shrubbery and trees; coverage 50-60%	Define background soil quality and gather data to evaluate erosion risk near proposed well pad JBR-02 and flowline in MFNP north of Nile R	
CA-1	S4	Proposed area of the industrial area Elevation: 651 m Slope: 2% Soils: grey sandy arenic Drainage: well drained Erosion: slight/nil Ground cover: overgrazed grasses, shrubs, trees, ground coverage 10% Heavily grazed area with sparse vegetation	Define background soil quality and gather data to evaluate erosion risk near proposed industrial area	

Block	Survey Point	Location and Description	Rationale	Photograph
LA-2 North	S5	Proposed location of NSO-03 north of exploration well Nsoga-2 Elevation 621 m Slope <1% Soils: sandy white grey soils with arenic properties Drainage: well drained Erosion: slight/nil Ground cover: sparse grassed, some trees and agriculture and grazing. Heavily grazed area with sparse vegetation	Define background soil quality and gather data to evaluate erosion risk near proposed well pad NSO-03 and flowline near Ngwedo Village	
LA-2 North	S6	In the vicinity of the proposed location of KW-02A near exploration well Kasamene-1 Elevation: N/A Slope 0% Soils: sandy white/grey soils arenic soil Drainage: well drained Erosion: slight/nil Ground cover: sparse dry grass overgrazed, coverage 10-15% Communal grazing area sparsely vegetated	Define background soil quality and gather data to evaluate erosion risk near proposed well pad KW-02A and flowline near Kisansya Village	

Block	Survey Point	Location and Description	Rationale	Photograph
LA-2 North	S7	Proposed location of NSO-04 west of exploration well Kigogole-2 Elevation: 665 m Slope <1% Soils: soil sandy grey/white arenic Drainage: well drained Erosion: Rills Ground cover: overgrazed grasses and shrubs, ground cover 25% Heavily grazed area with sparse vegetation	Define background soil quality and gather data to evaluate erosion risk near proposed well pad NSO-04 and flowline in uncultivated area south of Ngwedo Village	
LA-2 North	S8	Proposed location of KGG-04 southwest of exploration well Kigogole-2 Elevation: 660 m Slope: 1-2% Soils: grey sandy arenic Drainage: well drained Erosion: slight/nil Groundcover: cassava farm, ground cover 60%	Define background soil quality and gather data to evaluate erosion risk near proposed well pad KGG-04 and flowline near edge of cultivated area	

Block	Survey Point	Location and Description	Rationale	Photograph
LA-2 North	S9	Proposed location of KGG-06 northwest of exploration Kigogole-6 Elevation 659 m Slope 0% Soils: sandy grey/white arenic Drainage: well drained Erosion: slight/nil Ground cover: sparse grasses, shrubs, small trees, ground cover 20% Sparse grasses and shrubs	Define background soil quality and gather data to evaluate erosion risk near proposed well pad KGG-06 and flowline	
CA-1	S10	Proposed location of Industrial Area, with the CPF area Elevation: 679 m Slope: 2-5% Soils: grey sandy arenic Drainage: well drained Erosion: slight/nil Ground cover: overgrazed grasses, shrubs, trees, ground coverage 10% Communal grazing area and settlements	Define background soil quality and gather data to evaluate erosion risk near proposed Industrial Area	

Block	Survey Point	Location and Description	Rationale	Photograph
CA-1	S11	Downslope from proposed area of Industrial Area/CPF Elevation: 653 m Slope: 2-5% Soils: white/grey sandy arenic Drainage: well drained Erosion: slight/nil Ground cover: grass, shrubs, overgrazed, ground cover 10% Heavily grazed area with sparse vegetation	Define background soil quality and gather data to evaluate pollution runoff and erosion risk from proposed Industrial Area/CPF	
CA-1	S12	Upslope from proposed area of Industrial Area/CPF Elevation 653 m Slope: 10% Soils: white/grey sandy arenic Drainage: well drained Erosion: slight/nil Ground cover: overgrazed grass, shrubs, trees, ground coverage 10% Heavily grazed area with sparse vegetation	Define background soil quality and gather data to evaluate pollution run-on to Industrial Area/CPF	

Block	Survey Point	Location and Description	Rationale	Photograph
LA-2 North	S13	In the vicinity of the proposed location of NSO-01 north of Kibambura and exploration wells Nsoga-1 and Nsoga-3 Elevation 630 m Slope: 1-2% Soils: sandy grey/orange, arenic Drainage: well drained Erosion: slight/nil Ground cover: grass and cassava, ground cover 20% Cassava garden	Define background soil quality and gather data to evaluate erosion risk near proposed production well pad NSO-01 and flowline	
LA-2 North	S14	Proposed location of KGG-03 south of exploration well Kigogole-3 Elevation: 659 m Slope 1-2% Soils: grey sandy arenic Drainage: well drained Erosion: slight/nil Ground cover: cassava and maize farm, ground cover 25% Cassava and maize gardens	Define background soil quality and gather data to evaluate erosion risk near proposed production well pad KGG-03 and flowline	

Block	Survey Point	Location and Description	Rationale	Photograph
LA-2 North	S15	In the vicinity of the proposed location of KW-02B between Buliisa and exploration well Kasamene-3 Elevation: N/A Slope < 1% Soils: grey sandy arenic Drainage: well drained Erosion: slight/nil Ground cover: sparse course grasses and thicket, ground cover 50% Grazed area	Define background soil quality and gather data to evaluate erosion risk near proposed production well pad KW-02B and flowline	

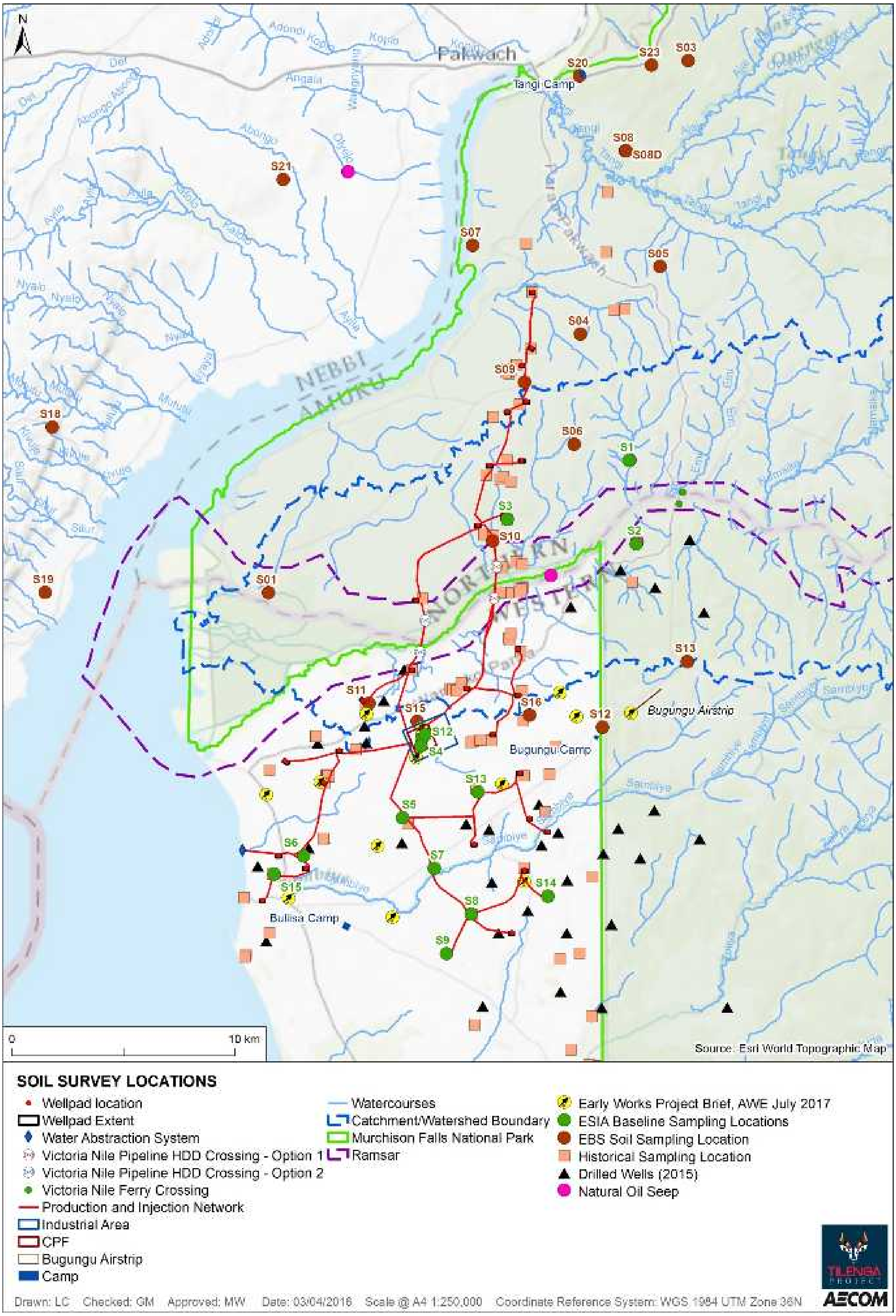


Figure 8-1: Soil Survey Locations

8.5.2.3.2 Sampling Activities – Baseline Soil Survey 2016

Two composite soil samples were collected using hand tools at each location: (1) from the surface (0 to 5 centimetres (cm) below ground surface (bgs)), and (2) at shallow depth (5 to 20 cm bgs). Each composite sample consisted of five sub-samples – one from each corner and one from the centre of the observation area (generally a 10m x 10m square however where heavy vegetation precluded a smaller 5m x 5m sampling area was selected) and then combined to create one composite sample. Soil was transferred to fill labelled sample containers and sampling equipment decontaminated between each sampling location. Samples were analysed in the laboratory for the parameters listed in Table 8-4.

Field conditions and soil descriptions were recorded on appropriate field forms. The visual appearance of each sample and any olfactory observations were noted on the field forms, and each sampling location was photographed to create a photo-documentary record of field activities. Soil sampling activities were performed during one field campaign (samples taken between 10th and 12th June 2017). The dates and locations of sampling activities are presented in Appendix J. The laboratory analytical results and selected field parameter measurements are summarised in Table 8-5 and Table 8-6.

All soil samples were shipped to Eurofins Analytico BV (Analytico) testing laboratory in The Netherlands for analysis. Analytico analysed the samples for a broad range of chemical constituents including metals, inorganic compounds (i.e., nitrate, nitrite, phosphorous, phosphate) and organic compounds (BTEX, and petroleum hydrocarbons). All analytical methods used by Analytico were based on national and international standards. Analytico is accredited against ISO/International Electrotechnical Commission (IEC) 17025 by the Dutch Accreditation Council (RvA).

The UK Soil Guideline Values and USEPA residential RSLs are also listed where applicable. Only the analytical parameters which were reported above the detection limit are presented in the table. The field forms and full analytical reports are provided in Appendix J.

Table 8-4: Soils Survey Laboratory Analysis

Soils Survey Laboratory Analysis	
Parameter	**Analytical Method**
Moisture content	Gravimetry
Particle size	In house method
pH	In house method
Total Organic Matter (TOM)	Cf. NEN 5754
Total Organic Carbon (TOC)	I.a.w. International Standards Organisation (ISO) 10694
Nitrate/nitrite, Total Kjeldahl Nitrogen (TKN)	In house spectrometry method, NEN-EN 13342
Total Phosphorous (P)	NEN-EN-ISO17294-2/CMA2/I/B.5
Exchangeable Bases (Calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na)	In house method
Cation Exchange Capacity (CEC)	In house method
Total Petroleum Hydrocarbons (TPH)	In house gas chromatography/flame ionisation detector (GC/FID) method, in acc. to EPA 8015b
Mono Aromatic Hydrocarbons (BTEX)	NEN-ISO 22155
Metals (Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium-total, Cobalt, Copper, Lead, Mercury, Molybdenum, Nickel, Selenium, Tin, Vanadium, Zinc)	NEN-EN-ISO17294-2/CMA2/I/B.5

8.5.2.4 Primary Data – Early Works Baseline Survey – 2017

A baseline study of soils and geology in the Project Area was undertaken by AWE in July 2017 as part of the Early Works Project Brief (Ref. 8-20). The baseline study was conducted to characterise the soils in relation to their physical, biological and chemical properties so that these attributes were known and documented prior to the commencement of the early works. The specific objectives of the survey included:

- Description of the soil profiles' properties of each horizon; and
- Soil sampling of the horizons in each profile to establish the quality and productivity of the soils in the Project Area in terms of soil nutrients and triangulating between the in-situ and ex-situ findings.

Test pits to assess soil properties were excavated at 13 locations within the Project Area, selected to include the Industrial Area, Bugungu airstrip, and roads (new and upgrades). The soil sampling locations are shown in Figure 8-1. Each test pit was 1.5 m^2 in area and excavated to approximately 2 m depth. The locations can be grouped as follows:

- One location in proximity to the Industrial Area, within a grazing area on the lower side of the Industrial Area;
- Eight locations within the southern part of CA-1, comprising:
  - Three locations to target the proposed A1 and A4 upgrade roads;
  - Three locations to target new roads N1, N2 and N3;
  - One location to provide baseline information about the soils in the lower horizons; and
  - One location to target the proposed Bugungu airstrip extension.
- Four locations in the northern part of LA-2 North, comprising:
  - Three locations to target the proposed B2, A2, and A4 upgrade roads; and
  - One location to provide baseline information about the soils in the lower horizons.

At each test pit location, the in-situ soil properties of all the horizons up to the parent material were recorded. For soil properties that could not be determined in-situ, soil samples were collected and taken to SGS Laboratory in Mombasa, Kenya for analysis. Representative soil samples were taken from each pit within each horizon for chemical and other physical properties. These included: pH, total Nitrogen, Organic matter, Organic carbon, Bulk density, Available phosphorus, Exchangeable bases (sodium, potassium, calcium and magnesium), Texture determination (percentages of sand, silt and clay), Particle size distribution, Trace elements (zinc, copper, iron and manganese), PAHs, as well as heavy metals such as Mercury (Hg), Lead (Pb), Cadmium (Cd) and Arsenic (As).

A copy of the Executive Summary from the Early Works PB is located within Appendix C of this ESIA.

In addition to the above, a further PB was submitted to NEMA in late 2017 entitled "*Geotechnical Surveys for the Enabling Infrastructure*" which contained further baseline data and information. A copy of the Executive Summary of the report is included within Appendix C of this ESIA.

8.5.3 Baseline Survey Results and Interpretation

The results of soil sampling are presented and interpreted in this Section. The geographic setting of the Project footprint for discussion purposes has been divided into the North Nile and South Nile areas. The North Nile area is characterised as natural and includes MFNP and riverine areas along the northern bank of the Victoria Nile and is considered to be generally undeveloped. The South Nile area includes the southern bank of the Victoria Nile, a section of the southwestern portion of the MFNP, and community areas south of the Victoria Nile extending to the shore of Lake Albert. It is primarily modified as a result of grazing and agricultural activities.

8.5.3.1 2014 Primary Data

Soil quality testing was conducted across CA-1 block (previously named EA-1) in 2014 by AECOM (sampling locations illustrated in Figure 8-1). Soil sampling was conducted during the first two EBS field campaigns – one during the "dry" season (in February) and one during the "wet" season (in April), to evaluate the effect of seasonality on soil quality. Detailed test results are recorded in the EA-1 Environmental Baseline Study (AECOM, 2015) (Ref. 8-2). A summary of the soil quality findings and a brief overview of potential contaminant characteristics are presented below:

- Some evidence of possible human impacts on soil quality across CA-1. However, no major contamination reported in any of the areas tested;
- BTEX was not detected in any of the samples collected through the baseline study;
- PAHs were detected in each of the three areas in developed and undeveloped areas albeit at low concentrations below health guidelines. The exact source of these was not determined but may have been natural or anthropogenic in origin;
- TPH concentrations were reported as being very low, below the reporting limits of most United States laboratories, therefore validity of the results cannot be verified. The highest recorded concentration (210 milligrams per kilogram (mg/kg)) was found in a sample collected along the northern boundary of CA-1 in close proximity to a highway which may be associated with vehicular traffic as a potential source;
- One or more metals were detected in every soil sample collected during the first and second campaigns. All occur naturally, and the resulting data establish approximate ranges of concentrations that are representative of soils;
- Heavy metals were detected in all areas of CA-1 but with no metal concentrations exceeding USEPA limits in the southern Nile area which borders the northern boundary of LA-2 North. Exceedances of USEPA limits of various metals including arsenic and cobalt were recorded in other areas but these were attributed to high natural background concentrations rather than contamination;
- Nitrate levels were low in the North Nile area and not detected in the South Nile area;
- Total phosphorus concentration averages for the North Nile area was 0.53 grams per kilogram (g/kg) and in the South Nile was 0.20 g/kg;
- No season differences in contaminant characteristics were noted; and
- Areas of severe soils erosion were recorded in all areas of CA-1.

BTEX are volatile aromatic compounds typically found in petroleum products, such as gasoline and diesel fuel, as well as coal tar and various organic chemical product formulations. BTEX are the most soluble of the major compounds found in gasoline, and therefore are common indicators of gasoline or diesel contamination.

PAH are neutral, nonpolar organic molecules that comprise two or more benzene rings arranged in various configurations. PAH are ubiquitous and are commonly associated with anthropogenic sources, including coal or wood combustion, vehicles, asphalt roads, incinerators, and petroleum processing. PAH are also generated by natural sources such as wildfires, volcanic eruptions, and degradation of biological materials, which has led to their formation in various sediments and fossil fuels.

TPH is a gross measure of petroleum contamination, although non-petroleum hydrocarbons sometimes appear in the analysis. TPH are ubiquitous and are commonly associated with anthropogenic sources, including coal or wood combustion, vehicles, asphalt roads, incinerators, and petroleum processing.

Nitrates and phosphorus and compounds containing phosphorous are nutrients required for plant growth and are common constituents of fertilisers.

8.5.3.2 2017 Primary Data

Soil analytical data reports for soil samples collected are presented in Appendix J. To evaluate the potential presence of toxic constituents, the results were compared to USEPA RSLs established for residential settings as well as the UK Soil Guideline Values. Only parameters above the laboratory reporting limit are presented in Table 8-5 and Table 8-6.

Table 8-5: Soils Analytical Results – Metals and Petroleum Hydrocarbons

Analytical Soils Results				Sample Number (Location- date –profile)																															
North Nile (NN) or South Nile (SN)				NN		SN		NN		SN		SN		SN		SN		SN		SN		SN		SN		SN		SN		SN		SN			
Parameter		UK Soil Guideline Values(1)	USEPA Residential RSL(2)	(S1-170611-T1)	(S1-170611-B1)	(S2-170611-T1)	(S2-170611-B1)	(S3-170611-T1)	(S3-170611-B1)	(S4-170611-T1)	(S4-170611-B1)	(S5-170611-T1)	(S5-170611-B1)	(S6-170610-T1)	(S6-170610-B1)	(S7-170611-T1)	(S7-170611-B1)	(S8-170611-T1)	(S8-170611-B1)	(S9-170611-T1)	(S9-170611-B1)	(S10-170611-T1)	(S10-170611-B1)	(S11-170611-T1)	(S11-170611-B1)	(S12-170611-T1)	(S12-170611-B1)	(S13-170611-T1)	(S13-170611-B1)	(S14-170611-T1)	(S14-170611-B1)	(S15-170610-T1)	(S15-170610-B1)	Maximum Value	Minimum value
Metals																																			
Chromium (Cr)	mg/kg dm	-	120,000	42	47	50	88	<15	<15	<15	<15	19	15	<15	<15	<15	<15	<15	17	<15	<15	18	17	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	88	15
Copper (Cu)	mg/kg dm	-	3,100	12	13	12	20	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	20	12
Nickel (Ni)	mg/kg dm	130	1,500	16	17	15	27	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	3.4	27	3.4
Zinc (Zn)	mg/kg dm	-	23,000	30	28	<17	25	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	<17	30	17
Barium (Ba)	mg/kg dm	-	15,000	110	110	140	200	20	25	22	26	25	16	<15	17	16	<15	34	<15	16	15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	15	200	15
Cobalt (Co)	mg/kg dm	-	23	8.8	9.4	13	21	3.2	4.1	4.6	4.7	3.7	4.3	3.6	4.4	1.8	2.4	4.7	4.5	3.5	4.4	3.1	3.4	2.7	3.2	2.2	2.5	5.7	6.1	5.4	6.1	3.2	4.3	21	1.8
Selenium (Se)	mg/kg dm	350	390	3.3	3.8	<0.7	4	1.1	1.4	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	0.91	<0.7	0.95	0.82	0.8	0.96	0.95	<0.7	0.96	1.1	<0.7	<0.7	<0.7	<0.7	1.5	1.6	0.82	<0.7	4	0.8
Vanadium (V)	mg/kg dm	-	390	41	43	42	70	13	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	12	12	<10	11	<10	11	<10	12	<10	12	10	14	70	10
Calcium (Ca)	mg/kg dm	-	-	2800	2300	1400	1200	350	360	280	290	230	220	160	320	160	240	100	63	180	150	130	100	130	100	270	91	230	140	320	240	330	500	2800	63
Potassium (K)	mg/kg dm	-	-	560	470	1200	1600	490	450	210	180	200	230	200	260	210	310	220	190	250	250	160	160	190	230	280	290	160	150	220	210	330	380	1600	150
Magnesium (Mg)	mg/kg dm	-	-	1600	1600	1300	2200	250	340	160	130	130	120	120	150	110	140	100	98	150	160	84	96	120	140	150	160	85	80	140	140	220	250	2200	80
Sodium (Na)	mg/kg dm	-	-	68	73	52	89	32	37	51	50	59	42	11	48	19	50	31	19	<11	17	27	62	25	30	59	62	39	76	36	24	23	69	89	10
Phosphorus total (P)	g/kg dm	-	-	0.23	0.13	0.15	0.11	0.098	0.11	0.11	0.092	0.08	0.065	0.08	0.083	0.067	0.071	0.075	0.065	0.078	0.072	0.061	0.052	0.06	0.055	0.079	0.066	0.081	0.078	0.09	0.07	0.09	0.064	0.23	0.052
Phosphorus total (PO_4)	g/kg dm	-	-	0.7	0.41	0.46	0.32	0.3	0.33	0.35	0.28	0.24	0.2	0.24	0.26	0.21	0.22	0.23	0.2	0.24	0.22	0.19	0.16	0.18	0.17	0.24	0.2	0.25	0.24	0.28	0.22	0.28	0.2	0.7	0.16
Phosphorus total (P_2O_5)	g/kg dm	-	-	0.52	0.3	0.34	0.24	0.23	0.25	0.26	0.21	0.18	0.15	0.18	0.19	0.15	0.16	0.17	0.15	0.18	0.16	0.14	0.12	0.14	0.13	0.18	0.15	0.19	0.18	0.21	0.16	0.21	0.15	0.52	0.12
Petroleum Hydrocarbons																																			
EPH (C30-C35)*	mg/kg dm	-	230,000	18	9.8	6.1	<6	<6	13	<6	6.2	<6	<6	6.9	10	<6	<6	<6	<6	<6	6.3	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	6.2	<6	18	6.1

Note:

**C19-C32 Petroleum Hydrocarbons (aliphatic high) Limit is 230,000 mg/kg; ND – Not detected above the laboratory reporting level; dm – dried mass; EPH refers to the extractable portion of petroleum hydrocarbons within a particular range.*

Table 8-6: Soils Analytical Results – Physical Characteristics

Analytical Soils Results Physical Characteristics				Sample Number (Location- date -profile)																															
North Nile (NN) or South Nile (SN)				NN		SN		NN		SN		SN		SN		SN		SN		SN		SN		SN		SN		SN		SN		SN		SN	
Parameter		UK Soil Guideline Values[(1)]	USEPA Residential RSL[(2)]	S1-170611-T1	S1-170611-B1	S2-170611-T1	S2-170611-B1	S3-170611-T1	S3-170611-B1	S4-170611-T1	S4-170611-B1	S5-170611-T1	S5-170611-B1	S6-170610-T1	S6-170610-B1	S7-170611-T1	S7-170611-B1	S8-170611-T1	S8-170611-B1	S9-170611-T1	S9-170611-B1	S10-170611-T1	S10-170611-B1	S11-170611-T1	S11-170611-B1	S12-170611-T1	S12-170611-B1	S13-170611-T1	S13-170611-B1	S14-170611-T1	S14-170611-B1	S15-170610-T1	S15-170610-B1	Maximum Value	Minimum Value
Physical Characteristics																																			
Dry matter	% (w/w)	-	-	92.2	91.1	96.2	93	90.4	91.2	100	99.3	99.8	99	99.7	99	99.5	98.4	99.3	98.2	99.5	98.5	99.7	98.5	99.6	98.7	99.3	98.1	99.7	98.3	97.6	96.9	99.4	98.3	100	90.4
Moisture residue	% (w/w)	-	-	7.8	8.9	3.8	7	9.6	8.8	<.1	0.7	0.2	1	0.3	1	0.5	1.6	0.7	1.8	0.5	1.5	0.3	1.5	0.4	1.3	0.7	1.9	0.3	1.7	2.4	3.1	0.6	1.7	9.6	0.3
Total Organic Carbon (TOC)	g/kg dm	-	-	21	9.2	6.7	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.2	<5.0	21	5.2
Organic matter	% (w/w) dm	-	-	5	3.9	2.7	2.2	1.3	2	1	0.7	0.9	0.7	<0.7	0.8	0.8	0.7	0.9	<0.7	<0.7	0.7	<0.7	<0.7	0.8	0.8	1	0.8	<0.7	<0.7	1.1	0.8	1.7	0.9	5	0.7
Residue on ignition	% (w/w) dm	-	-	93.3	94.5	96.4	95.7	98.2	97.4	98.8	99	98.8	98.9	99.1	99	98.9	98.9	98.8	98.9	99	98.9	99	99	99	98.9	98.7	98.8	98.9	98.9	98.5	98.6	98	98.6	99.1	93.3
Acidity (pH-CaCl2)	pH	-	-	5.2	5	5.7	4.8	5.8	4.6	5.6	5.3	5.6	5.1	5.4	4.8	4.9	4.6	5.3	4.7	5.3	4.7	5.8	4.8	4.9	4.5	5.8	4.6	5.4	4.7	6.2	5.4	5.3	4.5	6.2	4.5
Particle Size																																			
Fraction < 2000 µm	% (w/w) dm	-	-	91.7	87.8	87.9	100	96.6	94.2	97.5	97.6	95.5	97.2	97.3	91.7	94.2	95.9	97.1	96.5	96.1	95.4	98.5	96.4	95	92.2	95.8	95.8	95.2	98.8	95.7	96.3	83.2	91.5	100	83.2
Fraction < 63 µm	% (w/w) dm	-	-	31.8	30.9	23.3	40.2	14	68.8	11.5	11.5	14	15.9	10	9.1	20.4	20.8	12.5	14.4	14.4	16.3	11	12.3	14.3	17.4	12.2	11.9	12.2	11.5	12.5	16.1	11.4	17.1	68.8	9.1
Fraction < 45 µm	% (w/w) dm	-	-	30	28.6	18.9	36.4	10.5	12	9	9.2	9.5	11.3	7	6.6	11.4	14	9.1	10.3	9.5	12.2	8.7	9.5	8.8	11.5	8.8	9.4	8.4	9.5	9	12.9	8.8	12.6	36.4	6.6
Fraction < 16 µm	% (w/w) dm	-	-	27.6	25.7	15.8	33.3	8.6	10.1	6.7	6.8	5.6	7.4	5.1	4.6	5.5	8.1	6.4	7.8	5.7	8.3	5.3	7.2	4.4	6.8	6.6	7.3	6.8	7.7	6.6	10.2	5.9	9.5	33.3	4.4
Fraction < 2 µm	% (w/w) dm	-	-	24.5	23	13.7	30.2	7.3	9	4.2	4.6	3.8	5.6	3.7	3.1	3.9	5.9	4.9	6.2	3.7	5.9	3.7	5.6	2.5	4.7	5	5.6	5.7	6.3	5.1	8.4	3.4	6.7	30.2	2.5

Note: dm – dried mass; µm - micrometre

8.5.3.2.1 North Nile area

All concentrations for all constituents analysed for in the soil samples collected in the North Nile area were below the UK/USEPA guidelines.

No soil samples collected in the North Nile area contained measurable concentrations of BTEX. BTEX are volatile aromatic compounds typically found in petroleum products, such as gasoline and diesel fuel, as well as coal tar and various organic chemical product formulations. BTEX are the most soluble of the major compounds found in gasoline, and therefore are common indicators of gasoline or diesel contamination.

TPH is a gross measure of petroleum contamination, although non-petroleum hydrocarbons sometimes appear in the analysis. TPH results simply show that petroleum hydrocarbons are present in the sampled media and, therefore, there is a potential for human health effects. Petroleum hydrocarbons, of the heavier range C30 to C35 (hydrocarbon compounds containing 30 to 35 carbon atoms), were detected in soil samples from the two locations in the North Nile area, although none at concentrations posing a potential concern to human health. Petroleum hydrocarbons were detected in three of the four samples collected at two locations, S1 and S3, where natural hydrocarbon seeps have been reportedly observed. Petroleum hydrocarbons in this range are solids whereas lighter range fractions are usually liquids. The concentrations detected were between five to six orders of magnitude below the USEPA RSLs for this parameter. There are no UK Soil Guideline Values for TPH. Throughout the field survey there was no observable indication of petroleum hydrocarbons nor were there any odours. The results indicate that the detection of petroleum hydrocarbons can be attributed to non-anthropogenic sources.

One or more metals were detected in every soil sample collected in the North Nile area; none were detected above the UK Soil Guideline values or the USEPA RSLs. The principle soil nutrients are calcium, potassium, magnesium and phosphorous (and phosphorus containing compounds such as phosphate).

Nitrates and nitrites were not detected above the reporting limit in any of the soil samples.

Dry matter ranged from 90.4 % to 96.2 % and moisture content ranged between 3.8% and 9.6 %. The sum of the dry matter and moisture residue is 100%. Dry matter and moisture analysis are conducted to be able to ensure that the subsequent analysis results are based solely on the mass of the soil sample and not anything else. The results for most chemical analysis of soils are presented on an as per kilogram on a dried mass (dm) basis. The moisture content varies based on the source of the sample and is a general indication of soil conditions as a result of meteorological conditions (e.g. rainfall) or cover (e.g. vegetation) that prevents soil moisture from evaporation.

Residue on ignition ranged between 93.3% and 98.2%. Residue on ignition is performed to determine the percentage of inorganic substances in a sample. Organic matter generally comprises between 2-10% of a soils mass. Organic matter contributes to soil structure, moisture retention and availability amongst other functions. Organic matter in soil samples collected in the North Nile area ranged from 1.3% to 5%. Organic matter improves the water holding capacity of the soils and releases nutrients upon decomposition. Most soils contain 2-10 % organic matter (FAO,n.d.) (Ref. 8-21).

Carbon can be present in elemental, inorganic, or organic forms. Carbon is usually derived from weathering of the parent material/geology, the decomposition of plant and animal matter, or by addition through anthropogenic activities. Total organic carbon material is derived from decaying vegetation, bacterial growth, and metabolic activities of living organisms or chemicals. The organic carbon is in a form suitable for plant uptake and a rough measure of soil fertility. Total organic carbon in the North Nile samples ranged from less than 5.0 g/kg dm (0.5%) to 21 g/kg dm (2.1%). Typically the organic carbon content in dryland agricultural soils is between 0.7–4.0%. However, it can be as low as 0.3% for desert soils or as high as 14% for intensive dairy soils (Ref. 8-22).

The pH of the soils ranged from 4.6 to 5.7 indicative of acidic soils. Soil pH also affects the availability of nutrients in the soil. A soil pH around 6.5 allows for maximum availability of the soil nutrients and microbial activity (Ref. 8-23).

The particle size distribution is indicative of soils which range from sandy to silty/clays based on the British Standard Soil classification system BS59830 (Ref. 8-24). The range of particle sizes that can be encountered in soil is very large: from boulders with a diameter of over 200 millimetres (mm) down to clay particle diameter of less than 0.002 mm (2 micrometres (µm)). In the British Soil Classification System (BS 5930), soils are classified into named Basic Soil Type groups according to size as shown in Table 8-7.

Table 8-7: British Soils Classification System (BS 5930)

Soils Classification	Size Range (mm)
Clay	< 0.002
Silt	0.002 – 0.06
Sand	0.06 – 2
Gravel	2-60
Cobble	60 – 200
Boulder	> 200

Reference: http://environment.uwe.ac.uk/geocal/SoilMech/classification/default.htm (Ref. 8-24)

8.5.3.2.2 South Nile area

All concentrations for all constituents analysed for in the soil samples collected in the South Nile area were below the UK/USEPA guidelines.

No soil samples collected in the South Nile contained measurable concentrations of BTEX. Of the 12 locations sampled, low concentrations of TPH were detected in both shallow and deep soil samples collected; including one location where natural hydrocarbon seeps have been reportedly observed (S2). More specifically, TPH fractions were reported in the shallower samples (from 0-5 cm) collected at locations S2 and S15 (KW-02B). TPH fractions were detected only in the deeper samples (from 5-20 cm) collected at locations S4 (Industrial Area) and S9 (KGG-06). TPH fractions were detected in both the shallower and deeper samples collected at S6 (KW-02A). The hydrocarbons detected were of the heavier range C30 – C35. The concentrations detected above the reporting limit ranged between 6.1 and 10 mg/kg. None of the measured hydrocarbon concentrations represent a potential concern to human health. Throughout the field survey there was no observable indication of petroleum hydrocarbons nor were there any odours. The results indicate that the detection of petroleum hydrocarbons can be attributed to non-anthropogenic sources.

One or more metals were detected in every soil sample collected in the South Nile area during the survey. No metals were detected in soil samples from the South Nile area in concentrations exceeding a USEPA RSL or a UK SGV.

No nitrate or nitrite was detected above the laboratory detection limit in soil samples from the South Nile area. Dry matter ranged from 98.1 % to 100% and moisture content ranged between less than 0.1% and 3.1 %. The sum of the dry matter and moisture residue is 100%.

Residue on ignition ranged between 98.6% and 99.1%. Organic matter in soil samples collected in the South Nile area ranged from less than 0.7 % to 1.1%.

Total organic carbon in the South Nile samples ranged from less than 5.0 g/kg dm (0.5%) to 6.7 g/kg dm (0.5%).

The pH of the soils ranged from 4.5 to 6.2 indicative of acidic soils.

The results of the supplemental field program completed in June 2017 are consistent with previous studies noting that PAH analysis was dropped from the recent surveys as the toxicity is low compared to other constituents in petroleum hydrocarbons such as BTEX. Also, there are no UK Soil Guideline Values for PAHs.

8.5.3.3 Summary of Primary Data results

A summary of the soil quality findings for both North Nile and South Nile is as follows:

- BTEX was not detected in any of the samples collected;
- TPH was detected in both North Nile and South Nile (CA-1 and LA-2) locations albeit in very low concentrations and is presumed to be attributed to natural causes and orders of magnitude below USEPA Residential RSLs;
- The only heavy metal detected was chromium at very low concentrations in both North and South Nile. There were no exceedances of the USEPA limits for any metals. Arsenic was not detected in any of the samples however cobalt was reported in all samples collected; this is attributed to natural causes;
- Nitrates and nitrites were not detected above the reporting limit in any of the samples;
- Total phosphorus concentration averages for the North Nile area was 0.14 g/kg and in the South Nile was 0.074 g/kg;
- Areas of severe soils erosion were recorded in all areas of CA-1; and
- Soil cover was characterised as yellowish-red sandy clay loams, highly leached, reddish brown clay loams of low to medium productivity, and red clay loams of medium to high productivity in the North Nile. Soils in the South Nile ranged from sandy grey arenic soils to yellowish-red sandy clay loams; and
- The particle size distribution is indicative of soils which range from sandy to silty/clays based on the British Standard Soil classification system.

A summary of the soil quality findings from the baseline surveys undertaken as part of the AWE Early Works Project Brief is as follows:

- Between five and seven PAH compounds were detected in all of the soil samples collected; however, none of the reported concentrations exceeded the relevant USEPA RSLs;
- Heavy metals (arsenic, barium, cadmium, chromium, lead, silver, selenium and zinc) were detected in all of the soils samples collected. There were no exceedances of the relevant USEPA RSLs for barium, cadmium, chromium, lead, silver, selenium or zinc. Arsenic was detected in excess of the USEPA RSL (0.68 mg/kg) in 23 of the 27 soil samples collected and analysed with a maximum detected concentration of 14.05 mg/kg;
- Soil pH values ranged from 4.39 to 7.65, with an average pH of 5.6. The pH of both the shallower and deeper soil samples collected from five of the 13 test pit locations was below 5.5, and the pH of only the deeper soil samples from a further three test pit locations was below 5.5;
- Electrical conductivity values ranged from 0.152 micro Siemens per centimetre (μS/cm) to 0.536 μS/cm and indicated non-saline soils (below 0.2 μS/cm) at eight of the 13 test pit locations; and
- Soils were indicated to be predominantly ferralitic, deep and light textured, exhibiting poor rooting systems and weakly developed structure, and be very porous, loose and friable.

8.5.3.4 Data Assumptions and Limitations

The main assumption associated with the collection of primary data is that data gathered will be representative of actual conditions over the long term assuming that there is no change in land use, particularly with respect to chemical contamination. Previous studies have shown no season differences in soil quality. As such, only one round of sampling is sufficient to characterise soils recognizing that seasonal factors such as rainfall will affect moisture content and moisture related analysis results (electrical conductivity).

There is limited soil data on the exact route of the permanent and temporary access roads and flowlines. However, it is considered there is sufficient data from the Survey Area as a whole to infer likely ground conditions. No soil surveys were completed at the Masindi Vehicle Check Point; however, soil can generally characterised as sandy loams consistent with the predominant soil types in the Graben (Ref. 8-25).

The main limitations with the collection of primary data are the potential error associated with the monitoring methods and the inherent heterogeneity of soils. Errors can be caused by practices in the field during sample collection and in the laboratory during sample preparation and analysis. The most important phase in the process of soil testing and evaluation is acquiring a representative soil sample. A representative soil sample is one which accurately reflects the properties of large area or volume of soil. Soil is not homogeneous, but rather a heterogeneous body of material. Large variations in physical, chemical, and biological properties can be found in a small field. Differences in soil characteristics may be natural (e.g. topography) or man-made (e.g. compaction or contamination). Soils sampling locations were selected to be representative of the larger area at each sampling location. Every effort was made to prepare a homogenous sample comprised of discrete samples to be representative of the soils at each depth and location.

8.5.4 Secondary Data

The information and data related to the soils and geology environment directly relevant to the characterisation of the study area and ESIA process in general were obtained from a number of sources including:

- Block EA-1 Environmental Baseline Study for Block EA-1 (CA-1) in Uganda which assessed available information and data from secondary data sources, which related to the physical and biological environment as well as the collection of supplemental primary data for Block EA-1 completed in 2015;
- Various Environmental and Social Impact Assessments for exploration and appraisal phases in Blocks 1 and 2 completed between 2007 and 2013;
- Uganda Exploration Area 1 and Area 2. Environmental Due Diligence Assessment Reports which sought to identify existing and potential environmental liabilities within accommodation camps waste disposal sites and multiple well pad sites completed in 2012 and 2013 (Ref. 8-26 and Ref. 8-27);
- Phase 2 Biodiversity Study: Land cover mapping for the Albertine rift oil development basin exploration areas EA-1-3 (including EA-1A, CA-1 and LA-2 North) and interim report completed by Tullow in 2015 which study aimed to prepare a detailed land cover map to allow better understanding of the existing land cover and spatial distribution of natural and modified habitats including soil description and erosion status;
- The Environmental Monitoring Plan (EMP) for the Albertine Graben 2012-2017 (Ref. 8-28) outlining studies to address soils contamination and factors affecting erosion;
- Directorate of Water Resource Management (DWRM) boring data for Buliisa and Nwoya describing the lithology within the Project Area;
- Boring logs from drilling water supply wells for camps and exploration wells in Blocks CA-1 and LA-2 North provide additional stratigraphic and lithologic information of local soils and superficial geology; and
- Regional data including published maps of geology, environmental sensitivity (NEMA, 2010) (Ref. 8-29), real time earthquake data and seismicity archives (Network of European Research (NERA)) (Ref. 8-30), United States Geological Survey (USGS) (Ref. 8-31) and the Global Seismic Hazard Assessment (Ref. 8-32).

This information and data in conjunction with supplemental primary data were used in the production of the baseline characterisation.

8.6 Baseline Characteristics

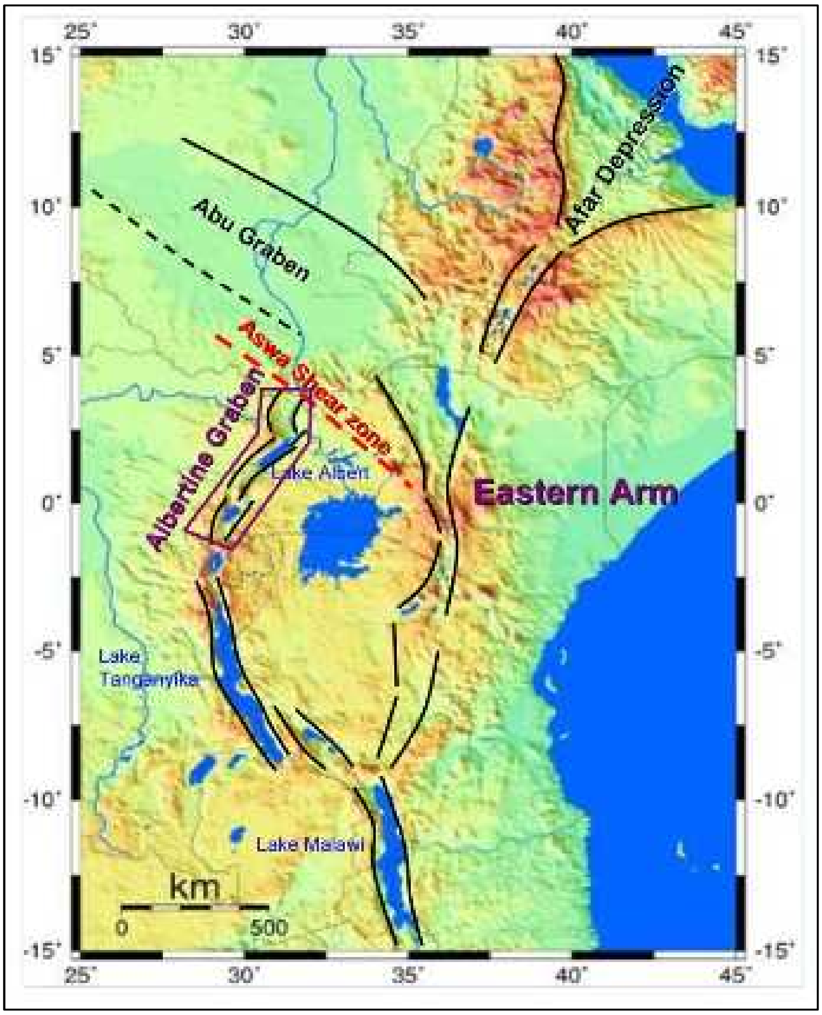
Topics of particular interest to soils and geology physical resources include local and regional geology, volcanism, seismicity, geomorphology, soil erosion risk, and soil quality.

8.6.1 Geology

The available information concerning the Albertine Graben region and Pakwach Basin provide a reasonably complete description of the geological and geomorphological setting of the Project Area.

8.6.1.1 Regional Geology

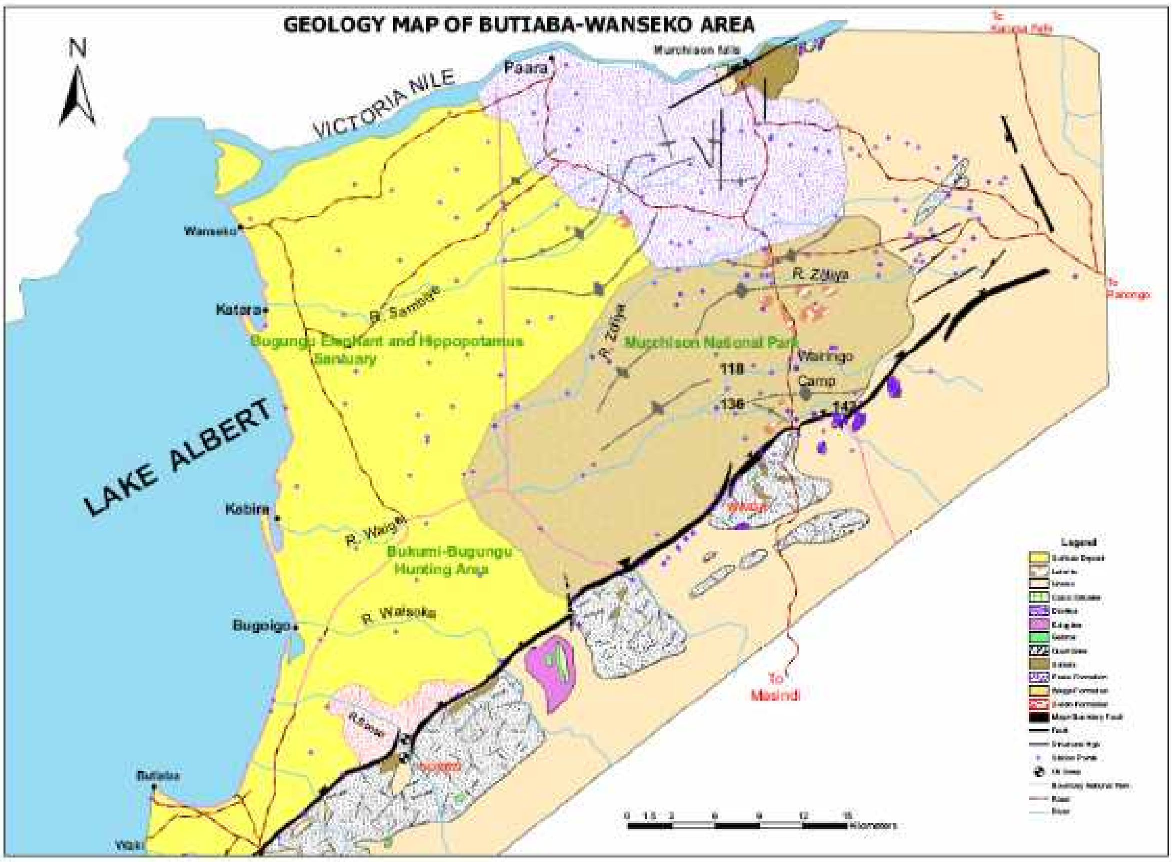
The Project Area is located at the northern end of the Albertine Graben: a transitional zone for three of Africa’s bio-geographical regions (Sudano-Sahelian, Guinea-Congolian and Zambezian) (NEMA, 2009) (Ref. 8-33). The Albertine Graben is currently the principal prospective area for petroleum in Uganda and forms the northern part of the western arm of the East African Rift System, stretching over 500 km from the border with Sudan in the north to Lake Edward in the south, covering an area of over 21,000 km². The Albertine Graben is a Cenozoic rift basin, started during the late Oligocene/Early Miocene and developed on the Precambrian orogenic belts of the African Craton. The Albertine Graben has undergone several tectonic episodes of both extensional and compression regimes; evidence of these movements are seen through the fault systems defining the basins (PEPD, 2011) (Ref. 8-1). A map of the East African Rift System is shown in Figure 8-2.



Source: (Tullow (TUOP), 2009), ESIA for Ngara-1 Field Appraisal Drilling Report (Ref. 8-34)

Figure 8-2: Map of the East African Rift System

The geological setting of the Albertine Graben consists of thick sequences of gneiss, schist derived sandstones and shales. Compared to the rest of the East African Rift System, it contains fewer volcanic and intrusive rocks. Due to the presence of sub-basins, the stratigraphy of the Albertine Graben is largely comprised of fluvial-deltaic and lacustrine deposits. Rift walls of uplifted Pre-Cambrian basement rocks rise steeply on either side of the lake. However, at the north of the lake, the escarpment is set back from the shore leaving a larger area of exposed sedimentary infill as shown in Figure 8-3.



Source: (Tullow (TUOP), 2009), ESIA for Ngara-1 Field Appraisal Drilling Report (Ref. 8-34)

Figure 8-3: Geology to South of Victoria Nile

Up to 4,000 m of sediments have accumulated in the Albertine Rift. The lowest part of the sequence is fluviatile deposits, intercalated with evaporates (principally gypsum). These are overlain by extensive lacustrine and lake margin sediments. These sedimentary deposits include silts and clays deposited along the axis of the rift by large rivers, and lobes of conglomerates, sands, silts and clays built out from the rift margins (Schulter 1997, Pickford et al 1993) (Ref. 8-35 and Ref. 8-36). Extensive work examining the basin infill has been carried out in the area, particularly in relation to oil field exploration. However, from a soils and geology perspective it is the near-surface geology which is of prime interest, a part of the sequence not usually considered in detail in geological assessments of the area.

8.6.1.2 Local Geology

The surface geology is mapped as undifferentiated Tertiary deposits over most of the Project Area, overlain by papyrus swamp and alluvial deposits of Quaternary age along river valleys and fringing the lake shore. A map of the superficial geology including the Project Area south and north of the Nile is provided in Figure 8-4.

Figure 8-4: Surface Geology

The Tertiary deposits, the Kaiso and Epi-Kaiso Group, comprise gravel; clay with diatomite; sand, grit and friable sandstone; iron-rich pisolite & intra-formational laterite (Geological Survey of Uganda 1964). The particular sequences reflect the Neogene to present day evolution of depositional environments in the lake and along the basin edge, influenced by sedimentation processes, changes in lake level and tectonic movement (Pickford et al 1993) (Ref. 8-36). Near shore, sediment loads are swept along rivers from the escarpment, leading to a build-up of sediment lobes. Coarse fanglomerates, sheet gravels, sands and silts (often weathered) are associated with these features. At the lake shore current action sorts the sediments and features such as beach bars, cuspate points and offshore sand bars develop.

On the landward side behind beach bars low lying swamp areas are formed, with dominant silt and clay sediments. Sand deposits and sometimes conglomerate are found along the lake edge but lake sediments tend to be silts and clays. The lake deposits also include ironstones, often laterally extensive, though thin, which are believed to have formed at medium water depths (Pickford et al 1993) (Ref. 8-36). The near surface geology of the Project Area will reflect a mixture of these sediment types, and may be expected to vary over relatively short distances.

Localised geological data is available for some boreholes and wells from the National Water Supply Database of Uganda, also referred to as the Directorate of Water Development (DWD) database and borehole data provide by TEP Uganda and TUOP. Further details and locations of boreholes and wells included in this database are discussed in ***Chapter 9: Hydrogeology***.

In summary, the available data at the regional and local levels provide an understanding of the geological features of the Project Area.

8.6.2 Soils

8.6.2.1 Soils Occurrence and distribution

The most dominant soil type in Uganda is ferralitic soil which accounts for about two thirds of the soils found in the country (Ref. 8-37). Ferralitic soils form in humid locales as a result of chemical weathering and decomposition of organic materials. They typically have low silica content and a high content of aluminium and iron. The soils in the Albertine Graben are predominantly yellowish-red clay loams on sedimentary beds. On the plateau towards Masindi and Hoima, the soils are highly leached, reddish brown clay loams, while along the axis of warp, dark brown, black loams can be found. Along the escarpment, the soils are of recent origin, predominantly shallow sandy soils that are prone to erosion and landslides, soil slips and rock falls (NBI/NELSAP, 2007) (Ref. 8-38).

Previous soil surveys confirmed the presence of ferralitic soils with variable permeability and, in some cases, severe signs of erosion in CA-1/EA-1A. Soils in the North Nile area include fine acidic, loam sand-silty soil with a single grain blocky structure and low permeability.

Soil cover was characterised as yellowish-red sandy clay loams, highly leached, reddish brown clay loams of low to medium productivity, and red clay loams of medium to high productivity; greyish black, acidic low productivity sands generally occupy rivers and valleys of the South Nile area.

Within LA-2 North soils are fairly similar, comprising mainly sands and clays. The sands are mostly unconsolidated, and are coarse to medium grained while clays, intercalated with the sands, are of varying composition. Ferralitic soils are known to cover a significant part of the South Nile area. Soils and sediments within river valleys comprise peaty sands and clays as well as reddish brown clay loams overlaying murram and ironstone. Mapped soils within the area are illustrated in Figure 8-5.

8.6.2.2 Soils Quality

Soil quality data within the Study Area was collected during individual baseline investigations commissioned by TEP Uganda and TUOP for exploration drilling sites. Across CA-1 block, soil samples throughout were found to be slightly acidic with soil pH's in the range of 4.6 to 5.7 and are largely free of PAH, TPH and heavy metal contamination.

In the LA-2 North block, soils throughout were found to be slightly acidic with soil pH's in the range of 5.5 to 6.8 and are largely free of PAH, TPH and heavy metal contamination (Ref. 8-2, 8-20 and 8-39 to 8-42).

8.6.2.3 Land cover and usage

The majority of the CA-1 is within the North Nile area and is described in the EA-1 Environmental Baseline Study (AECOM, 2015) (Ref. 8-1) as being dominated by shrubs and woody vegetation with land being used primarily for agriculture and as protected areas as shown in Figure 8-5. The South Nile area which comprises CA-1 in the northern portion and LA-2 North in the southern portion consists mainly of grassland and farmland with the primary usage reported for arable and grazing practices. A section of MFNP occupies the northern and north eastern portions of CA-1 within the North Nile area. Additional information is provided in ***Chapter 13*: *Terrestrial Vegetation*** of this ESIA.

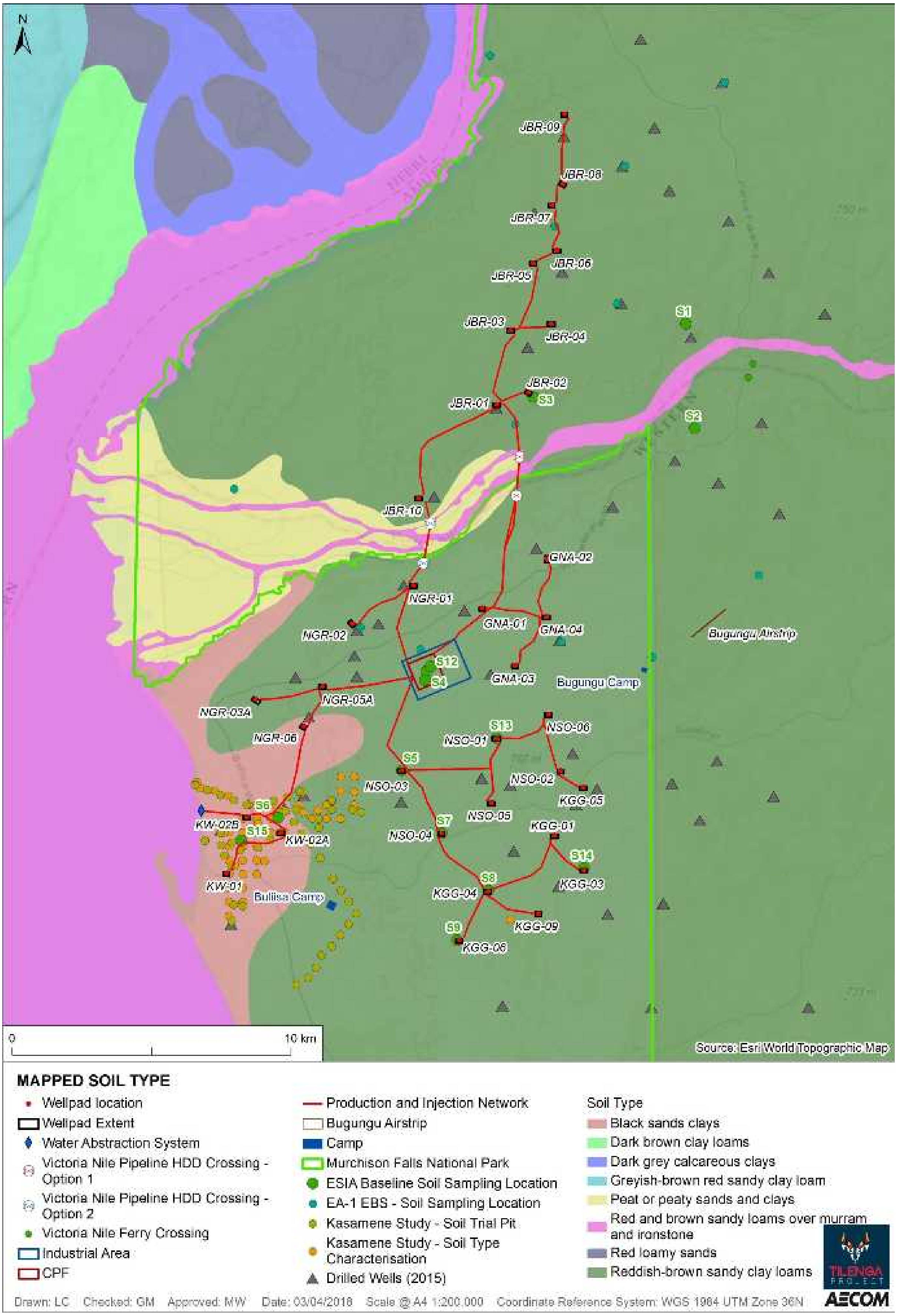


Figure 8-5: Mapped Soil Type

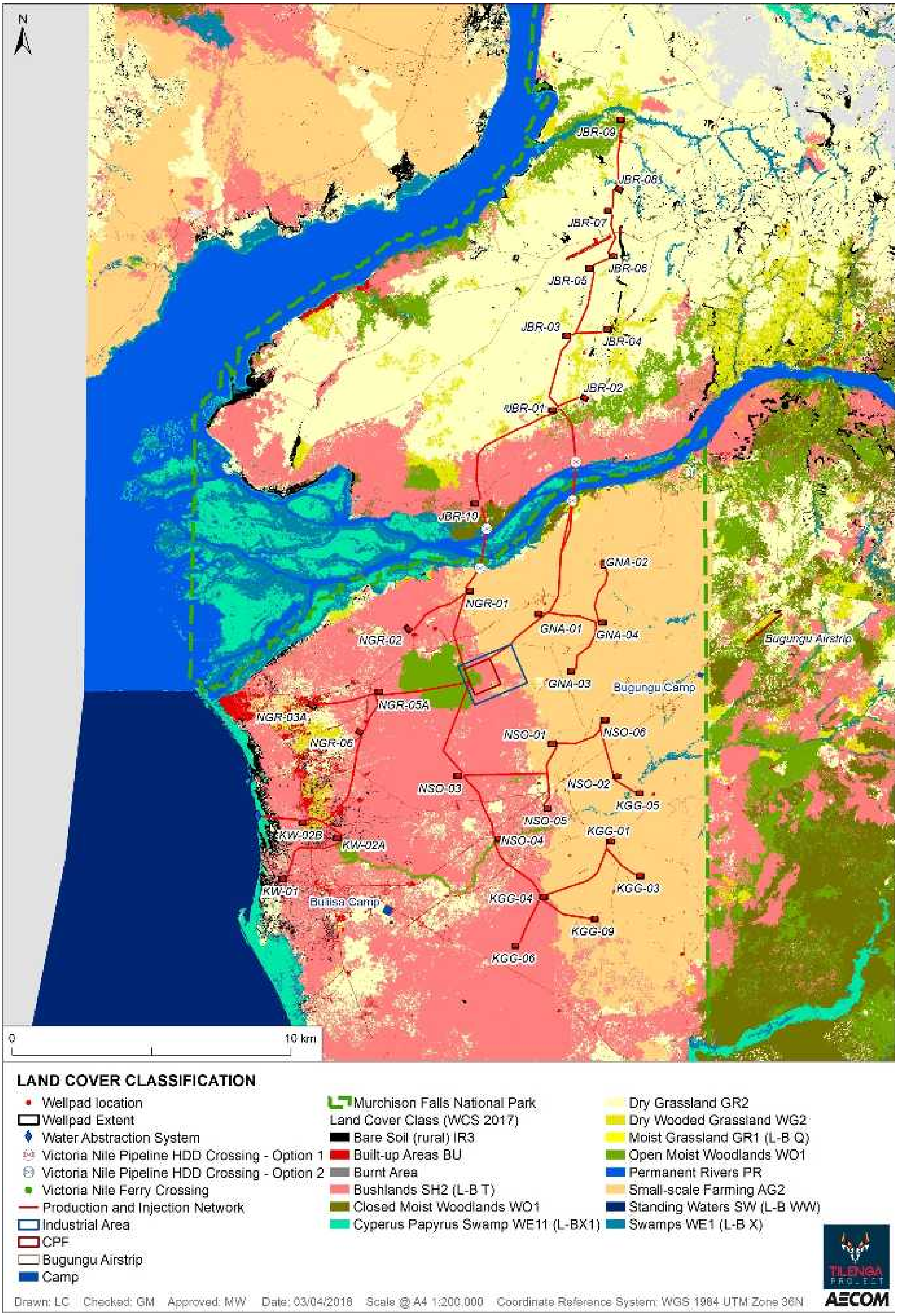


Figure 8-6: Land Cover Classification

8.6.3 Seismicity and volcanism overview

The Lake Albert region lies within the East Africa Rift (EAR), within central Africa extending from the eastern Democratic Republic of Congo (DRC), across Uganda, southern South Sudan, and western Kenya. The EAR, a major plate tectonic feature that is dividing the African continent, is comprised of a series of fault-bounded basins that define an approximately 3,000 km north-south trend in east Africa marking the divergent boundary between the Africa and Somalia plates. The EAR represents a volcanically and seismically active system atop a broad continental swell, the East African Plateau. The EAR trend consists of an eastern and western branch, separated by the Victoria microplate. The eastern side of the rift system is moving eastward relative to stable continental Africa (Fugro, 2013) (Ref 8-43).

The eastern and western branches of the East African Rift System (EARS) were developed by the same processes but have very different characteristics. The western branch, including the Albertine Graben, has a high level of seismic activity, compared to the eastern branch which is characterised by greater volcanic activity.

Specifically, the Lake Albert region lies within the northern extent of the western-branch of the EAR, marked by a series of fault-bounded grabens that extend through: eastern DRC, western Uganda, eastern Zambia, and into Malawi. Within the Lake Albert region, the continental crust is separated into three tectonic blocks: the African plate, the Victorian plate, and the Somalian plate. The western-branch of the EAR region is characterised by moderate to high level of seismic activity and susceptible to geological hazards. Historic seismicity indicates numerous small-magnitude earthquakes along the length of the western-branch of the EAR. Several large (defined as moment magnitude [Mw] greater than approximately seven) earthquakes have occurred in the historical record, which dates back to 1912 (Fugro, 2013) (Ref 8-43).

In relation to the Project Area, the greatest seismic activity occurred more than 250 km from the Project Area south of Lake Albert, in the area of the Rwenzori Mountains. The Rwenzori Mountains have a high concentration of earthquake epicentres and many earthquake events were reported during the last decade (2000s), with an average of 26 earthquakes per day (Atacama Consulting, 2012) (Ref. 8-44).

The Albertine region of Uganda is characterised by high levels of seismic activity and by many active normal faults (Bwambale et al, 2015) (Ref. 8-45). Seismicity in the EAR is wide spread but displays a distinctive pattern characterised by mainly shallow normal faults. The Fugro study indicated that the proposed site infrastructure is located very close or on top of the surface projection of major active faults. It is likely that the Project location may contain areas of soft soils and therefore, there is a potential of significant ground motion modification as the seismic waves propagate from the bedrock to the ground surface (Ref 8-43). Faults within the Albertine Graben are shown in Figure 8-7. The majority of events occur in the 10-25 km depth range (Hayes et al, 2014) (Ref. 8-46). The Global Seismic Hazard Map of Africa, prepared as part of the United Nations Global Seismic Hazard Assessment Project (GSHAP), depicts areas of relative seismic hazard on the continent. The seismic hazard is the degree of earthquake shaking that can be expected in a given place during a given time span. The GSHAP shows the peak ground acceleration (PGA) that a site can expect during the next 50 years with 10% probability of 0.163 g (acceleration due to Earth's gravity). Studies have shown that the Project Area is located in a seismic zone that has a PGA range from 0.152 g to 0.163 g, corresponding to a moderate hazard.

Earthquakes occurring in the vicinity of Lake Albert during the period 2000 to 2017 had a magnitude of between 4.2 and 5.6 bogy-wave magnitude (Mb), corresponding to light and moderate magnitude. The depth of the earthquake starting points range from 10 km to 30 km below ground. Details of the seismic events are provided in Appendix J. The locations of the seismic events are shown in Figure 8-7.

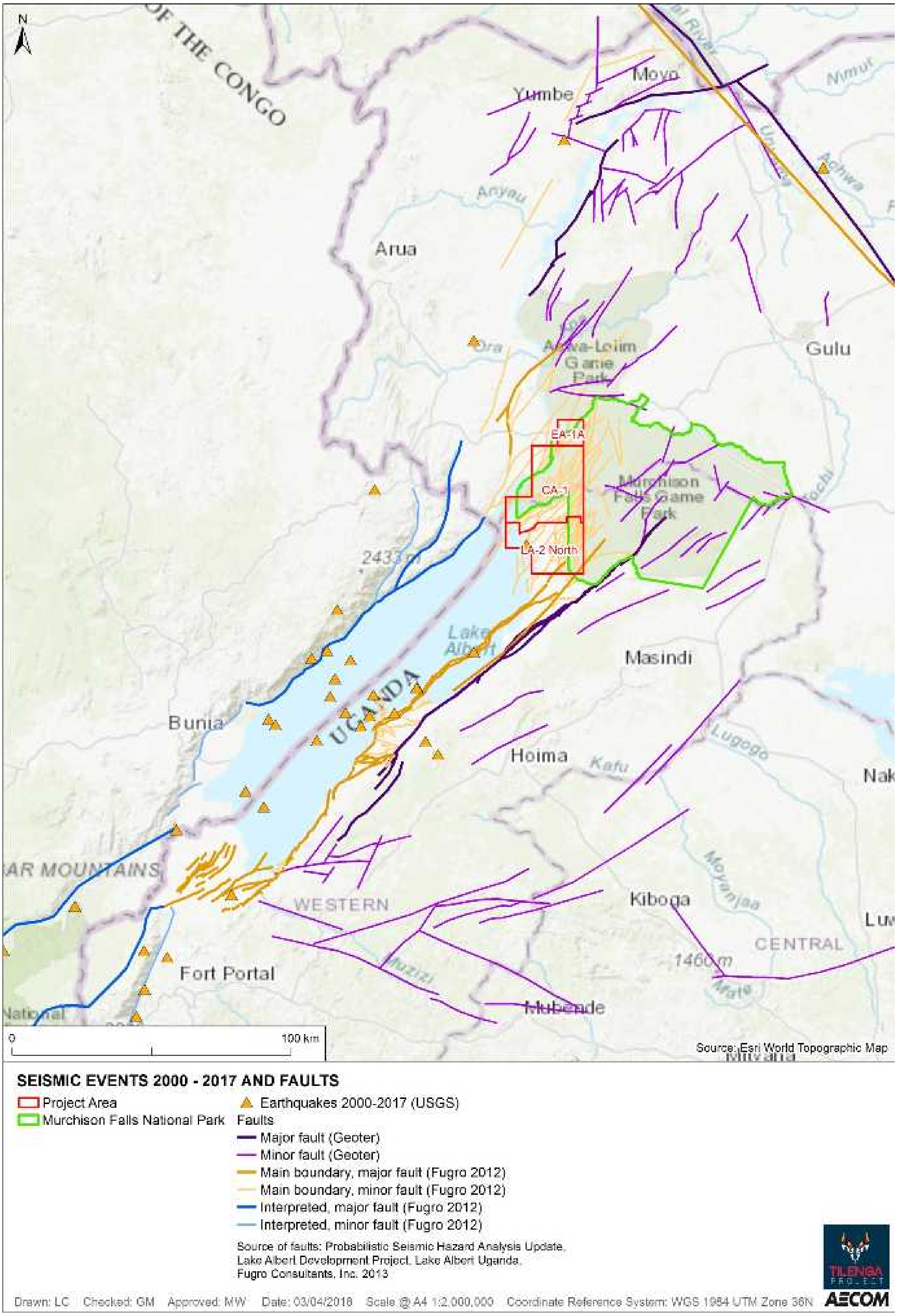


Figure 8-7: Seismic Events 2000- 2017 and Faults

Based on the Fugro Study, ground displacement during a major earthquake in the Project Area may result in a permanent change in base-level causing ground subsidence and submergence of the coastal areas. Tectonic subsidence and submergence will occur around the margins of Lake Albert during a major earthquake. The study identified slope conditions within the Project Area that pose potential landslide hazards citing the more moderately dipping slopes associated with the valley margins and eroded uplands. The hazards include landslide failures such as slow moving earth or mud flows, translational slides, and soil creep (Ref. 8-43). The southern areas of the North Nile within MFNP and the northern areas of the South Nile have undulating topographies potentially susceptible to landslide failures. Landslide GIS data provided by TEP Uganda does not show landslides in the Project Area.

Liquefaction occurs as seismic waves propagate through saturated granular or low plasticity fine sediment layers. The type and extent of ground failure depends on site geometry and the depth, thickness, ground slope, and lateral continuity of the liquefiable layer. The levels of strong motion estimated in the Fugro study are sufficient to trigger liquefaction if susceptible soils are present in the subsurface at specific locations (Ref. 8-43).

Volcanism is more pronounced in the eastern branch of EARS, although some volcanoes are located south of Lake Albert into the southern portion of the Albertine Graben. The nearest volcanic field (Fort Portal) is located north of the town of Fort Portal, about 200 km south of the Project Area. This volcanic field consists of a group of tuff cones and maars covering an area of about 145 km² between Lake Albert and Lake Edward. The field is composed of about 50 volcanic vents, some of which now contain crater lakes that erupted about 4,700 to 4,000 years ago, through basement rocks of Precambrian gneiss in a west-southwest to east-northeast-trending area.

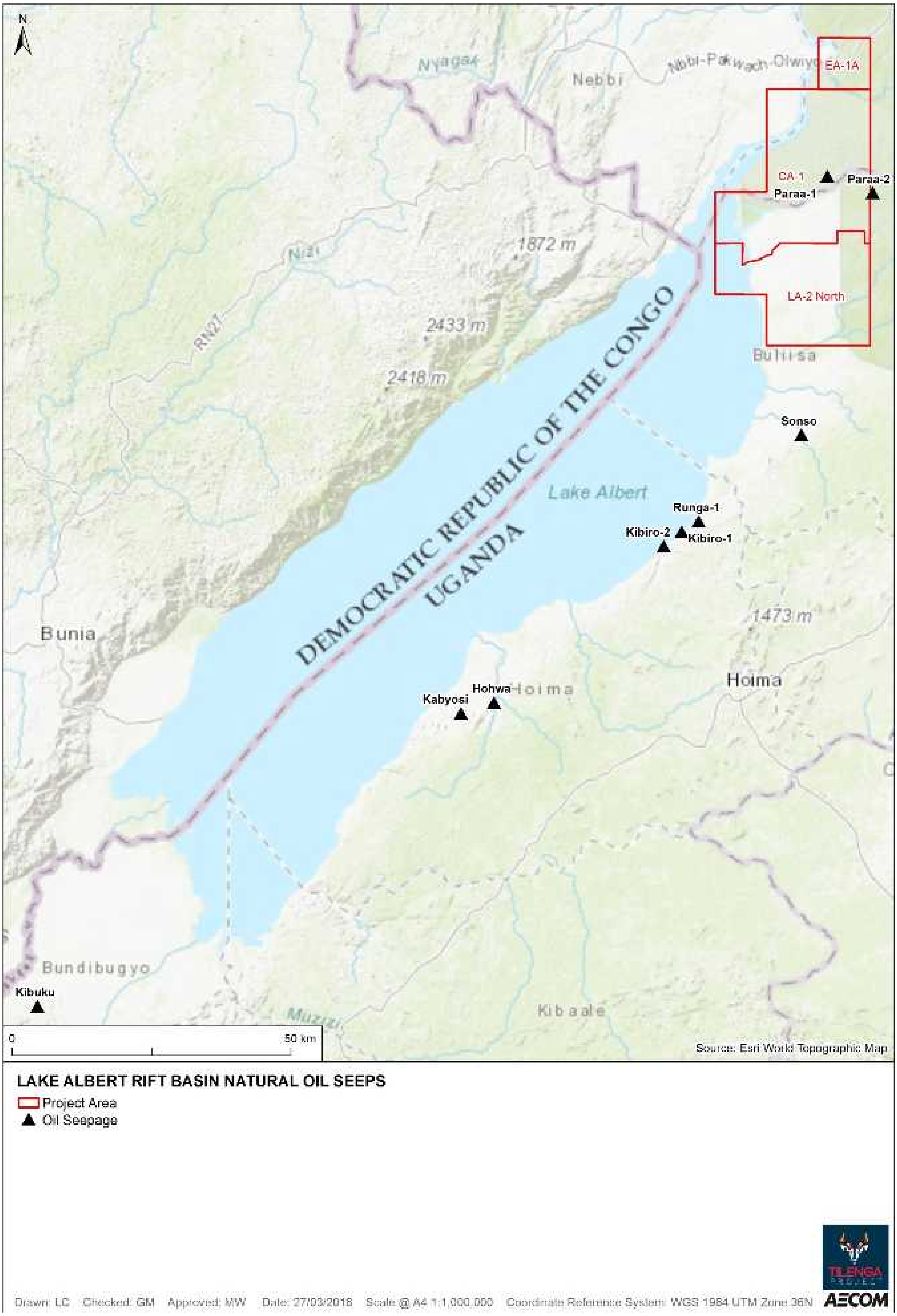
8.6.4 Natural and existing oil seeps

Wayland in his 1925 publication "Petroleum in Uganda" (Ref. 8-47) reported 52 hydrocarbon occurrences in and around Lake Albert. However, some of these are not substantiated or are no longer active. The presence of these oil seeps indicates that mature, organic-rich source rocks are present in the Albertine Graben, and that some of them have generated and expelled oil (PEPD, 2008) (Ref. 8-48). According to the Petroleum Authority of Uganda, there are nine confirmed seeps in the Albertine Graben as listed in Table 8-8 (Ref. 8-49).

Table 8-8: Oil Seeps in Albertine Graben

No.	Seep Name	Latitude (WGS 1984)	Longitude (WGS 1984)	X (WGS 1984 UTM Zone 36N)	Y (WGS 1984 UTM Zone 36N)
1	Sonso	31°28'18"E	01°51'24"N	330132	205120
2	Hohwa	30°58'38"E	01°25'03"N	274925	156957
3	Kibuku	30°14'27"E	00°55'30"N	192940	102430
4	Paraa-1	31°31'03"E	02°16'40"N	334793	251570
5	Paraa-2	31°35'16"E	02°14'54"N	342948	248574
6	Kibiro-1	31°16'48"E	01°41'50"N	308650	187670
7	Kibiro-2	31°15'03"E	01°40'25"N	305420	185070
8	Runga-1	31°18'27"E	01°42'50"N	311709	189515
9	Kabyosi	30°55'26."E	01°24'06"N	269000	155030

Source: Petroleum Authority of Uganda, 2017



Source: Petroleum Authority of Uganda, 2017

Figure 8-8: Lake Albert Rift Basin Natural Oil Seeps

Two oil seeps lie within the Project Area as shown in Figure 8-8. With respect to CA-1, the two active oil seeps have been confirmed on the Victoria Nile near Paraa, spreading over an area approximately half the size of a football field (PEPD, 2008) (Ref. 8-48). The presence of the oil seeps indicates that the lacustrine shales are capable of generating oil, and the presence of the seep could be because the basins may not seal perfectly (Heritage Oil Limited, 2008) (Ref. 8-50). However, during surveys conducted for this ESIA the seeps were not observed.

Geochemical analyses carried out by different laboratories on samples from four oil seeps in the Albertine Graben pointed to the occurrence of lacustrine sources of hydrocarbons. This has now been confirmed by analysis of oil recovered from recently drilled wells. The oil seep at Paraa on the Victoria Nile is postulated to originate from Cenozoic shales and mudstones, migrating laterally along faults into younger sandstone units to the surface. Geochemical analyses of the Paraa oil seeps suggest a moderate to mature source, indicating a mixture of oil and gas-prone (Type-I and III Kerogen) source deposited in a lacustrine environment (PEPD, 2011) (Ref. 8-1). According to Lirong (Lirong D. et al., 2004) (Ref. 8-51), the analyses show that seepage oils from Paraa localities were derived from Types I or II source rocks, deposited in semi-deep or deep-water lacustrine environments containing abundant freshwater algae (PEPD, 2011) (Ref. 8-1).

8.6.5 Soil Erosion

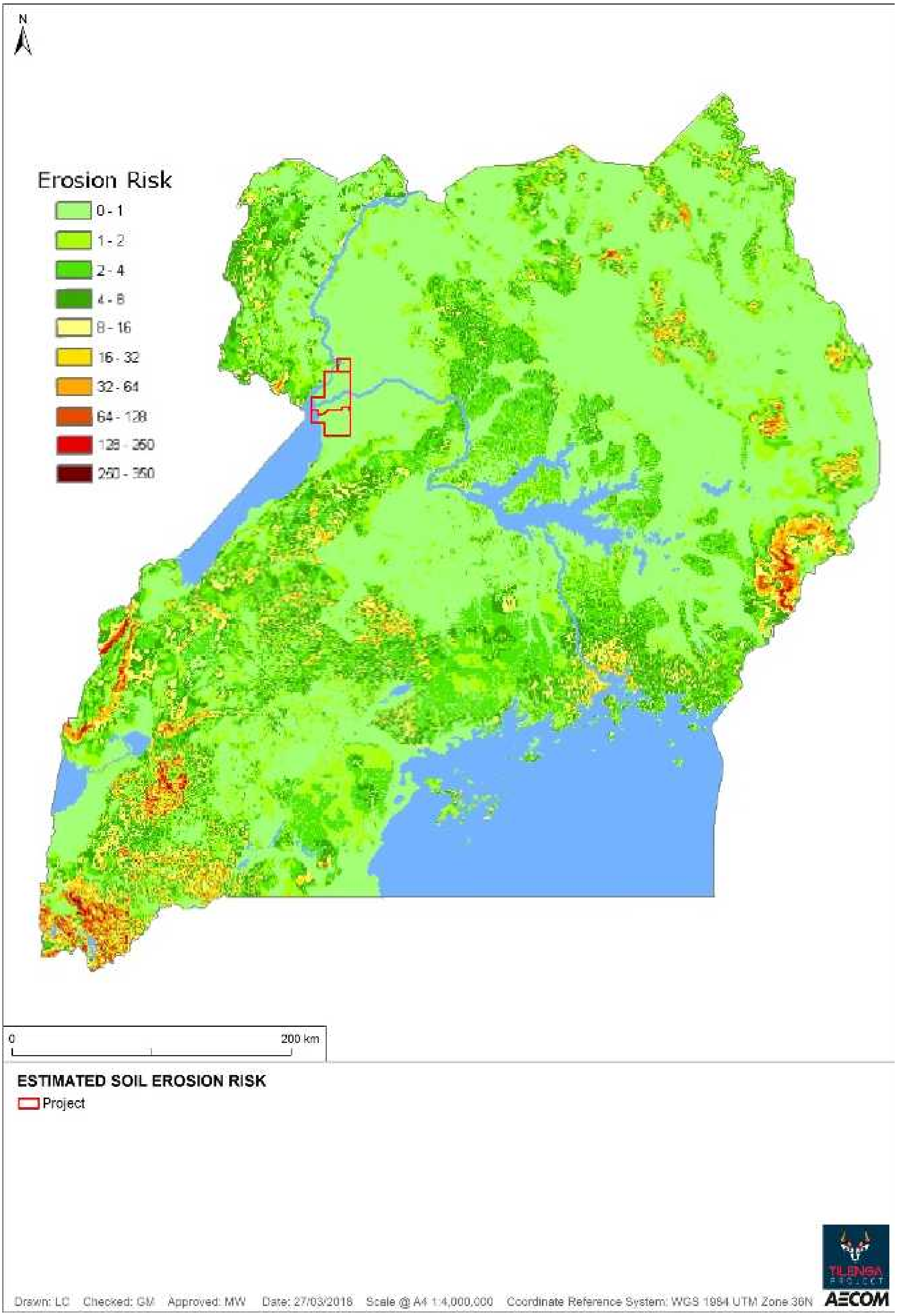
The combination of high intensity rainfall, sandy soils with high rates of water infiltration, and a relatively impervious underlying clay layer has made the Albertine Graben region prone to soil erosion (Oneka 1996) (Ref. 8-52), with high levels of herbivore grazing (NEMA, 2010) (Ref. 8-29). An assessment of the erosion hazard across the country was completed to predict the average annual rate of erosion over the long term taking into consideration rainfall, soil type, topography amongst other factors (MWE, 2013) (Ref. 8-3). Figure 8-9 depicts the estimated rate of soil loss per year on a scale from 1 to 350 tons per hectare per year (t·ha-1·y-1) for Uganda (MWE, 2013) (Ref. 8-3). The mean soil loss reported by Kariminga's Soil Erosion Risk Assessment for Uganda for Buliisa was 0.7 t·ha-1·y-1, Nwoya 2.1 t·ha-1·y-1 and for MFNP 1.06 t·ha-1·y-1 (Ref. 8-53). In general, the estimated soil loss due to erosion for the Tilenga Project Area is low as depicted in Figure 8-9.

Rates of estimated soil erosion risk of protected areas in Uganda are shown in Figure 8-10 (Karamange, 2017) (Ref. 8-53). The estimated rate of soil loss for Murchison Falls Conservation Area is 1-2 t·ha-1·y-1.

One of the significant consequences of soil erosion is the increased sediment loading on lakes and rivers. The susceptibility of soil to erosion is influenced by three main factors:

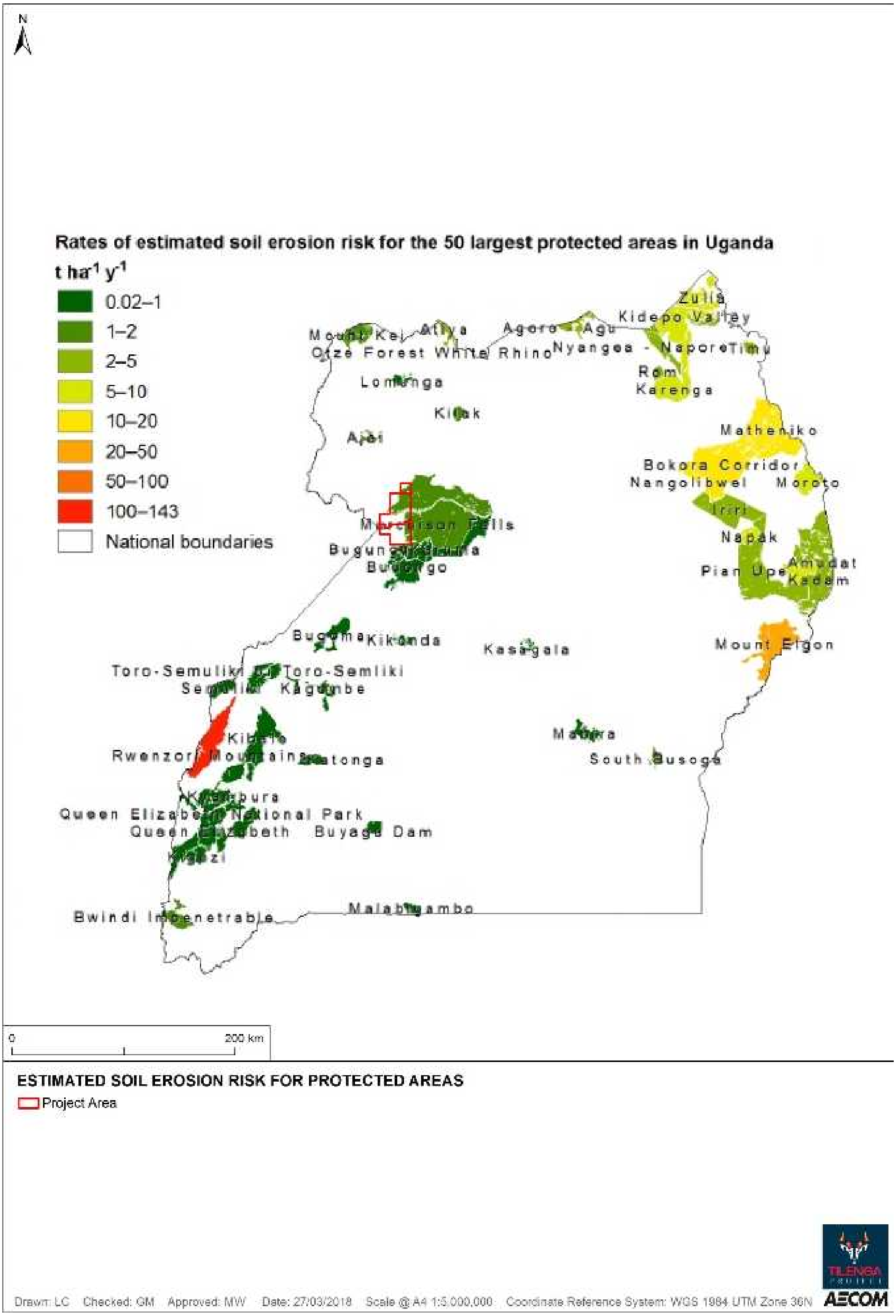
- Soil erodibility;
- Rainfall erosivity; and
- Slope gradient.

Each of these factors is described in more detail in the following sections.



Sources: MWE, 2013

Figure 8-9: Estimated Soil Erosion Risk



Source: *Karamange, 2017*

Figure 8-10: Estimated Soil Erosion Risk for Protected Areas

8.6.5.1 Soil Erodibility

Soil erodibility, or the resistance to disintegration of soil aggregates and dispersion of soil particles, can be assessed using the clay and silt percentage and organic matter content. The National Agricultural Research Laboratories, Kawanda, evaluated erodibility based on the organic matter and silt/clay ratio derived from soil survey data (topsoil 0 – 30 cm). Erodibility sub-ratings (Siderius, 1992) (Ref. 8-54) based on organic matter and silt/clay ratio is presented in Table 8-9 (NEMA, 2010) (Ref. 8-29).

Table 8-9: Rating of soil organic matter and carbon (%) and of the silt/clay ratio

Soil organic matter and carbon rating				Rating of the silt/clay ratio	
Rating	% Organic matter	% Carbon		Rating	Ratio
1	> 2	>3.0		1	< 0.2
2	2 – 5	1.2 – 3.0		2	0.2 – 0.6
3	< 2	< 1.2		3	0.6 – 1.0
-	-	-		4	> 1.0

Final soil erodibility ratings obtained by adding the soil organic matter sub-rating to the silt/clay ratio sub-rating are summarised in Table 8-10.

Table 8-10: Final soil erodibility rating

Rating	Description	Sum
1	High resistance to erosion (Low erodibility)	< 3
2	Medium resistance to erosion (Medium erodibility)	3 – 5
3	Low resistance to erosion (High erodibility)	> 5

Notes: Soil derived land qualities, ITC Enschede, The Netherlands. Source: NEMA, 2010

Based on the soil samples collected during the June 2017 field survey the soil erodibility can be estimated as shown in Table 8-11.

Table 8-11: Estimated Soil Erodibility for Project Area of Influence

Soil organic matter rating			Rating of the silt/clay ratio		Final Soil Erodibility	
Location	% Organic matter	Rating	Silt/Clay Ratio	Rating	Sum	Rating
North Nile	3	2	4.6	4	6	3
South Nile	1	3	6	4	7	3

Note: Average silt and clay values are presented; similar results were calculated for max and min silt/clay ratios.

Based on the known soil types within the Tilenga Project Area can be summarised as follows (NEMA, 2010, Tilenga ESIA 2017):

- High erodibility can be found in Ferralitic soils (Arenosols) characterised by sandy-textured soils that are located in almost all of the South Nile area, in the west of the North Nile area; and
- High to medium erodibility can be found in Ferralitic soils with a minor amount of sandy loam soils that are located particularly in the east of both the North and South Nile areas of CA-1 and LA-2.

8.6.5.2 Rainfall Erosivity

Rainfall erosivity represents a measure of the erosive force and intensity of rainfall. During a rainfall event, the falling raindrops disintegrate soil aggregates and cause soil erosion. The energy generated by rain erosivity can be calculated from mean annual rainfall values using the following equation (Ref. 8-29) for East African conditions:

$$R = 0.029 \times (3.96 \times P + 3122) - 26$$

(Where: R= Rain erosivity (J mm/m²/h) and P= Annual rainfall (mm/year)

As presented in Table 8-12, rainfall erosivity can be categorised using relative ratings from 1 to 5.

Table 8-12: Rainfall erosivity factor rating and categories

Rating	Erosivity (J mm/m²/h)	Categories
1	0 – 144	Very low
2	144 – 172	Low
3	172 – 199	Medium
4	199 – 227	High
5	227 – 254	Very high

Source: NEMA, 2010

In general, most of the Albertine Graben experiences a considerable variation in rainfall patterns. Mean annual rainfall closely related to the heights of the terrain. Within the study area, the zones with lower elevations (approximately between 600 – 800 m above sea level (ASL)) show a lower mean annual rainfall of between 800 - 1000 mm/year; as terrain elevations increase (approximately between 800 – 1000 m ASL) there is a corresponding increase of the mean annual rainfall with the higher values that reach 1400 - 1600 mm/year (AECOM EBS) (Ref 8-2). The rainfall erosivity based on elevation and annual rainfall for the Project Area is shown in Table 8-13.

Table 8-13: Rainfall Erosivity Rating in the Project Area of Influence

Elevation (m ASL)	Rainfall (mm/year)	Erosivity (J mm/m²/h)	Rating	Categories
600-800	800	156	2	Low
	1000	179	3	Medium
800 -1000	1400	225	4	High
	1600	248	5	Very High

Zones with a high mean annual rainfall are characterised by high rain erosivity. With reference to the Project Area, the area of high rainfall erosivity is focused along the east boundaries of CA-1 where the elevation of the reliefs is greater and the mean annual rainfalls are high. The topography and elevation of well pads are shown in Figure 8-11. The lowest elevations within CA-1 are along the shores of Lake Albert and the Nile River, with an elevation of 625 m, is characterised as low erosivity. In North Nile, within MFNP, elevations range between approximately 640m to 720 m with erosivity characterised as low to medium. In South Nile, elevations increase moving east of Lake Albert and south of the Victoria Nile with elevations ranging from approximately 625 m to 700 m, with Pakuba Airstrip at an elevation of 750 m. As elevations increase the erosivity increases from low to medium. Based on the field surveys there was evidence of erosion which ranged from minor gullying to severe outwash throughout the Project Area of Influence where local topography varied from the general character of the area.

8.6.5.3 Slope Gradient

The slope gradient is another important factor used to define soil erosion risk. The slopes are categorised into five classes with different erosion slopes as reported in Table 8-14.

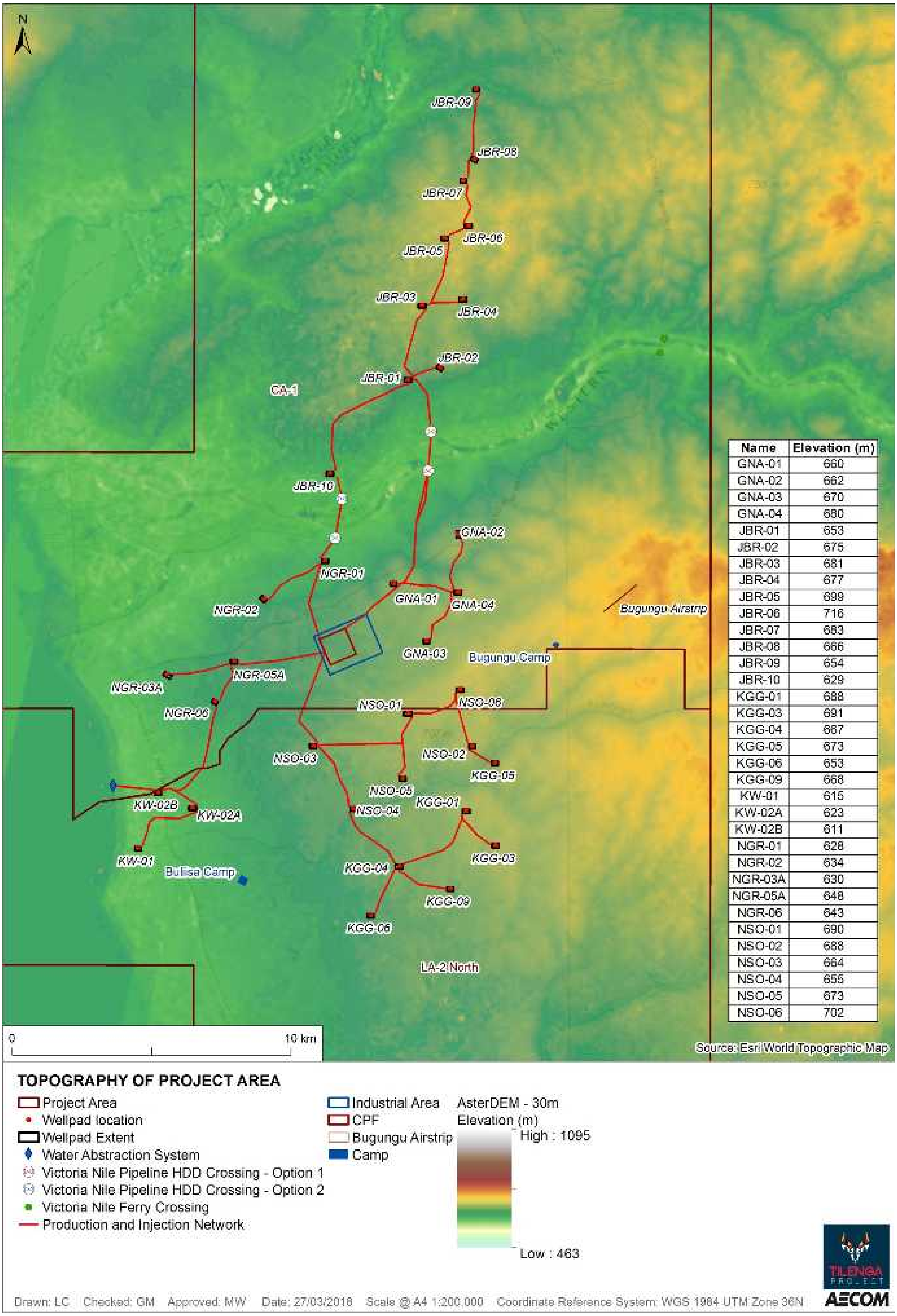
Table 8-14: Erosion slope rating and categories

Rating	Erosion slope (%)	Categories	Rating[1]
-2	0 – 3	Nearly level	Low
-1 to 0	3 – 8	Undulating to gently sloping	Low
+1 to +2	8 – 16	Rolling to steep	Medium
+3	16 – 30	Hilly to moderately steep	High
+4	> 30	Steep to very steep	High

Source: NEMA, 2010 (Ref. 8-29)

(1) Modified to include qualitative ratings of low, medium and high.

Erosion due to slope gradient is related to the terrain, in the Victoria Nile delta the terrain is generally level and rated low. Within MFNP, the terrain ranges from undulating to rolling with a corresponding rating from low to medium. The South Nile is characterised as nearly level near Lake Albert to gently sloping to rolling moving eastward. In the vicinity of Lake Albert the rating is low. The central and eastern areas of South Nile are rated as low to medium.



Name	Elevation (m)
GNA-01	660
GNA-02	662
GNA-03	670
GNA-04	680
JBR-01	653
JBR-02	675
JBR-03	681
JBR-04	677
JBR-05	699
JBR-06	716
JBR-07	683
JBR-08	666
JBR-09	654
JBR-10	629
KGG-01	688
KGG-03	691
KGG-04	667
KGG-05	673
KGG-06	653
KGG-09	668
KW-01	615
KW-02A	623
KW-02B	611
NGR-01	628
NGR-02	634
NGR-03A	630
NGR-05A	648
NGR-06	643
NSO-01	690
NSO-02	688
NSO-03	664
NSO-04	655
NSO-05	673
NSO-06	702

Figure 8-11: Topography of Project Area

Combining the factors of soil erodibility, rainfall erosivity and erosion slope rating, it is possible to identify soils that require soil conservation measures to minimise erosion. The soil erosion risk in the Project Area of Influence as a result of the three factors are summarised in Table 8-15.

Table 8-15: Soil Erosion Risk in the Project Area of Influence

Location	Soil Erodibility Rating	Erosivity Rating	Slope Gradient Rating	Overall Rating
North Nile	High	Low to Medium	Low to Medium	Medium
South Nile	High	Low to medium	Low to Medium	Medium
Lake Albert and Victoria Nile delta	High	Low	Low	Low

Note: Local variations may occur due to terrain, land cover and land use.

8.6.5.3.1 North Nile area

The elevation of the North Nile area ranges between 600 and 650 m ASL in the west and south, rising from 700 to 750 m ASL near the centre, and above 750 m ASL in the southeast, north of the Victoria Nile. Soils in the North Nile area include fine acidic, loam sand-silty soil with a single grain blocky structure and low permeability. These characteristics, compounded by high intensity rainfalls, intensive grazing, and steep slopes, have resulted in severe gully erosion in some areas. The erosion risk in the North Nile area has been mapped as low in the Victoria Nile delta, medium near the Albert Nile, high in an area near Paraa North of the Victoria Nile, and medium to high to the east and northeast.

8.6.5.3.2 South Nile area

The elevation of the South Nile area ranges from 600 to 650 m ASL near the Victoria Nile and Lake Albert in the West and North, and 750 to 800 m ASL towards the southeast. Previous soil surveys in the South Nile area have described the predominant soils as generally sandy loam, alluvial sands and clays, characterised by a low water retention capacity and high rate of infiltration.

Soils in some parts of the South Nile area have been noted for their susceptibility to erosion, which is enhanced by intense seasonal rainfall events and locally steep slopes. The erosion risk in the South Nile area has been mapped as being low in the west, high in the central area south of the Victoria Nile, and medium to high in the east.

8.7 Impact Assessment and Mitigation

This section discusses the principal environmental impacts during the four phases of the Project as described in ***Chapter 4: Project Description and Alternatives,*** relating to soils and geology, including proposed mitigation and management measures.

8.7.1 Impact Assessment Methodology

The impact assessment methodology is based on the principles of source-pathway-receptor. The assessment of impacts has been undertaken by identifying and evaluating a range of activities and scenarios that are likely to occur throughout the phases of the Project, as defined in ***Chapter 4: Project Description and Alternatives***. The sources in this context have been identified in relation to the identified Project activities. The receptors under consideration are soils, specifically the potential for direct impacts to change the physical, biological and chemical properties of soils (e.g. compaction and contamination) and loss of top soil (e.g. erosion). Pathways that could link the sources and receptors have been identified. Only where the complete linkage of source, pathway and receptor are present can impacts potentially occur.

The assessment of potential soils and geology impacts considered applicable Ugandan national standards, international standards, and recognised Good International Industry Practice (GIIP) regarding the control of soil erosion, soil compaction and degradation of soil quality.

The significance criteria utilised are based on applicable Ugandan legislation, international guidance (e.g. IFC performance standards) and recognised GIIP as presented in Section 8.3.

8.7.1.1 Potential Sources of Impact

Potential impacts to soils during routine activities arise from four basic sources:

- Movement of vehicles, heavy machinery and equipment;
- Earthworks and site clearance;
- Storage of equipment and materials; and
- Accidental release (i.e. spillage and leakage) of chemicals, fuels or wastes.

Potential impacts to soils can also occur as a result of unplanned events such as major fuel or chemicals spillages, loss of drilling muds, fluids and chemicals, frack out during Horizontal Directional Drilling (HDD) under the Victoria Nile, Well Blowout, sabotage of equipment or damage by seismic events or animals, and equipment failure. Further details on unplanned events relevant to the Project are described in ***Chapter 20: Unplanned Events***.

The key activities that could generate direct impacts to soils during each of the Project phases are included in Table 8-16.

Table 8-16: Project Activities which may lead to potential impacts

Phase	Activity
Site Preparation and Enabling Works	Mobilisation of plant and construction vehicles to the Project Site
	Deliveries of materials and supplies (including fuel and other hazardous substances) to the Project Site
	Increased vehicle movements on the local and national road network
	Drilling of boreholes for water abstraction (Buliisa camp, Bugungu camp, Tangi Camp, well pads and Industrial Area)
	Waste generation, storage and disposal (hazardous and non-hazardous)

Phase	Activity
	Disposal of waste water (grey and black)
	Storage of fuel and hazardous materials
	Refuelling of plant and machinery within Project Site
	Excavation from borrow pits and quarries and the movement of excavated materials
	Restoration of borrow pits and quarries
	Physical movement of vehicles and plant (Industrial Area, well pads, Water Abstraction System, Masindi Vehicle Check Point, Bugungu Airstrip and Victoria Nile Ferry Crossing Facilities)
	Clearance of vegetation and soils (Industrial Area, well pads, Water Abstraction System, Masindi Vehicle Check Point, Bugungu Airstrip and Victoria Nile Ferry Crossing Facilities)
	Civil works activities at well pads and Water Abstraction System sites
	Installation of structure around well pads in the north of the Victoria Nile
	Installation of temporary facilities at the Masindi Vehicle Check Point
	Construction of Victoria Nile Crossing Facility, including piling for the jetties
	Installation of facilities at Victoria Nile Ferry Crossing
	Construction of new access roads (W1, C1, C2, C3, N1, N2, N3 and inter field access roads south of the Victoria Nile) and upgrade works of existing roads (A1, A2, A3, A4, B1 and B2) including the installation of drainage
	Discharge of surface runoff from roads
	Restoration of Rights of Way (RoWs)
Construction and Pre-Commissioning	Mobilisation of plant and construction vehicles to the Project Site
	Deliveries of materials and supplies (including fuel and other hazardous substances) to the Project Site
	Increased vehicle movements on the local and national road network
	Operation and discharge from temporary SuDS drainage system (including use of storm water facility)
	Disposal of waste water (grey and black)
	Installation of structures around all key Project components
	Waste generation, storage and disposal (hazardous and non-hazardous)

Phase	Activity
	Refuelling of plant and machinery within Project Site
	Storage of fuel and hazardous materials
	Construction activities at the Industrial Area and Water Abstraction System
	Excavation of construction material from quarries and movement and of excavated materials
	Restoration of borrow pits and quarries
	Physical movement of construction vehicles and plant within the Project Site
	Transportation of materials and supplies including hazardous substances (i.e. drill cuttings) within the Project Site
	Drilling of wells (on a 24 hour basis)
	HDD activities at the Victoria Nile crossing points (on a 24hr basis)
	Containment and storage of drilling fluids and drill cuttings
	Operation of Industrial Area plant and equipment
	Clearance of vegetation and soils for Production and Injection Network RoW, Water Abstraction System pipeline RoW and HDD Construction Area
	Movement of construction vehicles for Production and Injection Network RoW, Water Abstraction System pipeline RoW and HDD Construction Area
	Painting and coating of pipeline at Tangi and Industrial Area Construction Support Base
	Construction of Production and Injection Network (i.e. Pipelines and Flowlines) and Water Abstraction System pipeline RoW including trenching, welding, pressure testing
Commissioning and Operations	Delivery of materials and supplies (including fuel and other hazardous substances) to the Project Site
	Physical movement of vehicles and plant within the Project Site
	Waste generation, storage and disposal (hazardous and non-hazardous)
	Discharge of treated waste water from Waste Water Treatment plant
	Storage of fuel and hazardous materials
	Refuelling of plant and machinery within Project Site
	Treatment of water(produced water and water from Lake Albert)

Phase	Activity
	Well pad maintenance activities (including the use of work-over rig)
	Production and Injection Network maintenance (e.g. pigging activities)
	Discharge of surface runoff from all permanent facilities via drainage system (SuDS)
Decommissioning	Dependent upon Decommissioning strategy - but expected to be the same as those for Construction

8.7.1.2 Pathways

Pathways are the means by which an activity can affect a receptor. In some cases this may be a physical migration pathway, such as direct release of contamination to soils, or it may be the inherent nature of the activity itself; for example, excavation of soil will have a physical impact on the soil. For the purpose of this assessment some activities (such as excavation) are considered as an activity and a pathway.

Only where an activity (source), a pathway and receptor are present can an impact occur. The pathways considered in the ESIA process are summarised below:

- Physical disturbance of soils;
- Erosion and transport of soils by surface run-off;
- Direct release of contaminants to soil;
- Leaching of contaminants through soils;
- Ingestion, dermal contact and inhalation (particulates and vapour) of contaminants in soil and sediment by construction and maintenance workers or local residents utilising land for farming following construction; and
- Incidental exposure of wildlife to contaminated soils.

8.7.1.3 Receptors

The receptors under consideration are soils, specifically the potential for direct impacts to change the physical, biological and chemical properties of soils (e.g. compaction and contamination) and loss of top soil (e.g. erosion). Direct impacts have the potential to result in indirect impacts on different physical, biological or social receptors (e.g. contamination of groundwater via leaching). Indirect impacts to other environmental components (e.g. hydrology, and terrestrial and aquatic biodiversity) are identified in this chapter however they are assessed in the corresponding chapters (***Chapter 9: Hydrogeology***; ***Chapter 10: Surface Water***; ***Chapter 13: Terrestrial Vegetation***; ***Chapter 14: Terrestrial Wildlife***; and ***Chapter 15: Aquatic Life***).

Potential impacts to the health of construction or maintenance workers have also been considered. Although the soil baseline data from the Project Area do not indicate the presence of contaminated soils representing a potential risk to human health, any impacts to soil quality which occur during Project activities may also affect workers through ingestion, dermal contact, or inhalation of particulates and/or vapours associated with the contaminated soil.

Members of the public / local residents will not have access to any areas of construction during the Site Preparation and Enabling Works and Construction and Pre-Commissioning phases and to Project facilities during Commissioning and Operations. However, during the Commissioning and Operations phase, local residents may be permitted to grow crops within the pipeline and flowline permanent Rights of Way (RoW) and are therefore considered to be potential human health receptors.

Areas required for the operations (including safety buffers) will be smaller than the areas required for construction. As the land will be acquired on behalf of the Government, at the end of Construction and Pre-Commissioning phase the areas which are not required for the operations will be returned to the Government. At the end of the Decommissioning phase, areas used for Operations will be returned to the Government.

8.7.2 Impact Assessment Criteria

Criteria have been developed for assessing the potential impacts to soils from the Site Preparation and Enabling Works, Construction and Pre-Commissioning, Commissioning and Operations; and Decommissioning Phases of the Project, and include impact magnitude and receptor sensitivity. The impact significance matrix in ***Chapter 3: ESIA Methodology*** is used to determine the significance of each impact.

8.7.2.1 Receptor Sensitivity

Receptor sensitivity is based on multiple characteristics which take into consideration three factors: vulnerability, value and resilience. Soils may be directly affected physically, biologically and chemically as a result of Project activities.

The sensitivity of a receptor may be rated as negligible, low, moderate or high. The sensitivities of soil receptors have been categorised by their nature using the criteria in Table 8-17 to help determine the potential significance of effects.

Table 8-17: Geology and Soils Receptor Sensitivity

Sensitivity	*Description*
High	• Highly vulnerable to physical disturbance, structurally prone to compaction or erosion, and taking >10 years to recover. • Highly leachable. • The soil provides a substrate that has the physical qualities and/or degree of productivity to support a variety of plants including the development of important (in terms of nature conservation or concentration of biomass) and/or indigenous species of flora and fauna. • The soil is intrinsically linked to the hydrological cycle; water is fundamental to its structure; and the soil plays a key ecosystem role in water regulation. • Wet or water saturated soils (i.e. wetland soils). • Sandy soils highly prone to erosion (i.e. shoreline sands of Lake Albert and the Victoria Nile).
Moderate	• Vulnerable to physical disturbance, structurally prone to compaction or erosion but able to recover by mitigation measures within a period of 10 years. • Moderately leachable. • The soil provides a substrate that has the physical qualities and degree of productivity to support the development of species of flora and fauna in some abundance and levels of diversity. • The soil has some capacity for water retention and regulation and plays some role in the hydrological cycle in terms of a degree of water regulation and as a substrate for channelling run-off.

Sensitivity	Description
Low	• Shows resilience to physical disturbance, structurally prone to compaction or erosion and/or impermeable to contamination. • The soil constitutes no particular favourable substrate for the development of floral habitats, invertebrates and other fauna. • The soil plays little or no role in the hydrological cycle or regulation of water.
Negligible	• Completely resilient to physical disturbance and/or impermeable to contamination.

Based on the baseline characterisation of the soils in the Project Area, the soils and subsoils are considered to have a moderate sensitivity in most locations, with the exception of wetland and shoreline areas where the sensitivity is high.

Earthworks that change landform and soils may have consequences for other aspects of the environment, notably water quality and hydrology, ecological habitats and archaeology and cultural heritage.

Table 8-18: Description of Identified Receptors

Receptor	Description	Receptor Sensitivity
Soils and subsoils	Soils range from sandy to sandy, silty clay and are vulnerable to physical disturbance, structurally prone to compaction or erosion but able to recover by mitigation measures within a period of 10 years. They are moderately leachable as they tend to be sandy soils. Subsurface layers of clay in some areas provide some measure of resistance to leaching. The soils are suitable substrate that has the physical qualities and degree of productivity to support the development of species of flora and fauna in some abundance and levels of diversity. The soils have some capacity for water retention and regulation and play some role in the hydrological cycle in terms of a degree of water regulation and as a substrate for channelling run-off. Soils in the MFNP (North Nile) have a higher organic content and have a greater potential for water retention than those in the agricultural/grazing areas (South Nile). Roads in the project area are generally unpaved and constructed of murram.	Moderate
	Sandy shoreline areas are more susceptible to erosion due to the lack of vegetation that provides stability to the soils reducing the effects of erosive forces (i.e. water, wind, waves).	High
Human Receptors	Construction and Maintenance Workers Local Residents utilising land post construction/ decommissioning	High*

* Human health sensitivity was not calculated based on the criteria listed in Table 8-18 above. It is assumed that human health receptors are highly sensitive to contamination impacts from soil. Ecological (flora and fauna) receptors are addressed in the relevant vegetation and wildlife chapters of the ESIA.

8.7.2.2 Impact Magnitude

The impact magnitude considers reversibility, duration and areal extent of the impact to soils.

Table 8-19: Impact Magnitude

Sensitivity	Description
High	• The potential for soil quality and/or physical structure to be permanently impacted (Long term 10 years+). • The area affected is predicted to be large (>20 hectares (ha)).
Moderate	• The impact on soil quality and condition may recover through natural processes and the impact will be medium term (5-10 years). • The area affected is predicted to be a medium extent (>2ha and <20 ha). • Partially reversible or reversible with interventions.
Low	• The impact on soil quality and condition is predicted to recover rapidly through natural processes and the duration of impact is short term (0-5 years). • The area affected is predicted to be a minor extent (<2 ha). • Reversible.
Negligible	• No changes distinguishable from natural variability.

8.7.2.3 Potential Impacts

Potential impacts on soils are compaction, soil quality (contamination) and soil erosion.

8.7.2.3.1 Soils Compaction Impacts

Soil compaction is a direct potential impact which may result in changes to physical, chemical and biological properties of soils.

Physical Properties

Soil compaction changes soil structure (e.g. pore space, size and distribution) and soil strength. Soil compaction occurs when soil particles are pressed together, reducing pore space between them. Heavily compacted soils contain few large pores and have a reduced rate of both water infiltration and drainage from the compacted layer. Soil compaction in the surface layer can increase runoff, thus increasing soil and water losses resulting in potential indirect impacts to hydrology from increased sedimentation and siltation and reduction in localised groundwater infiltration.

Some soils are more prone to compaction than others, particularly soils with a lot of fine sand and silt and little organic matter. Wet clay is much more easily compacted than dry sandy soil. Clayey and silty soils are most susceptible to compaction because their particles hold more water for longer than sands or loams. Compaction is more severe when the soil is wet and less able to withstand compression (Ref. 8-55). Soils in the Project AoI are prone to compaction.

Soil compaction can result from the movement of heavy machinery or stockpiling (i.e. laydown) of equipment or excavated soils.

Biological Properties

Soil compaction can also lead to potential indirect impacts to the biological properties of soils. Excessive soil compaction impedes root growth and therefore limits the amount of soil explored by roots. This, in turn, can decrease the plant's ability to take up nutrients and water. Compacted soil inhibits plant growth as roots must exert greater force to penetrate the compacted layer (Ref. 8-56).

A reduction in soil productivity can occur due to the mixing of soil horizons during soil stripping and stockpiling, which causes dilution of fertility in topsoil.

Stockpiling also has adverse effects on biological properties. When soil is stockpiled in piles that are more than one metre high, chemical effects such as accumulation of ammonium and anaerobic conditions occur in the soil at the base of the pile. Anaerobic conditions created at the base of larger stockpiles result in decreases in microbial activity. Biomass carbon of stockpiled soils has been found to be significantly lower compared to the original soils. This can lead to potential indirect impacts such as reduced nutrient cycling and lower availability of nutrients, having adverse effects on the establishment and production of plants when revegetating during site restoration (Ref. 8-57).

Invasive species may colonise disturbed and stockpiled soils and compacted areas. Invasive species may be introduced naturally (e.g. seed dispersal via wind, water or animals) or through anthropogenic activity (e.g. tracked by vehicles or be present in imported construction materials). Soil disturbance is meant to describe any situation where soil is disturbed, including disturbance from excavation, vehicular traffic, and soil displacement or stockpiling. It includes any activity where soil is moved, removed, or brought in. Invasive species colonisation is considered to be a potential indirect impact.

Chemical Properties

Chemical properties of soils can be affected by prolonged stockpiling of soils or stockpiling of soils in large mounds. This can be attributed to the fact that, when soils are stored for a long time, nutrients released by microbiological activity are continually lost due to leaching and erosion, the nutrient cycle is broken down, and the soil ultimately become unproductive. As the age of soil stockpile increases, the concentrations of suitable plant growth nutrients in soil gradually decrease (Ref. 8-58). In addition, when soil is stockpiled in piles that are more than metre high, chemical effects such as accumulation of ammonium and anaerobic conditions occur in the soil at the base of the pile. This would be considered as a potential indirect impact which has the potential to affect restoration activities using stockpiled soils.

8.7.2.3.2 Soil Erosion Impacts

Soil erosion may be exacerbated by construction activities, in particular the clearance of topsoil and vegetation when preparing ground surfaces for construction result in exposed soils, stockpiling of loose material, and vehicle and equipment movement over unpaved surfaces. Grading of sites can alter surface runoff patterns. Earthen bunding can be prone to erosion due to steep slopes and exposed soils. The quality of the roads is variable and deteriorates during the rainy season. Off road movements of vehicles will continue on unpaved flowline RoWs throughout the life of the Project. This can lead to soil erosion from compacted soils. Tarmac roads have the potential to increase run off velocities leading to erosion of adjacent areas. During heavy rain events, excessive storm water flows from site drainage can cause erosion of discharge channels and discharge points.

A potential indirect impact of soil compaction is increased runoff resulting in erosion and reduction in water infiltration. Erosion of soil/sand by wind and rain may have potential indirect impacts on water resources leading to a decline in water quality and smothering of aquatic habitats. Erosion may also lead to the blockage of drainage channels and culverts causing localised flooding. Potential indirect impacts resulting from soil erosion are addressed in ***Chapter 10 Surface Water.***

Landscape scarring may occur on any areas which are cleared but then not built upon for an extended time (e.g. between site clearance and construction activities) or are no longer required (e.g. following decommissioning), the severity of which will depend on the success of rehabilitation efforts to restore the area such that erosion is reduced and the area can progress towards the restoration goals in a timely manner.

8.7.2.3.3 Soil Quality Impacts

Soil contamination can result from accidental spills or leaks of waste, fuels, oils and lubricants from Project vehicles, equipment, and storage tanks. This is not routine and is a result of unplanned events. These potential impacts can occur throughout the life of the Project. Potential impacts would be dependent on the type and size of spill. Surface runoff and drainage channels have the potential to transport contaminants to surface soils.

As noted above, soil compaction of stockpiled soils can also have a potential impact on the chemical properties of soils, however, the soils will be reused for construction, restoration and bunding, and hence degradation of soil quality from stockpiling is considered to be negligible and has not been further addressed.

The potential impacts of soil contamination are expected to be localised, however if not appropriately and immediately cleaned-up then contaminants could be carried or leached to surface and groundwater sources respectively. Only potential direct impacts are addressed in the following sections. Potential indirect impacts to surface water and groundwater are discussed in the relevant Chapters. Major releases are discussed in ***Chapter 20: Unplanned Events***.

8.7.2.3.4 Human Health Impacts

Potential impacts to soil quality from the release of contaminated materials to ground may also impact the health of construction and maintenance workers and the future health of local residents utilising land which has been contaminated. The Project activities impacting soil quality are also applicable to the human health impact assessment due to a potential direct pollutant linkage being present between soil contaminants and humans.

8.7.3 Embedded Mitigation

In-built design (embedded) mitigation measures are features of the design of Project components that are intended to preclude potential adverse impacts to the environment. A list of embedded mitigation measures already built into the design of the Project are outlined within ***Chapter 4: Project Description and Alternatives***. These measures have been taken into account when predicting the significance of the potential impact. The embedded mitigation measures of particular relevance to the soils and geology chapter are listed in Table 8-20.

Table 8-20: Embedded Mitigation Measures for the Protection of Soils

Embedded Mitigation Measures for the Protection of Soils
All fuels and hazardous materials will be stored within appropriate bunds and drip trays, providing appropriate containment, where practicable
Chemicals and hazardous liquids will be supplied in dedicated tote tanks made of sufficiently robust construction to prevent leaks/spills. Dedicated procedures will be developed for fuel and hazardous material transfers and personnel will be trained to respond. Spill kits will be available at all storage locations
Main refuelling facilities will be located within the Industrial Area, the camps and the Masindi Vehicle Check Point. Facilities will be located within bunded areas with appropriate capacity (110% tank containment). The refuelling pumps will be equipped with automatic shut off and there will be dedicated procedures and spill kits available. Bunds will be designed to minimise ingress of surface water, facilities roofed where practicable and any contaminated water collected will be trucked off site for disposal
With the exception of the CPF which has a bespoke drainage arrangement, drainage arrangements for the permanent facilities will be as follows: • Potentially contaminated areas (i.e. fuel and chemical storage areas) will be provided with local effluent collection (sumps, kerbing and bunding) whereby the potentially contaminated water will be collected and removed by road tanker to a licenced waste disposal facility; and • Uncontaminated areas which will drain naturally to the environment via Sustainable Drainage System (SuDS) comprising filter drains and soakaways. The SuDS design is subject to further detailed design. Sampling points will be established for all potentially contaminated areas to enable samples to be collected for analysis

Embedded Mitigation Measures for the Protection of Soils
There will be a 15 m wide buffer from the perimeter security structure, which will be cleared of vegetation. Within the MFNP, the structure will be designed to prevent the ingress of animals entering the well pads and will comprise a bund wall structure
Each well pad will include an emergency pit with capacity for up to 50 cubic metres (m^3) for use should there be an unplanned event i.e. blowout. The pit will be lined and covered to prevent rainwater ingress
An anticorrosion coating will be applied for external protection and a corrosion inhibitor will be injected for internal protection
The pipelines will comprise carbon steel with adequate corrosion allowance built into material specifications (wall thickness) to prevent leaks
The drainage arrangement of the CPF will be designed to segregate clean and potentially contaminated effluent streams. The drainage for the CPF will be segregated as follows: • Continuously Contaminated Drains will collect hazardous fluids from process and utility equipment. All effluent collected in the closed drainage system will be returned back to the oil treatment trains. There will be no discharge to environment from the closed drains system; • Potentially Contaminated Drains will collect rainfall, wash-water or fire water that falls on paved process and equipment areas that could contain contaminants such as hydrocarbons, metals and solids. Drip pans and kerbs will be provided below every process or utility system that may potentially leak or overflow. Any drips or leaks will be routed to the open drain system via a sump. Roofing will be provided where practicable to prevent surface water ingress. During normal operating conditions, rainwater from potentially contaminated areas will be directed to an the oil water separator prior to discharge to environment in accordance with applicable discharge standards as presented in Chapter 10: Surface Water. When the oil-water separator is full, it will overflows to an associated storm basin via an overflow diverter which will act as a buffer. When the level in the separator falls, the water collected in the storm basin will be sent by storm water pumps back to the overflow diverter and on to the separator. The storm water basin will be sized to withstand a 1 in 100 year event. An oil in water analysers will be installed on the discharge point of the potentially contaminated drains to provide continuous monitoring of the discharge; and • Uncontaminated Drains will manage clean surface water from uncontaminated areas via suitably designed SuDS (network of filter drains and soakaways).
Drainage channels will be installed along the edges of the upgraded roads to prevent excessive runoff and cross drainage culverts will be installed, where appropriate. All drainage infrastructure will be designed taking into account the Uganda Ministry of Works and Transport - Road and Bridge Works Design Manual for Drainage (January 2010)
All site clearance activities will be undertaken in line with the Site Clearance Plan which will be developed by the Contractor(s) prior to commencing the Site Preparation and Enabling Works Phase to limit extent of vegetation clearance, wherever possible
Surface water will be managed via temporary sustainable drainage systems (SuDS) to manage flood and contamination risk. The requirements for construction SUDS will be adapted depending on the nature of the activities utilising the principles as outlined in Chapter 23: Environmental and Social Management Plan
During site clearance, vegetation stripping will be undertaken using a phased approach to minimise sediment pollution from runoff
Contaminated run off will be minimised by ensuring adequate storage facilities are in place for materials stockpiles, waste, fuels/chemicals/hazardous materials, vehicles/washing areas, parking facilities
Clean surface water will be diverted away from exposed soils with use of diversion drains and bunds
All dewatering from excavations or isolated work areas will be provided with appropriate level of treatment prior to discharge
The topsoils will be removed to a required depth; material will be temporarily stored areas within designated areas
It is planned to reuse removed soil onsite wherever possible. Through detailed design, the Project will ensure the generation of excess material is minimised as far as practicable and reused, wherever possible
All temporary land required associated with the construction of the roads will be restored following construction in line with the Site Restoration Plan as developed by the Contractor specifically for the roads
All drill cuttings from borehole drilling activities will be collected and disposed of appropriately. Disposal methods will be pre-agreed with NEMA prior to commencement of activities

Embedded Mitigation Measures for the Protection of Soils
Unused material will be reused within the Project footprint or used to restore the borrow pits as much as practicable
All borrow pits and quarries used by Project Proponents will be re-habilitated following completions of extraction in line with the Site Restoration Plan as developed by the Contractor
Laydown areas at each of the well pad sites will be located within the footprint of the well pad; there will be no additional site clearance required outside the well pad footprint during the Construction and Pre-Commissioning Phase
All wells will be drilled using a Blow Out Preventer (BOP) system prior to entering hydrocarbons bearing reservoirs to prevent an uncontrolled release of hydrocarbons in the event that well control issues are experienced during drilling
A down-hole safety valve (DHSV) will be fitted on all production wells crossing major fault lines
Synthetic Based Muds will be transferred from the Liquid Mud Plant to the well pads via truck in dedicated sealed containers to reduce the risk of spillage during storage, handling and transportation operations
A Wellbore Surveying Management Strategy will be implemented to address the main challenges related to wellbore positioning and collision avoidance aspects
• Mud Products will comply with Uganda's Health, Safety and Environment Regulations. Only Chemicals ranked E or D in the OCNS (Oil Chemical National Scheme classification) will be allowed to be used; • All products for completion and drilling fluids will be free of chlorides; the upper limit will be 2% by weight; • All Products entering in the mixing of drilling, completion and cementing will be free of aromatic Hydrocarbon, the upper limit is fixed at 300 parts per million (ppm); and • No asphalt, no gilsonite, nor equivalent so called "black" products will be permitted in the drilling fluids and cementing formulations.
Spent muds will be temporary stored in containers prior to removal by a vacuum truck, waste cuttings will collected via augers to the Roll-on Roll-off (Ro-Ro) skips (or equivalent) and transferred off the well pad for treatment and disposal
Disposal of drill cuttings will be in accordance with Ugandan Legislation and IFC Environmental Health and Safety (EHS)
There will be no routine well testing after wells are completed
Construction activities will be contained within the permanent RoW which will have a width of 30 m and is designed to accommodate the pipeline trench(s), stockpile areas, laydown, welding, and the movement of construction equipment alongside the trench(s)
During construction and hydrotesting activities, there will be access restrictions to the RoW for safety reasons. Once complete there will be no restrictions to the public using the area
Material from trenching activities will be stored within the pipeline RoW and used as backfill. Excess material will be reused on site where possible. Options for the reuse of uncontaminated excess subsoil material will be assessed during detailed engineering e.g. borrow pit restoration
The Production and Injection Network RoW will be restored in line with the Site Restoration Plan as developed by the Contractor specifically for the RoW
The temporary land required for the HDD Construction Areas roads will be restored following construction in line with the Site Restoration Plan as developed by the Contractor
Any residues and wastes generated from pre-commissioning activities will be managed in accordance with the site Waste Management Plan
For any chemical usage [with respect to pre-commissioning], a thorough Chemical Risk Assessment will be undertaken and lowest toxicity chemicals will be used wherever possible
A Road Safety and Transport Management Plan will be developed prior to commencing the Construction and Pre-Commissioning Phase
[Decommissioning of Masindi] All wastes will be removed and disposed of at dedicated waste treatment facilities in accordance with the Waste Management Plan. A detailed Decommissioning Plan will be developed for the works during the Site Preparation and Enabling Works Phase of the Project

Embedded Mitigation Measures for the Protection of Soils
Decommissioning work at the Buliisa Camp, Bugungu Camp and 17 ha of the Tangi Camp will be undertaken at the end of the Construction and Pre-Commissioning Phase. The land will be restored in line with the Site Restoration Plan as developed by the Contractor
Commissioning tests will be undertaken using feedstock oil, natural gas, methanol and chemicals. All commissioning fluids will be managed either at CPF or transferred off site for disposal
A dedicated Pipeline Integrity Management System will be implemented during the Commissioning and Operations Phase. This will include regular preventative maintenance including operational pigging, intelligent pigging and inspection campaigns to monitor the status of pipelines
The chemicals used for polymer injection will be subject to detailed environmental risk assessment prior to use taking into account all chemical /biological properties and the specific requirements for early oil recovery use
Given that the Project Area is located within the EARS, the Project Proponents will establish a Passive Seismic Network programme, of seismograph stations in the area to enable detection of naturally occurring seismic events
The Project Proponents will undertake analysis of archive images from Interferometric Synthetic Aperture Radar (InSAR) for ground movement data in the Project Area
The permanent RoW will be kept clear of trees, deep rooting vegetation, poles, structures and graves. Regular monitoring will be undertaken, which will include removal of vegetation overgrowth and uprooting tree seedlings
There will be no permanent access restrictions to the pipeline RoW
A review of relevant studies, if necessary, will be undertaken during the Commissioning and Operations Phase to confirm that the planned decommissioning activities utilise good industry practices and are the most appropriate to the prevailing circumstances and future land use
In general, the following principles will be adopted where practicable and will be subject to detailed assessment prior to decommissioning: • Above ground infrastructure will be removed to 0.5 m below ground level and backfilled and vegetated; • Access roads may be left in place depending upon the subsequent use of the land; • Shallow foundations for infrastructure may be excavated, demolished and disposed of; • Where piled foundations exist, these may be excavated to a depth of 1 m below the existing ground level and removed; • Excavations resulting from the removal of foundations will be backfilled; • It is expected that pipelines will be cleaned, capped and let in situ, to prevent disturbing the reinstated habitats; and • Where the environment assessment identifies it is acceptable, in some locations pipeline sections may be cleaned, reclaimed and re-used.
During the Decommissioning Phase the following assumptions are applicable regarding supporting facilities: • Localised effluent collection facilities will be provided for chemical storage, hazardous materials storage, liquid waste storage, tanks, and fuelling facilities. Such containment will include impermeable areas, kerbing, bunding and drip trays as appropriate; • Drainage systems will remain until sites are free of contamination. SuDS will also manage flood risk during this phase of work; • No discharge of water used for decommissioning activities will be discharged to the environment; • Sewage will be treated by existing wastewater treatment plants (WWTPs) and discharged in accordance with wastewater treatment standards as presented in Chapter 10: Surface Water or collected and transferred to suitably licensed treatment facilities for processing and disposal; • A Construction Support Base will be constructed within the Industrial Area for use during the Decommissioning Phase; and • Waste will be segregated and managed in accordance with a Waste Management Plan.
Depending on the final land use agreed with the Ugandan authorities, all or part of the site may need to be rehabilitated. In such circumstances, the Project Proponents will also develop a monitoring programme for completion criteria to verify that the sites are being returned to the agreed representative state
A Waste Management Plan will be developed and maintained to cover the duration of the Project; and will address the anticipated waste streams, likely quantities and any special handling requirements. The Project Proponent's will implement a waste tracking system to ensure traceability of all wastes removed off site

Embedded Mitigation Measures for the Protection of Soils
Prior to transfer offsite to a licensed waste treatment facility, waste materials will be segregated and stored in appropriate containers to prevent: • Accidental spillage or leakage; • Contamination of soils and groundwater; • Corrosion or wear of containers; • Loss of integrity from accidental collisions or weathering; • Theft; and • Odour and scavenging by animals.
The existing camps have operating WWTPs. Sewage produced from the camps will be treated at the WWTPs in compliance with regulatory requirements (refer to Chapter 10: Surface Water). Sewage from other Project Areas (e.g. road work sites) will be collected and transferred to WWTPs and/or suitably licensed treatment facilities for processing and disposal. All sewage sludge will be removed periodically from WWTPs and transferred off site for disposal
A flow meter will be integrated at the discharge point of the WWTPs to record to all discharges and a sample point will be established to collect spot samples for analysis
For the Masindi Vehicle Check Point, waste will be collected and transferred to an approved waste treatment facility for recycling, treatment, recovery and/or disposal
Sewage produced from the camps and other Project Areas will be treated at the WWTPs located at the camps in compliance with regulatory requirements (refer to Chapter 10: Surface Water). Wastewater from the well pads will be collected and transferred by tanker to the nearest WWTPs
For the Masindi Vehicle Check Point, sewage will either be treated by a wastewater treatment plant on site and discharged in accordance with the wastewater treatment standards presented in Chapter 10: Surface Water or transferred to the Masindi sewage treatment plant for processing (depending on capacity and approval)
During the Commissioning and Operations Phase waste will be stored and processed at the Integrated Waste Management Area located south of Victoria Nile. There will be no waste management facility located north of the Victoria Nile within the MFNP
For the well pads, Victoria Nile Ferry Crossing Facility and the Lake Water Abstraction System, sewage will be collected and transferred to suitably licensed treatment facilities for processing and disposal

8.7.4 Assessment of Impacts: Site Preparation and Enabling Works

The Site Preparation and Enabling Works Phase covered under this ESIA is expected to take approximately 5 years. This will include land acquisition clearance, earthworks, fencing, civil works, road modifications/construction and construction of supporting infrastructure required prior to commencement of the Construction and Pre-Commissioning phase as described in ***Chapter 4: Project Description and Alternatives.***

8.7.4.1 Potential Impacts - Site Preparation and Enabling Works

8.7.4.1.1 Site Clearance and Land Preparation at Industrial Area

The Industrial Area is a key component of the Project located to the south of the Victoria Nile, outside of the MFNP. The Industrial Area is expected to cover a total land space of approximately 307 ha which will be cleared and prepared for construction of the proposed facilities. Site activities include clearing (including demolition), tree/bush felling and uprooting, stripping of top soil and sub soil; excavation of drainage channels; site pre-levelling; compaction; and final levelling. Industrial Area site preparation and enabling works will take approximately one year.

Soil Compaction – Industrial Area

Site activities will be reversible, and of short duration (temporary facilities will remain for the duration of this phase, up to 5 years). The areas potentially impacted are considered to exceed 20 ha. The impact magnitude is considered to be high. Soils are sandy, silty and clayey which are susceptible to compaction; especially during wet conditions hence the receptor sensitivity is moderate. The potential impact significance is **High Adverse**.

Soil Erosion – Industrial Area

Site activities will be reversible, temporary and of short duration (<12 months). The areas potentially impacted are considered exceeding 20 ha. The impact magnitude is high due to the size of the area. Soils are generally sandy, silty and clayey which are moderately susceptible to erosion; receptor sensitivity is considered to be moderate. The potential impact significance is **High Adverse**.

Soil Quality – Industrial Area

Site activities will be reversible, temporary and of short duration (<12 months). The areas potentially impacted are considered to be within the footprint of the Industrial Area. Spills and surface water discharges would be localised in extent (<2 ha). The impact magnitude is low. Soils are generally sandy, silty and clayey which are moderately leachable. Subsurface layers of clay in some areas provide some measure of resistance to leaching. The receptor sensitivity is considered to be moderate. The potential impact significance is **Moderate Adverse**.

8.7.4.1.2 Site Preparation and Civil Works at Well Pads

There will be a total of 34 well pads located in CA-1 and LA-2; more specifically, 10 well pads in MFNP north of the Victoria Nile and 24 well pads south of the Victoria Nile. Site preparation activities at each well pad include clearing (including demolition), tree/bush felling and uprooting, stripping of top soil and sub soil; excavation of drainage channels; site pre-levelling; compaction; and final levelling. Subsequent to site preparation, civil works for well pads will be undertaken consisting of laying concrete foundation slabs for drilling rigs; construction of well cellars; construction of structures around well pads to prevent wildlife ingress within the MFNP; installation of conductor pipes; construction of internal drilling access road; and construction of drainage. Overall, the site clearance and civil works are anticipated to take up to 5 years. Vegetation clearance around each well pad will be limited to 15m wide buffer from perimeter security structure.

Soil Compaction – Wells Pads

Site activities will be reversible, temporary and of short term duration (<5 years at each well pad location). The areas potentially impacted are not to exceed 20 ha. The impact magnitude is moderate. The receptor sensitivity is moderate and the potential impact significance is **Moderate Adverse**. Once the site drainage is installed all works thereafter will be contained within this area.

Soil Erosion – Well Pads

Site activities will be reversible, temporary and of short duration (<5 years at each well pad location). The areas potentially impacted are considered to be along the perimeter of the footprint of the well pad. The impact magnitude is moderate. The receptor sensitivity is moderate and the potential impact significance is **Moderate Adverse**. Once the site drainage is installed and wildlife ingress prevention structures surrounding well pads in the MFNP constructed, all works thereafter will be contained within the well pad area.

Soil Quality – Well Pads

Site activities will be reversible, temporary and of short duration (<5 years at each well pad location). The areas potentially impacted are considered to be within the footprint of the well pads. Spills and surface water discharges would be localised (<2 ha). The impact magnitude is low and the sensitivity of the soils is moderate. Until all construction is completed, the potential impact significance is assessed to be **Moderate Adverse**.

8.7.4.1.3 Site Preparation and Civil Works for Water Abstraction System

There are currently two options under consideration by the Front-End Engineering Design (FEED) engineers for the location of the Water Abstraction System facilities, these are 1) facility to be housed on a floating platform with onshore facility, or 2) onshore facility near the lake shore. Both options will have onshore facilities, in particular, laydown areas for the pipeline construction. The option for the floating platform will still have an onshore facility (i.e. pump stations). The impact assessment covers both options.

For both options, the area of direct impact associated with the W1 access road is assumed to be approximately 8 ha. Site preparation activities include clearing (including demolition), tree/bush felling and uprooting, stripping of top soil and sub soil; excavation of drainage channels; site pre-levelling; compaction; and final levelling. Subsequent to site preparation, civil works for the onshore Water Abstraction System facilities will consist of construction of drainage and installation of boundary fencing. The site clearance and civil works for the Water Abstraction System are anticipated to take 6 months.

Soil Compaction – Water Abstraction System

Site activities will be reversible, temporary and of short duration (<12 months). In both options, the areas potentially impacted is between 2 ha and 20 ha. The impact magnitude is moderate. The receptor sensitivity is moderate and the potential impact significance is **Moderate Adverse**.

Soil Erosion – Water Abstraction System

Site activities will be reversible, temporary and of short duration (<12 months). The areas potentially impacted are not to exceed 20 ha. The impact magnitude is moderate. The receptor sensitivity is moderate and the potential impact significance is **Moderate Adverse.**

Soil Quality – Water Abstraction System

Site activities will be reversible, temporary and of short duration (<12 months). The areas which could be potentially impacted are considered to be <2 ha. Spills and surface water discharges would be localised and contained within a temporary drainage system. The impact magnitude is low and the sensitivity of the soils is moderate. Until all construction is completed, the potential impact significance is assessed to be **Moderate Adverse**.

8.7.4.1.4 New Roads Construction and Road Upgrades

New Roads Construction

Three new roads (N1, N2, and N3) are proposed in South Nile outside of MFNP and three new roads (C1, C2 and C3) are proposed within MFNP (C1 and C2 in the north and C3 in the south). Construction of these new roads is anticipated to take up to 9 months. Construction of the new roads is expected to involve the following activities: bush clearing, topsoil removal, compaction, fill with gravel material for the road base, excavation for side drains and installation of cross drainage culverts.

The new ‘N’ designated roads, N1, N2 and N3, are to be 10 m in width, surfaced with asphalt and have lengths not to exceed 3.2 km. The new ‘C’ designated roads, C1, C2 and C3, are to be 6.4 m in width, surfaced with murram and have lengths ranging from approximately 600 m to 10 km. Each N road will have a construction RoW of 40 m, whilst C roads will have a construction RoW of 30 m. The areas of potential direct impact for ‘N’ roads, including RoW, range from approximately 1.2 ha to 12.8 ha, and the areas of potential impact for ‘C’ roads range from approximately 1.8 ha to 30 ha. Drainage channels will be excavated along the edges of the roads. Cross drainage culverts will also be installed, where appropriate. Depending on the surface water features (i.e. size and permanency) water course crossings may be constructed.

Twenty four inter field access roads (D1 to D3, D5 to D6, D8 to D20 and D22 to D27) will be provided south of the Victoria Nile through upgrades to existing tracks or construction of new roads. The ‘D’ designated roads are to be 5 m in width, surfaced with murram or gravel, and have lengths between 0.032 km and 1.85 km. Each road will have a construction right of way of 15 m. The areas of potential direct impact, including RoW, for the inter field access roads are between 0.05 ha and 2.8 ha. Construction of the inter field access roads is expected to take up to 9 months.

Inter field access to well pads located north of the Victoria Nile will be provided using new roads C1 and C2 or using new single lane access roads surfaced in murram or gravel, constructed within the Production and Injection Network RoW.

Soil Compaction – New Roads

Site activities will be reversible, temporary and of short duration (<12 months). Soils are sandy, silty and clayey which are susceptible to compaction, especially during wet conditions; therefore, the receptor sensitivity is moderate. Although the impact magnitude criteria provided in Table 8-19 dictates that an area of direct impact greater than 20 ha should be considered as high, the linear nature of the works would allow for the impact magnitude to be considered as moderate. The potential impact significance is **Moderate Adverse**.

Soil Erosion – New Roads

Site activities will be reversible, temporary and of short duration (<12 months). Road works are linear in nature and would progress down the length of the road and within the RoW, with areas of direct impact anticipated to be <20 ha at any one time. The areas potentially impacted are considered to be areas adjacent to the roads. The potential impact magnitude is moderate. The receptor sensitivity is moderate and the potential impact significance is **Moderate Adverse**.

Soil Quality – New Roads

Drainage channels will be excavated along the edges of the roads and cross drainage culverts will also be installed, where appropriate. Drainage channels have the potential to allow potentially contaminated soils to migrate off site via runoff. Site activities will be reversible, temporary and of short duration (<12 months). Road works are linear in nature and would progress down the length of the road and within the RoW, with areas of direct impact anticipated to be <20 ha at any one time; however, spills and surface water discharges would be further localised to areas <2 ha although there is a potential for migration during heavy rain events. The impact magnitude is low and the sensitivity of the soils is moderate. The potential impact significance is assessed to be **Low Adverse**.

Road Upgrades

A number of existing small roads and tracks (A1, A2, A3, A4, B1, B2 and M1) within the Project Area of lengths ranging from approximately 1 km to 12 km are proposed to be upgraded. The construction activities are the same as for the new roads and it is anticipated to take up to 9 months. Roads A1, A2, A3, A4, B1 and B2 are to be 10 m in width and surfaced with asphalt and gravel. Road M1 (serving the Masindi Vehicle Check Point) is to be 3 m in width and surfaced with gravel. The areas of potential direct impact, including up to a 40 m construction RoW, for the upgraded roads are between 4.0 ha and 48 ha. The potential impacts resulting from the upgrading of roads will be similar to those identified for the construction of the new roads.

Soil Compaction – Road Upgrades

Site activities will be reversible, temporary and of short duration (<12 months). The linear nature of the works would allow for the impact magnitude to be considered as moderate. The receptor sensitivity is moderate and the potential impact significance is assessed to be **Moderate Adverse**.

Soil Erosion – Road Upgrades

Site activities will be reversible, temporary and of short duration (<12 months). Road works are linear in nature and would progress down the length of the road and within the RoW, with areas of direct impact anticipated to be <20 ha at any one time. The areas potentially impacted are considered to be areas adjacent to the roads. The impact magnitude is moderate. The receptor sensitivity is moderate and the potential impact significance is assessed to be **Moderate Adverse**.

Soil Quality – Road Upgrades

Site activities will be reversible, temporary and of short duration (<12 months). Road works are linear in nature and would progress down the length of the road and within the RoW, with areas of direct impact anticipated to be <20 ha at any one time; however, spills and surface water discharges would be further localised to areas <2 ha although there is a potential for migration during heavy rain events. The impact magnitude is low and the sensitivity of the soils is moderate. The potential impact significance is assessed to be **Low Adverse**.

8.7.4.1.5 Masindi Vehicle Check Point Construction

The Masindi Vehicle Check Point will be constructed on the site of the current Masindi airstrip. The Masindi Vehicle Check Point construction works are expected to take approximately 6 months. The Check Point will be 2 km length by 200 m wide constructed on an existing grass airstrip. Construction activities will consist of upgrade of the existing airstrip surface to gravel; installation of utilities, drainage and fencing; and installation of temporary buildings (i.e. containers). The total footprint of the facility is approximately 25 ha. All works will be contained within the confines of the airstrip property.

Soil Compaction – Masindi Vehicle Check Point

Site activities will be reversible, temporary and of short duration (<12 months). The Masindi Check Point footprint is >20 ha. The magnitude of potential impacts is considered to be high, the receptor sensitivity is moderate and the potential impact significance is **High Adverse.**

Soil Erosion – Masindi Vehicle Check Point

Site activities will be reversible, temporary and of short duration (<12 months). The areas potentially impacted are considered to be adjacent to the footprint of the check point site (>20 ha). The impact magnitude is high. The receptor sensitivity is moderate and the potential impact significance is assessed to be **High Adverse.**

Soil Quality – Masindi Vehicle Check Point

Site activities will be reversible, temporary and of short duration (<12 months). Spills and surface water discharges would be localised (<2 ha) although there is a potential for migration during heavy rain events. The impact magnitude is low and the sensitivity of the soils is moderate. The potential impact significance is assessed to be **Low Adverse.**

8.7.4.1.6 Bugungu Airstrip Upgrade

The existing Bugungu airstrip upgrades are to take approximately 6 months and include the extension of the runway by 250 m, and increasing its width to 30 m. Extension of the runway will include the following activities: extension of runway and surfacing with asphalt, repair of perimeter fencing and upgrade of existing facilities. Asphalted surfaces increase the rate of runoff potentially resulting in erosion as the water does not have the ability to infiltrate into the ground. The total area of runway construction is 5.4 ha not including laydown areas. All works will be contained within the confines of the airstrip property.

Soil Compaction – Bugungu Airstrip Upgrade

Site activities will be reversible, temporary and of short duration (<12 months). The Project component footprint is <20 ha. The areas potentially impacted are considered to be the footprint of the Project component. The magnitude of potential impacts is considered to be moderate, the receptor sensitivity is moderate and the potential impact significance is **Moderate Adverse.**

Soil Erosion – Bugungu Airstrip Upgrade

Site activities will be reversible, temporary and of short duration (<12 months). The areas potentially impacted are considered to be adjacent to the footprint of the airstrip. The impact magnitude is moderate. The receptor sensitivity is moderate and the potential impact significance is **Moderate Adverse.**

Soil Quality – Bugungu Airstrip Upgrade

Site activities will be reversible, temporary and of short duration (<12 months). Spills and surface water discharges would be localised (<2 ha) although there is a potential for migration during heavy rain events. The impact magnitude is low and the sensitivity of the soils is moderate. The potential impact significance is assessed to be **Low Adverse.**

8.7.4.1.7 Borrow Pit/Quarry Use

Existing borrow pits and quarries will be used to source stone and murram for roads and construction base and substrate materials as much as practicable. Borrow pits and quarries will be accessed via existing tracks and no upgrades to these tracks are planned as part of the Project. Material sourcing will involve the following activities: bush clearing (if required), stripping and stockpiling of soil for future use during restoration, site drainage works, excavation and transportation of material to Project sites.

All borrow pits and quarries will be restored to their pre-project state following completions of extraction in line with the Site Restoration Plan as developed by the Contractor specifically for the borrow pits and quarries. The surface area of borrow pits to be opened is not known at this time.

Soil Compaction – Borrow Pit/Quarry Use

Site activities will be reversible, temporary and of short duration (<5 years). The areas potentially impacted are considered to be localised and within the borrow pit area, estimated >2 ha and <20 ha. The magnitude of potential impacts is considered to be moderate, the receptor sensitivity is moderate and the potential impact significance is **Moderate Adverse.**

Soil Erosion – Borrow Pit/Quarry Use

Site activities will be reversible, temporary and of short duration (<5 years). The areas potentially impacted are considered to be within the footprint of the borrow pits and adjacent areas as well as access roads with increased vehicle movement. The impact magnitude is moderate. The receptor sensitivity is moderate and the potential impact significance is **Moderate Adverse.**

Soil Quality – Borrow Pit/Quarry Use

Site activities will be reversible, temporary and of short duration (<5 years). The areas potentially impacted are considered to be within the footprint of the borrow pits and adjacent areas as well as access roads. Spills and surface water discharges would be localised although there is a potential for migration during heavy rain events. The impact magnitude is low and the sensitivity of the soils is moderate. The potential impact significance is assessed to be **Low Adverse.**

8.7.4.1.8 Victoria Nile Ferry Crossing Facility Construction

The Victoria Nile Ferry Crossing Facilities will comprise a number of onshore facilities and jetties extending from both the north and south banks of the Victoria Nile. South of the Victoria Nile the jetty will extend approximately 70m over the river (excluding 30 m across an area of wetland area) and north of the Victoria Nile the jetty will extend up to 40 m. A piling rig and ancillary equipment will be used to install 3 walls of sheet piles and 2 mooring dolphins required on both the southern and northern banks of the river banks, and will be used to install the tubular piles necessary for the jetty structures. Installation of the piles will be undertaken from the land-side utilising a crawler crane. The piles will be installed to a depth appropriate and adequate to withstand the live, dead and seismic loads and may be socketed in the rock (if at reasonable depth) with a concrete plug. The jetty structure will delivered to the site as modular units to enable off site manufacturing. It is also planned to construct a deck on a piled structure across the area of wetland south of the Victoria Nile. The landing structures will comprise a double Roll-on/roll-off ramp placed approximately 90 m from the shore line on the south side and 22 m on the northern side at a required minimum water depth of -3.5m MWL (mean water level) for the ferry to berth. The ramp will be connected to the riverbank by an embankment with road access.

Installation of associated buildings (i.e. containers) and development of parking areas will also be undertaken. The footprint for the Victoria Nile Ferry Crossing Facility is estimated to be 1.3 ha including the northern and southern banks, and construction is estimated to take approximately 9 months to complete.

Soil Compaction – Victoria Nile Ferry Crossing Facility Construction

Site activities will be reversible, temporary and of short duration (<12 months). The areas potentially impacted are considered to be the footprint (<2 ha); therefore, the magnitude of potential impacts is considered to be low. Due to the location of the component in the vicinity of wetlands/shoreline, the receptor sensitivity is considered to be high. The potential impact significance is **Moderate Adverse**.

Soil Erosion – Victoria Nile Ferry Crossing Facility Construction

Site activities will be reversible, temporary and of short duration (<12 months); and any erosion of the river bed caused by the installation of the jetty piles is likely to recover rapidly through natural processes. The areas potentially impacted are considered to be within the footprint of the facility and adjacent areas (<2 ha). The impact magnitude is low. Due to the location of the component in the vicinity of the shoreline, the receptor sensitivity is high. The potential impact significance is **Moderate Adverse**.

Soil Quality – Victoria Nile Ferry Crossing Facility Construction

Site activities will be reversible, temporary and of short duration (<12 months). The areas potentially impacted by spills and surface water discharges are considered to be localised within the footprint of the facility and adjacent areas (<2 ha). The impact magnitude is low. Given the location of the component in the vicinity of wetlands/shoreline, the receptor sensitivity is high. The potential impact significance is assessed to be **Moderate Adverse**.

8.7.4.1.9 Drilling of Groundwater Boreholes

During the Site Preparation and Enabling Works Phase, water will be supplied from both existing boreholes and new boreholes for potable and general use. The proposed boreholes will be located as close as possible to the infrastructure to reduce the length of temporary piping where possible to a maximum of 500 m. New groundwater boreholes will be installed at well pads, the Industrial Area and at construction camps (Tangi and within the Industrial Area). The abstraction boreholes will be drilled to target deep water aquifer zones using water and bentonite. All drill cuttings from borehole drilling activities will be collected and disposed of appropriately. Disposal methods will be agreed with NEMA prior to commencement of activities.

Soil Compaction – Groundwater Boreholes

The potential impact on soil compaction from groundwater borehole drilling activities would be temporary and localised. The impact magnitude is negligible. The receptor sensitivity is moderate and the potential impact significance is **Insignificant**.

Soil Erosion – Groundwater Boreholes

Site activities will be reversible, temporary and of short duration (<12 months). The impact magnitude is negligible. The receptor sensitivity is moderate and the potential impact significance is **Insignificant**.

Soil Quality – Groundwater Boreholes

Site activities will be reversible, temporary and of short duration (<12 months). The areas potentially impacted are considered to be the adjacent areas as well as roads and access roads for vehicle movement during transport of generated waste. Spills and surface water discharges would be localised and drill cuttings are not anticipated to contain hazardous materials (water and bentonite used for drilling). The impact magnitude is low. The receptor sensitivity is moderate and the potential impact significance is **Low Adverse**.

8.7.4.1.10 Human Health Impact Assessment

Impacts to soil quality from the release of contaminated materials to ground may also impact the health of construction workers during the Site Preparation and Enabling Works phase, and the future health of local residents utilising land which has been potentially contaminated.

On the basis of the available information, the potential impacts to human health before mitigation within each Project component is of **High Adverse** significance given that humans have a high receptor sensitivity and high impact magnitude due to a potential pollutant linkage being present between soil contaminants and humans.

8.7.4.2 Additional Mitigation and Enhancement

The in-built design measures presented in Section 8.7.3 can be supplemented with further mitigation measures to control and reduce potential impacts from soil compaction, degradation of soil quality (including human health) and soil erosion as summarised in the following table. Monitoring of site activities for potential impacts will allow for timely maintenance, remediation and restoration to minimise potential direct and indirect impacts.

Table 8-21: Additional Mitigation Measures

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
SG.1	Implementing a **Grievance Management Procedure**, to allow recording and follow up of any complaints related to Project activities, in a timely manner	X	X	X	X
SG.2	Regular inspection, servicing and maintenance of vehicles and plant to ensure they are operating as per manufacture's specification. Use manufacturer approved parts to minimise potentially serious accidents caused by equipment malfunction or premature failure	X	X	X	X
SG.3	Vehicle/equipment maintenance should only be done in designated areas	X	X	X	X
SG.4	Allowing only trained and accredited (as required) personnel in the use of machines	X	X	X	X
SG.5	An **Environmental Monitoring Programme** to be established. This will include soil monitoring such as but not limited to quality and erosion, at relevant locations	X	X	X	X
SG.6	An **Oil Spill Contingency Plan** to be established. This will define notification procedure, response strategy, means, and post-spill actions such as clean-up, monitoring, etc. in the event of uncontrolled/accidental discharge		X	X	
SG.7	MSDS for any chemicals are to be displayed at the point of storage	X	X	X	X
SG.8	Ensure proper handling of fuels and hazardous materials. Handling as per Materials Safety Data Sheets (MSDS) guidelines	X	X	X	X
SG.9	Develop and implement HSE Policies and Procedures, to include details of required safety measures (including personal protective equipment (PPE)) for construction and maintenance workers	X	X	X	X
SG.10	Educate workers (as part of training provided) about the potential for environmental contamination and communicate expectation that suspected areas of potential contamination should be reported	X	X	X	X
SG.11	Develop and implement a Spill Prevention Plan, incorporating secondary containment as far as practicable for liquids contained on site	X	X	X	X
SG.12	Ensure adequate controls are in place for the movement of drill cuttings from well pads to waste consolidation area and final treatment / disposal facility , including use of trucks with sealed bodies to prevent spillage		X		
SG.13	Drilling fluids are to be stored within tanks. Drilling fluids will not be stored in below ground pits		X		
SG.14	Plan site layouts such that fuel storage and refuelling areas will be built on hardstanding, isolated and located away from the ground and surface water receptors as far as practicable	X	X	X	X
SG.15	Remove contaminated soils that result from recent spills from work site for storage and subsequent treatment and/or disposal at an appropriate licensed facility	X	X	X	X

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
SG.16	Ensure spill response equipment (including sampling and personal protective equipment) is readily available on site to contain and clean any spillages as soon as reasonably practicable after the event	X	X	X	X
SG.17	Have adequate sumps and drainage around construction areas to capture spills	X	X		X
SG.18	Undertake regular site inspections and audits during course of operations, including of machinery and chemical storage tanks to identify early signs of failure	X	X	X	X
SG.19	All traffic and plant movement will be confined to access roads and within designated site footprint. This will assist in reducing soil cover erosion	X	X	X	X
SG.20	Fixed traffic routes (one-track or single-track policy): Fixed traffic routes will limit the development of extensive braided tracks. Where reasonably feasible, vehicles will be limited to signposted, flagged and fixed routes in order to prevent cross-country driving and the use of shortcuts. This will assist in reducing soil cover erosion	X	X	X	X
SG.21	Optimising the logistics to maximise use of available vehicles, reduce number of trips and reduce movements on more sensitive routes where possible; using convoys when appropriate (e.g. via using one shared logistics service provider who can ensure appropriate planning across all parts of the Project and ensure efficiencies are made)	X	X	X	X
SG.22	Sensitise drivers (as part of training), emphasising the need to adhere to designated routes and speed limits, and to avoid making wide turns at the edges of the site, as far as reasonably practicable	X	X	X	X
SG.23	Minimise stockpile and laydown areas for storage of equipment and materials in the area of works	X	X		X
SG.24	Undertake scarification after compaction to avoid long term compaction of the affected areas, only where necessary and where it would not adversely affect existing vegetation	X	X		X
SG.25	Avoid unnecessary changes and minimise disturbance to natural drainage patterns, where possible. Consider topography and natural drainage patterns in drainage design for roads, well pads, Industrial Area. Existing artificial drainage to be diverted maintaining gravity flows	X	X		
SG.26	Drainage will be designed to avoid concentrating flows and increasing runoff velocities, where feasible	X	X		
SG.27	Access and servitude roads should be designed to drain efficiently through formalised storm water crossings comprising an earth berm and causeway. The placement of these should be assessed per road portion	X			
SG.28	Storm water must be directed to areas of high stability (i.e. not prone to erosion) with the ability to reduce storm water velocity	X	X	X	X
SG.29	Changes in natural gradients due to construction activities should be avoided where possible and minimised where unavoidable	X	X		X

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
SG.30	Engineer slopes and drainage to minimise erosion and slope failure	X	X		X
SG.31	Contouring and minimising length and steepness of slopes, to aid slope stabilisation and minimise erosion potential	X	X		X
SG.32	Exposed slopes shall be minimised as part of the design. Where slopes created are steep, appropriate design shall be installed and additional anti-erosion mechanisms implemented (such as knocking in stakes, installing gabions, geotextiles or similar)	X	X		X
SG.33	Terracing will be used at Industrial Area to reduce exposure along slopes, depending on the site terrain. Other measures such as use of gabions, stone pitching and interlocking blocks should be considered depending on the site terrain	X	X		
SG.34	Use perimeter drainage ditches and design for storm conditions	X	X	X	X
SG.35	Make adequate drainage considerations during design in accordance with industry recognised design standards such as: use of cut-of drains, box culverts along flood plains, adoption of appropriate diameters, openings and strength of the hydraulic drainage structures	X	X		
SG.36	Incorporate erosion protection measures through reuse of cleared material, scours checks, silt traps lining of drains and stepped drains in areas of steep gradient, vegetation cover, and slope protection	X	X		X
SG.37	Where required, settlement areas and silt traps will be provided downstream of the construction areas to remove or filter out sediment originating from access tracks or construction site drainage and protect water courses, wetlands, drainages and riparian areas. The most appropriate sedimentation and siltation control measures will be designed prior to excavation during the construction period, and will be dependent on site-specific characteristics	X	X		X
SG.38	Design and management of site drainage to reduce risk of soil erosion in exposed subsoil areas or in stockpiles	X	X	X	X
SG.39	Maintain a buffer of vegetation around the site (particularly in the lower lying areas) to prevent any eroded soil from leaving the site and being deposited in downstream water sources	X	X		X
SG.40	Use sediment control measures such as straw bales or silt curtains, where required. Permeable check dams, made from coarsely graded rock fill, will be used to slow the discharge velocity in the drainage channels. Particular care will be taken at and close to watercourse crossings, and when construction is located close to watercourses	X	X		X
SG.41	Suspended solids within water leaving the footprint area should not contain significantly higher levels of suspended solids (e.g. >10%) than water within locally occurring water resources	X	X	X	X
SG.42	Protecting all stockpiled material including construction material from being washed away by rain run-off and wind by covering the stockpiles with tarpaulin (or equivalent), bunding the edges, vegetating and not storing in areas susceptible to erosion	X	X		X

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
SG.43	Topsoil shall be stockpiled separately from subsoil with all soils being reinstated in the reverse order to that in which they have been removed in order to initiate rehabilitation. All stockpiles shall be stabilised, not be higher than 3 m, and must blend in with the surrounding topography. Topsoils will also be monitored (e.g. for organic content)	X	X		X
SG.44	Should additional bedding material or backfill be required, only material from an approved source free of alien invasive fauna and flora may be used	X	X		X
SG.45	Topsoil shall only be handled when necessary such as during excavation and reinstatement activities	X	X		X
SG.46	Avoid stockpiling near watercourses, within floodplains or unstable slopes	X	X		X
SG.47	Care must be taken not to cause compaction of ground near wetlands resulting in hydrological or hydrogeological changes that may affect those habitats	X	X		X
SG.48	Undertake regular site inspections and audits during course of construction, including checks around the construction areas for signs of erosion, blocked water courses, and localised flood. If encountered, undertake corrective measures	X	X		X
SG.49	Any work in watercourses and wetlands will be avoided as far as is practicable in periods of heavy rainfall	X	X		X
SG.50	Restore affected areas after completion of works; break-up compacted surfaces/replace topsoil	X	X		X
SG.51	Re-vegetate exposed areas/soil stockpiles to stabilise surfaces as soon as practicable	X	X		X
SG.52	Design, management and monitoring of hydrotest carried out in line with the appropriate Hydrotest Specification for Pipeline hydrotesting		X		
SG.53	Prior to decommissioning, an intrusive ground investigation will be carried out as deemed necessary based on historical site data and monitoring data done throughout the life of the field				X
SG.54	Before decommissioning, a Decommissioning Management Plan will be prepared and agreed with NEMA prior to the commencement of any on-site works. It will include details on the methods and activities associated with the decommissioning of the infrastructure, including the transportation and final disposal or re-use strategy for Project components and wastes. Completion criteria will be detailed in the management plans				X
SG.55	Prior to release of land within the Project Area for agricultural purposes, testing must be undertaken to ensure the soils comply with the Minimum Standards for Management of Soil Quality (National Environment Regulations, 2001) and the baseline conditions as a minimum.				X
SG. 56	Decommissioning activities will be confined within the Project footprint as much as practicable				X

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
SG. 57	Roads will be designed so that their permanent and construction footprint will be minimised	X			

8.7.4.3 Residual Impacts - Site Preparation and Enabling Works

A summary of the residual impacts are provided below.

8.7.4.3.1 Soil Compaction

The risk of soil compaction during site preparation and enabling works construction activities cannot be completely removed. Adoption of recommended mitigation measures can reduce the risk of extensive soil compaction from occurring and enhance site restoration efficacy. The overall residual impact significance is classed as being **Insignificant** or **Low Adverse** for all components. The pre-mitigation and residual impacts for soil compaction are summarised in Table 8-22.

8.7.4.3.2 Soil Erosion

The environmental impacts associated with disturbance of soils leading to erosion may create long-term issues if left unmitigated. However, it is envisaged that if the correct mitigation measures are in place, the magnitude and time-scale of such impacts can be reduced and in the long-term soils will stabilise and vegetation will re-establish. The residual impacts for soil erosion are classified as being **Insignificant** or **Low Adverse** for all components**.** The pre-mitigation and residual impact significance classifications for soil erosion are summarised in Table 8-23.

8.7.4.3.3 Soil Quality

The risk of spillage during enabling works cannot be completely removed. Adoption of good construction, fuel and chemical storage, and handling practices can significantly reduce the risk of a spill occurring. Rapid and effective clean up and remediation in the event of a spill will reduce the risk of long-term environmental issues. Appropriate management of discharges will reduce the likelihood that transfers of potentially contaminated materials to soils will occur. The overall residual impact significance is classed as being **Insignificant** or **Low Adverse** for all components. The pre-mitigation and residual impact significance classifications for soil quality are summarised in Table 8-24.

8.7.4.3.4 Human Health

The risk of spillage during construction activities cannot be completely removed. Adoption of good construction, fuel and chemical storage, and handling practices can significantly reduce the risk of a spill occurring. An awareness of the presence of potentially contaminative materials, appropriate disposal or treatment of contaminated soil and the use of appropriate PPE will reduce the potential impacts of soil contamination to human health. The residual impacts to human health resulting from the drilling of groundwater boreholes are considered to be **Insignificant.** The residual impacts at all other Project Components have been classified as **Low Adverse** Significance. The pre-mitigation and residual impact significance classifications for human health are summarised in Table 8-25.

Table 8-22: Residual Impact Assessment of Soil Compaction – Site Preparation and Enabling Works

Project Component	Industrial Area			Well Pads			Water Abstraction System			New Roads			Upgrade Roads			Masindi Vehicle Check Point			Bugungu Airstrip			Borrow Pits / Quarries			Victoria Nile Ferry Crossing			Groundwater Boreholes		
Soil Compaction	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	H	M	**H**	M	M	**M**	M	M	**M**	M	M	**M**	M	M	**M**	H	M	**H**	M	M	**M**	M	M	**M**	L	H	**M**	N	M	**I**
Residual	L	M	**L**	L	M	**L**	N	M	**I**	N	M	**I**	N	M	**I**	L	M	**L**	N	M	**I**	L	M	**L**	N	H	**L**	N	M	**I**

Note: H is high, M is Moderate, L is Low

Table 8-23: Residual Impact Assessment of Soil Erosion - Site Preparation and Enabling Works

Project Component	Industrial Area			Well Pads			Water Abstraction System			New Roads			Upgrade Roads			Masindi Vehicle Check Point			Bugungu Airstrip			Borrow Pits / Quarries			Victoria Nile Ferry Crossing			Groundwater Boreholes		
Soil Erosion	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	H	M	**H**	M	M	**M**	M	M	**M**	M	M	**M**	M	M	**M**	H	M	**H**	M	M	**M**	M	M	**M**	L	H	**M**	N	M	**I**
Residual	L	M	**L**	L	M	**L**	L	M	**L**	L	M	**L**	L	M	**L**	L	M	**L**	L	M	**L**	L	M	**L**	N	H	**L**	N	M	**I**

Note: H is high, M is Moderate and L is Low

Table 8-24: Residual Impact Assessment for Soil Quality – Site Preparation and Enabling Works

Project Component	Industrial Area			Well Pads			Water Abstraction System			New Roads			Upgrade Roads			Masindi Vehicle Check Point			Bugungu Airstrip			Borrow Pits / Quarries			Victoria Nile Ferry Crossing			Groundwater Boreholes		
Soil Quality	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	L	M	**M**	L	M	**M**	L	M	**M**	L	M	**L**	L	M	**L**	L	M	**L**	L	M	**L**	L	M	**L**	L	H	**M**	L	M	**L**
Residual	L	M	**L**	L	M	**L**	L	M	**L**	N	M	**I**	N	M	**I**	N	M	**I**	N	M	**I**	N	M	**I**	N	H	**L**	N	M	**I**

Note: H is high, M is Moderate, L is Low

Table 8-25: Residual Impacts of Human Health – Site Preparation and Enabling Works

Project Component	Industrial Area			Well Pads			Water Abstraction System			New Roads			Upgrade Roads			Masindi Vehicle Check Point			Bugungu Airstrip			Borrow Pits / Quarries			Victoria Nile Ferry Crossing			Groundwater Boreholes		
Soil Quality	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	H	H	**H**	H	H	**H**	H	H	**H**	H	H	**H**	H	H	**H**	H	H	**H**	H	H	**H**	H	H	**H**	H	H	**H**	H	H	**H**
Residual	N	H	**L**	N	H	**L**	N	H	**L**	N	H	**L**	N	H	**L**	N	H	**L**	N	H	**L**	N	H	**L**	N	H	**L**	N	H	**I**

Note: H is high, M is Moderate, L is Low, and N is Negligible

8.7.5 Assessment of Impacts: Construction and Pre-commissioning

The Construction and Pre-commissioning phase is expected to last approximately 7 years. This will include construction, installation and pre-commissioning of plant and equipment within the Industrial Area, water abstraction facility and at each well pad; drilling at each well pad (412 wells across 34 pads) and land acquisition clearance, construction, installation and pre-commissioning of the pipeline network including HDD at Nile crossing as described in ***Chapter 4: Project Description and Alternatives***.

8.7.5.1 Potential Impacts – Construction and Pre-commissioning

Potential impacts on soils resulting from soil compaction, soil quality (contamination) and soil erosion have the potential to cause changes to the physical, chemical and/or biological properties of soils.

The activities that could generate direct impacts to soils during construction and pre-commissioning works are included in Table 8-16. The assessment of potential impacts during the Construction and Pre-commissioning phase of the project are presented in the following sections.

8.7.5.1.1 Construction, Installation and Pre-Commissioning of Plant and Equipment at Industrial Area

The Industrial Area which includes the Central Processing Facility (CPF), camps, tank farm, liquid mud plant facility, temporary construction area and buffer zones will require a total land take of approximately 307 ha at a single location. Construction is expected to take 2.5 years to complete.

Soil Compaction – Industrial Area

The underlying soils will be compacted as a result of facilities, equipment and various activities at the Industrial area. Since restoration is planned for during decommissioning, the impact will be reversible and of long term duration (+10 years). The area of direct impact is >20 ha; therefore, the impact magnitude is considered to be high. Soils are generally sandy, silty and clayey which are moderately susceptible to erosion; receptor sensitivity is considered to be moderate. The potential impact significance is **High Adverse.**

Soil Erosion – Industrial Area

All work at the Industrial Area will be within the confines of the site which will include a temporary drainage network. The potential impacts from water erosion will be reversible, temporary and of short duration (<5 years). The impact magnitude is negligible. Soils are generally sandy, silty and clayey which are moderately susceptible to erosion; receptor sensitivity is considered to be moderate. The potential impact significance is **Insignificant.**

Soil Quality – Industrial Area

The drainage system will be designed to segregate clean uncontaminated storm water from drainage water generated from potentially contaminated areas, and meet the discharge standards as presented in ***Chapter 10: Surface Water***. Drainage from potentially contaminated areas will pass through an appropriately designed oil/water separator before being discharged to the environment.

Site activities will be reversible, temporary and of short duration (<5 years). The areas potentially impacted are considered to be within the footprint of the Industrial Area, with spills localised and surface water discharges limited to discharge points of the site drainage system. The impact magnitude is low. Soils are generally sandy, silty and clayey which are moderately leachable. Subsurface layers of clay in some areas provide some measure of resistance to leaching. The receptor sensitivity is considered to be moderate. The potential impact significance is **Moderate Adverse** due to the potential presence of contaminants in the storm water.

8.7.5.1.2 Erection of Temporary Facilities and Expansion of Construction Camps

To provide sufficient accommodation for the Project construction workers a new temporary construction camp will be erected within the Industrial Area and existing camp (Tangi) will be expanded for use during the Construction and Pre-Commissioning Phase. A temporary Construction Support Base will also be developed within the boundary of the Industrial Area. The existing Buliisa and Bugungu camps will not be expanded but will be utilised during this phase at their current capacity.

The existing footprint of Tangi Support Base is 8 ha and this will be expanded by 14 ha for the duration of the Construction and Pre-Commissioning Phase. Following this, with the exception of 5 ha, the site will be reinstated to its pre-Project condition.

Soil Compaction – Temporary Facilities / Construction Camps

Site activities at Tangi Camp will be reversible, temporary and of short term duration (<5 years). The areas potentially impacted will not exceed 20 ha. The impact magnitude is moderate. The receptor sensitivity is moderate and the potential impact significance is **Moderate Adverse.** Once the site drainage is installed all works thereafter will be contained within this area.

Soil Erosion – Temporary Facilities / Construction Camps

Site activities will be reversible, temporary and of short duration (<5 years). The areas potentially impacted are considered to be adjacent to the footprints of each area and not exceed 20 ha. The impact magnitude is moderate. The receptor sensitivity is moderate and the potential impact significance is **Moderate Adverse.**

Soil Quality – Temporary Facilities / Construction Camps

Site activities will be reversible, temporary and of short duration (<5 years). Spills and surface water discharges would be localised (<2 ha) although there is a potential for migration during heavy rain events. The impact magnitude is low and the sensitivity of the soils is moderate. The potential impact significance is assessed to be **Low Adverse.**

8.7.5.1.3 Construction, Installation and Pre-Commissioning of Plant and Equipment at the Water Abstraction System, including Associated Pipeline

The Water Abstraction System will comprise an intake pipeline installed along the lake bed extending 1.5 km into the lake from the shoreline, an onshore 24-inch buried pipeline approximately 10 km in length to the CPF, and a Water Abstraction System facility installed either onshore or offshore (subject to FEED selection). The construction, installation and pre-commissioning of plant and equipment at the Water Abstraction System and installation of the associated pipelines is anticipated to take 9 months. All pipe stringing and welding will be done onshore for pulling the pipe out into the lake. Following stringing, a work barge will be used to pull the pipe out into the lake.

The water abstraction pipeline to the CPF will be approximately 10 km in length with a total area of direct impact; including the RoW, of approximately 30 ha. The pipeline will be buried using an open cut trench technique. The pipeline will be hydrotested for integrity following installation.

Soil Compaction – Water Abstraction System

Site activities will be reversible, temporary and of short duration (<12 months). The area of direct impact is less than 2 ha at the Water Abstraction System site. All pipeline works will be within the pipeline right of way and impacts will be localised along the route and not exceed 20 ha. The potential impact magnitude is moderate. Soils are generally sandy, silty and clayey which are moderately susceptible to erosion; however, give that construction works will be undertaken on or adjacent to the shoreline, the receptor sensitivity is considered to be high. The potential impact significance is **High Adverse.**

Soil Erosion – Water Abstraction System

The areas potentially impacted are considered to be localised and not exceed 2 ha. The potential impacts from erosion on the land will be reversible, temporary and of short duration occurring primarily during heavy rain events. Any erosion impacts of the lake bed caused by the laying of the intake pipeline would likely recover rapidly through natural process. The impact magnitude is low. Soils are generally sandy, silty and clayey which are moderately susceptible to erosion and given that construction works will be undertaken on or adjacent to the shoreline, receptor sensitivity is considered to be high. The potential impact significance is **Moderate Adverse.**

Soil Quality – Water Abstraction System

The areas potentially impacted are considered to be adjacent to the site works areas. Spills and the migration of potentially contaminated soils would be localised. The potential impact magnitude is low.

Soils are generally sandy, silty and clayey which are moderately leachable but subsurface layers of clay in some areas provide some measure of resistance to leaching. However, given the location of the works near the shoreline, the receptor sensitivity is considered to be high. The potential impact significance is **Moderate Adverse.**

8.7.5.1.4 Construction, Installation and Pre-Commissioning of Plant and Equipment at Well Pads and Well Drilling

Construction of the well pads and drilling all wells is expected to take up to 6 years. It is expected that the construction of each well pad will take up to 6 months and several well pads may be constructed concurrently. It is expected that the duration of drilling of the requisite wells at each well pad will not exceed one year. Each well pad will comprise various types of wells including: production wells, injection wells and observation wells and supporting plant.

The well pad area will constitute a number of different surfaces, with compacted murram used for the majority of the area. Concrete areas have been considered only around well-heads for rig support and to improve effluent drainage during drilling operation.

Soil Compaction – Well Pads and Drilling

The underlying soils that will be compacted due the presence of the well pad area will have to be restored during decommissioning. Hence, the impact will be reversible and have long term duration (+10 years). The areas potentially impacted are considered to be within the footprint of the completed well pads. The impact magnitude is moderate, the receptor sensitivity is moderate and the potential impact significance is **Moderate Adverse.**

Soil Erosion – Well Pads and Drilling

All work at the well pads will be within the confines of the footprint which includes a temporary drainage network. Excessive amount or storm water can result in erosion at discharge points. Site activities will be reversible, temporary and of short duration (<5 years). The areas potentially impacted are considered to be within the footprint of the completed well pads. The impact magnitude is negligible. Soils are generally sandy, silty and clayey which are moderately susceptible to erosion; therefore, receptor sensitivity is considered to be moderate. The potential impact significance is **Insignificant.**

Soil Quality – Well Pads and Drilling

Exposure of drill cuttings or drilling fluids to soils may result in medium term impact (5-10 years), reversible only with interventions. The areas potentially impacted are considered to be within the footprint of the Project components (well pads) as well as roads and access roads for vehicle movement. The impact magnitude is moderate. Soils are generally sandy, silty and clayey which are moderately leachable. Subsurface layers of clay in some areas provide some measure of resistance to leaching. The receptor sensitivity is considered to be moderate. The potential impact significance is **Moderate Adverse.**

8.7.5.1.5 Production and Injection Network

A network of pipelines and flowlines will need to be installed to connect the CPF to the wells. It is estimated that the total combined pipeline network will be around 180 km in length, comprising 34 segments ranging in length from approximately 0.84 km to 4.8 km. A 30 m working RoW will be required for all pipelines during construction. The area of direct impact ranges from 2.52 ha to 14.4 ha. The duration of the construction and pre-commissioning of the Production and Injection Network will overlap with the construction of the well pads and is expected to last approximately 5 years; however, the construction of individual segments would be of shorter duration.

The Production and Injection Network outside of the Industrial Area will be trenched and buried.

During pipeline RoW preparation, bush will be cleared and topsoil will be stripped across the construction corridor and stored appropriately for reinstatement after works are complete. The pipelines will be installed using open-cut trench methods as detailed in ***Chapter 4: Project Description and Alternatives***. The depth of the trenches will be between 0.8 m to 2 m. Open trench lengths will be approximately 1 km. Once the pipelines are in place, hydrotesting will be undertaken. The pipeline trenches will then be backfilled with stored subsoil and topsoil, with surplus or unsuitable backfill material removed from site for reuse or disposal.

The base case for management of hydrostatic test water is for the treated water to be left in situ until start up and then disposed via the Produced Water Treatment Train and transferred back via the Production and Injection Network to the well pads for re-injection.

During construction and hydrotesting activities, there will be access restrictions to the RoW for safety reasons. Once complete there will be no restrictions to the public using the area; therefore, the RoW may be used for cultivating shallow rooting crops.

Soil Compaction – Construction of the Pipelines and Flowlines

Site activities will be reversible, temporary and of short duration (<12 months for each segment). All works will be within the pipeline RoW. These are a linear features and impacts will be localised along the route and not exceed 20 ha during the site works. The impact magnitude is moderate. Soils are generally sandy, silty and clayey which are moderately susceptible to compaction hence receptor sensitivity is considered to be moderate. The potential impact significance is **Moderate Adverse.**

Soil Erosion – Construction of the Pipelines and Flowlines

All works will be within the pipeline RoW. The area of direct impact is less than 20 ha for each pipeline segment (2.52 ha to 14.4 ha). Potential impacts will be reversible, temporary and of short duration (<12 months for each segment). The impact magnitude is moderate. Soils are generally sandy, silty and clayey which are moderately susceptible to erosion; receptor sensitivity is considered to be moderate. The potential impact significance is **Moderate Adverse.**

Soil Quality – Construction of the Pipelines and Flowlines

The areas potentially impacted are considered to be within the pipeline RoW and the area of direct impact is less than 20 ha for each pipeline segment. The pipeline construction period for each segment will be short duration (<12 months). Chemicals used for hydrotesting have the potential to impact soil quality. Spills and leakages and the migration of potentially contaminated soils would likely be localised. The impact magnitude is moderate. Soils are generally sandy, silty and clayey which are moderately leachable. Subsurface layers of clay in some areas provide some measure of resistance to leaching. The receptor sensitivity is considered to be moderate. The potential impact significance is **Moderate Adverse.**

8.7.5.1.6 Victoria Nile River Crossing Using HDD

To connect the well pads in MFNP to the CPF there will be a pipeline crossing under the Victoria Nile which will include three pipelines installed using horizontal directional drilling.

HDD will require a total construction area of approximately 20 ha north and south of the Victoria Nile for laydown, machine, oil tanks, drilling mud storage (in mud tanks), pipe extension and welding. An additional pipe stringing area of 8 ha will be utilised north of the Victoria Nile within MFNP.

During HDD, pressure is maintained by mud pressure. In addition to holding the hole open during construction the mud is used to transport the cuttings back to the drill site for clean-up and removal. Muds will be transferred to the HDD Construction Area for reuse.

Soil Compaction – Victoria Nile HDD Crossing

Site activities will be reversible, temporary and of short duration (<12 months). Works will be within the construction area and stringing area. The impact magnitude is high. Soils are generally sandy, silty and clayey which are moderately susceptible to compaction hence receptor sensitivity is considered to be high. The potential impact significance is **High Adverse.**

Soil Erosion – Victoria Nile HDD Crossing

Site activities will be reversible, temporary and of short duration (<12 months). Works will be within the construction area and stringing area. The impact magnitude is high. Soils are generally sandy, silty and clayey which are moderately susceptible to erosion; receptor sensitivity is considered to be high. The potential impact significance is **High Adverse.**

Soil Quality – Victoria Nile HDD Crossing

Site activities will be temporary and of short duration (< 12 months) and although drill cuttings are unlikely to represent a source of contaminants, contact between drilling fluids and soils could result in medium term impacts, reversible only with interventions. The areas potentially impacted are considered to be localised within the Project component and associated RoW and laydown areas (<20 ha). The impact magnitude is moderate. Soils are generally sandy, silty and clayey which are moderately leachable. Subsurface layers of clay in some areas provide some measure of resistance to leaching. The receptor sensitivity is considered to be high. The potential impact significance is **High Adverse.**

8.7.5.1.7 Human Health Impact Assessment

Potential impacts to soil quality from the release of contaminated materials to ground may also impact the health of construction and maintenance workers during the Construction and Pre-Commissioning phase, and the future health of local residents utilising land which has been contaminated.

The potential impacts described above with respect to soil quality are also applicable to the human health impact assessment. On the basis of the available information, the potential impacts to human health before mitigation within each Project component is of **High Adverse** significance given that humans have a high receptor sensitivity and high impact magnitude due to a potential pollutant linkage being present between soil contaminants and humans.

8.7.5.2 Additional Mitigation and Enhancement

Mitigation measures to control and reduce potential impacts from soil compaction, degradation of soil quality and erosion during the Construction and Pre-Commissioning phase are summarised in Table 8-21.

8.7.5.3 Residual Impacts - Construction and Pre-commissioning

A summary of the residual impacts associated with the Construction and Pre-Commissioning phase is provided below.

8.7.5.3.1 Soil Compaction

The risk of soil compaction during construction and pre-commissioning activities cannot be completely removed. Adoption of recommended mitigation measures can reduce the risk of extensive soil compaction from occurring and enhance site restoration efficacy. Residual soil compaction impacts from the fitting of well pads and well drilling are classified as **Insignificant** as most activities will be confined to the well pad site. Residual impacts for the Industrial Area, Temporary Facilities/Construction Camps, Water Abstraction System, Pipeline and Injection Network, and Victoria Nile HDD Crossing are all classified as **Low Adverse** Significance. The pre-mitigation and residual impact assessments for soil compaction are summarised in Table 8-26.

8.7.5.3.2 Soil Erosion

The environmental impacts associated with disturbance of soils leading to erosion may create long-term issues if left unmitigated. However, it is envisaged that if the correct mitigation measures are in place, the magnitude and time-scale of such impacts can be reduced and in the long-term soils will stabilise and vegetation will re-establish. Residual impacts leading to soil erosion for the Water Abstraction System and the Victoria Nile HDD Crossing are classified as **Low Adverse** Significance. Residual impacts for the Industrial Area, Temporary Facilities/Construction Camps, Well Pads and Well Drilling and Production and Injection Network are classified as **Insignificant**.

The pre-mitigation and residual impact assessments for soil erosion are summarised in Table 8-27.

8.7.5.3.3 Soil Quality

The risk of spillage of contaminative materials during construction and pre-commissioning activities cannot be completely removed. Adoption of good construction, fuel and chemical storage, and handling practices can significantly reduce the risk of a spill occurring. Rapid and effective clean up and remediation in the event of a spill will reduce the risk of long-term environmental issues. Appropriate management of discharges will reduce the likelihood that transfers of potentially contaminated materials to soils will occur. Residual impacts on soil quality for the Water Abstraction System, Industrial Area, well pads and well drilling, Production and Injection Network and Victoria Nile HDD Crossing are all classified as **Low Adverse** Significance. Residual impacts for the Temporary Facilities/Construction Camps are classified as **Insignificant**. The pre-mitigation and residual impact assessments for soil quality are summarised in Table 8-28.

8.7.5.3.4 Human Health

The risk of spillage during construction activities cannot be completed removed. Adoption of good construction, fuel and chemical storage, and handling practices can significantly reduce the risk of a spill occurring. An awareness of the presence of potentially contaminative materials and the use of appropriate PPE will reduce the potential impacts of soil contamination to human health. Residual impacts on human health for the Water Abstraction System, well drilling, Industrial Area, Production and Injection Network and the Victoria Nile HDD Crossing are all classified as **Low Adverse** Significance. Residual impacts for the Temporary Facilities/Construction Camps are classified as **Insignificant**. The pre-mitigation and residual impact assessments for human health are summarised in Table 8-29.

Table 8-26: Residual Impact Assessment of Soil Compaction – Construction and Pre-commissioning

Project Component	Industrial Area			Temporary Facilities / Construction Camps			Water Abstraction System			Well Pads and Well Drilling			Production and Injection Network			Victoria Nile HDD Crossing		
Soil Compaction	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	H	M	**H**	M	M	**M**	M	H	**H**	M	M	**M**	M	M	**M**	H	H	**H**
Residual	L	M	**L**	L	M	**L**	N	H	**L**	N	M	**I**	L	M	**L**	L	M	**L**

Note: H is high, M is Moderate, L is Low, I is Insignificant and N is Negligible

Table 8-27: Residual Impact Assessment of Soil Erosion – Construction and Pre-commissioning

Project Component	Industrial Area			Temporary Facilities / Construction Camps			Water Abstraction System			Well Pads and Well Drilling			Production and Injection Network			Victoria Nile HDD Crossing		
Soil Erosion	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	N	M	**I**	M	M	**M**	L	H	**M**	N	M	**I**	M	M	**M**	H	H	**H**
Residual	N	M	**I**	N	M	**I**	N	H	**L**	N	M	**I**	N	M	**I**	L	M	**L**

Note: H is high, M is Moderate, L is Low, I is Insignificant and N is Negligible

Table 8-28: Residual Impact Assessment of Soil Quality – Construction and Pre-commissioning

Project Component	Industrial Area			Temporary Facilities / Construction Camps			Water Abstraction System			Well Pads and Well Drilling			Production and Injection Network			Victoria Nile HDD Crossing		
Soil Quality	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	L	M	**M**	L	M	**L**	L	H	**M**	M	M	**M**	M	M	**M**	M	H	**H**
Residual	L	M	**L**	N	M	**I**	N	H	**L**	L	M	**L**	N	M	**L**	L	M	**L**

Note: H is high, M is Moderate, L is Low, I is Insignificant and N is Negligible

Table 8-29: Residual Impact Assessment of Human Health – Construction and Pre-commissioning

Project Component	Industrial Area			Temporary Facilities / Construction Camps			Water Abstraction System			Well Pads and Well Drilling			Production and Injection Network			Victoria Nile HDD Crossing		
Soil Quality (Human Health)	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	H	H	**H**	H	H	**H**	H	H	**H**	H	H	**H**	H	H	**H**	H	H	**H**
Residual	N	H	**L**	N	H	**I**	N	H	**L**	N	H	**L**	N	H	**L**	N	H	**L**

Note: H is high, M is Moderate, L is Low, I is Insignificant and N is Negligible

8.7.6 Assessment of Impacts: Commissioning and Operations

The Commissioning and Operation phase is expected to last 25 years. This will include commissioning activities (including energisation of electrical systems, emergency shutdown system checking and start-up of utility systems, operational testing), start-up (including well testing) and operation and maintenance of permanent components as described in ***Chapter 4: Project Description and Alternatives***.

8.7.6.1 Potential Impacts – Commissioning and Operations

The activities that could generate direct potential impacts to soils (soil compaction, soil quality (contamination) and soil erosion) during the Commissioning and Operations phase are included in Table 8-16. The assessment of potential impacts during the Commissioning and Operations phase of the project are presented in the following sections.

8.7.6.1.1 Commissioning and Operation of Industrial Area

The CPF will house oil processing facilities to separate crude, water and gas, and will receive production fluids from both north and south fields. Treated crude will flows to two Oil Export Tanks for storage and export (or to a tank for recycling if it does not meet specification). The separated produced water will be sent to the Produced Water Treatment System which removes residual dispersed oil, solids and dissolved gas from the produced water before re-injection back into the wellheads. No produced water will be discharged to the environment.

Soil Compaction – Industrial Area

No notable soil compaction impacts have been identified for operations at the Industrial Area during this Project Phase. The potential impact significance is therefore **Insignificant**.

Soil Erosion – Industrial Area

All work at the Industrial Area will be within the confines of the site which will include a drainage network and a Storm Water Basin sized to withstand a 1 in 100 year event. Therefore, the impact magnitude is negligible. Soils are generally sandy, silty and clayey which are moderately susceptible to erosion; receptor sensitivity is considered to be moderate. The potential impact significance is **Insignificant**.

Soil Quality – Industrial Area

The drainage system will be designed to capture and treat rain and storm water runoff from potentially contaminated areas. Exposure of oils or chemicals to soils from spillages may result in localised medium term impact (5-10 years), reversible only with interventions. The impact magnitude is moderate. Soils are generally sandy, silty and clayey which are moderately leachable. Subsurface layers of clay in some areas provide some measure of resistance to leaching. The receptor sensitivity is considered to be moderate. The potential impact significance is **Moderate Adverse.**

8.7.6.1.2 Commissioning and Operation of Well Pads

During start-up, well testing will be undertaken on the installed wells, comprising flowing of formation fluids to the surface where measurements are made to evaluate well performance characteristics. Start-up of well pads and pipelines will be conducted using a phased approach over 4 years. There will be no discharges of well testing fluids at the well pads.

When well pads are operational, they will be unattended except for maintenance activities and should an accidental event occur. The exception is the JBR-04 well pad which will be used as a pilot for approximately 18 months to test the effectiveness polymer addition to increase production.

Soil Compaction – Well Pads

No notable soil compaction impacts have been identified for operations at the well pads during this Project Phase. The potential impact significance is therefore **Insignificant**.

Soil Erosion – Well Pads

All work at the well pads will be within the confines of the component footprint which will include a drainage system. Therefore, the impact magnitude is negligible. Soils are generally sandy, silty and clayey which are moderately susceptible to erosion; receptor sensitivity is considered to be moderate. The potential impact significance is **Insignificant**.

Soil Quality – Well Pads

Exposure of oils or chemicals to soils from spillages may result in localised medium term impact (5-10 years), reversible only with interventions. The impact magnitude is moderate. The receptor sensitivity is considered to be moderate. The potential impact significance is **Moderate Adverse.**

8.7.6.1.3 Commissioning and Operation of Production and Injection Network

The Production and Injection Network will have a 30 m RoW (15 m either side of the centreline of the pipeline). Ongoing access will be required to the pipeline route throughout the Operation Phase of the Project and for well pads located north of the Victoria Nile the permanent RoW will be used for inter field access.

Production fluids and produced sand will be transported to the CPF via the production network. Some sands will be retained in the network; therefore, it is expected that regular maintenance and pigging activities will require to be undertaken to maintain the network throughout the Commissioning and Operations Phase. For maintenance and pigging operations, temporary collection facilities shall be mobilised. Solid material will be removed from the location and transported via appropriate vehicles to a site suitable for treatment and/or disposal.

Soil Compaction – Production and Injection Network

Driving within the RoW will be required during monitoring activities and potentially for inter field access north of the Victoria Nile. Potential compaction impacts from off-road driving will be reversible, temporary, and of a limited spatial extent (<2 ha); therefore, the impact magnitude is considered to be low. Soils are generally sandy, silty and clayey which are moderately susceptible to erosion; receptor sensitivity is considered to be moderate. The potential impact significance is **Low Adverse**.

Soil Erosion – Production and Injection Network

Maintaining the 30 m RoW along the Production and Injection Network may lead to increased soil erosion in the absence of trees, and deep rooting vegetation. The area of potential direct impact is >20 ha and impacts may be medium to long term. The impact magnitude is high. Soils are generally sandy, silty and clayey which are moderately susceptible to erosion; receptor sensitivity is considered to be moderate. The potential impact significance is **High Adverse.**

Soil Quality – Production and Injection Network

Potential pipeline failure is considered an Unplanned Event and assessed in ***Chapter 20: Unplanned Events***. There is a risk of potential impact to soil quality from localised spillages of fuel during maintenance activities on the RoW with an area of impact <2 ha. The impact magnitude for normal operations is negligible. The receptor sensitivity is considered to be moderate. The potential impact significance is **Insignificant**.

8.7.6.1.4 Access Roads and Victoria Nile Ferry Crossing Facility

The Victoria Nile Ferry Crossing will operate throughout the Commissioning and Operations phase, and will comprise a ferry operating 8 hours a day. The facility will include vehicle parking, a waiting area, a workshop; diesel storage facilities and a general storage area.

The new and upgraded roads to be used for the Project will have up to a 50 m permanent RoW.

Soil Compaction – Access Roads and Ferry Crossing

No notable soil compaction impacts have been identified for operation of the Victoria Nile Ferry Crossing or use of access roads during this Project Phase. The potential impact significance is therefore **Insignificant**.

Soil Erosion – Access Roads and Ferry Crossing

Operational activities will take place within the confines of the access roads and Ferry Crossing Facility which include drainage networks. Therefore, the impact magnitude is negligible. Soils are generally sandy, silty and clayey which are moderately susceptible to erosion; receptor sensitivity is considered to be high. The potential impact significance is **Insignificant**.

Soil Quality – Access Roads and Ferry Crossing

There is a risk of impact to soil quality from localised spillages of fuel and truck loads during operational activities with an area of impact <2 ha. The impact magnitude is low. The receptor sensitivity is considered to be high. The potential impact significance is **Moderate Adverse.**

8.7.6.1.5 Human Health

Potential impacts to soil quality from the release of contaminated materials to ground may also impact the health of maintenance workers during the Commissioning and Operations phase, the health of local residents who may be utilising the pipeline RoW for crop cultivation, and the future health of local residents utilising land which has been contaminated.

The potential impacts described above with respect to soil quality are also applicable to the human health impact assessment. On the basis of the available information, the potential impacts to human health before mitigation within each Project component is of **High Adverse** significance given that humans have a high receptor sensitivity and high impact magnitude due to a potential pollutant linkage being present between soil contaminants and humans.

8.7.6.2 Additional Mitigation and Enhancement- Commissioning and Operations

Mitigation measures to control and reduce potential impacts from soil compaction, degradation of soil quality and erosion during the Commissioning and Operations phase are summarised in Table 8-21.

In addition, the Project is committed to preparing a standard operating and maintenance procedure governing all activities which will be in place ahead of the commencement of the operational phase of work. Monitoring of site activities for potential impacts will allow for timely maintenance, remediation and restoration to minimise potential direct and indirect impacts.

8.7.6.3 Residual Impacts – Commissioning and Operations

A summary of the residual impacts associated with the Commissioning and Operations phase is provided below:

8.7.6.3.1 Soil Compaction

The risk of soil compaction during commissioning and operations activities cannot be completely removed. Adoption of recommended mitigation measures can reduce the risk of extensive soil compaction from occurring and enhance site restoration efficacy. Residual soil compaction impacts are classified as **Insignificant**. The pre-mitigation and residual impact assessments for soil compaction are summarised in Table 8-30.

8.7.6.3.2 Soil Erosion

The environmental impacts associated with disturbance of soils leading to erosion may create long-term issues if left unmitigated. However, it is envisaged that if the correct mitigation measures are in place, the magnitude and time-scale of such impacts can be reduced and in the long-term soils will stabilise and vegetation will re-establish. Residual impacts leading to soil erosion for the Industrial Area, Well Pads, Victoria Nile Ferry Crossing and access roads are classified as **Insignificant**. Residual impacts for the Production and Injection Network RoW are classified as **Low Adverse** significance. The pre-mitigation and residual impact assessments for soil erosion are summarised Table 8-31.

8.7.6.3.3 Soil Quality

The risk of spillage of contaminative materials during commissioning and operations activities cannot be completely removed. Adoption of good construction, fuel and chemical storage, and handling practices can significantly reduce the risk of a spill occurring. Rapid and effective clean up and remediation in the event of a spill will reduce the risk of long-term environmental issues. Appropriate management of discharges will reduce the likelihood that transfers of potentially contaminated materials to soils will occur. Residual impacts on soil quality for the Industrial Area, Well Pads, Production and Injection Network, Victoria Nile Ferry Crossing and access roads are classified as **Insignificant**. The pre-mitigation and residual impact assessments for soil quality are summarised in Table 8-32.

8.7.6.3.4 Human Health (Residual impact – Insignificant / Low Adverse)

The risk of spillage during commissioning and operations activities cannot be completed removed. Adoption of good construction, fuel and chemical storage, and handling practices can significantly reduce the risk of a spill occurring. An awareness of the presence of potentially contaminative materials and the use of appropriate PPE will reduce the potential impacts of soil contamination to human health. Residual impacts on human health for the Industrial Area and Well Pads are classified as **Low Adverse** significance. Residual impacts for the Victoria Nile Ferry Crossing, Production and Injection Network and access roads are classified as **Insignificant**. The pre-mitigation and residual impact assessments for human health are summarised in Table 8-33.

Table 8-30: Residual Impact Assessment of Soil Compaction – Commissioning and Operations

Project Component	Industrial Area			Well Pads			Production and Injection Network			Access Roads and Nile Ferry Crossing		
Soil Compaction	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre-mitigation	N	M	**I**	N	M	**I**	L	M	**L**	N	H	**I**
Residual	N	M	**I**	N	M	**I**	N	M	**I**	N	H	**I**

Note: L is Low; M is Moderate; N is Negligible; I is Insignificant

Table 8-31: Residual Impact Assessment of Soil Erosion – Commissioning and Operations

Project Component	Industrial Area			Well Pads			Production and Injection Network			Access Roads and Nile Ferry Crossing		
Soil Erosion	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre-mitigation	N	M	**I**	N	M	**I**	H	M	**H**	N	H	**I**
Residual	N	M	**I**	N	M	**I**	L	M	**L**	N	H	**I**

Note: L is Low; H is High; M is Moderate; N is Negligible; I is Insignificant

Table 8-32: Residual Impact Assessment of Soil Quality – Commissioning and Operations

Project Component	Industrial Area			Well Pads			Production and Injection Network			Access Roads and Nile Ferry Crossing		
Soil Quality	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre-mitigation	M	M	**M**	M	M	**M**	N	M	**I**	L	H	**M**
Residual	N	M	**I**	N	M	**I**	N	M	**I**	N	H	**I**

Note: L is Low; M is Moderate; N is Negligible; I is Insignificant

Table 8-33: Residual Impact Assessment for Human Health – Commissioning and Operations

Project Component	Industrial Area			Well Pads			Production and Injection Network			Access Roads and Nile Ferry Crossing		
Soil Quality (Human Heath)	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre-mitigation	H	H	**H**	H	H	**H**	H	H	**H**	H	H	**H**
Residual	N	H	**L**	N	H	**L**	N	H	**I**	N	H	**I**

Note: L is Low; H is High; M is Moderate; N is Negligible; I is Insignificant

8.7.7 Assessment of Impacts: Decommissioning

8.7.7.1 Introduction

An environmental assessment may be required before decommissioning commences in order to confirm that the planned activities are the most appropriate to the prevailing circumstances. This assessment would aim to demonstrate that the decommissioning activities would not cause potentially unacceptable environmental and social impacts and would lead to the development of specific management controls.

In general, the following principles will apply:

- Above ground infrastructure shall be removed to 0.5 m below ground level and backfilled and vegetated;
- Access roads may be left in place depending upon the subsequent use of the land;
- Shallow foundations for infrastructure may be excavated, demolished and disposed of;
- Where piled foundations exist, these may be excavated to a depth of 1 m below the existing ground level and removed;
- Excavations resulting from the removal of foundations will be backfilled;
- Generally it is expected that pipelines will be cleaned, capped and left in situ to prevent disturbing the reinstated habitats, but this would be confirmed ahead of any decommissioning activities taking place; and
- Where the environmental assessment identifies it is acceptable, pipeline sections may be cleaned, reclaimed and re-used.

Potential impacts associated with decommissioning activities may include the following:

- Erosion and sedimentation;
- Soils compaction; and
- Spills of hazardous substances.

Prior to undertaking decommissioning activities, TEP Uganda will undertake a review of historical monitoring data and incidents on site that might have caused contamination. Depending on the final land use agreed with the authorities, all or part of the site may need to be rehabilitated. In such circumstances, TEP Uganda will also develop a monitoring programme for completion criteria (e.g. agricultural soils standards) to verify that the sites are being returned to the agreed representative state.

During the Decommissioning Phase, activities associated with the removal of infrastructure that could result in impacts to soils include:

- Mobilisation of plant and construction vehicles to the Project Site;
- Deliveries of materials and supplies (including fuel and other hazardous substances) to the Project Site;
- Waste generation, storage and disposal (hazardous and non-hazardous);
- Storage of fuel and hazardous materials;
- Refuelling of plant and machinery within Project Site; and
- Physical movement of construction vehicles and plant within the Project Site.

8.7.7.2 Potential Impacts - Decommissioning

Potential impacts to soils (compaction, quality and erosion) would be similar in duration and magnitude to those identified during the Construction and Pre-Commissioning phase of the Project. Potential impacts associated with compaction, soil quality and soil erosion during these phases are considered to be **Insignificant** to **High Adverse** Significance.

Potential impacts to soil quality from the release of contaminated materials to ground may impact the health of construction workers during the Decommissioning phase, and the future health of local residents utilising land which has been contaminated. The potential impacts to human health before mitigation within each Project component is of **High Adverse** Significance given that humans have a high receptor sensitivity and high impact magnitude due to a potential pollutant linkage being present between soil contaminants and humans.

8.7.7.3 Additional Mitigation and Residual Impacts

Mitigation measures to control and reduce potential impacts from soil compaction, degradation of soil quality and erosion during the Decommissioning phase are summarised in Table 8-21.

Once restoration activities have been completed, it is anticipated that there will be limited residual impacts. The significance of the residual impact to geology and soils during decommissioning after mitigation measures are in place is considered to be **Insignificant** to **Low Adverse** Significance.

8.8 In-Combination Effects

As described in ***Chapter 4: Project Description and Alternatives***, the Project has a number of supporting and associated facilities that are being developed separately (i.e. they are subject to separate permitting processes and separate ESIAs or EIAs). These facilities include:

- Tilenga Feeder Pipeline;
- East Africa Crude Oil Export Pipeline (EACOP);
- Waste management storage and treatment facilities for the Project;
- 132 Kilovolt (kV) Transmission Line from Tilenga CPF to Kabaale Industrial Park; and
- Critical oil roads.

The in-combination impact assessment considers the potential joint impacts of both the Project and the supporting and associated facilities. This is distinct from the Cumulative Impact Assessment (CIA) which consider all defined major developments identified within the Project's AoI (and not just the associated facilities) following a specific methodology which is focussed on priority Valued Environmental and Social Components (VECs) (see ***Chapter 21: Cumulative Impact Assessment***). The approach to the assessment of in-combination impacts is presented in ***Chapter 3: ESIA Methodology***.

The majority of the East Africa Crude Oil Export Pipeline (EACOP) is spatially removed from the proposed Project infrastructure. Therefore, there are no in-combination impacts with respect to soils and geology.

The waste management storage and treatment facilities for the Project are largely located remote from the Project Area. The existing waste management and treatment facilities are described in ***Chapter 12:***

Waste Management. With the exception of a non-hazardous landfill in Buliisa District (Ngwedo) all other waste management facilities are outside of the Project Area. Overall, it is considered that all of these facilities are at a sufficient distance from the elements of the Project that there are no potential for in-combination soils and geology impacts.

Sections of the Tilenga Feeder Pipeline, transmission line, and the critical oil roads are within the Project AoI. There is a possibility that the critical oil roads and the Tilenga Feeder pipeline will constructed concurrently with Phase 1 Site Preparation and Enabling Works for the Project. Impacts during the construction and operational phases of these facilities would be the similar for each of the project as to those identified within the assessment for the Tilenga Project. During the construction phase of the pipelines, transmission line and roads, impacts to soils and geology will mainly result from minor accident spills and leakages resulting in soils contamination. Soil compaction or erosion impacts may also occur. Impacts to soils during the operational phase of these would result from minor spills and leakages during maintenance activities. Each project will put in a place a whole suite of embedded and additional mitigation measures to help prevent any significant adverse impacts. Activities associated with these facilities are mostly spatially removed from the proposed Project infrastructure consequently, there are expected to be no significant in-combination impacts with respect to soils and geology.

8.9 Unplanned Events

Potential impacts to soils can also occur as a result of unplanned events such as major fuel or chemicals spillages, loss of drilling muds, fluids and chemicals, frack out during HDD under the Victoria Nile, Well Blowout, sabotage of equipment or damage by seismic events or animals, and equipment failure. Hence the significance of the impact to geology and soils generated by unplanned events may potentially be of High Adverse Significance if not responded to in a timely manner by the appropriately trained personnel. Further details on unplanned events relevant to the Project are detailed in ***Chapter 20: Unplanned Events***.

8.10 Cumulative Impact Assessment

Chapter 21: Cumulative Impact Assessment provides an assessment of the potential cumulative effects of the Project together with other defined developments in the Project AoI. The CIA focussed on VECs that were selected on the basis of set criteria including the significance of the effects of the Project, the relationship between the Project and other developments, stakeholder opinions and the status of the VEC (with priority given to those which are of regional concern because they are poor or declining condition). On the basis of the selection process, the quality of the soils and geology was not considered to be a priority VEC and is therefore not considered further in the CIA as no significant impacts are anticipated.

The other schemes identified within the CIA are largely located away from the Project Area and due to the localised nature of any identified soils and geology impacts, along with the array of additional mitigation measures that are likely to be implemented by each scheme, no CIA is predicted.

8.11 Conclusions

Impact assessment criteria were developed and utilised for assessing the potential impacts to soils and geology from the Site Preparation and Enabling works, Construction and Pre-Commissioning, Commissioning and Operations; and Decommissioning Phases of the Project, and include impact magnitude and receptor sensitivity. The assessment of impacts has been undertaken by identifying and evaluating a range of activities and scenarios that are likely to occur throughout the phases of the Project. Direct potential impacts include changes to the physical, biological and chemical properties of soils (e.g. compaction and contamination) and loss of top soil (e.g. erosion). Direct impacts have the potential to result in indirect impacts on different physical, biological or social receptors; these have been identified where appropriate and relevant. Taking into consideration impact magnitude, likelihood and receptor sensitivity, and the potential significance of impacts was established for the pre-mitigation and post-mitigation scenarios.

The residual impacts for each phase of the Project are summarised in Table 8-34.

Table 8-34: Residual Impact to Soils and Geology – Post-Mitigation

Potential Impact	Impact Significance (Post mitigation)			
	Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
Soil Compaction	Insignificant to Low Adverse	Insignificant to Low Adverse	Insignificant	Insignificant to Low Adverse
Soil Erosion	Insignificant to Low Adverse	Insignificant to Low Adverse	Insignificant to Low Adverse	Insignificant to Low Adverse
Soil Quality	Insignificant to Low Adverse	Insignificant to Low Adverse	Insignificant	Insignificant to Low Adverse
Human Health	Insignificant to Low Adverse	Insignificant to Low Adverse	Insignificant to Low Adverse	Insignificant to Low Adverse

Overall, the significance of the residual impact to geology and soils during the Site Preparation and Enabling Works, Construction and Pre-Commissioning, Commissioning and Operations and Decommissioning phases of the Project are considered to be of **Insignificant** to **Low Adverse**.

No significant in-combination effects have been identified based on the temporal and spatial extent of the Project components and activities in relation to supporting infrastructure and associated facilities hence in combination effects are considered to be **Insignificant**.

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09 – Hydrogeology

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9.1 Introduction

This Environmental and Social Impact Assessment (ESIA) Chapter presents an assessment of the impacts of the Project on the existing groundwater conditions (level and quality) within the Project Area. It includes a detailed overview of the geological and hydrogeological baseline conditions which are found within the Project Area and surrounding area, referred to as the Study Area. Addressed in the assessment are the potential impacts associated with the Site Preparation and Enabling Works, Construction and Pre-Commissioning, Commissioning and Operations and Decommissioning phases of the Project. It also identifies mitigation measures required in order to remove and/or minimise potentially adverse impacts to the groundwater environment.

Groundwater is a significant economic resource. It is widely distributed and acts as a primary source of drinking water in the Study Area. It also contributes flow to some of the watercourses, wetlands and water dependent ecologically sensitive sites in the area. Groundwater use and protection is, therefore, of fundamental importance to human life and economic activity within the vicinity of the Study Area. Consequently, any land use activities that might directly or indirectly impact on groundwater levels or contaminate groundwater can lead to adverse social-economic and environmental impact. In the context of the Project, groundwater is, therefore, a critical component for consideration for this ESIA.

9.2 Scoping

The Scoping process identified the potential impacts to the groundwater conditions that could occur as a result of the construction, operation and decommissioning of the Project. These potential impacts are summarised in Table 9-1. It is worth noting that the Project phasing and identified list of potential impacts have evolved during the completion of this ESIA and consequently build and expand on those originally identified in Table 9-1 during the Scoping phase.

Table 9-1: Potential Hydrogeology Impacts as defined in Scoping Report

Potential Impact	Potential Cause	Potential Sensitivity	Phase
Potential impacts on groundwater quality.	Construction/decommissioning and operational activities including drilling, storage of fuel or other materials, management of water runoff, seepage from wells, discharge of processed and water from hydro testing or other operations and discharges of untreated or insufficiently treated sanitary waste.	Groundwater and aquifers located within and hydrogeologically connected to the Project Area.	Construction Operation Decommissioning.
Potential impacts on groundwater flow.	Construction/decommissioning and operational activities including drilling, groundwater abstraction, management of water runoff, seepage from wells, discharge of processed and foul water.	Groundwater and aquifers located within and hydrogeologically connected to the Project Area.	Construction Operation Decommissioning.
Potential indirect impacts on groundwater users (e.g. for drinking water and commercial or agricultural use) as a result of potential changes in groundwater flow and quality.	Construction/decommissioning and operational activities including drilling, groundwater abstraction, storage of fuel, management of water runoff, seepage from wells, discharge of processed and foul water.	Residential, commercial and agricultural receptors located within and hydrogeologically connected to the Project Area.	Construction Operation Decommissioning.
Leaching of contaminants through natural breaks, pores and fractures.	Drilling and operational activities and waste storage areas.	Groundwater and aquifers located within and hydrogeologically connected to the Project Area.	Construction Operation Decommissioning.
Reduction in infiltration of surface water reaching groundwater.	Construction activities leading to compaction of surfaces, removal of vegetation, removal of natural surface depressions and all Project facilities that will result in new impermeable surfaces.	Groundwater and aquifers located within and hydrogeologically connected to the Project Area.	Construction Operation Decommissioning.

9.3 Legislative Framework

9.3.1 Introduction

All relevant environmental standards prescribed in accordance with the National Environment Act Cap 153 (Ref. 9-1) and national regulations shall apply to the Project. Wherever applicable, the national standards shall take precedence over international standards unless such relevant national standards do not exist (upon where the international standards shall be used).

9.3.2 National Policies, Laws and Regulations

There are several national policies, laws and regulations relevant to groundwater and applicable to the ESIA of the proposed Project and its environmental aspects. Details of these are presented in ***Chapter 2: Policy, Regulatory and Administrative Framework***.

The following policies and regulations are applicable to groundwater:

- The National Environment Management Policy (NEMP) (1994);
- The National Water Policy (1999);
- National Policy for the Conservation and Management of Wetland Resources (1995);
- The Constitution of the Republic of Uganda, 1995 (as amended);
- The National Environment Act, Cap. 153;
- The Water Act, Cap 152;
- The Environmental Impact Assessment Regulations, 1998;
- The National Environment (Wetlands, River Banks and Lake Shores Management) Regulations, 2000;
- The National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations (1st Revised Draft), 2014; and
- The Water (Waste Discharge) Regulations, 1998.

9.3.3 National Standards Related to Groundwater

The relevant national environmental standards related to the groundwater environment and applicable to the proposed Project and its environmental aspects are prescribed in the Water Act, Cap 152 (Ref. 9-1) and are in accordance with the National Environment Act Cap 153 (Ref. 9-2), are as follows:

- National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations, S.I. No 5/1999 (Republic of Uganda, 1999) (Ref. 9-3);
- National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations, S.I. No 5/1999, 1st Revised Draft, 2014 (Ref. 9-4), and
- Uganda National Bureau of Standards: (UNBS) US EAS 12: 2014, Potable Water – Specification (Ref. 9-5).

9.3.4 National Guidelines Related to Groundwater

In addition to national laws and regulations, further guidance on ESIA practice in Uganda related to the groundwater environment is provided through a number of general and sector-specific guidelines that include:

- Guidelines for Environmental Impact Assessment in Uganda (NEMA 1997) (National Environment Management Authority, 1997) (Ref. 9-6);
- Environmental Impact Assessment Guidelines for Water Resources Related Projects in Uganda (MWE 2011) (Ministry Water and Environment, 2011) (Ref. 9-7); and

- Operational Waste Management Guidelines for Oil and Gas Operations (NEMA 2012) (Ref. 9-8).

The guidelines describe the recommended approach to all aspects of the ESIA including stakeholder engagement and public participation, report structure and presentation, baseline studies and mitigation measures.

9.3.5 Potable Water

Uganda National Bureau of Standards (UNBS) US EAS 12: 2014, Potable Water – Specification, is particularly relevant to groundwater in the area because groundwater is the primary source of drinking water for the local population. It sets minimum requirements for physical, chemical and microbiological characteristics that affect safety and quality of drinking water, and is intended to ensure the provision of safe drinking water for human consumption. It also specifies requirements and methods of sampling and testing for potable water (treated potable water and natural, or untreated, potable water).

The standards for natural, untreated groundwater are applicable to the majority of existing community boreholes in the Study Area, which provide untreated water for domestic use. Uganda has not established national water quality standards for non-potable groundwater resources. The Uganda National Bureau of Standards: (UNBS) US EAS 12: 2014, for treated and natural potable water are shown in Table 9-2.

Table 9-2: Ugandan Standards for Treated and Natural Potable Water

Characteristic	Treated potable water	Natural potable water
Physical requirements for potable water		
Colour (TCUa max)	15	50
Turbidity (NTU max)	5	25
pH	6.5 – 8.5	5.5-9.5
Taste	Not objectionable	Not objectionable
Odour	Odourless	Odourless
Conductivity (µS/cm)max	1,500	2,500
Suspended matter	Not detectable	Not detectable
Quality requirements for potable water (mg/l max.)		
Total dissolved solids	700	1,500
Total hardness, as $CaCO_3$,	300	600
Aluminium, as Al+++,	0.2	0.2
Chloride, as Cl-	250	250
Total Iron as Fe	0.3	0.3
Sodium, as Na+	200	200
Sulphate SO_4	400	400
Zinc, as Zn++	5	5
Magnesium, as Mg++	100	100
Calcium, as Ca++	150	150
Limits for inorganic contaminants (mg/l, max)		
Arsenic, as As	0.01	0.01
Cadmium, as Cd	0.003	0.003
Lead, as Pb	0.01	0.01
Copper, as Cu	1.000	1.000
Mercury (total as Hg)	0.001	0.001
Manganese, as Mn	0.1	0.1
Selenium, as Se	0.01	0.01
Ammonia (NH_3)	0.5	0.5
Chromium Total, as Cr	0.05	0.05
Nickel, as Ni	0.02	0.02
Cyanide, as CN	0.01	0.01
Barium, as Ba	0.7	0.7
Nitrate as NO_3-	45	45
Boron,as Boric acid	2.4	2.4
Fluoride, as F	1.5	1.5
Bromate, as BrO_3-	0.01	0.01
Nitrite[1]	0.003	0.003
Molybdenum	0.07	0.07
Phosphates, as PO43-	2.2	2.2

Characteristic	Treated potable water	Natural potable water
Residual free Chlorine	0.2-0.5	Absent
Organic contaminants (µg/l, max)		
Aromatics		
Benzene	10	10
Toluene	700	700
Xylene	500	500
Polynuclear aromatic hydrocarbon	0.7	0.7
Chlorinated Alkanes and Alkenes		
Carbon tetrachloride	2	2
1,2-Dichloroethane	30	30
1,1-Dichloroethylene	0.3	0.3
1,1-Dichloroethene	30	30
Tetrachloroethene	40	40
Phenolic substances		
Phenols	2	2
2,4,6-Trichlorophenol	200	200
Trihalomethanes		
Chloroform	30	30
Microbiological limits		
Total viable counts at 22 ºC, in mL, max. a)	None	100
Total viable counts at 37 ºC, in mL, max	None	50
Total Coliforms b) in 100 mL	None	Absent
E. coli b)in 100 mL	None	Absent
Staphylococcus aureus in 100 mL	None	Absent
Sulphite reducing anaerobes in100 mL	None	Absent
Pseudomonas aeruginosa fluorescence in 100 mL	None	Absent
Streptococcus faecalis in 100mL	None	Absent
Shigella in 100 mL	None	Absent
Salmonella in 100 mL	None	Absent

Note: The previous standard for nitrite was 0.2 milligrams per litre (mg/l). The new standard is reported to be 0.003 mg/l. The World Health Organisation (WHO) standard is 3.0 mg/l. The WHO standard will be adopted for describing water quality for two reasons: (1) the analytical detection limit for nitrite is higher (0.03mg/l) than the new standard where any concentrations present below the detection level would not be reported and (2) the WHO standard is an accepted international standard for potable water quality.

9.3.6 Effluent discharge

Control on the standard of effluent discharged to land, groundwater and surface water is achieved through the National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations, 1999 (Ref. 9-3). In 2014, draft legislation was produced to replace the existing regulations. The draft legislation provides delimiting maximum concentrations of physical, chemical and biological parameters for various types of discharges including standards for unspecified effluent discharges (5th Schedule) and sector specific oil and gas exploration and production effluent standards (8th Schedule). The unspecific standards are applicable to wastewater discharges. The sector specific standards apply to discharges of drilling fluids, produced water, hydrotest water, well completion and well-workover fluids, storm water drainage and sewage (Ref. 9-3 and 9-4). Based on the Project design as described in ***Chapter 4: Project Description and Alternatives***, only the effluent standards for storm water drainage and sewage are applicable.

The Project Proponents have developed Project standards which are to be applied to all phases of the Project (Ref. 9-9). The draft legislation for effluent discharges has been adopted. Table 9-3 provides the effluent standards specified under the 1999 Regulations and the proposed maximum permissible limits provided in the draft legislation.

Table 9-4 presents the specific standards for wastewater discharges adopted for the Project.

Table 9-3: Ugandan Standards for Effluent Discharge

Parameter	Standard 1999	Standard (Draft) 2014	Parameter	Standard 1999	Standard (Draft) 2014
1,1,1, -Trichloroethane	3.0 mg/l	3.0 mg/l	Iron	10 mg/l	5.0 mg/l
1,1,2, - Dichloroethylene	0.2 mg/l	0.2 mg/l	Lead	0.1 mg/l	0.01 mg/l
1,1,2,- Trichloroethane	0.06 mg/l	0.06 mg/l	Magnesium	100 mg/l	100 mg/l
1,2 - Dichloroethane	0.04 mg/l	0.04 mg/l	Manganese	1.0 mg/l	1.0 mg/l
1,3 - Dichloropropene	0.2 mg/l	0.2 mg/l	Mercury, total	0.01 mg/l	0.001 mg/l
Aluminium	0.5 mg/l	0.5 mg/l	Nickel	1.0 mg/l	1.0 mg/l
Ammonia Nitrogen	10 mg/l	5.0 mg/l	Nitrate N	20 mg/l	5.0 mg/l
Arsenic	0.2 mg/l	0.01mg/l	Nitrite N	2.0 mg/l	1.0 mg/l
Barium	10 mg/l	10 mg/l	Nitrogen Total	10 mg/l	10 mg/l
Benzene	0.2 mg/l	Nil	Oil and Grease	10 mg/l	5.0 mg/l
BOD5	50 mg/l	30 mg/l	pH	6.0-8.0	6.0-9.0
Boron	5 mg/l	0.25 mg/l	Phenols	0.2 mg/l	0.02 g/l
Cadmium	0.1 mg/l	0.10 mg/l	Phosphate (total)	10 mg/l	1.0 mg/l
Calcium	100 mg/l	100 mg/l	Phosphate (soluble)	5.0 mg/l	1.0 mg/l
Chloride	500 mg/l	250 mg/l	Selenium	1.0 mg/l	0.02 mg/l
Chlorine	1 mg/l	0.2 mg/l	Silver	0.5 mg/l	1.0 mg/l
Chromium (total)	1 mg/l	1 mg/l	Sulphate	500 mg/l	50 mg/l
Chromium (VI)	0.05 mg/l	0.05 mg/l	Sulphide	1.0 mg/l	1.0 mg/l
Cis 1,2 – Dichloroethylene	-- mg/l	0.4 mg/l	TDS	1200 mg/l	1200 mg/l
Cobalt	-- mg/l	0.1 g/l	Temperature	20-350°C	+/- 3°C of ambient
COD	100 mg/l	60 mg/l	Tetrachloroethylene	0.1 mg/l	0.3 mg/l
Coliforms	10,000 counts/100 ml	<400 counts/100ml	Tetrachloromethane	0.02 mg/l	0.02 mg/l
Colour	300 TCU	50 TCU	Tin	5 mg/l	5.0 mg/l
Copper	1.0 mg/l	0.5 mg/l	Total Suspended Solids, TSS	100 mg/l	100 mg/l
Cyanide	0.1 mg/l	0..05 mg/l	Tricholoroethylene	0.3 mg/l	0.3 mg/l
Detergents	10 mg/l	10 mg/l	Turbidity	300 NTU	30 NTU
Dichloromethane	0.2 mg/l	0.2 mg/l	Zinc	5 mg/l	5.0 mg/l

Note: Standards for Pesticides, PCBs and Radioactive materials have not been included in the table; refer to the Draft Standards for discharge limits. The sector specific draft regulations have proposed maximum permissible limits for storm water drainage – Oil & Grease (10 mg/l) and Process Oil (nil).

Table 9-4: Standard for Sanitary Effluent Discharges

Pollutants	Units	Regulation 1999	Regulation 2014	IFC EHS Guidelines	Standards for Project
pH	pH	**6-8**	6-9	6-9	6-8
BOD	mg/l	50	30	**30**	30
COD	mg/l	**100**	60	125	100
Total nitrogen	mg/l	**10**	10	10	10
Total phosphorus	mg/l	10	5	**2**	2
Oil and grease	mg/l	**10**	5	10	10
Total suspended solids	mg/l	100	100	**50**	50
Total coliform bacteria	MPN/100ml	10,000	400	**400**	400

9.3.7 Groundwater Permits and Licensing Policy

The national legislation of Uganda establishes a number of approvals, permits and licences that are required prior to commencement of the project or specific activities within the scope of the project. The Water Act, Cap 152, requires a person wishing to construct any works (e.g. borehole) or to take and use groundwater to apply to the Directorate of Water Resource Management (DWRM) for a permit to do so prior to groundwater abstraction. Groundwater permits are issued only for boreholes drilled to depths greater than 30 metres (m) below ground level (bgl) and operated using motorised pumps. Permits are issued by DWRM with conditions, including acceptable maximum water abstraction volumes. A summary of the DWRM groundwater abstraction permits issued to Total Exploration & Production (E&P) Uganda B.V (TEP Uganda) and to Tullow Uganda Operations Pty Ltd (TUOP) is listed in Appendix K, Annex 1.

9.3.8 International Standards

9.3.8.1 IFC Performance Standards

The International Finance Corporation (IFC) Performance Standards (PSs) (Ref. 9-10) are directed towards project developers, providing guidance on how to identify risks and impacts, and are designed to help avoid, mitigate, and manage risks and impacts as a way of doing business in a sustainable way. The standards include stakeholder engagement and disclosure obligations for the Project. IFC PS that are applicable to groundwater resources include:

- *IFC PS 1: Assessment and Management of Environmental and Social Risks and Impacts* - establishes requirements for social and environmental performance management throughout the life of a project;
- *IFC PS 3: Resource Efficiency and Pollution Prevention* - defines an approach to pollution prevention and abatement in line with current internationally disseminated technologies and good practice. There is a requirement to address potential adverse impacts on ambient conditions such as groundwater; and
- *IFC PS 4: Community Health, Safety and Security* – requires that adverse impacts on water resources in use by communities are avoided or minimised.

IFC guidelines that are applicable to groundwater resources are the following:

- IFC Environmental Health and Safety (EHS) Guidelines (IFC, 2007) (Ref. 9-11) are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS guidelines are designed to be used together with the General EHS Guidelines document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors.

- The EHS Guidelines for Onshore Oil and Gas Development (IFC, 2007) (Ref. 9-12) include information relevant to production drilling; development and production activities; transportation activities including pipelines; other facilities including pump stations, metering stations, pigging stations, compressor stations and storage facilities; ancillary and support operations; and decommissioning. These industry-specific Guidelines were scheduled to be updated in 2017. However at the time of submission of this ESIA, there has been no update. These guidelines address management of the following EHS issues that are relevant to groundwater; waste water/effluent discharges; solid and liquid waste management; and spills.
- The EHS Guidelines for Water and Sanitation require that the potential adverse effects of groundwater abstraction are evaluated. This is to include modelling of changes in groundwater level and consequent impacts to surface water flows. Extraction rates and locations should be modified to prevent unacceptable adverse current and future impacts, taking account of realistic future increases in demand.

When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever regulation is more stringent. Furthermore, the IFC Performance Standards on Environmental and Social Sustainability (IFC, 2012.) suggest that, where none exist nationally, internationally recognised standards should be used.

9.3.8.2 WHO Guidelines

The World Health Organisation (WHO) has published Guidelines for Drinking Water Quality, which are kept up to date through a process of rolling revision. The most recent version of the guidelines is found in the 4th Edition, published in 2011 (Ref. 9-13).

Tables of guideline values are presented in the 4th Edition of the Guidelines for chemicals of health significance in drinking water. Where there is no Ugandan standard for a particular parameter, the WHO guideline value has been adopted. The WHO guidelines values are provided at Appendix K Annex 2.

9.4 Spatial and Temporal Boundaries

The Project is part of the wider oil and gas development being undertaken in the Lake Albert region. The total Project Area covers approximately 110,000 hectares (ha) of which approximately 101,700 ha is the land area that receives recharge to the groundwater. Figure 9-1 shows the Project Area including the Project's appraisal boundary and key elements of the Project. The ESIA Project Area covers the Project's physical boundary which includes Contract Area CA-1, Exploration Area EA-1A and Licence Area LA-2 (North) and environs. It is defined to include potential groundwater receptors that may be affected by all phases associated with the proposed Project.

However, for the purpose of evaluating groundwater resources, the Study Area extends beyond the Project's physical boundary and is therefore defined by the extent of the key groundwater aquifer systems occurring within the sedimentary geology beneath the Project's above ground locations. This includes aquifers which may be affected by the proposed Project activities and the catchment zones of groundwater sources. The Study Area for the hydrogeological assessment is defined to the south and east by the faulted junction between the sediments of the Albertine Rift and the Pre-Cambrian basement rocks; to the west by Lake Albert and the Albert Nile; and, to the north by the northern boundary of the Project Area.

The proposed timescales for the different phases of the Project are set out in ***Chapter 4: Project Description and Alternatives***. A brief summary of the timescales are provided below:

- Site Preparation and Enabling Works Phase expected to take approximately 5 years;
- Construction and Pre-Commissioning is expected to take up to 7 years;
- Commissioning and Operations is expected to commence approximately 36 months after effective date of the main construction contract award. The lifetime of the Project is 25 years; and
- Decommissioning is planned for the end of the 25 year operation.

The phases overlap and in total the duration through all phases will be approximately 28 years. The duration of activities which may lead to potential groundwater impacts differ between short and long term episodes, all of which are described within the assessment.

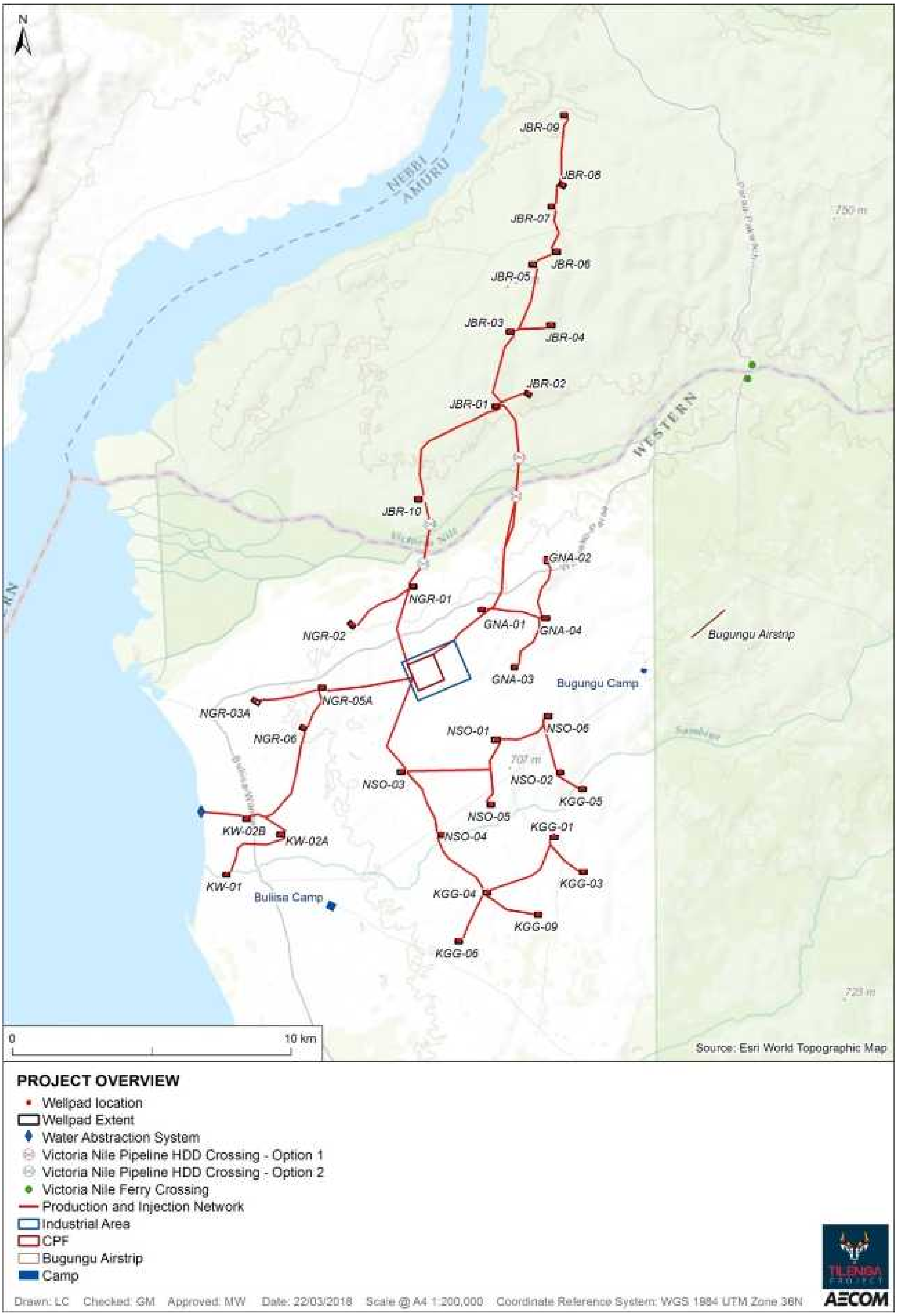


Figure 9-1: Project Overview

9.5 Baseline

9.5.1 Introduction

The baseline hydrogeological conditions in the Study Area are discussed in respect of three main elements, the geology of the area; the hydrogeological characteristics of the area; and the groundwater quality in the strata which underlie the area. The characterisation of groundwater resources is important to define the natural (background) conditions and to identify the potential interactions that could occur as a result of planned project activities. Baseline conditions have been established through a number of primary and secondary sources.

Primary sources of data include groundwater sampling and monitoring results from 2014, 2016 and 2017. Secondary sources included reports, Geographic Information System (GIS) data and raw data sets, such as:

- TEP Uganda GIS datasets and reports;
- TUOP GIS datasets and reports;
- Other GIS data;
- Satellite images;
- Other readily available published books, reports and scientific literature;
- Ugandan government publications (referred to throughout the chapter); and
- Internet websites.

The TEP Uganda and TUOP reports include many Environmental Impact Assessments (EIAs) for the exploration phase activities in the Project Area as well as project briefs, interim reports and draft reports of ongoing studies as well as the scopes of work for planned studies not yet initiated. Furthermore, many of the reports held in the libraries of TEP Uganda and TUOP have been produced by a broad range of public and private organisations, institutions and government ministries and consulting. Specific secondary data used in the development of the hydrogeology baseline characterisation is included in the relevant sections.

The baseline hydrogeological conditions in the Study Area with respect to the geology and the hydrogeological characteristics of the Study Area are presented in Section 9.5.4. Groundwater quality is addressed in Section 9.5.5.

9.5.2 Data Gap Analysis

A data gap analysis was undertaken during the scoping phase of the Project which reviewed available information sources to identify any areas for which further data collection would be advantageous in the characterisation of the baseline hydrogeological conditions. The findings of the data gap analysis are summarised below:

- A large scale groundwater project covering Hoima and Buliisa districts (funded by Tullow (Ref. 9-14)) mapped the distribution of groundwater resources (quantity and quality), including delineation of major aquifers in the area, assessment of groundwater development potential and determining the potential risk of groundwater resources to pollution. Groundwater resources quantity and quality data was only reported for boreholes up to a maximum depth of 150 m. Although relevant to the baseline assessment, the majority of the information in this report relates to the Hoima district which is outside of the Project Area;
- Groundwater quality data was collected for various exploration ESIA studies across Blocks EA-1A, CA-1 (formerly known as EA-1) and LA-2 North (formerly known as EA-2), as well as during the environmental baseline surveys in Block EA-1. However, there is limited understanding of temporal and spatial coverage, consistency and quality of water quality between various data sets; and
- DWRM, TEP Uganda and TUOP data on borehole logs provides hydrogeological data, although the lithological logs are missing for many of the boreholes. Data on water quality does not address all regulated potable water quality constituents that may be present.

9.5.3 Baseline Data Collection Methods

In general, groundwater quality data from previous surveys (including the DWRM Groundwater Resources report of Buliisa and Hoima) provide an indication of the overall status of groundwater quality in some parts of the Study Area. However, this does not cover the entire Study Area and does not adequately characterise groundwater quality in the vicinity of the major Project elements and sensitive receptors nearby. On the basis of these findings, it was considered that additional groundwater surveys were necessary, in particular to further establish baseline groundwater quality conditions within the Project Area. For this purpose, two rounds of groundwater sampling were undertaken by Tilenga ESIA team in November/December 2016 and June 2017.

Groundwater level and flow data have been sources from existing reports and baseline surveys. In addition, a study currently is being undertaken to further clarify the groundwater conditions, both in terms of groundwater level and groundwater quality. Water quality data available at the time of the writing of this report from these studies has been incorporated. The results of the Front End Engineering Design (FEED) Water Abstraction Study will be used to refine the conceptual site model and to improve the understanding of these conditions across the Project Area.

9.5.4 Baseline Conditions Geology and Hydrogeology

9.5.4.1 Introduction

The baseline hydrogeological conditions in the Study Area are discussed with respect to the geology and the hydrogeological characteristics of the Study area in this section. Information on these aspects has been obtained from the following sources:

- Previous reports on the groundwater conditions of the Albertine Graben;
- 1:1,000,000 scale Geological Map of Uganda;
- Environmental Impact Assessments prepared for earlier phases of the Project;
- A review of borehole logs and permits provided by DWRM, TUOP and TEP Uganda for water supply and oil exploration boreholes in the Study Area;
- The results of pumping tests carried out on boreholes in the Study Area; and
- The results of borehole drilling and groundwater monitoring at the Industrial Area/Central Processing Facility (CPF) in 2018.

The baseline characterisation of the geology and hydrogeology are based primarily on secondary date which is supplemented by the recent data collected in 2018 at the Industrial Area. Hence, the primary and secondary data have not been discussed separately and the characterisation developed taking into consideration the data available; the sources of data have been included, where necessary. Additional information on soils and geology in the Study Area are provided in ***Chapter 8: Geology and Soils***.

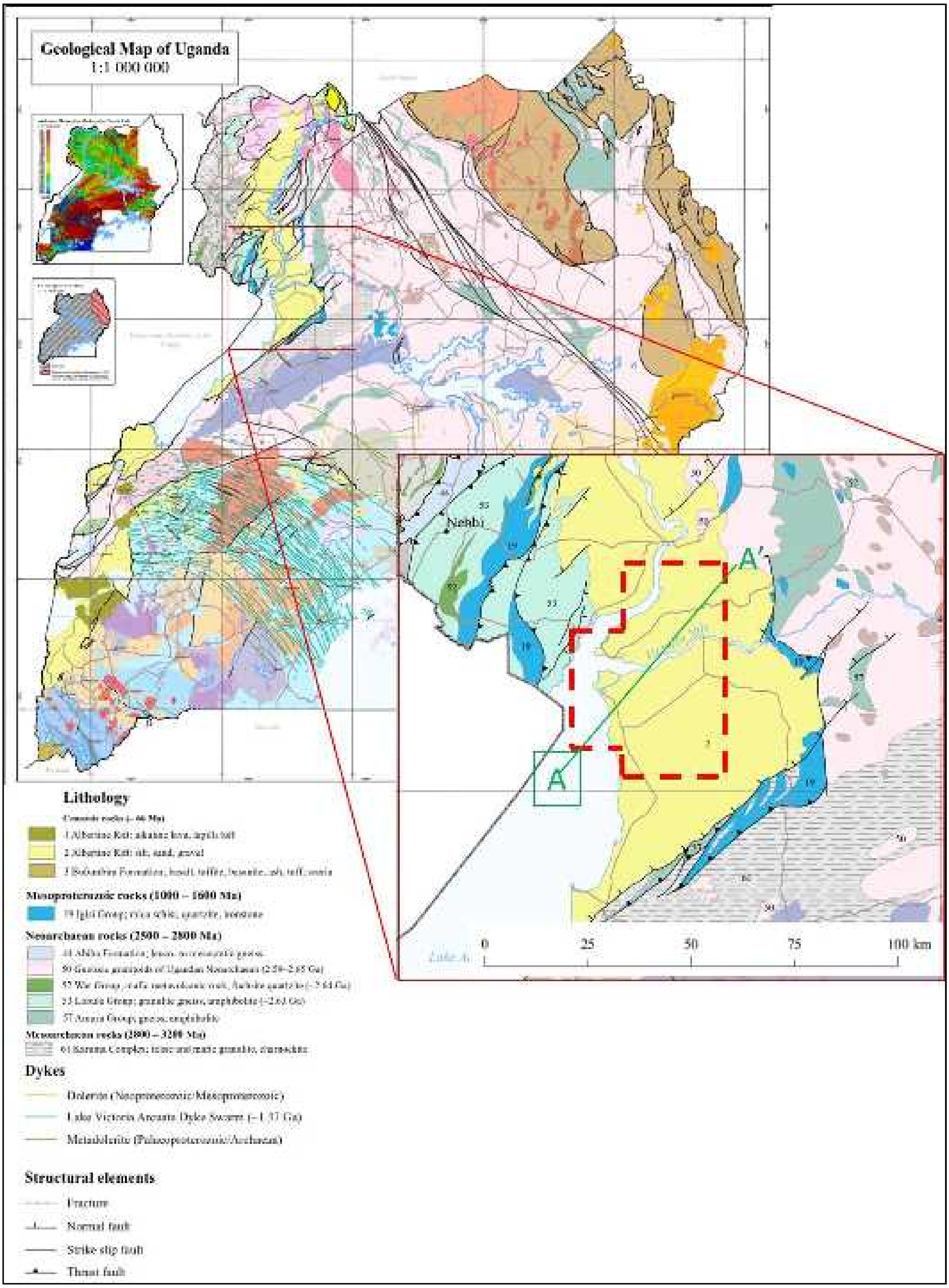
9.5.4.2 Geology

9.5.4.2.1 Regional Geology

The Project Area lies within the Lake Albert Basin, or Albertine Rift, at the northern end of the western branch of the East African Rift system. Rift walls of uplifted Pre-Cambrian basement rocks rise steeply on either side of the lake. A regional geological map showing the Study Area is presented in Figure 9-2.

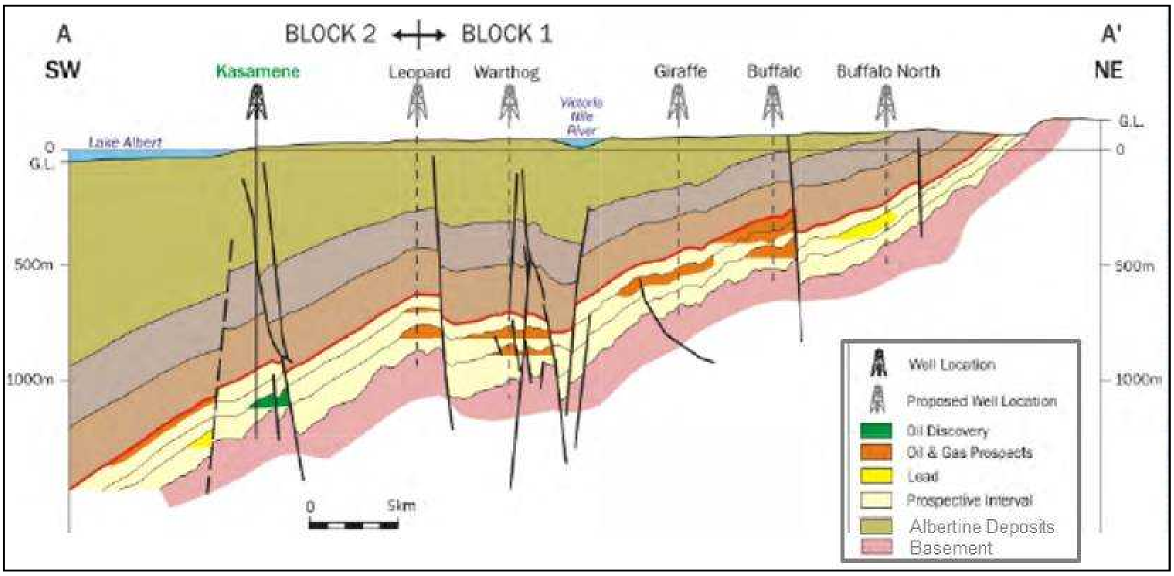
The rift valley has been infilled with sedimentary deposits (Schulter 1997) (Ref. 9-15). On the Ugandan side, the lake shore comes close to the rift escarpment in the Kaiso-Tonya area to the south of the Study Area but in the Kasamene area, at the northern end of the lake, the shore is set back from the escarpment by approximately 40 kilometres (km) leaving a larger area of exposed sedimentary infill. The Victoria Nile passes over a low point in the rift wall, plunging over the Murchison Falls and flowing into Lake Albert around the central part of the Study Area.

Up to 4,000 m of sediments of Cretaceous – Tertiary age have accumulated in the Albertine Rift. The lowest part of the sequence comprises of fluviatile deposits, intercalated with evaporites (principally gypsum). These are overlain by extensive lacustrine and lake margin sediments. These sedimentary deposits include silts and clays deposited along the axis of the rift by large rivers, and lobes of conglomerates, sands, silts and clays built out from the rift margins (Schulter 1997, Pickford et al 1993 (Ref. 9-16)). The Albertine Graben sedimentary deposits that exist at depths of more than 2,000 m form the main hydrocarbon-bearing sequence beneath the Study Area (see Figure 9-3). It consists of terrigenous sediments, alkaline/sodic volcanic and ultra-potassic and carbonate volcanic rocks at depths between 2,000 m – 3,000 m. Extensive work examining the basin infill has been carried out in the area, particularly in relation to petroleum exploration. However, from a hydrogeological perspective, it is the near-surface (i.e. 0 – 150 m) geology which is of prime interest, a part of the sequence, which was not usually considered in detail in previous geological assessments of the area.



Source: From 1:1,000,000 scale Geological Map of Uganda

Figure 9-2: Regional Geological Map of the Study Area



Source: From 1:1,000,000 scale Geological Map of Uganda

Figure 9-3: Schematic Geological Cross-section across the Study Area

9.5.4.2.2 Local Geology

The shallow (upper 500 m) geology beneath the Study Area consists of undifferentiated Tertiary deposits, overlain by papyrus swamp and alluvial deposits of Quaternary age along the river valleys and fringing the lake shore. The Tertiary deposits, the Kaiso and Epi-Kaiso Group, comprise gravel; clay with diatomite; sand, grit and friable sandstone; iron-rich pisolite and intra-formational laterite (Geological Survey of Uganda 1964) (Ref. 9-17). The sedimentary layers of the overlying Albertine Graben thicken and dip gently at approximately 3 – 4 m/km towards the centre of the depositional basin on the western margin of the Albertine Rift.

Previous assessments of the geological and hydrogeological conditions across the Project Area have confirmed that detailed geological information is primarily available for the upper approximately 150 m of the sedimentary sequence (Ref. 9-12). There are few borehole logs in the Study area for the strata below approximately 150 m depth to confirm the presence of deeper aquifers within the sedimentary sequence within the Gunya oil field area. Geological data are also available for several of the exploration wells drilled in the Jobi, Kasamene, Kigogole, Ngiri and Nsoga areas, from water supply boreholes and for groundwater monitoring boreholes at the Industrial Area, although information is limited to the upper layers. Appendix K Annex 3 provides borehole logs which show the inferred geology within the upper 100 m – 150 m bgl beneath the Study Area interpreted from borehole completion records located in Blocks CA-1 and LA-2 North. The lithological logs for the four groundwater monitoring boreholes at the Industrial Area are provided at Appendix K Annex 3. These logs indicate the likely local geological sequences across the Project Area.

Information on the full thickness of the sedimentary deposits has been interpolated from the logs of five oil exploration wells drilled in the Gunya area northeast of the Industrial Area/CPF. The boreholes vary in depth between 734 m and 866 m. The boreholes show a surface layer of loose sand (approximately 50 m and 95 m thick) with increasing clay content with depth. The sand layer is underlain by a layer of interbedded sand and claystones to depths in excess of 177 m. The thickness and number of the claystone bands increase with depth. The sequence below this layer is dominated by claystones and siltstones with minor sand, ironstone, coal and sandstone bands. The basement bedrock was proved in Gunya borehole 1 at 782 m depth, where it is represented by an amphibole gneiss. An interpretation of the Gunya borehole logs, shows predominately cohesive claystones at depths below 150 m. These strata are unlikely to yield large quantities of water and hence it is considered unlikely that the deeper strata form significant aquifers.

In the other boreholes, the basement was interpreted as a weathered layer of sand and conglomerate.

Geological logs also are available for several of the exploration wells drilled in the Jobi, Kasamene, Kigogole, Ngiri and Nsoga areas and from water supply boreholes, although information analysed for the purposes of impact assessment is limited to the upper layers to a maximum depth of 178 m. The borehole logs and a plan showing the borehole locations are provided at Appendix K Annex 3. The descriptions of the logs suggest the near-surface geology beneath the Study Area is mainly Quaternary sediments, predominantly beach sands and gravels with finer silts and clays. In general, the first 50 m or more below ground is dominated by sand (typically coarse, loose sand with occasional discontinuous layers of conglomerate), with interbedded clay layers at depths of between 50 m – 70 m below ground, although clay layers are present at shallow depths in some locations. Below this depth, the sequence is dominated by clay with subordinate sand layers. Logs from adjacent wells indicate that the geological layers are not laterally continuous. However, geological cross-sections drawn from a number of boreholes within the area suggest that clay layers are extensive closer to Lake Albert (further discussion on cross sections is provided below). A review of the database of borehole logs (Appendix K Annex 3) from the Study Area also suggests that the clay and silt layers vary in depth and thickness and are discontinuous, as they are absent in some of the logs.

From an interpretation of the logs of four boreholes from the Jobi area, north of the Victoria Nile drilled to depths between 75 m and 115 m, up to six lithological units can be inferred from most of the boreholes. A surface red sand and gravel unit is present only in borehole Jobi C, where it is 12 m thick. In the other three boreholes, the surface layer consists of a brown or grey clay between 6 m and 12 m thick. The surface unit in all four boreholes is underlain by a thick cream sand unit with occasional brown clay bands. This unit is between 36 m (Jobi C) and 48 m thick (Jobi East 5). In all four boreholes, the sand unit is underlain by a brownish grey or grey clay between 9 m and 15 m thick. Another sand or clayey sand unit underlies the clay band. This unit is variously described as a grey, brown or cream clayey sand or sandy clay and is between 12 m (Jobi East F) and a maximum 27 m in Jobi C. The base of this unit generally is between 78 m and 87 m below ground apart from borehole Jobi East F, in which it is at 60 m depth. In boreholes Jobi East 3, East 5 and East F, the sandy clay unit is underlain by a grey clay and sand unit to the base of the boreholes, a thickness of 15 m, at 93 m, 102 m and 75 m, respectively. In Jobi C, the grey clay and sand unit also is present to the base of the borehole at 115 m, a thickness of 28 m. The base of this unit was not proven.

Other boreholes in Block EA-1, north of the Victoria Nile - TIL, Rii-B and RAA show a similar sequence, although the boreholes were completed at shallower depths of 75 m, 69 m and 54 m respectively. Both Rii-B and RAA terminate in a grey clay unit present between 36 m and 69 m in borehole RAA and between 45 m and 54 m in borehole Rii-B. The TIL borehole shows a surface clay band 6 m thick, overlying a brown clay and sand sequence to 36 m and a grey sand to 51 m. The grey sand is underlain by a mixed clay and sand sequence to the base of the borehole at 75 m.

The logs for boreholes drilled south of the Victoria Nile are generally less detailed and simply record and upper layer of medium to coarse unconsolidated sand between 45 m and 60 m depth, overlying interbedded sand and claystone to a maximum depth of 80 m.

The only boreholes with a detailed lithological log are boreholes Mpyo-F and Mpyo-H, which are both 75 m deep. These two boreholes show different sequences. Mpyo-F shows a surface grey clay unit 6 m thick over a cream and brown clay to 30 m. The clay is underlain by 18 m of brown and grey clayey sand and a sand and gravel layer to 48 m depth. The strata in the remainder of the borehole to 75 m comprise a grey clay and silt over a grey clay and sand.

Mpyo-H borehole record shows a similar surface layer of grey clay to 6 m. In this borehole, the clay overlies a 12 m thick band of yellowish brown sand, which overlies a brown sandy clay to a depth of 39 m. A brown sand and clayey sand is present to 66 m depth, a thickness of 27 m. This is underlain by a 12 m thick layer of quartz sand to 72 m depth, which overlies a dark grey clay to the base of the borehole at 75 m.

In September and October 2017, a series of geotechnical and groundwater monitoring boreholes were drilled in the proposed Industrial Area/CPF. The four groundwater monitoring boreholes were drilled to a depth of approximately 55m. The lithological logs for the four groundwater monitoring boreholes CPF MW-1 to CPF MW-4 are provided at Appendix K Annex 3. The borehole locations are indicated on Figure 9-4.

The geology proved in the boreholes is similar to that interpreted from other boreholes across the Study Area for the upper part of the sedimentary sequence. A surface layer of mottled orangish-brown and greyish-orange sand and sand and gravel was proved to a depth between approximately 7.6 m (CPF MW-3) and 12.2 m (CPF MW-4). The upper granular layer is underlain by a band of greenish-grey sandy and silty clay between 8.5 m (CPF MW-3) and 18.2 m (CPF MW-1) thick to depths between 16.0 m (CPF MW-3) and 29.9 m (CPF MW-1). The clay band is underlain in all four boreholes by a greenish grey and yellowish brown sand. This unit varies in thickness between approximately 11.4 m (CPF MW-1) and 22.5 m (CPF MW-3 and MW-4). In all four boreholes this sand unit includes a greenish grey sandy silt band between 1.4 m (CPF MW-1) and 4.5 m thick (CPF MW-4). The sand is underlain by a sandy silt and clay between 1.9 m (CPF MW-3) and a maximum 5.5 m thick in borehole CPF MW-2. The base of the silty clay is between 40.4 m (CPF MW-3) and 50.1 m (CPF MW-4). In boreholes CPF MW-2 and MW-4, the silty clay is underlain by a band of light grey or greenish-grey sand to the base of the borehole at a depth of approximately 55 m, a thickness of at least 11.3 m and 4.9 m respectively. In boreholes CPF MW-1 and CPF MW-3, the sand unit is 4.8 m and 5.6 m thick respectively and is underlain by a band of grey clayey silt to the base of each borehole, with a thickness of at least 4.5 m and 9 m respectively.

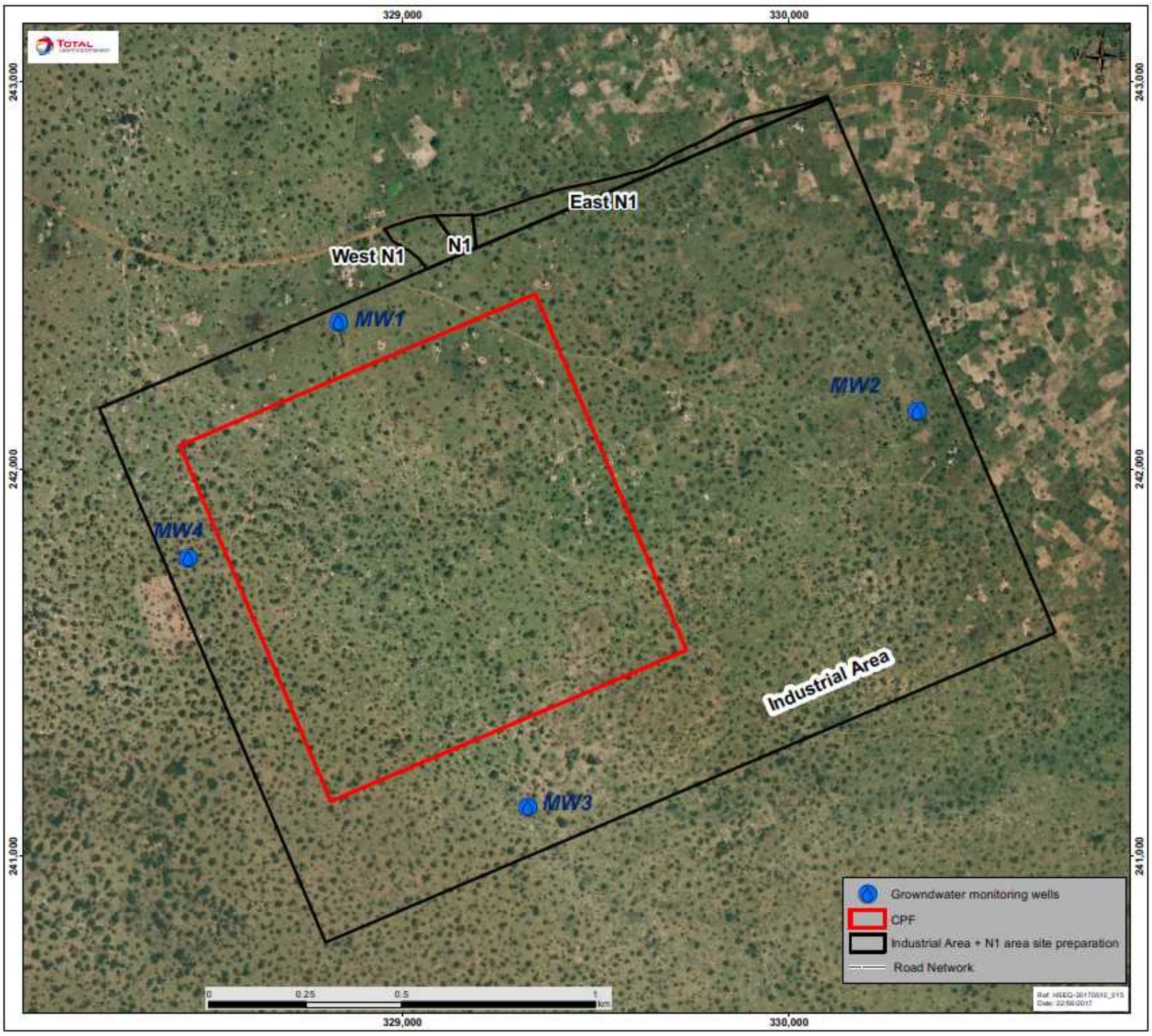


Figure 9-4: Monitoring Wells in the Industrial Area

It is considered that the lithology proved in the four monitoring boreholes generally is consistent across the Industrial Area, with minor lateral variations in strata similar to other parts of the Study Area. Accordingly, it is concluded that the geological conditions proved in the boreholes are representative of the proposed Industrial Area.

Geological cross sections have been prepared based on the borehole logs in the vicinity of proposed Project infrastructure. The lines of the cross sections are shown on Figure 9-5. Figure 9-6, Figure 9-7 and Figure 9-8 show geological cross-sections of the upper part (approximately 150 m) of the sedimentary sequence. The cross-section shows the lateral variation in the lithology of the units. Figure 9-6 shows the lithological variation in a north to south direction through the Study Area. Figure 9-7 shows the lithological variation in a southwest to northeast direction through the area south of the Victoria Nile and Figure 9-8 shows the variation in a west to east direction through the Industrial Area through the Industrial Area. Below a depth of approximately 130 m to 150 m, thick claystones are present, with only limited sand bands. The geological cross-sections show the lateral variations in the lithology across the Study Area. In general, the cross-sections show that granular units dominate the central part of the area with clays dominant in the north and east and adjacent to Lake Albert. In the DWRM report of November 2013 (Ref: 9-14) the geological conditions are summarised as:

"Based on information from the cross sections it can be concluded that the main aquifer unit in the northern part of the Albertine Graben in Buliisa district is composed of fine sands that are thicker and more productive while the dominant aquifer unit in the southern part of the Graben is composed of more clayey sands that are thinner and less productive."

The available borehole logs are adequate to facilitate an assessment of the geology of the upper layer of the unconsolidated deposits. These deposits form the principal sequence for the hydrogeological assessment and the sequence which supports the existing and proposed water supplies in the Project area. As there is no evidence from the available data of a deeper aquifer, for the purpose of the ESIA, the assessment has concentrated on the surface deposits to a depth of 150 m.

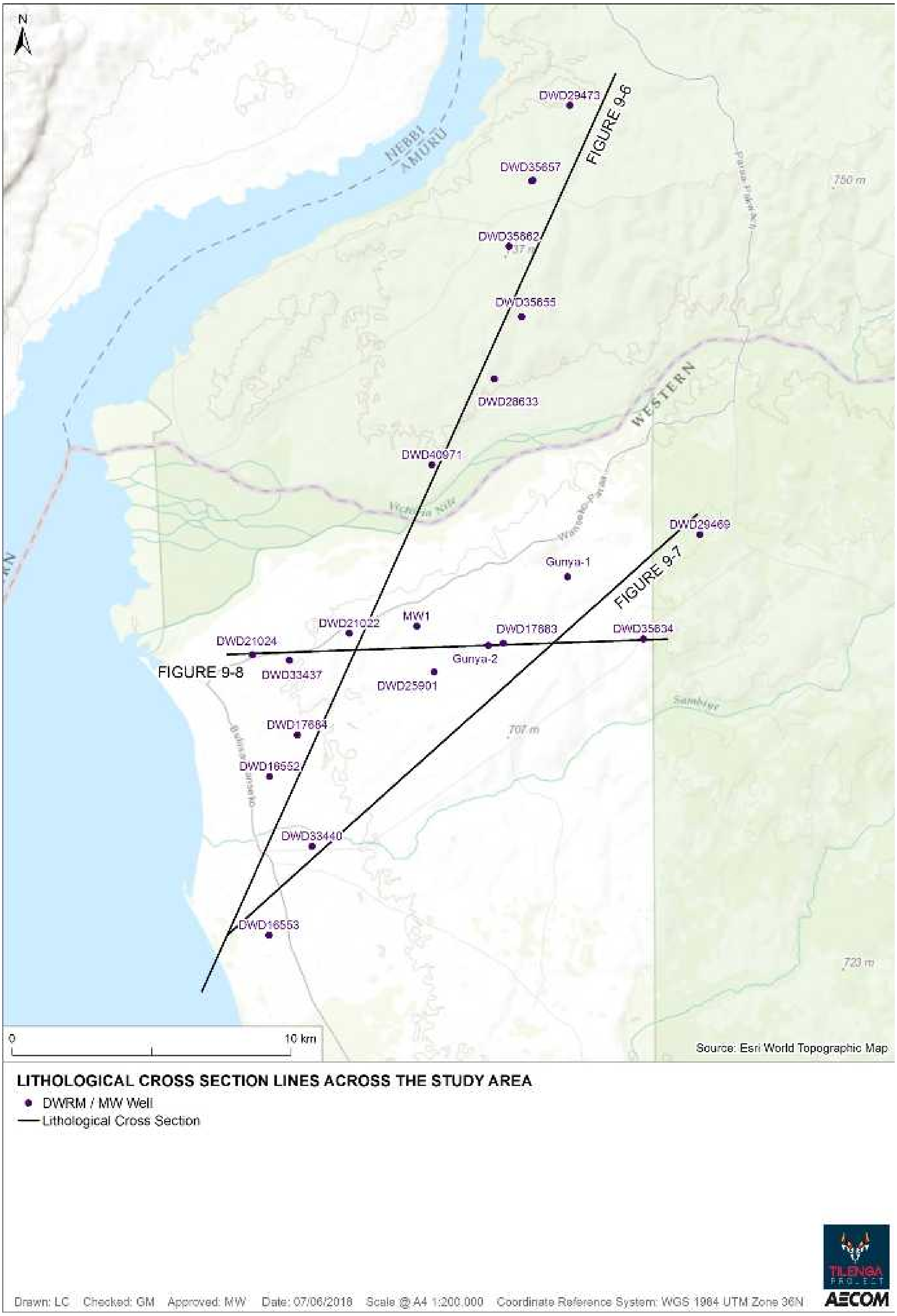


Figure 9-5: Lithological Cross Sections lines across the Study Area

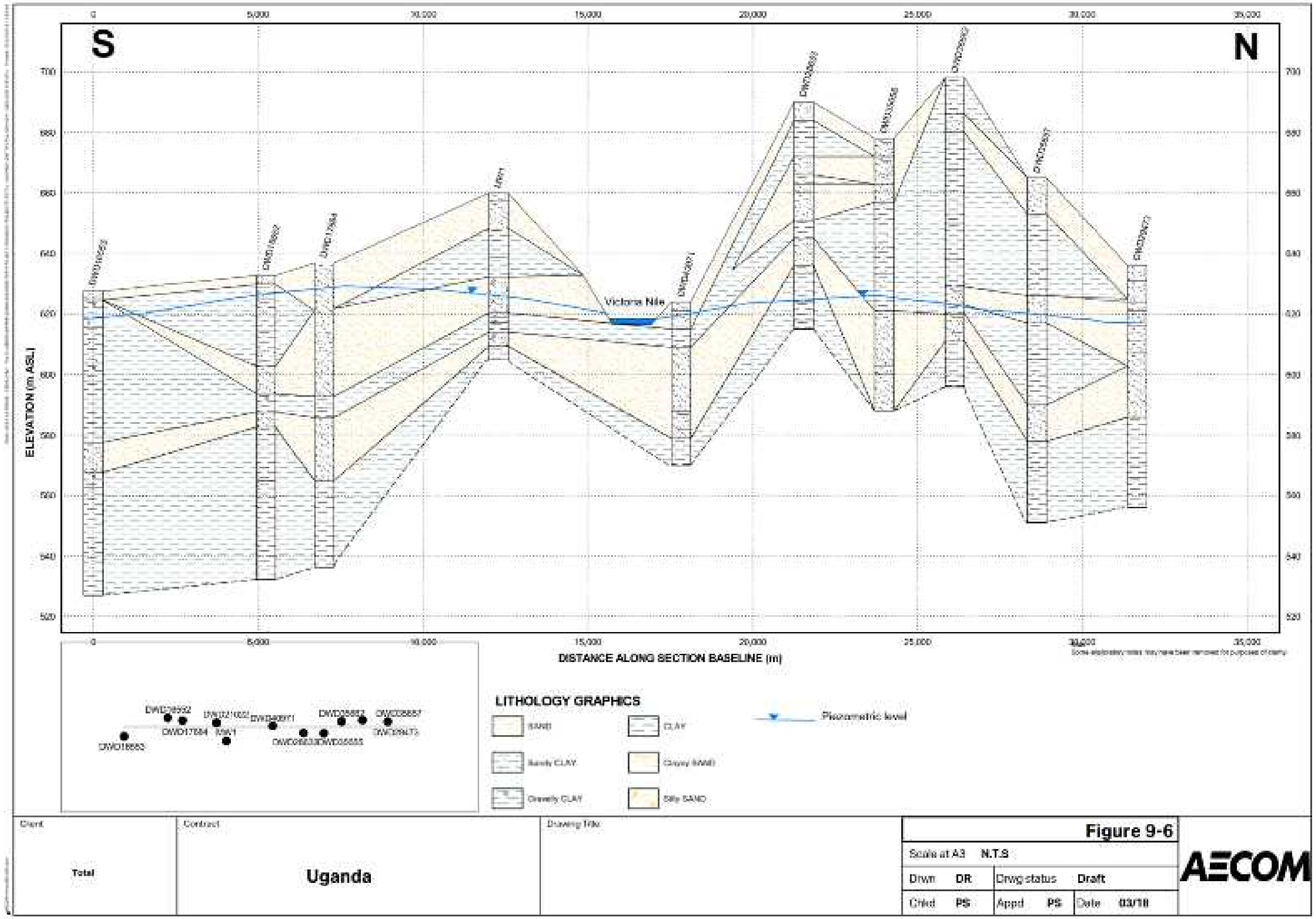


Figure 9-6: Geological cross-section through the upper part of the sedimentary sequence in a north to south direction through the Project Area

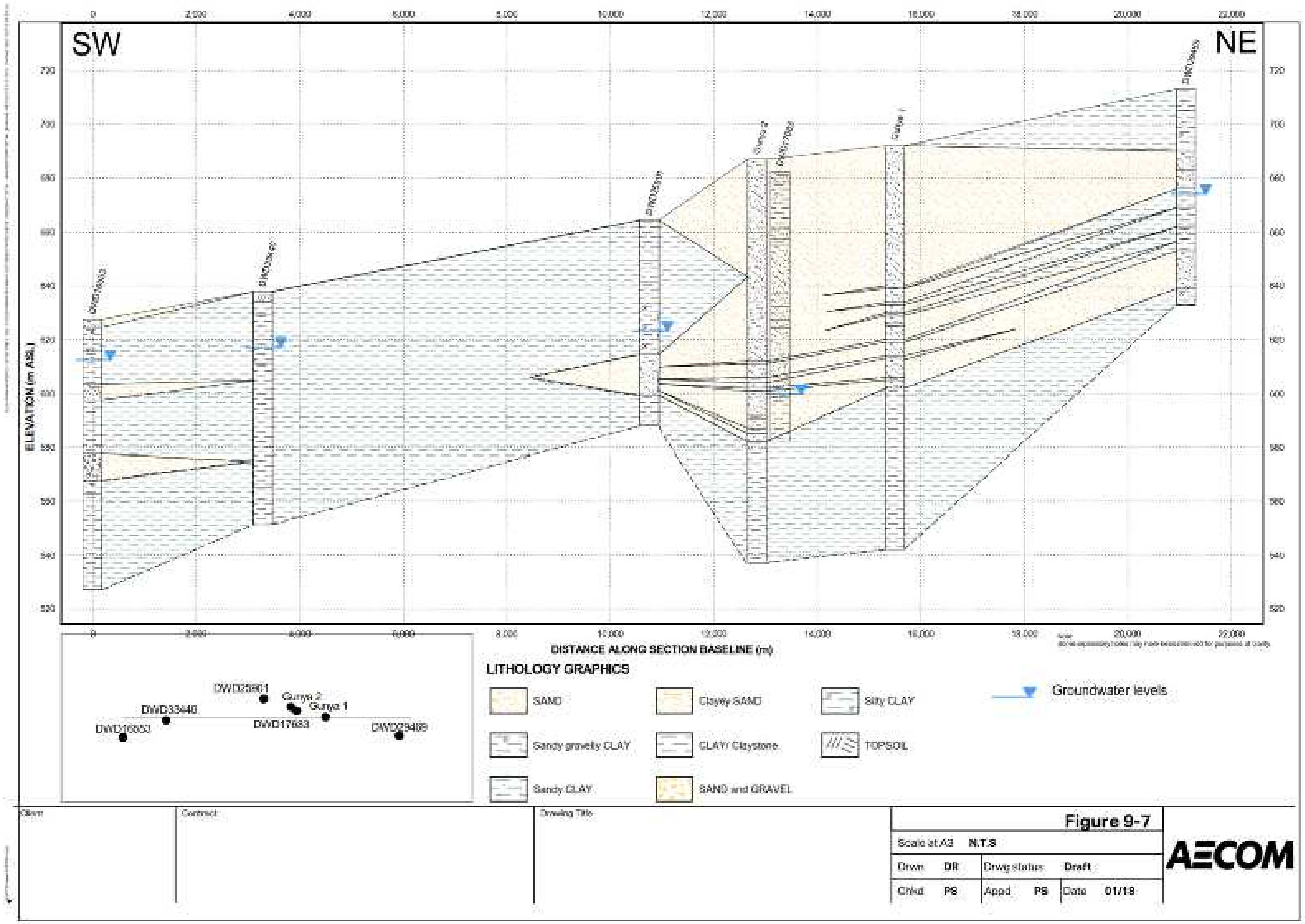


Figure 9-7: Geological cross-section through the upper part of the sedimentary sequence in a southwest to northeast direction through the area south of the Victoria Nile

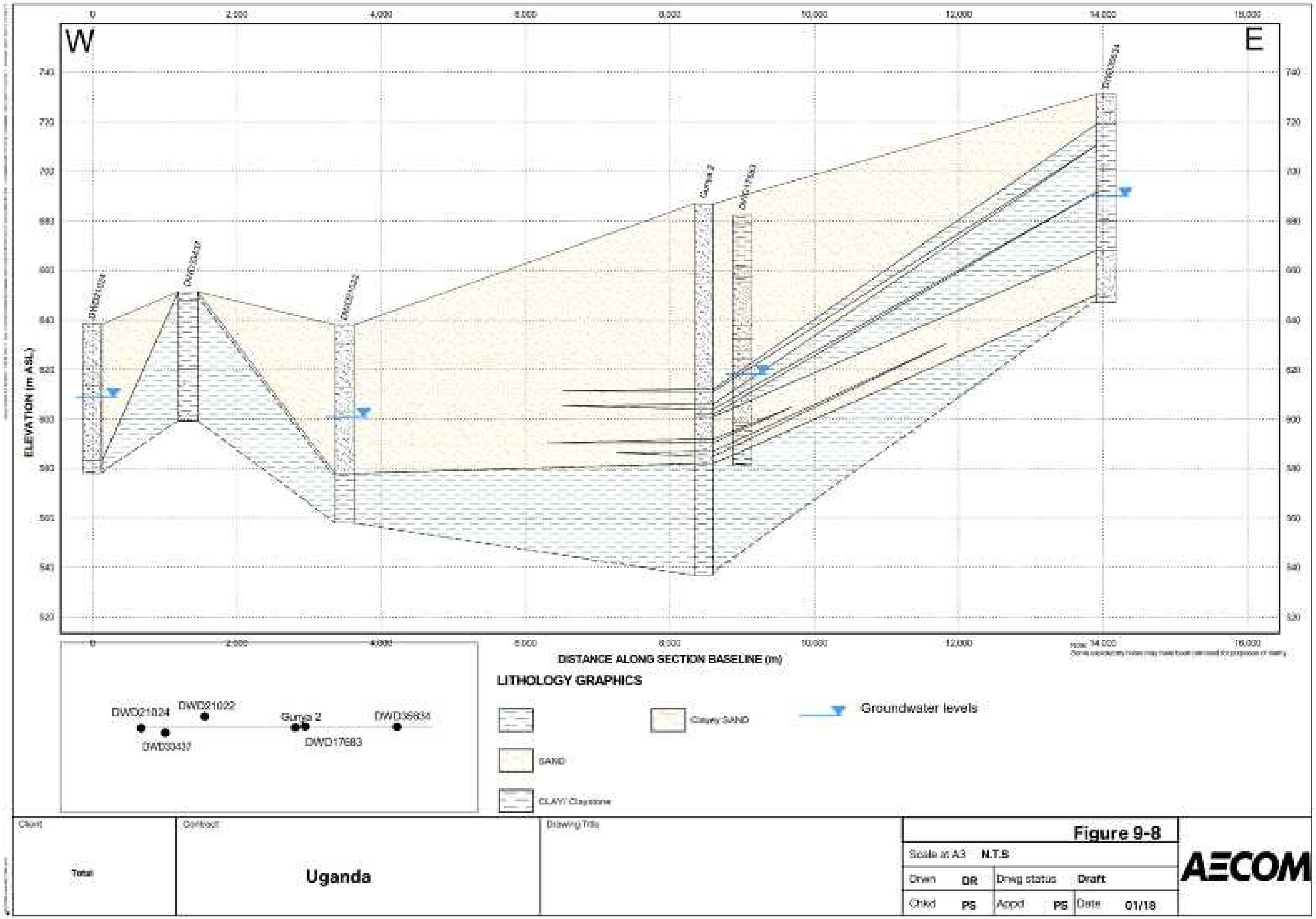


Figure 9-8: Geological cross-section through the upper part of the sedimentary sequence in a west to east direction through the Industrial Area

9.5.4.3 Hydrogeology

This section provides a summary of the hydrogeology baseline conditions of the main aquifer (i.e. the upper unconsolidated sand layer) beneath the Study Area. The upper unconsolidated sand forms the main aquifer for existing and proposed water supplies across the Study Area. Below a depth of approximately 150 m, the strata consist mainly of low permeability claystones with limited groundwater potential. There is potential locally for minor perched groundwater where interbedded clay layers within the sand are laterally extensive. Accordingly, the hydrogeology assessment concentrates primarily on the upper 150 m of sediments. Information was gathered from numerous sources - both secondary and primary, and used to determine the baseline hydrogeological conditions beneath the Study Area. Readily available data was collected, reviewed and evaluated based on their relevance and suitability and was used to characterise the baseline hydrogeological conditions of the Study Area The information used has been drawn from a number of key sources and reports of studies carried out in the region including:

- Hydrogeological Map of Uganda (1989) (Ref. 9-18);
- Groundwater Resources Report on Buliisa and Hoima Districts and supporting maps (DWRM and Tullow, 2013 Ref. 9-14);
- A series of National and District 1:160,000 scale hydrogeological groundwater maps produced under the EU-Funded mapping of groundwater resources programme (Ref. 9-19);
- National Water Resources Report produced by the Government of Uganda through Ministry of Water and Environment (DWRM 2013) (Ref. 9-20);
- Reports from previous hydrogeological studies carried out within the Study Area;
- Baseline survey data gathered during the ESIA sampling surveys carried out in 2014, November 2016 and June 2017; and
- Groundwater monitoring carried out in the vicinity of the Industrial Area/CPF in 2018.

The Pre-Cambrian basement rocks are considered to be of low permeability and have little groundwater potential other than in fractures. Where these outcrop on the edge of the rift valley or are present at a shallow depth on the sides of the rift below the sedimentary sequence, it is likely that they act as a barrier to vertical groundwater flow and support a perched aquifer in the overlying sedimentary sequence. The basement rocks underlie the sedimentary sequence across the whole Study Area. The depth to the basement rocks varies as shown in Figure 9-3.

The upper unconsolidated sand layer is water-bearing and forms an important aquifer for community water supplies in the Study Area. Based on an interpretation of the geological information for the Study Area, it is considered that the surface sand layer has a high to moderate permeability, which facilitates groundwater flow and forms an important aquifer for water supply. It is likely that groundwater in the sand aquifer provides base flow support to the main permanent watercourses in the Study Area, the Victoria Nile and the Albert Nile, and to Lake Albert. Where the groundwater level is shallow, groundwater may provide a water source to support wetland areas.

It is considered that the clays and claystones have a lower permeability which restrict groundwater flow and may support perched water in the overlying sand unit. Where thick clay layers are present within the lower interbedded sand and clay sequence, it is possible that locally a series of individual aquifers have developed. However, it is considered that from a regional perspective, the strata in the upper approximately 150 m can be regarded as a single aquifer.

From logs of the Gunya boreholes, it is interpreted that the lithology at depth is unlikely to support a significant aquifer and that groundwater will be limited to the thin granular units locally present in the sequence.

Groundwater levels can vary significantly over both the short-term (seasonally) and the long-term (yearly). The water table may rise or fall depending on several factors. Heavy rains may increase recharge and cause the water table to rise. In contrast, an extended period of dry weather or a drought may reduce recharge and cause the water table to fall. Ground clearing, construction and increasing the slope of the ground can result in soil erosion and greater runoff that carries water away from an area before much of it can infiltrate. Water abstraction can also cause water levels to fall.

Similarly, the groundwater flow direction can vary locally due to groundwater abstractions; however, the general flow direction will remain constant. The indicative characterisation of the aquifer (e.g. flow direction, depth to water) is based on available information from within the Study Area with the limitations noted. Groundwater flow is discussed in more detail in Section 9.5.4.7.

9.5.4.4 Groundwater occurrence

The surface sand layer forms an important aquifer for existing and proposed groundwater supplies in the Study Area. The data collected by the DWRM (DWRM, 2013 Ref. 9-14) for various groundwater sources was processed and analysed for the Buliisa and Hoima districts to identify the lithology of the aquifer units, which influence the vulnerability of groundwater to potential contamination. The total borehole depths were up to 150 m bgl but they were screened over specific zones (mainly around 30 m – 60 m bgl), where the sandier horizons are located and within the saturated section of the aquifer. This analysis suggests that there may be two aquifer units within the upper Albertine Graben – an upper more extensive unit composed of fluvial/alluvial gravel and sands and a lower, less productive unit composed of interbedded clays and sands. However, there is insufficient information to confirm this assumption. The data also indicated that from the local geology, the aquifer is unconsolidated and generally unconfined or semi-confined below the lower permeability silts and clays. This is a hydrogeological condition and has no bearing on the water yielding capability of the aquifer.

For the purpose of the assessment, it is assumed that the upper part (150 m) of the sedimentary sequence forms a single, continuous aquifer. It is also assumed that shallow groundwater is where the groundwater level is within 10 m of the ground surface. 'Deep' groundwater is where the groundwater level is more than 10 m bgl. Recharge to the aquifer beneath the Study Area is likely to be mainly from rainfall across the entire area either by direct infiltration or underground seepage and sub-surface flow from the mountainous region in the east. In those parts of the Study Area where the water level is at depth, there is potential for additional recharge to the aquifer from permanent and ephemeral watercourses, which leak into the underlying sand aquifer.

Yields of more than 50 cubic metres per hour (m^3/hr) are possible from boreholes in the sedimentary aquifer as reported in the literature (Upton et. al. 2016) (Ref. 9-21). However, lower yields of between approximately 2 m^3/hr – 16 m^3/hr have also been reported for boreholes across the Study Area (Atkins 2010 Ref. 9-22). It should be noted that these yields may not reflect the aquifer potential, as the boreholes may have been constructed for a specific purpose rather than to explore the full yield potential of the aquifer.

Although the principal oil-bearing strata are at depth (i.e. between 250 m and 900 m bgl), natural oil seepages have been identified in the Study Area. Oil seepages have been identified on the southern boundary of the Study Area along the faulted junction between the sedimentary sequence and the basement bedrock. Other natural oil seepages have been recorded along the Victoria Nile with one located north of the river adjacent to Mpyo-4; one located on the northern bank of the river, east of the proposed Nile Crossing and two located on the southern bank, north of Mpyo-1. Figure 9-9 shows the location of the natural oil seepages within the Project Area.

9.5.4.5 Aquifer properties

Information on the hydraulic properties of the unconsolidated, sedimentary aquifer is important to facilitate an assessment of the likely impacts of the additional groundwater abstraction proposed for the Project. In particular, information on groundwater level, aquifer transmissivity and aquifer storage is necessary to determine the effects of the proposed abstractions on existing boreholes in the locality. The aquifer properties can be evaluated from the results of pumping tests carried out on boreholes in the unconsolidated aquifer.

However, good quality pumping test data for boreholes in the unconsolidated aquifer within the Study Area is scarce, with few boreholes having been pumped for an extended period. Table 9-5 provides details of boreholes within the Study Area for which pumping tests have been carried out and the hydraulic conductivity (transmissivity) values derived from the tests. Information also is provided on the quality of the pumping tests.

Hydraulic conductivity[1] values between 0.02 m/day and 15 m/day, an average transmissivity[2] of 34 square metres per day (m^2/day) with an average storage coefficient[3] of 0.1 have been reported for the aquifer in the Study Area.

Transmissivity values of between 100 m^2/day and 150 m^2/day have been calculated using available pumping test data from two boreholes, one located in the central part of the Study Area in Buliisa district near the Industrial Area and the other in the southern part of the Study Area near Kasamene, from which reliable pumping test data is available. A review of pumping test information for four boreholes south of the Victoria Nile, one of which is remote from the Project elements, shows transmissivity values between 7 m^2/day for borehole DWD40959 on the eastern of the Study Area and a maximum of 130 m^2/day for borehole DWD21665, north of KW-02A.

A review of pumping test information for eight boreholes north of the Victoria Nile, three of which are remote from the project elements, shows transmissivity values between 5 m^2/day for borehole DWD40964 to the northeast of JBR-09 and a maximum of 266 m^2/day for borehole DWD35655, south of JBR-03 and JBR-04. Figure 9-9 shows the borehole locations for which aquifer properties have been calculated from pumping tests. Further information on the hydraulic properties of the unconsolidated sand aquifer will be obtained from the current FEED study and from pumping tests undertaken at each proposed water supply borehole. This information will allow a refinement of the baseline hydrogeological conditions.

Table 9-5: Results of Pumping Test Analyses

Borehole No.	Borehole Depth (m)	Average Pumping Rate (m^3/hr)	Rest water level (mbgl)	Pumping water level (mbgl)	Drawdown (m)	Transmissivity (m^2/day)
North Nile						
DWD40971 (Rii-B)	54	9	10.8	12.83	2.02	233
DWD40964 (Jobi East 3)	93	8.4	4.78	43.8	39.02	5
DWD28633 (Heritage Giraffe)	75	12.9	n/a	n/a	2.81	77
DWD35655 (Jobi D)	90	10.3	53.37	60.65	7.28	266
DWD35657 (Jobi C)	114	7.2	64.34	67.4	3.06	145
DWD35662 (Jobi East 5)	140	4.3	74.13	83.62	9.49	25
DWD40955	75	12	29.8	34.83	5.03	92

[1] A coefficient of proportionality describing the rate at which water can move through a permeable medium.
[2] The rate at which water is transmitted through a unit width of an aquifer. It corresponds to the rate at which a contaminant will be transmitted from a source to receptor.
[3] The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head or groundwater level.

Borehole No.	Borehole Depth (m)	Average Pumping Rate (m^3/hr)	Rest water level (mbgl)	Pumping water level (mbgl)	Drawdown (m)	Transmissivity (m^2/day)
North Nile						
(Mpyo-H)						
DWD40957 (Mpyo-F)	66	8.1	19.7	34.05	14.35	17
South Nile						
DWD35634 (Bugungu Camp)	84	9.8	40.49	49.53	9.04	35
DWD40959 (Mpyo-D)	140	4.8	29.58	50.02	19.94	7
DWD21665 (Kasemene)	120	13.6	17.25	19.8	2.55	130
DWD33444 (Kichoke)	95.7	n/a	32.6	n/a	n/a	43
DWD40597	75	8.7	19.68	34.03	14.35	17

Table 9-6 and Table 9-7 provide information on the borehole depth, rest water level, the pumping water level and yield for borehole sources within the CA-1 and LA-2 (North) areas.

Table 9-6: CA-1 Borehole Data (Source: Watertech)

Location	DWD No.	Altitude (mad)	Depth (m bgl)	Screen (m bgl)	Static Water Level (mad)	Yield (m^3/hr)	Drawdown (m)	EC (µS/cm)	Hardness as (mg/l $CaCO_3$)	TDS
Jobi C	35657	665	114	60.5-66 77-88 99-110	600	7.2	3.06	No	No	No
Jobi East 3	40964	672	93	45.7-70.4	667.2	4.1	39.02	462	160	296
Jobi East 5	35662	698	102	64.4-67.2 69.9-78.2 80.9-89.0 91.7-100	623.8	4.3	9.49	430	188	215
Jobi East F	40958	691	87	57.7-85.2	642.8	10.5	3.72	257	88	164
Mpyo-F	40957	650	66	38.5-66	630.3	8.07	14.35	610	90	390
Mpyo -H	40955	681	75	49.5-81.5(?)	651.2	12	5.03	212	78	136
RAA	35668	638	69	16.5-22 48.7-68	620.1	3.2	32.9	3660	940	1830

Location	DWD No.	Altitude (mad)	Depth (m bgl)	Screen (m bgl)	Static Water Level (mad)	Yield (m^3/hr)	Drawdown (m)	EC (µS/cm)	Hardness as (mg/l $CaCO_3$)	TDS
RII-B	40971	624	54	13.7-19.2 24.7-33 41.5-52.2	613.2	9	2.03	1127	130	620
Tangi Camp 1	35646	-	60	38-49 54.5-60	19.7*	12.67	4.65	446	76	285
Tangi Camp 2	35670	645	81	52.2-79.7	636.3	11.6	13.2	2950	160	1888
TIL	35666	685	75	48-75	640.4	9	13.9	342	170	171

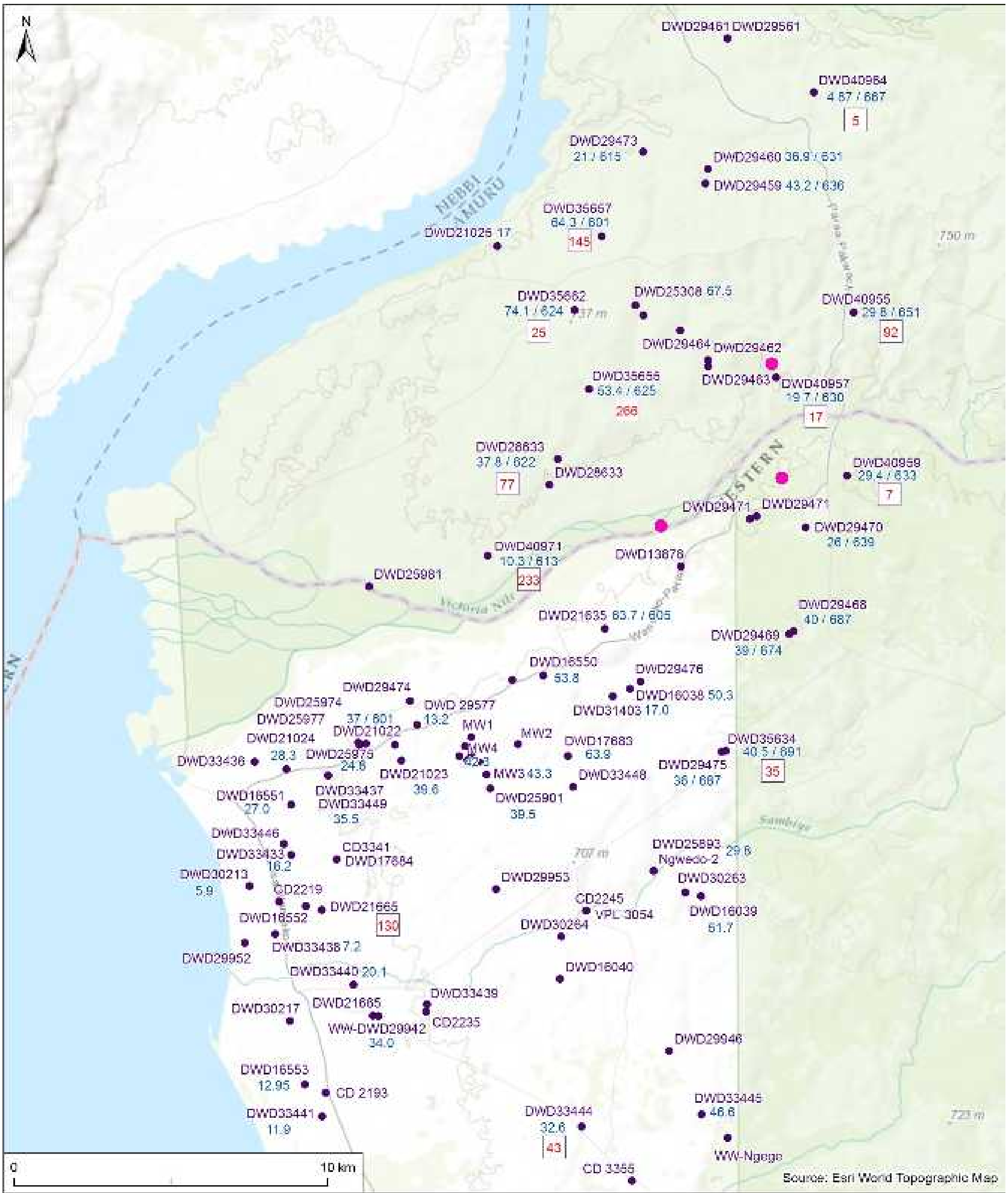
Notes: mad - metres above datum; * - measured as metres below ground level (m bgl); EC – Electrical Conductivity; TDS – Total Dissolved Solids

Table 9-7: LA-2 Borehole Data (Source: Watertech in Atkins 2010)

Location	DWD No.	Altitude (mad)	Depth (m bgl)	Screen (m bgl)	Static Water Level (m bgl)	Yield (m^3/hr)	Draw-down (m)	EC (µS/cm)	Hardness as (mg/l $CaCO_3$)	TDS
Kizikya		632	53.3	44.5-50.3	15.65	9	3.66	2000	620	1280
Kigwera SW		626	57.5	47.6-53.6	9.73	10	5.87	950	280	608
Ndamfamira		633	53.6	55.5-60.5	11.62	7.8	1.45	1600	404	1024
Katalera		661	60.67	46.12-52	43.8	7.6	2.92	400	120	256
Beroya		699	57.6	46.55-57.55	No	None	No	No	No	-
Kimbambura		679	58.46	41.7-59	No	None	No	No	No	-
Ngwedo		704	75.87	41.78-59	No	None	No	No	No	-
Kiryango		678	85.3	60-82	No	2.7	No	No	No	-
Oribo		670	86.5	55.15-58 and 75.1-83.65	27.92	5.14	7.29	Medium	No	-
Ngwedo2 (Kigogle Community BH)	25893	680	90	70-80	26.9	11.02	2.45	-	-	
Ngwedo 1		692	NA	NA	No	10	-	-	-	
Kigogle 1 Borehole	NA	694	120	28.5-51.3	No	None	-	-	-	Dry
Ngege	21661	669	131	45.6-59.85 and 68.4-76.95	20.2	16.21	4.66	384	80	193
Kasemene	21665	635	120	34.2-54.15	17.25	13.58	2.55	963	288	479

Location	DWD No.	Altitude (mad)	Depth (m bgl)	Screen (m bgl)	Static Water Level (m bgl)	Yield (m^3/hr)	Draw-down (m)	EC (µS/cm)	Hardness as (mg/l $CaCO_3$)	TDS
Buliisa Old Seismic camp	21659	638	78.34	NA	22.85	2	19.98	-	-	-
Karuku 1	21663	700	132	11.6-23 and 28.75-40.2	0	-	-	-	-	-
Karuku 1-2	21664	-	100	No lining	0	-	-	-	-	-
Awaka - 1	29905	684	87	39.5-61.5	25.14	7.14	6.58	194	72	124
Ngara 1	28633	663	60	32.5-54.5	18.9	7.74	6.58	199	68	127

Notes: mad - metres above datum; m bgl – metres below ground level; EC – Electrical Conductivity; TDS – Total Dissolved Solids



LOCATION OF PUMPING TEST INFORMATION AND GROUNDWATER LEVELS

- Natural Oil Seep
- DWRM / MW Well

26 / 639 Groundwater level (m below ground/mad)

10 Borehole with pumping test information (T in m2/day)

Drawn: LC Checked: GM Approved: MW Date: 22/03/2018 Scale @ A4 1:200,000 Coordinate Reference System: WGS 1984 UTM Zone 36N

TILENGA PROJECT

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Figure 9-9: Locations of pumping test information and recorded groundwater levels

9.5.4.6 Groundwater Availability and Use

9.5.4.6.1 Groundwater Availability

In 2011, the Directorate of Water Resources Management assessed the groundwater resources in Uganda and calculated the sustainable exploitable groundwater resources per district, evaluating the proportion of the resource that can be exploited on a sustained basis without resulting in unacceptable consequences for the water environment. The estimated availability of groundwater resources for the entire country has been classified as medium-high, with a groundwater recharge rate ranging between 25 millimetres (mm) and 100 mm/year. The Study Area has low to medium groundwater recharge rates between 19.1 mm and 39.9 mm/year (Ref. 9-23).

9.5.4.6.2 Groundwater use

Groundwater is a significant source of water which is put to a variety of uses including domestic water supply, irrigation and flow augmentation of streams and wetlands within the Study Area. Priority of water resources utilisation and development in the area and in Uganda is given to domestic water supply for both human consumption and livestock. Rural domestic water demand is by far greater than the urban demand because about 80% of the country's population is rural. Of the 98 operational public water supply schemes in Uganda, 78 are based on groundwater and the majority of these schemes are in rural areas. Figure 9-10 presents the public groundwater supply sources identified in the ESIA Project Area and environ.

Groundwater is the primary source of drinking water and meets 80% or more of the water supply demand, but its availability is strongly influenced by seasonal variations. Within the Murchison Falls National Park (MFNP) groundwater abstraction is mainly associated with the safari lodges, whereas south of the Victoria Nile (Buliisa and Masindi districts) groundwater is used throughout the populated areas. The DWRM database of boreholes in Buliisa district shows that there are 93 private water supply boreholes within the vicinity of the Study Area. However, it is not known how many of these boreholes are still functional.

The main sources of water supply for Buliisa district are shallow wells (i.e. hand-dug well with depth less than 30 m) and deep (i.e. greater than 30 m) boreholes; 20% of Buliisa district population is served by two groundwater pumped/piped water supply systems, while 80% relies on individual borehole sources.

The primary sources of water supply in the Masindi district are deep (i.e. >30 m) boreholes and shallow (i.e. <30 m) wells, with five groundwater pumped/piped water supply systems serving approximately 12% of the population, while 88% of the population is served by private water supply boreholes.

9.5.4.7 Groundwater Levels and Flow Direction

It is considered that groundwater in the unconsolidated sand aquifer is in hydraulic continuity with the main watercourses in the area and that groundwater flows in a generally westerly direction towards Lake Albert and the Albert Nile and locally towards the Victoria Nile.

Information on the depth to groundwater suggests that the groundwater level varies over the Study Area with levels ranging from 1 m to over 70 m bgl. In general, the depth to groundwater is shallow (less than 10 m below ground) in areas adjacent to permanent water bodies such as the Victoria and Albert Nile Rivers and Lake Albert. On the higher ground to the east, the depth to groundwater is greater with recorded rest groundwater levels in excess of 50 m bgl. The depth to groundwater is one factor that affects its vulnerability to potential contamination, with shallow groundwater being more sensitive than deep groundwater due to the thickness of intervening unsaturated soil which can attenuate the downward migration of pollutants. However, from the available borehole logs, it is interpreted that the shallower layers of the aquifer generally are consistent and sandy and would not provide an effective barrier to the vertical percolation of contaminants.

A groundwater potentiometric map for the Study Area was constructed during the Environmental Baseline Study (EBS) using historical depth to groundwater measurements in water supply boreholes installed to support the Block 1 exploration activities (provided by TEP Uganda). The map was prepared to assist in evaluating groundwater elevation and infer the groundwater gradient and flow direction. The hydraulic gradient and flow direction are generally from the higher ground to the east, where groundwater levels are greater than 675 metres above datum (mad) towards the major water bodies, such as Lake Albert, where the average water level is approximately 622 mad (Figure 9-11). This may be modified as a result of local abstractions within certain parts of the Study Area. Figure 9-11 also shows the recorded depth to groundwater in boreholes across the Study Area.

The main surface water features within the Project Area (Lake Albert, the Victoria Nile and the Albert Nile) are expressions of groundwater discharge from the unconsolidated sand aquifer. The abstraction from water from these surface water features will have no impact on groundwater resources or flow, as there is no connection between surface water abstraction from Lake Albert and groundwater availability.

From Figure 9-11, it is clear that across the majority of the Project Area the groundwater level is at a depth in excess of 25 m. For the area north of the Victoria Nile, the maximum depth to groundwater is reported for borehole DWD35662, at a depth of 74.13 m bgl. Shallower groundwater is recorded for boreholes closer to the Victoria Nile in borehole DWD40971 at 10.8 m bgl and borehole DWD40957 at 19.68 m bgl. For the area south of the Victoria Nile, the maximum depth to groundwater is reported for borehole DWD17683, at a depth of 63.9 m bgl. The shallowest levels have been reported for boreholes close to Lake Albert, at boreholes DWD30213 at 5.9 m bgl and DWD30217 at 10.85 m bgl. Groundwater level information from four monitoring boreholes recently drilled at the CPF (MW1-MW4) shows that the groundwater is at a depth of between approximately 30 m and 43 m bgl.

The exact depth to the water table at many of the locations of the other key components of the Project currently is not known. The depths to water at these locations will be assessed in more detail following future ground investigations as part of the FEED study and the installation of the proposed water supply wells at the well pads and camps and in the Industrial Area.

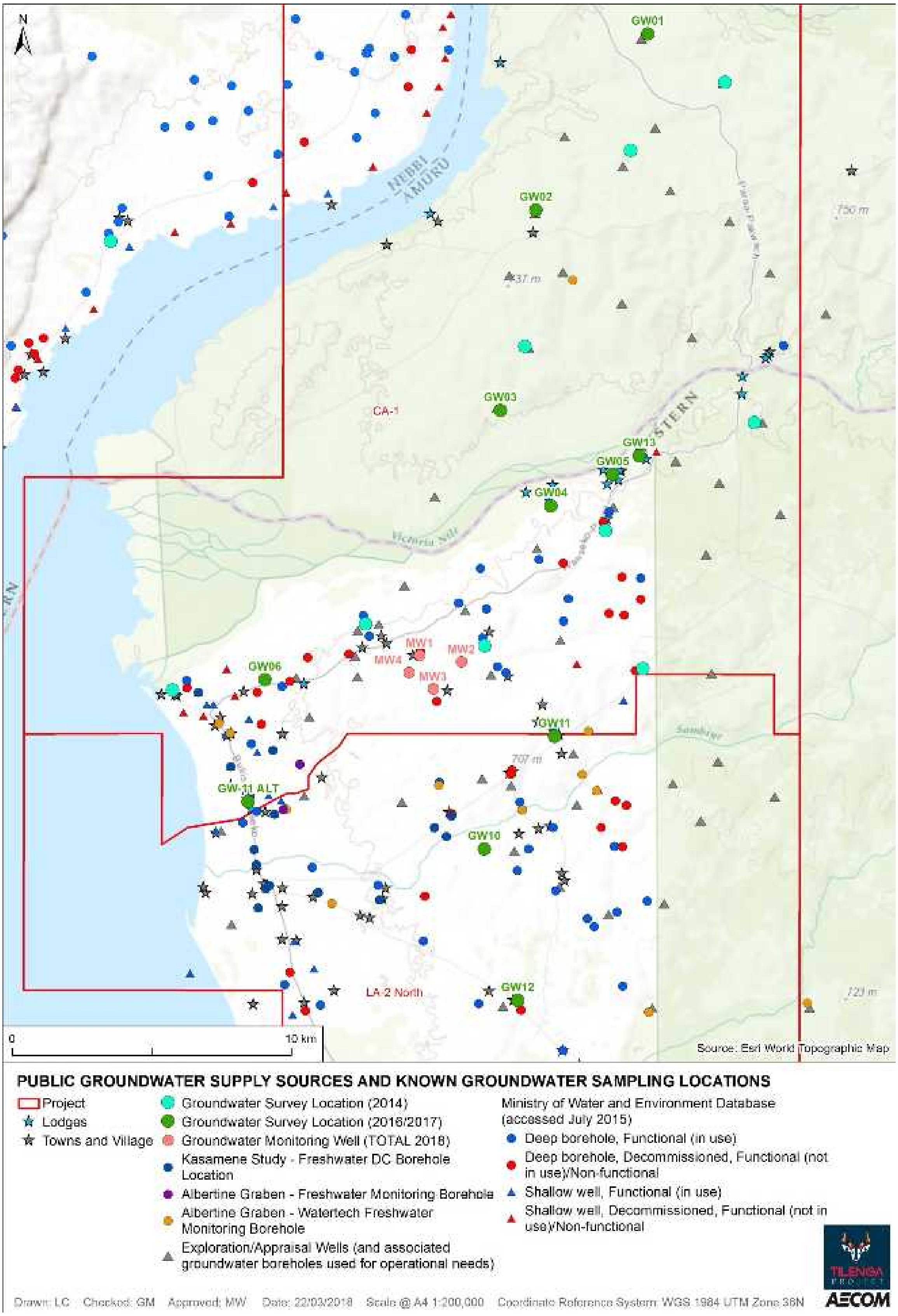
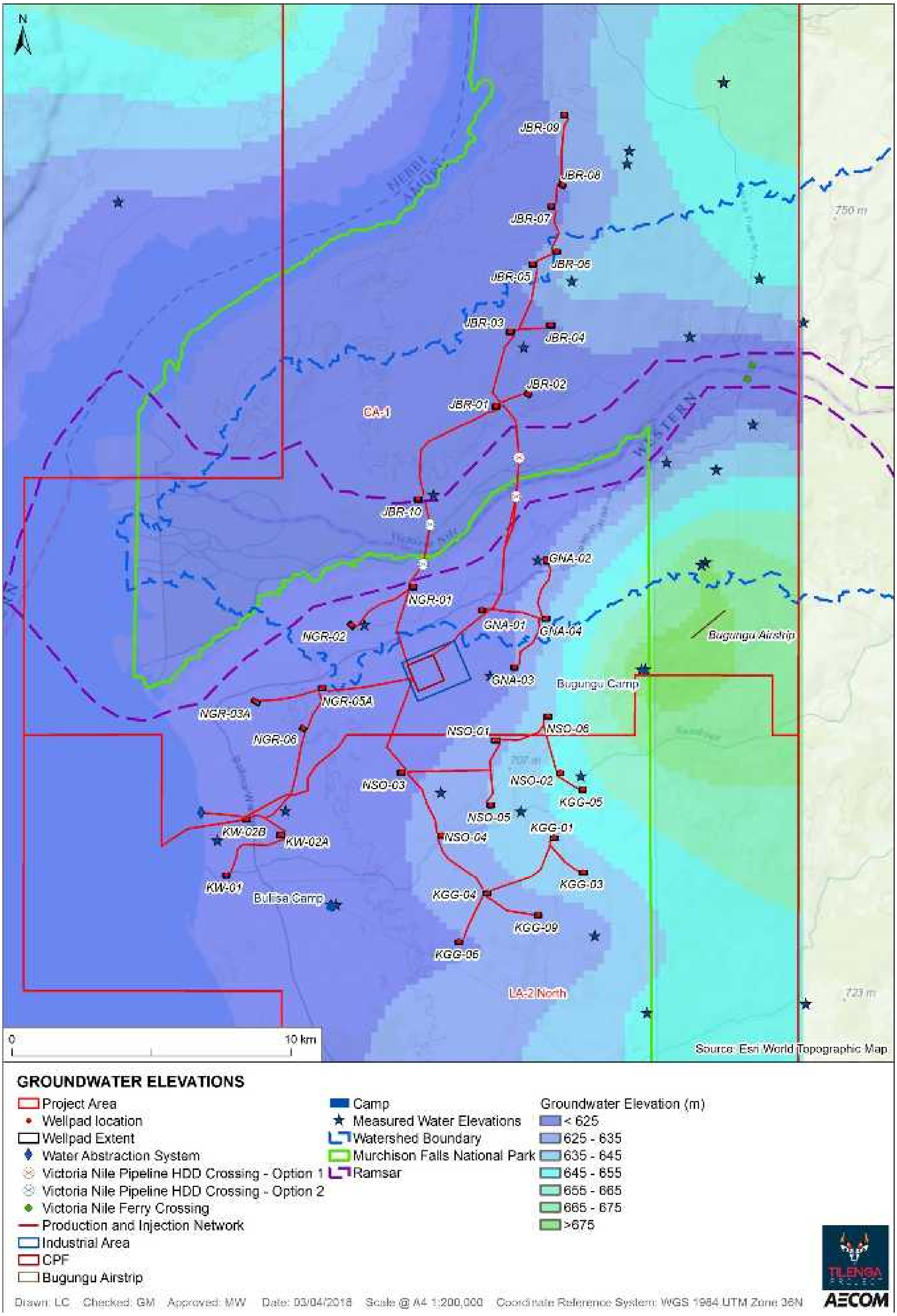


Figure 9-10: Public Groundwater Supply Sources and Groundwater Sampling Locations


JBR-09
JBR-08
JBR-07
JBR-06
JBR-05
JBR-03
JBR-04
JBR-02
JBR-01
JBR-10
CA-1
750 m
GNA-02
NGR-01
GNA-01
GNA-04
NGR-02
Bugungu Airstrip
GNA-03
Bugungu Camp
NGR-05A
NGR-03A
NSO-01
NSO-06
NGR-06
707 m
NSO-02
NSO-03
KGG-05
NSO-05
KGG-01
KW-02B
KW-02A
NSO-04
KGG-03
KW-01
Bulisa Camp
KGG-04
KGG-09
KGG-06
LA-2 North
723 m
0
10 km
Source: Esri World Topographic Map
GROUNDWATER ELEVATIONS
Project Area
Wellpad location
Wellpad Extent
Water Abstraction System
Victoria Nile Pipeline HDD Crossing - Option 1
Victoria Nile Pipeline HDD Crossing - Option 2
Victoria Nile Ferry Crossing
Production and Injection Network
Industrial Area
CPF
Bugungu Airstrip
Camp
Measured Water Elevations
Watershed Boundary
Murchison Falls National Park
Ramsar
Groundwater Elevation (m)
< 625
625 - 635
635 - 645
645 - 655
655 - 665
665 - 675
>675
TILENGA PROJECT
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Drawn: LC Checked: GM Approved: MW Date: 03/04/2018 Scale @ A4 1:200,000 Coordinate Reference System: WGS 1984 UTM Zone 36N

Figure 9-11: Groundwater Elevation across the Study Area

9.5.5 Groundwater Quality and Baseline Surveys

9.5.5.1 Introduction

An overview of the groundwater quality issues is provided in the 2012 report on groundwater resources in Uganda (Ref. 9-24). It is reported that there are no widespread chemical groundwater quality issues. By far the most significant problem is bacteriological contamination, particularly of springs and shallow wells, as a result of human activity.

The main issues are identified as:

- Bacteriological contamination – widespread near population sources. Scoop wells and pit latrines the major source of contamination in high groundwater level areas;
- High fluoride levels, above the US EAS12 limit of 1.5 mg/l have been reported. It is likely that the fluoride levels are a result of natural conditions in the aquifer;
- Elevated iron and manganese concentrations, frequently above the US EAS12 limit of 3 mg/l are widespread in the central and western parts of the country. It should be noted that the limit is based on aesthetic rather than health grounds;
- Elevated nitrate levels, more than twice the WHO limit of 10 mg/l, have been reported for some parts of the country. Levels are highly variable and suspected sources are latrines and pollution from markets; and
- Groundwater in deeper aquifers in the Rift Valley is saline.

9.5.5.2 Baseline Data Collection Methods

This section provides details of previous and more recent (i.e. over the last year) groundwater quality surveys undertaken within the Study Area as part of the proposed Project development as well as details of data sourced from other secondary sources. All of this information as described in subsequent sections of this Chapter has been used to help establish the baseline groundwater quality beneath the Study Area. Primary data is presented first.

9.5.5.3 Primary Data and Baseline Surveys

The key focus of the groundwater quality data compiled during the EBS field survey campaigns is on the proposed Project Area and potentially affected groundwater receptors and to provide a more comprehensive coverage than prior studies in the area (AECOM 2015, Ref: 9-25). It is considered that the data represents the range of physical characteristics and chemical concentrations currently found in groundwater within Block CA-1 at different seasons/environmental conditions.

Primary data for this ESIA therefore includes the baseline data collected during the 2014 field surveys and 2016/2017 surveys. The locations of the groundwater sampling points for the 2014-2017 survey are shown in Figure 9-12.

9.5.5.3.1 Primary Data – 2014 Baseline Surveys

The EBS compiled an inventory of physical, chemical and biological characteristics of groundwater resources in Block CA-1 (formerly known as EA-1). Groundwater sampling was conducted during four field survey campaigns in February, April, June and September 2014. A total of 15 groundwater samples were collected from four boreholes (GW01-GW04) located in the North Nile area and 23 samples from eight boreholes in the South Nile area. Four samples were collected from seven boreholes during the sampling campaign. In the other boreholes, the number of samples taken varied between one and three. The boreholes sampled included community supplies near former exploration sites, as well as in undeveloped areas within the MFNP. The results of the 2014 surveys are provided in the Environmental Baseline report (Ref. 9-25) and summarised at Appendix K Annex 4.

9.5.5.3.2 Primary Data – 2016/2017 Surveys

The most recent ESIA groundwater survey consisted of two field campaigns undertaken in November 2016 (Campaign 1) and June 2017 (Campaign 2) involving groundwater level measurement and sample collection at selected locations, including community boreholes as well as boreholes installed to support initial oil exploratory drilling operations in the past. The groundwater survey locations were chosen to improve the temporal and spatial coverage, consistency and quality of groundwater quality data. The locations were also selected to improve the current understanding of the quality and availability of water and the condition of wells used by communities and businesses. Samples were collected from the same sample points during both campaigns to assess the groundwater quality stability over this period. Discrete survey locations for both campaigns within the Study Area were selected as follows:

- Three sample points (GW1, GW2 and GW3) located north of the Victoria Nile within the MFNP near proposed well pads and pipeline corridors;
- Two sample points (GW4 and GW6) located south of the Victoria Nile in CA-1/EA-1A near proposed well pads and pipeline corridors. The boreholes are the community water supplies for Kilyango and Kirama respectively;
- Two sample points (GW5 and GW13) located south of the Victoria Nile in CA-1/EA-1A at commercial tourist lodges (Murchison River Lodge and Bakers Lodge);
- Four sample points (GW10, GW11, GW12alt, and GW12) south of the Victoria Nile in LA-2 North near proposed well pads and/or pipeline corridors. All four boreholes are used as community water supplies; and
- Four proposed monitoring boreholes (GW7, GW8, GW9, and GW14) in the Industrial Area. However, these boreholes had not been drilled at the time of the sampling surveys.

None of the boreholes sampled duplicated those sampled in 2014. The locations of the groundwater boreholes sampled during the November 2016 and June 2017 ESIA survey campaigns are shown in Figure 9-12. At three of the boreholes, GW2, GW5 and GW11, it was only possible to collect a sample in November 2016.

Table 9-8 provides a summary of the rationale on which the groundwater sample locations were selected including their coordinates and characteristics of each borehole location. Photographs of each survey location are presented at Appendix K Annex 5.

The survey activities included the measurement of groundwater depth, where possible, and field (groundwater quality) parameters, followed by the collection of representative groundwater samples for laboratory analysis. Observation notes were made at each location to record pertinent local conditions at the time of sampling. Field parameters were measured and groundwater samples collected in accordance with established professional protocols and procedures to ensure accuracy and completeness. The groundwater samples were shipped to a certified commercial testing laboratory for chemical analysis.

A calibrated multi-parameter water quality meter was used to measure the groundwater quality field parameters, including temperature, electrical conductivity, salinity, resistivity, dissolved oxygen, pH, oxidation-reduction potential, and turbidity. After purging, groundwater samples were collected from each borehole and shipped to an accredited, analytical testing laboratory (Eurofins Analytico in The Netherlands) for laboratory analysis of total petroleum hydrocarbons (TPH), mono-aromatic hydrocarbons (benzene, toluene, ethylbenzene, xylenes), metals, major anions and cations and total suspended solids. Groundwater samples were also collected at each borehole and shipped to EnviroServ Uganda in Nyamisoga Village, Hoima District, for analysis of colour and faecal coliform bacteria. Quality assurance/quality control (QA/QC) samples were collected and shipped to Eurofins Analytico to gauge the precision and accuracy of the results.

The full laboratory analytical results from both campaigns are presented in Appendix K Annex 6. A summary of the available construction details of the sampled boreholes is presented in Table 9-9. The results have been compared against the Ugandan potable water standards (EAS 12:2014) for natural untreated groundwater and the WHO drinking water guidelines where applicable to determine any exceedances - highlighted in red in Table 9-10. Descriptions of the main findings from the results are presented in Section 9.5.5.4.

9.5.5.3.3 Primary Data – 2018 Industrial Area/CPF Monitoring

Groundwater samples were collected from three boreholes in the CPF area in January 2018 –from groundwater monitoring borehole MW-3 and geotechnical boreholes CPF BH9 and CPF BH11. The samples were analysed for the main determinants and for coliforms by Envirochem Consultants (U) Limited of Kampala. The laboratory analytical data sheets are provided at Appendix K Annex 7.

Further groundwater samples were collected in February 2018 from boreholes MW-1 and MW-4. The laboratory analytical data sheets for these samples also are provided at Appendix K Annex 7.

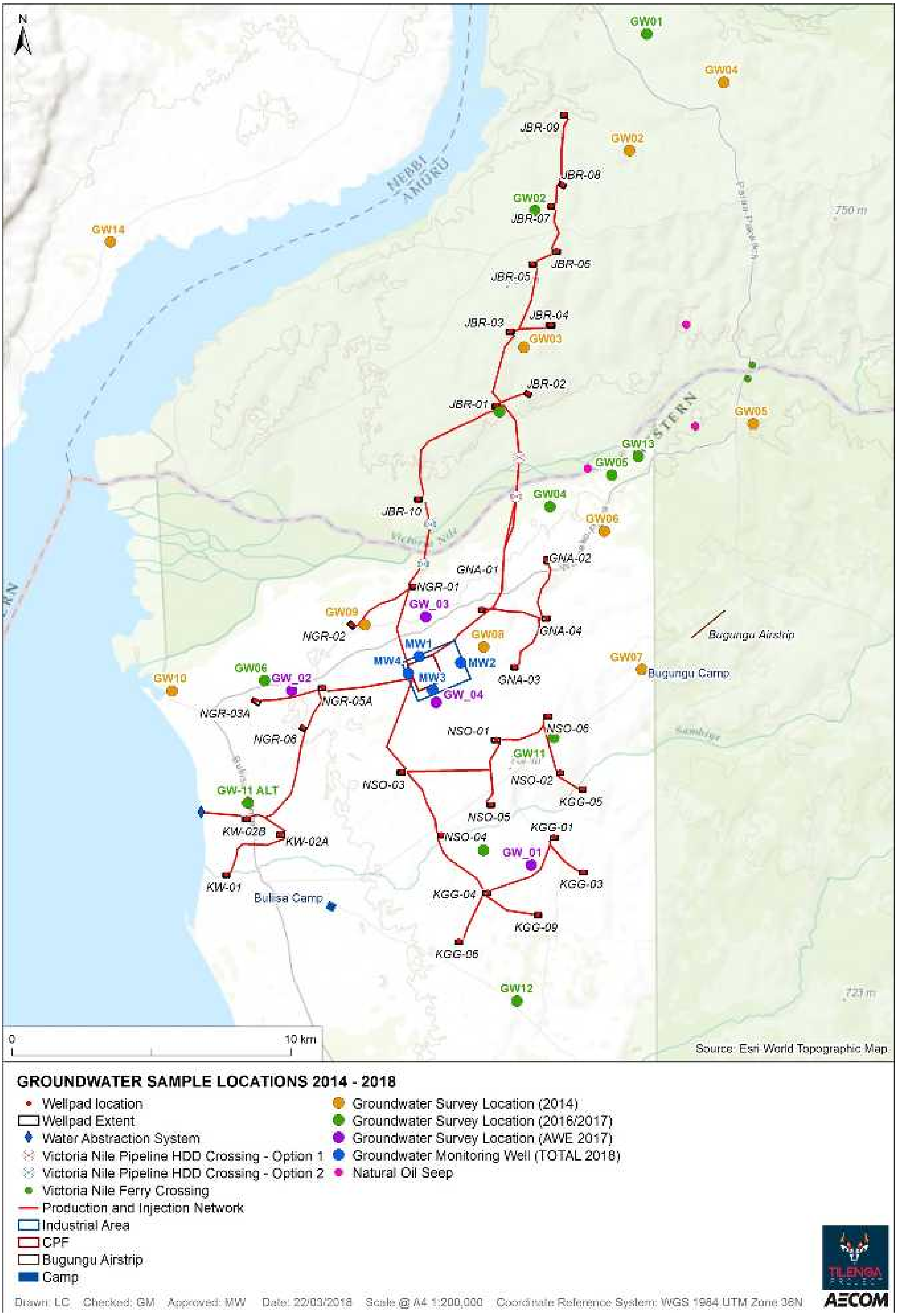
GW01
GW04
JBR-09
GW02
JBR-08
NEBBI
AMURU
GW02
JBR-07
GW14
JBR-06
JBR-05
JBR-04
JBR-03
GW03
JBR-02
JBR-01
GW05
GW13
GW05
JBR-10
GW04
GW06
Victoria Nile
GNA-02
GNA-01
NGR-01
GW_03
GW09
NGR-02
GNA-04
GW08
Bugungu Airstrip
MW1
MW4
MW2
GW07
Bugungu Camp
GW10
GW06
GW_02
MW3
GNA-03
NGR-05A
GW_04
NGR-03A
NSO-01
NSO-06
NGR-06
GW11
NSO-03
NSO-02
GW-11 ALT
KGG-05
NSO-05
KW-02B
KGG-01
KW-02A
NSO-04
GW_01
KGG-03
KW-01
Bulisa Camp
KGG-04
KGG-09
KGG-06
GW12
0
10 km
Source: Esri World Topographic Map
GROUNDWATER SAMPLE LOCATIONS 2014 - 2018
Wellpad location
Wellpad Extent
Water Abstraction System
Victoria Nile Pipeline HDD Crossing - Option 1
Victoria Nile Pipeline HDD Crossing - Option 2
Victoria Nile Ferry Crossing
Production and Injection Network
Industrial Area
CPF
Bugungu Airstrip
Camp
Groundwater Survey Location (2014)
Groundwater Survey Location (2016/2017)
Groundwater Survey Location (AWE 2017)
Groundwater Monitoring Well (TOTAL 2018)
Natural Oil Seep
Drawn: LC Checked: GM Approved: MW Date: 22/03/2018 Scale @ A4 1:200,000 Coordinate Reference System: WGS 1984 UTM Zone 36N
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Figure 9-12: Groundwater Sample Locations 2014 – 2017

Table 9-8: ESIA Groundwater Survey Locations and Rationale: November 2016 and June 2017

Block	Survey Point	Location	Rationale and intended receptor
CA-1	GW1	Northwest of JBR-01. Utilise existing borehole (DW.D29461) associated with exploration well Jobi East-2.	Needed to determine baseline groundwater depth and quality near proposed well pads & pipelines within MFNP near northern part of Project Area in CA-1.
CA-1	GW2	North of Pakuba airfield near JBR-07. Utilise existing borehole (DWD35657) associated with exploration well Jobi-4 (Jobi-C).	Needed to determine baseline groundwater depth and quality near proposed well pads & pipelines within MFNP near Pakuba airfield & Lake Albert in CA-1.
CA-1	GW3	North of Victoria Nile near JBR-01. Utilise existing monitoring borehole or existing borehole (DWD28633) associated with exploration well Rii-1.	Needed to determine baseline groundwater depth and quality near proposed well pads & pipelines within MFNP north of Victoria Nile in CA-1.
CA-1	GW4	In use deep borehole (DWD36317) at Kilyango Village south of Victoria Nile near pipeline crossing location.	Needed to determine baseline groundwater quality in existing community borehole near proposed pipeline river crossing south of Victoria Nile in CA-1.
CA-1	GW5	In use borehole at Murchison River Lodge on southern bank of Victoria Nile.	Needed to determine baseline groundwater quality at tourist lodge near southern bank of the Victoria Nile and in Ramsar Area in CA-1.
CA-1	GW6	In use deep borehole (DWD10770) at Kirama Village south of Victoria Nile southwest of NGR-03.	Needed to determine baseline groundwater quality at existing community borehole near proposed well pad south of Victoria Nile in CA-1.
CA-1	GW7 (MW1)	New monitoring borehole in proposed Industrial Area.	Needed to determine groundwater depth, flow direction and baseline groundwater quality, and evaluate seasonal effect on water level and groundwater flow gradient in area of proposed CPF where local groundwater data is lacking. Monitoring results will establish baseline conditions for the CPF. Borehole can be incorporated into future monitoring program during construction and operations.
CA-1	GW8 (MW2)	New monitoring borehole in proposed Industrial Area.	Needed to determine groundwater depth, flow direction and baseline groundwater quality in area of proposed CPF where local data is lacking. Results will establish baseline conditions for the CPF. Borehole can be incorporated into future monitoring program during construction and operations.
CA-1	GW9 (MW3)	New monitoring borehole in proposed Industrial Area.	Needed to determine groundwater depth, flow direction and baseline groundwater quality in area of proposed CPF where local data is lacking. Results will establish baseline conditions for the CPF. Borehole can be incorporated into future monitoring program during construction and operations.
CA-1	GW 14 (MW4)	New monitoring borehole in proposed Industrial Area.	Needed to determine groundwater depth, flow direction and baseline groundwater quality in area of proposed CPF where local data is lacking. Results will establish baseline conditions for the CPF. Borehole can be incorporated into future monitoring program during construction and operations.
LA-2 North	GW10	In use deep borehole (DWD30264) south of Victoria Nile near Kijumbya Village, N and west of exploration well Kigogole-2.	Needed to determine baseline groundwater quality at existing community borehole near proposed well pad, pipelines and former exploratory well in LA-2 North.

Block	Survey Point	Location	Rationale and intended receptor
LA-2 North	GW11	An existing deep community borehole near Ngwedo Primary to the east of NSO-01 and south of NSO-06.	Needed to determine baseline groundwater quality at existing community borehole near proposed well pad, pipelines and former exploratory wells in LA-2 North.
LA-2 North	GW11 Alt	An existing deep community borehole at Kisansya West to the west of NGR-07 and northwest of KW-02.	Needed to determine baseline groundwater quality at existing community borehole near proposed well pad, pipelines and former exploratory wells in LA-2 North.
LA-2 North	GW12	In use deep borehole south of Victoria Nile near Kichoke Village, southeast of KGG-02, and exploration well Kigogole-6.	Needed to determine baseline groundwater quality at existing community borehole near proposed pipeline, well pad and former exploratory well at southern end of LA-2 North.
CA-1	GW13	In use borehole at Bakers Lodge on southern bank of Victoria Nile.	Needed to determine baseline groundwater quality at tourist lodge receptor near southern bank of the Victoria Nile and Ramsar Area in CA-1.

*Note: (*GW) Proposed sample points for future surveys to improve spatial coverage of baseline data and impact assessment*

Table 9-9: Details of the Sampled Groundwater Boreholes 2016/2017

Area	Borehole	Borehole ID	Depth (mbgl)	Outer Diameter (mm)	Inner Diameter (mm)	RWL (mbgl)	Comments
CA-1	GW1	DWD29461	49	140	127	27	Inactive.
CA-1	GW2	DWD35657	n/k	140	127	64	Inactive
CA-1	GW2-alt	DWD35662	n/k	n/k	n/k	74	Inactive
CA-1	GW3	DWD28633	n/k	n/k	n/k	28	Active, hand pump
CA-1	GW4	DWD36317	n/k	n/k	n/k	n/k	Active, borehole at Kilyango Village.
CA-1	GW5	n/k	n/k	n/k	n/k	n/k	Active, borehole at Murchison River Lodge
CA-1	GW6	DWD10770	n/k	n/k	n/k	n/k	Active, deep borehole at Kirama Village
CA-1	GW7 (MW1)	n/k	55.1	126	63	Dry	New monitoring borehole
CA-1	GW8 (MW2)	n/k	55.0	126	63	Dry	New monitoring borehole
CA-1	GW9 (MW3)	n/k	55.0	126	63	43.3	New monitoring borehole
CA-1	GW14 (MW4)	n/k	55.0	126	63	42.3	New monitoring borehole
LA-2 North	GW10	DWD30264	n/k	n/k	n/k	n/k	Active, deep borehole near Kijumbya Village.
LA-2 North	GW11	n/k	n/k	n/k	n/k	n/k	Active, deep community borehole near Ngwedo Primary.
LA-2 North	GW11-alt	n/k	n/k	n/k	n/k	n/k	Active, deep community borehole at Kisansya West.

Area	Borehole	Borehole ID	Depth (mbgl)	Outer Diameter (mm)	Inner Diameter (mm)	RWL (mbgl)	Comments
LA-2 North	GW12	n/k	n/k	n/k	n/k	n/k	Active borehole near Kichoke Village.
LA-2 North	GW13	n/k	n/k	n/k	n/k	n/k	Active borehole at Bakers Lodge.

Notes: Data obtained in the field or from boring logs; n/k – not known, not possible to confirm due to borehole construction; RWL – resting water level; mbgl – metres below ground level

9.5.5.4 Baseline Survey Results and Interpretation

The results of the groundwater sampling in 2014, 2016 and 2017 are presented and interpreted in this section. An assessment also is made of the results of groundwater sampling carried out in the proposed Industrial Area/CPF in January 2018. The geographic setting of the Project Area for discussion purposes has been divided into the North Nile and South Nile areas. The North Nile area includes MFNP and riverine areas along the northern bank of the Victoria Nile and is considered to be generally undeveloped. The South Nile area includes the southern bank of the Victoria Nile, a section of the southwestern portion of the MFNP, and community areas south of the Victoria Nile extending to the shore of Lake Albert.

9.5.5.4.1 2014 Primary Data

The EBS (Ref: 9-25) compared baseline groundwater quality data for 2014 against Uganda Class II Potable Standards, which have since been replaced by the UNBS US EAS 12 standard. The following summary updates the comparison against the US EAS 12 standards. Where no Ugandan Standard is available, the WHO standard is referenced.

North Nile area (Block 1 – CA-1)

In general, groundwater in the North Nile area as indicated from samples showed relatively low dissolved oxygen and more reducing conditions compared to surface waters in the area (except for isolated pools affected by biological growth and evaporation). Groundwater quality was found to be poorest in an active borehole near the Tangi gate (GW01) at the northern entrance to MFNP, where salinity was highest and inorganic compounds (iron, manganese, chloride and sodium) exceeded the current UNBS US EAS 12 standards for natural and treated potable water.

Iron concentrations exceeded the US EAS 12 standard at three of the four boreholes (Tangi Gate (GW01), Jobi-East-1(GW02) and Jobi-East-3 (GW04)). Manganese concentrations exceeded the current standard at boreholes GW01 and GW02. Barium exceeded the standard at two locations (GW02 and GW04). Sodium exceeded the standard at one location (GW01).

Elevated iron and manganese concentrations typically are reported together and often occur naturally in sedimentary deposits such as those present in the Study Area. In addition, ironstone bands have been reported in the geological sequence and reducing conditions, conducive to the release of iron and manganese are present in the aquifer. While barium is commonly used in drilling fluids, its presence at these locations cannot be directly attributed to exploration drilling activity, as these locations are remote from previous drilling locations. Sodium concentrations in excess of 200 mg/l may give rise to an unacceptable taste; concentrations detected at GW01 exceeded this value (380 mg/l – 400 mg/l).

Chloride exceeded the Ugandan standards in the Tangi gate borehole (GW01) at concentrations between 350mg/l and 700mg/l. Ortho-phosphate detected in one borehole (GW04) exceeded the Ugandan standard. Ammonia was detected in three boreholes (GW01, GW03 and GW04) above the Ugandan standard. Nitrate and nitrite were not detected above the reporting limits in any samples. It is assumed that the chloride is from natural sources. However, the reported concentration of chloride at borehole GW01 is anomalously high compared with the results of the other samples. The cause of the elevated chloride and sodium concentrations, indicative of brackish groundwater, in the Tangi Gate borehole (GW01) is unclear.

Phosphates are plant nutrients and originate from the decomposition of organic material in the soil. Ammonia is a major component of the metabolism of mammals and in the environment originates from metabolic, agricultural and industrial processes.

Of the major ions, the cations magnesium, potassium and sodium, and the anion fluoride were below the standards for potable water. Total dissolved solids (TDS) exceeded the Ugandan standard in the Tangi Gate borehole (GW01).

Hydrocarbons (PAH, TPH, BTEX) were detected below the laboratory detection limits (0.205 micrograms per litre (µg/l), 38µg/l and 1µg/l respectively) with the exception of one BTEX analysis at location GW02, in which BTEX was reported at 1.2 µg/l. More specifically, toluene and total xylenes were detected at concentrations of 0.72µg/l and 0.48µg/l, respectively. With respect to discrete petroleum hydrocarbon ranges, the C_{10}-C_{12} fraction was detected in GW04, C_{12} – C_{16} was detected in all four boreholes and C_{16}-C_{21} was detected in GW02. There are no Ugandan or WHO standards for these parameters. The source of the hydrocarbons is not known. The locations are remote from recorded natural oil seepages.

South Nile area (CA-1 South Nile) and LA-2 North)

Similar to the North Nile area, groundwater in the South Nile area as indicated from the water samples has relatively low dissolved oxygen and is more reduced compared to surface waters in the area. The pH measurements of samples from three boreholes, near Ngiri-2 (GW09), the CPF (GW08), and Bugungu camp (GW07) were less than the minimum Uganda Class II standard for potable water (6.5 pH units). Compared to the US EAS 12 standards, these values fall within the acceptable range for natural potable water sources (5.5-9.5). Lead, iron and manganese were detected in one or more boreholes at concentrations exceeding the US EAS 12 standard. Barium and lead were detected in concentrations about the standards in Mpyo-5 in MFNP (GW05) and the community borehole near Mpyo-6 (GW06), respectively. Iron was detected above the standard in five boreholes (GW05 - GW09). Manganese was detected above the standard in five boreholes (GW06-GW-10). Chromium and copper were not detected above the US EAS 12 standards.

Ammonia was detected in four boreholes with concentrations above the US EAS 12 standard of 0.5mg/l in two boreholes; Mpyo-5 in MFNP (GW05) and near Ngiri-2 (GW09) at maximum concentrations of 1.2 mg/l and 1.4 mg/l respectively.

Nitrate was detected below the US EAS 12 standard in boreholes at Bugungu camp (GW07), in the area of the proposed CPF (GW08), and in Wanseko (GW10). Nitrite was detected in three boreholes: Mpyo-6 (GW06), near the CPF (GW08) and Wanseko (GW10). One sample (GW08) contained nitrite slightly above the previous Ugandan standard of 0.2 mg/l with a reported concentration of 0.21 mg/l. The current Ugandan standard of 0.003 mg/l is below the method detection limit of 0.03 mg/l. All concentrations less than this limit, if present, would be reported as not detected (<0.03 mg/l). The WHO standard of 3 mg/l has been adopted and was not exceeded in any sample where nitrite was detected. Anthropogenic sources of nitrite and nitrate include leakage from septic tank systems and infiltration from fertiliser use, although this is not believed to be widespread in the Study Area. Phosphates were detected in three boreholes at concentrations below the US EAS 12 standard.

Of the major ions, the cations magnesium, potassium and sodium, and the anions chloride, fluoride and sulphate were below the standards for natural potable groundwater.

Concentrations of TPH, just above the limit of detection of 38 µg/l, up to a maximum of 44 µg/l, were detected on one or more times in the eight boreholes sampled in the South Nile area. Benzene was detected only once, in a sample from a disused borehole near Mpyo-5 in MFNP (GW05), at a concentration below the current US EAS 12 standard. PAH was detected once in a sample from one of the Bugungu camp borehole (GW07) and once in a community borehole near Mpyo-6 (GW06), at concentrations below the Ugandan Standards. The source of the low concentrations of organic compounds is not known, although known natural seepages of oil have been recorded in the vicinity of borehole GW06.

9.5.5.4.2 ESIA baseline surveys (November 2016)

The first campaign involved the sampling of groundwater at eleven boreholes, three north and eight south of the Nile River in CA-1 and LA-2 (North). The sampling locations are shown in Figure 9-12.

A summary of the groundwater quality laboratory analytical results for those constituents detected at concentrations above the laboratory detection limit are shown in Table 9-10. Results reported above the Ugandan standards are highlighted in red. A full list of parameters analysed is presented in Appendix K Annex 6. The Ugandan potable water quality standards (UNBS) and WHO drinking water guidelines are listed and referred to as applicable to compare the conformity of the results, considering their importance as groundwater represents the primary source of drinking water within the Study Area.

All water samples were shipped to Eurofins Analytico BV (Analytico) testing laboratory in The Netherlands for analysis. Analytico analysed the samples for a broad range of chemical constituents including metals, inorganic compounds (i.e., nitrate, nitrite, phosphorous, phosphate) and organic compounds (BTEX, and petroleum hydrocarbons). All analytical methods used by Analytico were based on national and international standards. Analytico is accredited against ISO/IEC 17025 by the Dutch Accreditation Council RvA. Microbial analysis was conducted at EnviroServ in Hoima as the analysis is time constrained and must be conducted within 24 hours of sample collection. EnviroServ is in Uganda is not yet accredited but is operated under the protocols of their South African Parent Company which is ISO certified.

North Nile

In the North Nile area, concentrations of arsenic and iron exceeded the Ugandan potable water standards in two boreholes with maximum arsenic concentrations detected at 25 µg/l (GW03), the Rii-1 water supply borehole and iron at 0.95 mg/l (GW01), Jobi East-2 water supply borehole, respectively. The concentrations exceed the Ugandan standards of 10 µg/l for arsenic and 0.3 mg/l for iron. Barium and manganese were detected in all three borehole samples at concentrations below the Ugandan Standards for potable water. Zinc was detected in only one sample at a concentration below the standards. Aluminium, cadmium, chromium, cobalt, copper, lead, nickel and uranium were not detected above the respective laboratory reporting limits and were below the US EAS12 standards.

Nitrite was detected at one location (GW03) at a concentration of 0.056 mg/l which is below the previous Ugandan standard of 0.2 mg/l but above the revised standard of 0.003 mg/l. The reported value does not exceed the WHO standard of 3mg/l. Phosphates were also detected in this sample below the Ugandan standard. Nitrites and ortho-phosphates were not detected above the reporting limit in the other two samples. Chloride and sulphate were detected at all three sample locations at concentrations significantly below the Uganda standards. The elevated chloride and sodium levels recorded in the Tangi Gate borehole in 2014 were not reported for any of the samples. Inorganic compounds of bromide and nitrate were not detected in any of the samples above the laboratory reporting limit.

The Ugandan potable water standard and WHO guideline for total coliforms is “absent”. Total coliform colonies were detected in the groundwater samples collected from all sampling locations, ranging from 17 CFU/100ml to 74 CFU/100ml. The presence of total coliforms may indicate that the water has been contaminated with faecal material of humans or animals. However, the presence of coliforms in water may not be directly harmful, but indicative of the potential presence of pathogens.

Ethylbenzene was detected in one sample at a concentration of 0.32 µg/l (GW01). There is no Ugandan standard for ethylbenzene. The WHO standard is 300 µg/l. Mono aromatic hydrocarbons of benzene, toluene and xylene were not detected in any samples. Hydrocarbons (total petroleum hydrocarbons, non-aromatic hydrocarbons) were not detected in any of the groundwater samples collected during the November 2016 ESIA sampling.

Table 9-10: Groundwater Quality Results – 2016/2017

Parameter	Location ID		GW01		GW02	GW03		GW04		GW05	GW06		GW10		GW11	GW-11 ALT		GW12		GW13	
	Description NN- North Nile, SN - South Nile		Jobi East-2 water supply borehole (NN)		Jobi-4 water supply borehole (NN)	Rii-1 water supply borehole (NN)		Kilyango community borehole (SN)		Murchison River Lodge (SN)	Kirama community borehole (SN)		Kijumbya community borehole (SN)		Community borehole near Ngwedo Primary (SN)	Kisansya West community borehole (SN)		Kichoke community borehole (SN)		Bakers Lodge (SN)	
		Sample ID	GW1-161107	GW1-1706-15	GW2-161107	GW3-161107	GW3-1706-15	GW4-161108	GW4-1706-16	GW5-161108	GW6-161108	GW6-1706-16	GW10-161106	GW10-1706-16	GW11-161106	GW11ALT-161109	GW11-ALT-1706-16	GW12-161106	GW12-1706-17	GW13-161109	GW13-1706-16
		Sample Date	7/11/2016	15/6/2017	7/11/2016	7/11/2016	16/6/2017	11/8/2016	16/6/2017	11/8/2016	8/11/2016	16/6/2017	6/11/2016	16/6/2017	11/6/2016	9/11/2016	16/6/2017	9/11/2016	17/6/2017	11/9/2016	16/6/2017
Chemical Name	**US EAS 12 Limit**	**Units**																			
Metals																					
Arsenic	10	ug/l	< 5	<5.0	16	25	28	< 5	<5.0	25	< 5	<5.0	< 5	<5.0	< 5	< 5	<5.0	< 5	<5.0	19	<5.0
Barium	700	ug/l	640	600	78	370	400	160	190	390	200	270	140	200	70	< 50	<50	< 50	52	680	52
Cadmium	3	ug/l	< 0.4	<0.40	< 0.4	< 0.4	<0.40	< 0.4	<0.40	< 0.4	< 0.4	<0.40	0.57	<0.40	< 0.4	< 0.4	<0.40	1	<0.40	< 0.4	<0.40
Chromium	50	ug/l	< 1	<1.0	< 1	< 1	<1.0	< 1	<1.0	< 1	< 1	<1.0	< 1	<1.0	< 1	< 1	<1.0	2.9	1.5	< 1	1.5
Copper	1000	ug/l	< 5	<5.0	< 5	< 5	<5.0	< 5	<5.0	< 5	< 5	<5.0	< 5	<5.0	< 5	5.5	5.4	< 5	<5.0	< 5	<5.0
Iron	0.3	mg/l	0.95	0.98	0.16	0.53	0.56	0.29	0.21	2.9	8.3	14	0.68	5.9	2.3	1.9	2.3	0.42	10	1	10
Lead	10	ug/l	< 5	<5.0	< 5	< 5	<5.0	< 5	<5.0	< 5	< 5	<5.0	12	<5.0	< 5	< 5	<5.0	< 5	<5.0	< 5	<5.0
Manganese	0.1	mg/l	0.08	0.055	0.01	0.039	0.039	0.046	0.047	0.42	0.56	0.64	0.67	0.85	0.5	0.089	0.087	0.043	0.13	0.81	0.13
Mercury	1	ug/l	< 0.05	<0.050	0.081	< 0.05	<0.050	< 0.05	<0.050	< 0.05	< 0.05	<0.050	< 0.05	<0.050	< 0.05	< 0.05	<0.050	< 0.05	<0.050	< 0.05	<0.050
Zinc	5000	ug/l	14	<10	< 10	< 10	<10	51	25	< 10	970	920	9200	55	1600	200	570	4000	120	< 10	120
Mono Aromatic Hydrocarbons																					
Ethylbenzene	None	ug/l	0.32	<0.20	< 0.2	< 0.2	<0.20	< 0.2	<0.20	0.44	0.4	<0.20	< 0.2	<0.20	0.3	< 0.2	<0.20	< 0.2	0.76	< 0.2	<0.20
Physical Analyses																					
Colour	50	TCU	5	N/A	15	15	N/A	20	N/A	10	15	N/A	0	N/A	20	20	N/A	5		25	N/A
Turbidity	25	NTU	5.63	<1.0	1.36	0.35	<1.0	2.02	<1.0	1.02	1.73	<1.0	2.09	3.1	1.78	0.72	<1.0	0.47	5.5	5.43	<1.0
pH	5.5-9.5	Std. Units	7.24	7.1	8.02	7.28	7.2	7.96	7.76	6.87	6.62	6.48	6.81	6.74	8.15	6.60	6.60	6.49	6.46	6.99	6.89
Conductivity	2500	µS/cm	447	467	617.3	587.1	531.5	675	625.9	555.3	730.8	686.5	893.9	545.0	0	0.88	796	604.8	589.6	1142.5	1175.5
Total Suspended Solids	ND	mg/l	10	15	2.9	< 2	<3.8	< 2	<3.8	5.8	22	17	2.2	12	9.4	5.4	7.4	< 2	20	6.2	7.4
Inorganic Compounds																					
Nitrate (as N)[1]	None	mg/l	< 0.2	<0.20	< 0.2	< 0.2	<0.20	< 0.2	<0.20	0.81	< 0.2	<0.20	0.36	<0.20	< 0.2	0.52	<0.20	0.23	<0.20	< 0.2	<0.20
Nitrate (NO3)[1]	45	mg/l	< 0.9	<0.90	< 0.9	< 0.9	<0.90	< 0.9	<0.90	3.6	< 0.9	<0.90	1.6	<0.90	< 0.9	2.3	<0.90	1	<0.90	< 0.9	<0.90
Nitrite (as N)[1]	None	mg/l	< 0.01	<0.010	< 0.01	0.017	<0.010	0.046	<0.010	3.2	< 0.01	<0.010	< 0.01	<0.010	0.39	< 0.01	<0.010	< 0.01	<0.010	< 0.01	<0.010
Nitrite (NO2)[1]	0.003	mg/l	< 0.03	<0.030	< 0.03	0.056	<0.030	0.15	<0.030	11	< 0.03	<0.030	< 0.03	<0.030	1.3	< 0.03	<0.030	< 0.03	<0.030	< 0.03	<0.030
Ortho Phosphate (PO4)	2.2	mg/l	< 0.06	<0.020	< 0.06	0.28	0.1	0.24	0.079	0.3	0.47	<0.020	0.23	0.024	1.5	0.62	0.034	0.32	<0.020	< 0.06	0.021
Ortho Phosphate (PO4-P)	None	mg/l	< 0.02	<0.060	< 0.02	0.09	0.31	0.078	0.24	0.098	0.15	<0.060	0.076	0.074	0.5	0.2	0.1	0.1	<0.060	< 0.02	0.064
Bromide	0.01	mg/l	< 0.3	<0.30	< 0.3	< 0.3	<0.30	< 0.3	<0.30	0.31	0.48	0.43	0.54	<0.30	0.43	0.49	<0.30	0.7	0.63	0.44	0.38
Chloride	250	mg/l	16	22	11	12	12	12	12	45	80	74	85	27	52	70	13	97	95	13	12
Fluoride	1.5	mg/l	< 0.05	0.062	0.28	< 0.05	0.057	< 0.05	<0.050	0.16	0.16	0.18	0.21	0.19	0.26	0.22	<0.050	0.24	0.21	0.3	0.36
Sulphate	400	mg/l	1.5	1.2	0.58	0.6	1.1	0.57	0.7	0.79	18	19	88	30	69	38	180	22	18	1	0.7
Biological Parameters																					
Total coliforms	Absent	CFU/ 100ml	74	14	17	21	78	33	0	1080	4	0	19	14	10	29	<0.000	4	30	19	4
Ammonia	0.5	mg/l	NA	0.22	NA	NA	2.05	NA	1.53	NA	NA	1.37	NA	0.74	NA	NA	0.26	NA	0.07	NA	0.8
BOD5	None	mg/l	NA	6.76	NA	NA	5.21	NA	8.82	NA	NA	4.1	NA	3.68	NA	NA	3.53	NA	3.75	NA	7.96
COD5	None	mg/l	NA	8.07	NA	NA	3.64	NA	0.25	NA	NA	<0.1	NA	<0.1	NA	NA	<0.1	NA	1.81	NA	12.7

*red text indicates an exceedance

The physical parameters of colour, turbidity, pH and electrical conductivity were all below the Ugandan standards. Total suspended solids concentrations exceeded the Ugandan standard (not detectable) in two samples at concentrations of 2.9 mg/l (GW02) and 10 mg/l (GW01), respectively. This may be attributed to issues during sampling, such as the disturbance of sediment in the base of the borehole, rather than being representative of the groundwater quality.

South Nile

The arsenic standard was exceeded at the two tourist lodge boreholes; at a concentration 25 µg/l at Murchison River Lodge (GW05) and 19 µg/l at Baker's Lodge (GW13). Arsenic concentrations measured in samples from the six community boreholes were below the Ugandan standard. Arsenic is classified as a carcinogen but there is considerable uncertainty over actual risks for long term exposure at low concentrations. The WHO guideline for arsenic is provisional and not health based, rather it is based on the difficulty in accurately measuring lower concentrations and limitations of practical removal technology. The concentration in drinking water below which no effects can be observed remains to be determined. WHO states the overall goal is to keep arsenic concentrations in drinking water as low as reasonably possible.

The concentration of lead slightly exceeded the Uganda limit (10 µg/l) for one sample collected during this campaign from the Kijumbya community borehole (GW10), where lead was reported at 12 µg/l.

Concentrations of iron and manganese exceeded the Ugandan potable water standards in most of the community boreholes and in the boreholes at the tourist lodges, except for the Kilyango community borehole (GW4) where the iron level was just below the limit at 0.29 mg/l. WHO evaluated potential health effects of these two metal constituents and determined that guidelines were not warranted. Iron is an essential element in human nutrition, and concentrations of 1 mg/l to 3 mg/l can be acceptable, although taste and appearance can be affected (WHO 2003). The Ugandan standard for iron is 0.3 mg/l. The highest concentration of iron was detected in the sample collected from the Kirama community borehole (GW6) at 8.3 mg/l. Manganese was reported above the US EAS 12 level of 0.1 mg/l in five boreholes at concentrations between 0.42 mg/l (GW5) and a maximum of 0.81 mg/l in the borehole at Bakers Lodge (GW13).

Zinc was especially elevated in the samples from the Kijumbya (GW10) (9.2mg/l) and Kichoke (GW12) (4 mg/l) community boreholes and in a borehole near Ngwedo Primary School (GW11) (1.6 mg/l). Only the Kijumbya sample exceeded the Ugandan potable water standard of 5 mg/l. Natural background concentrations of zinc in groundwater usually range from 0.01 to 0.04 mg/l. Drinking water containing zinc at levels above 3 mg/l tends to be opalescent, develops a greasy film when boiled, and has an undesirable astringent taste (WHO 2003). The cause of the elevated to high zinc concentrations currently is unclear.

Nitrate was detected in four boreholes at concentrations below Ugandan standards. Nitrite exceeded the Ugandan potable water standard (0.003 mg/l) in samples from the community boreholes near Kilyango (GW4) (0.15 mg/l) and Ngwedo Primary School (GW11) (1.3 mg/l), and the well at Murchison River Lodge (GW5) (11 mg/l). The current WHO standard is 3mg/l which only GW5 exceeded. Elevated nitrite levels can cause methaemoglobinaemia in infants, a condition characterised by interference with oxygen transport in the body. Ammonia was not analysed for any of the samples taken.

Barium, cadmium, chromium, cobalt and copper were detected in one or more samples at concentrations below Ugandan standards.

Coliform colonies were detected in groundwater samples collected from all sampling locations, ranging from 4 (Karama and Kichoke community boreholes) to 1,080 CFU/100ml (Murchison River Lodge). The presence of total coliforms may indicate that the water has been contaminated with faecal material of humans or animals. However, the presence of coliforms in water may not be directly harmful, but indicative of the potential presence of pathogens.

Ethylbenzene was detected in three locations at concentrations ranging from 0.3 µg/l to 0.44 µg/l which are well below the WHO standard of 300 µg/l. Hydrocarbons (total petroleum hydrocarbons, non-aromatic hydrocarbons) were not detected in any of the groundwater samples collected during the November 2016 ESIA sampling.

9.5.5.4.3 ESIA baseline surveys (June 2017)

The second campaign involved the sampling of eight groundwater boreholes at specific locations - two north and six south of the Victoria Nile. These eight boreholes were also sampled in November 2016. Three boreholes were not able to be sampled during the June survey. The results have been divided into sample locations: North Nile (GW1 and GW3) and South Nile (GW4, GW6, GW10, GW11-ALT, GW12 and GW14).

Consistent with the results of the November 2016 survey, the groundwater quality was generally within the Ugandan standards in all the sampled boreholes, with generally minor exceedances for arsenic, iron, manganese, bromide and ammonia. In contrast to the data collected in November 2016, concentrations of nitrite were all below the laboratory limit of detection of 0.03 mg/l. Metals and inorganic parameters are likely due to natural conditions as anthropogenic sources have not been identified.

Arsenic concentrations were slightly above the Ugandan potable water limit of 10 µg/l in one sample (GW3) north of the Victoria Nile at 28 µg/l. Reported arsenic concentrations for the remainder of the samples were below the laboratory detection limit of 5 µg/l.

The concentration of manganese exceeded the Ugandan potable water standard of 0.1 mg/l in four of the six sampling locations south of the Victoria Nile ranging in concentrations between 0.013 mg/l and a maximum of 0.85 mg/l in the Kijumbya community borehole (GW10). Manganese levels in both boreholes north of the Victoria Nile were below the Ugandan standard. Iron concentrations exceeded the Ugandan potable water standard of 0.3 mg/l in both boreholes sampled north of the Victoria Nile with concentrations at 0.56 mg/l and 0.98 mg/l. Iron concentrations south of the Victoria Nile exceeded the Ugandan potable water standard in five out of six sample locations ranging between 2.3 mg/l (GW11 alt) and a maximum of 14 mg/l in the Kirama borehole (GW6), consistent with the November 2016 analysis. Bromide was above the Ugandan standard of 0.01mg/l in three of the six boreholes sampled south of the Victoria Nile at concentrations of 0.43 mg/l (GW6); 0.63 mg/l (GW12); and 0.35 mg/l (GW13). Bromide concentrations in the remainder of the samples north and south of the river were below the laboratory detection limit.

Nitrite concentrations were all below the laboratory detection limit at less than 0.03 mg/l. However as the Ugandan potable water standard is 0.003 mg/l, it cannot be confirmed if these are below the standard. Ammonia concentrations were above the Ugandan potable water standard of 0.5 mg/l in one sample north and four samples south of the Victoria Nile. The sample north of the river at GW3 reported ammonia at 2.05 mg/l. Elevated ammonia concentrations in samples taken south of the river ranged between 0.74 mg/l and 1.53 mg/l in the Kilyango community borehole (GW4).

In the November 2016 sampling campaign, elevated concentrations of zinc of 9.2 mg/l and 4 mg/l were reported for the Kijumbya (GW10) and Kichoke (GW12) community boreholes. The samples taken in June 2017 at these two locations reported much lower zinc concentrations of 0.055 mg/l and 0.12 mg/l respectively, similar to concentrations reported for the other sampling boreholes.

Total coliform colonies were detected in samples from both boreholes (GW01 and GW03) north of the Victoria Nile at 14 and 78 CFU/100ml. Coliforms were detected in three out of the six samples collected south of the river ranging between 4 and 30 CFU/100ml. Hydrocarbons (total petroleum hydrocarbons, non-aromatic hydrocarbons) were not detected above the limits of detection in any of the groundwater samples during the June 2017 ESIA sampling campaign.

Table 9-11 and Table 9-12 provide a summary of the water quality data for boreholes north and south of the Victoria Nile respectively taken between 2014 and 2017 during the EBS and ESIA baseline surveys.

9.5.5.4.4 Groundwater monitoring 2018

Groundwater samples were analysed from three boreholes in the Industrial Area/CPF south of the Victoria Nile collected in January 2018. The analytical results are provided at Appendix K Annex 7. The analytical results are generally consistent with the findings of earlier samples taken from the sand aquifer. For the majority of the determinands, the reported concentrations were below the Ugandan standards for natural potable water.

Minor exceedances of the Ugandan standards were reported for arsenic and nitrite in one sample (CPF BH11). Elevated iron and manganese concentrations of 4.94 mg/l and 0.54 mg/l respectively, above the Ugandan standard were reported for the sample from borehole CPF BH9. The results for this borehole also reported high turbidity, colour and suspended solids and may reflect a sampling issue rather than natural groundwater quality. The elevated iron and manganese levels also may be attributed to the sampling technique disturbing sediment in the borehole.

The analysis for borehole CPF BH9 also reported an anomalously high barium concentration of 7.01 mg/l, significantly above the Ugandan standard. The barium concentration recorded for the other two samples was less than 0.01 mg/l and 0.003 mg/l and the high value for CPF BH9 may be erroneous. Aliphatic hydrocarbons were below the laboratory limit of detection of 0.01 mg/l in all three samples. Coliforms also were absent in all three samples.

Additional samples were analysed from two boreholes (MW-1 and MW-4) in the Industrial Area/CPF collected in February 2018 and the results also are provided at Appendix K Annex 7. The analysis for the sample from borehole MW-1 on the northern boundary of the area is generally consistent with the results from the samples taken in January 2018. The analysis for the sample from borehole MW-4 is anomalous and inconsistent with the other samples from the Industrial Area. The results from the sample from MW-4 show concentrations significantly higher than the other samples. For example, the chloride concentration of 319 mg/l, above the Ugandan standard of 250 mg/l, compared with concentrations of 25 mg/l to 104 mg/l in the other boreholes; an Electrical Conductivity of 1707µS/cm compared with 280 µS/cm to 540 µS/cm; and, magnesium 31.3 mg/l compared with 5.5 mg/l to 10.3 mg/l. Consistent with the previous samples, both samples reported elevated iron and manganese concentrations above the Ugandan standards. Hydrocarbons were absent from both samples. The cause of the anomalous concentrations reported for borehole MW-4 is unclear. It is considered that further samples should be collected from all the monitoring boreholes on the site to assess whether the analysis for borehole MW-4 can be replicated.

The results of the samples taken in 2018 are included in Table 9-12, although the sample from borehole MW-4 has been excluded.

Table 9-11: Selected Groundwater Parameters from Boreholes North of the Victoria Nile 2014 - 2017

Northern Nile							
Parameter	**Units**	**Min**	**Max**	**No of sample locations**	**No. of samples**	**EAS 12:2014**	**No. of exceedances**
pH		6.5	7.55	7	21	5.5 - 9.9	0
EC, uS/cm**		303	2347	7	21	2500	0
Arsenic	mg/l	<0.005	0.028	7	21	0.01	3
Barium*	mg/l	0.078	1.7	7	21	0.7	4
Calcium	mg/l	7	120	4	16	150	0
Iron	mg/l	0.16	3.6	7	21	0.3	12
Magnesium	mg/l	2.3	19	4	16	100	0
Manganese	mg/l	0.01	0.51	7	21	0.1	8
Potassium	mg/l	3	11	4	16	-	-
Sodium	mg/l	58	400	4	16	200	5
Barium*	mg/l	0.078	1.7	7	21	0.7	4
Zinc*	mg/l	<0.01	0.75	7	21	5	0
Ammonia	mg/l	0.091	3.8	7	19	0.5	11
Chloride	mg/l	11	700	7	21	250	5
Nitrate (NO3)	mg/l	<0.9		7	21	45	0
Coliforms	CFU/100ml	14	78	2	2	absent	2
PAH 16 EPA (sum)	µg/l	<0.205		4	16	0.7	0
BTEX, summation	µg/l	<1	1.2	7	-	-	-
TPH Sum (C10-C40)	µg/l	<38		7	-		-

Table 9-12: Selected Groundwater Parameters from Boreholes South of the Victoria Nile 2014 - 2018

South of Victoria Nile							
Parameter	Units	Min	Max	No of sample locations	No. of samples	EAS 12:2014	No. of exceedances
pH		5.5	7.7	18	42	5.5 - 9.9	0
EC, uS/cm**		211	2331	18	41	2500	0
Arsenic	mg/l	<0.005	0.025	18	42	0.01	3
Barium*	mg/l	<0.05	7.01	18	42	0.7	5
Calcium	mg/l	5.3	93	10	28	150	0
Iron	mg/l	0.071	14	18	42	0.3	30
Magnesium	mg/l	1.1	29	10	28	100	0
Manganese	mg/l	0.025	1.1	18	42	0.1	26
Potassium	mg/l	1.4	8.3	10	28	-	-
Sodium	mg/l	7.5	190	10	28	200	0
Zinc	mg/l	<0.01	9.2	18	42	5	1
Ammonia (mg/l)	mg/l	0.07	1.53	15	31	0.5	11
Chloride	mg/l	3.1	104	18	42	250	0
Nitrate (NO_3)	mg/l	0.04	20	18	42	45	0
Coliforms	CFU/100ml	0	30	10	10	absent	3
PAH 16 EPA (sum)	µg/l	<0.01	0.07	7	25	0.7	0
BTEX, summation	µg/l	<1	<1	18	42	-	-
TPH Sum (C_{10}-C_{40})	µg/l	<38	44	18	42	-	-

**Possible 2014 erroneous result 54.2 excluded

9.5.5.5 Secondary Data

Information and data related to the groundwater environment directly relevant to the characterisation of the Study Area and the ESIA process in general were obtained from a number of secondary data sources listed in Table 9-13. These information and data were used in the production of the baseline characterisation.

Table 9-13: Groundwater Related Reports

Document Title	Source and Format	Date of Information	ESIA-Relevant Content
Environmental and Social Impact Assessments for exploration and appraisal phases in Blocks 1 and 2. Prepared by various consultants (Atacama, AWE, Eco & Partner, BIMCO etc.) between 2007 and 2013	TEP Uganda Reports	2007-2013	Multiple ESIAs prepared for seismic and drilling projects that took place in the area where the Buliisa development is planned. Each report describes the physical, biological and social environment baseline conditions at the regional level and reports field survey data specific to the Project Area.
Albertine Rift development project injection water supply study. Groundwater review. (Atkins, 2010 Ref. 9-22)	TEP Uganda Report	Groundwater data 2007 - 2010	This study provides information on regional groundwater issues and investigates water supply options for provision of injection of water for the Kasamene oil field development and the wider basin development south of the Victoria Nile. The report analyses the geology, groundwater yields and quality. The study also provides general information about Lake Albert physiography and hydrology. The report contains relevant hydrogeological data for the Kasamene area which is within the Buliisa field development.

Document Title	Source and Format	Date of Information	ESIA-Relevant Content
Groundwater Resources Report on Buliisa and Hoima Districts and supporting maps (DWRM and Tullow, 2013 Ref. 9-14)	TEP Uganda Report and supporting maps	Groundwater data 1990s to 2013	The project involved mapping the distribution of groundwater resources including delineation of major aquifers in the area, assessment of groundwater development potential and determining the potential vulnerability of groundwater resources to pollution and over-exploitation in the districts of Hoima and Buliisa. • National Groundwater Database (NGWDB), held at the Directorate of Water Resource Management (DWRM), Entebbe. • Data collected during 2009/10 for the update of the Water Atlas (WATSUP). • Data collected as part of the 2002 Water Atlas project (MIS2002). • Data stored in the DRILCON database (collected by a now defunct company). • Sources located from field mapping undertaken by Lahmeyer International. • Data provided by Tullow Oil. • Data held by the District Water Office.
Lake Albert Basin Upstream Development: Water Source Evaluation for Development and Production March 2017	Tullow Oil	Groundwater and surface water information 2009 to 2013.	Summary report of works carried out in Blocks EA-1, EA-1A and EA-2. Largely refers to the potential use of Lake Albert as the water source for the development and operational phases of the scheme but also considers potential for groundwater use.
National Water Supply Database Uganda Ministry of Water and Environment (MWE)	Uganda Ministry of Water and Environment public website GIS files, pdf files	Various	A web based public database that allows users to extract data, including operational status of water supply sources in 112 Uganda districts, including piped water systems, protected springs, shallow wells, deep boreholes, rainwater harvesting tanks, dams, and valley tanks, with the exception of obtaining water quality data.
Watertech Boring Completion logs	TEP Uganda Reports	Various	Boring lithology and hydrogeological details
Groundwater abstraction permits and borehole lithological logs	DWRM	Various	Borehole details

9.5.5.6 Groundwater Quality

The general condition of groundwater quality beneath the Study Area has been determined from the following information sources. A summary of the main findings in the sources is presented below:

- Albertine Rift Development Project Injection Water Supply Study (Atkins 2010) and water monitoring data report by Schlumberger Water Services Ltd (SWS) (2010) (Ref. 9-26);
- Certificates of analysis from the National Water and Sewerage Corporation (NWSC) Central Laboratory, obtained when the boreholes were first commissioned, and subsequent groundwater monitoring data required under conditions of groundwater abstraction permits; and
- Groundwater quality data from assessments carried out as part of the exploration and appraisal phases within EA-1, CA-1 and LA-2 North (formally referred to as Blocks 1 and 2).

The Albertine Rift Development Project water monitoring programme conducted by Schlumberger Water Services (SWS) included groundwater analytical data from water supply boreholes in addition to surface water samples from lake and river waters. A wide range of parameters was tested including physico-chemical characteristics, organic and inorganic constituents. The analysis of the SWS data for the Buliisa area which comprised 14 boreholes indicates the general characteristics of the groundwater condition as follows:

- Groundwater pH is low (6.02 - 6.98) and considerably lower than that of Lake Albert (9.3) and the Victoria Nile River (8.7);
- Electrical conductivity (EC) (an indication of the total ions in solution) is elevated (1089-1403 microSiemens per centimetre (μS/cm)) in the boreholes nearer the lake shore (Kasamene, Buliisa Seismic camp) and much lower (199-464 μS/cm) at those in the upper catchment (Awaka, Ngege, and Ngara1). EC values for the lake water are around 600 μS/cm and for the Victoria Nile 110 μS/cm;
- The ionic balance for the Kasamene and Buliisa Seismic camp boreholes is dominated by bicarbonate (alkalinity) and calcium plus sodium. At Buliisa there is also a significant chloride component with the highest concentration detected of 213 mg/l at the Buliisa Seismic camp borehole; and
- Despite the differences in concentrations, the waters from Awaka, Ngege and Ngara (i.e. south of the Victoria Nile) show a broadly similar ionic balance to the Kasamene groundwater and to the surface waters. Ngwedo2 and Oribo have a stronger sodium chloride signature.

The groundwater sampling results from the Albertine Rift Development Project water monitoring programme identified some boreholes where concentrations exceeded WHO guidelines for manganese or nitrite. Elevated iron levels were also detected at some locations. The groundwater quality results were compared to the Ugandan potable water standards. Concentrations of iron and manganese exceeded the standards in seven boreholes within the Study Area. This is consistent with the results of the groundwater samples taken between 2014 and 2017.

Major ion chemistry for groundwater and surface waters is a reflection of recharge water and the nature of the sediments with which they are in contact. Evaporation, dissolution and precipitation, mixing and ion exchange can modify the balance between constituents. The overall similarities in the major ions between the waters reflect the similar nature of the basin infill sediments.

The local differences in groundwater chemistry probably relate to residence time in the aquifer and possibly borehole depth. The Awaka waters are dominated by fresh recharge whereas the Kasamene sample represents the downstream end of a groundwater flow path with a longer opportunity for dissolution of minerals and reaction with the sediments. The waters around Kasamene and Buliisa are also at a shallower depth below ground and there may be direct evaporation from the water table leading to elevated concentrations. Some variability in groundwater chemistry across the area is expected due to the heterogeneity in the sediments (SWS, 2009).

Groundwater quality data from assessments carried out as part of the exploration and appraisal phases within Blocks 1 and 2 are available. These assessments included sampling and analysis of community water supply boreholes and camp boreholes in the vicinity of proposed drilling locations (Gunya, Jobi, Kasamene, Kigogole, Lyec, Mpyo, Ngara, Ngege, Ngiri, Nsoga, Raa, Rii, Riwu, and Wairindi). Groundwater samples were also collected and analysed during the assessments associated with the seismic, geophysical and geotechnical surveys.

The list of constituents and parameters analysed varied and were determined by the level of assessments required. Many of the groundwater analytical data sets included some inorganic constituents but lacked heavy metals and organic compounds. However, the results are still useful in establishing baseline groundwater quality for the area.

In summary, the results from these studies indicate that the groundwater quality in the area is generally free of significant contamination with the majority of the determinands analysed below the US EAS 12 standards.

9.6 Baseline Characteristics – Summary

9.6.1 Baseline Water Quality

Based on the results of the groundwater samples taken between 2014 and 2018 and data from the secondary sources, it is considered that the groundwater in the unconsolidated sand aquifer generally is of good quality, meaning within or slightly above Ugandan standards.

Iron and manganese are present in most samples at concentrations above the Ugandan standards. This is attributed to the natural geological conditions. Coliforms have been recorded in several samples, which most likely is due to local anthropogenic activities in close proximity to the boreholes. Slightly elevated bromide and ammonia concentrations also have been reported for some borehole samples. Wide variations in the arsenic concentration have been reported, with several groundwater samples reporting concentrations below the laboratory detection limit of 5 µg/l but other showing levels above the Ugandan standard of 10 µg/l up to more than 25 µg/l.

Although the results of the groundwater quality analyses have been interpreted based on the borehole locations, north and south of the Victoria Nile River, it is considered that there is no significant variation in the groundwater quality in the sedimentary aquifer in boreholes either side of the river.

The depth to the groundwater level varies significantly across the Study Area, reflecting the topography of the area with the deeper groundwater levels on the higher ground away from the Victoria Nile River and Lake Albert. Where the groundwater is shallow in the vicinity of the principal watercourses and the shore of Lake Albert and in the absence of a low permeability clay cover to provide protection to the aquifer, the groundwater is likely to be vulnerable to contamination infiltrating from the surface.

9.6.2 Conceptual Hydrogeological Model (Summary)

Based on the assessment of the available baseline information on geology, groundwater levels and groundwater quality, an initial conceptual hydrogeological model has been developed for the Study Area. The conceptual model forms the basis for the impact assessment of the Project. The conceptual model will be further refined as additional information becomes available. A summary of the conceptual hydrogeological model is displayed in Figure 9-13 and a description is provided below:

- The local geology beneath the Study Area consists of a variable thickness up to over 4 km of a sedimentary sequence of the Albertine Graben and Albertine Nile formation deposited during the Cretaceous – Tertiary and Quaternary Age respectively;
- The Albertine Graben overlies the basement rock and forms the hydrocarbon-bearing sequence of sediments and volcanic rocks;
- Hydrogeologically, the main aquifer (i.e. water bearing horizon) beneath the Study Area occurs within the upper section of approximately 150 m of the Albertine Nile deposits. This is the main section of the aquifer that is of primary interest from a groundwater risk assessment point of view in relation to the Project and the ESIA. It is unclear if deeper aquifer(s) exist;
- The aquifer in the Albertine Nile sediments is generally unconfined with unconsolidated deposits that predominantly comprise beach sands and gravels with discontinuous interbedded layers of

finer silts and clays that occasionally create semi-confining conditions and possibly minor discrete aquifers within some parts of the sequence beneath the Study Area;

- Due to the discontinuous nature of the lower permeability confining sediments (i.e. silts and clays), it is considered that the upper part of the sedimentary sequence can be treated as a single aquifer unit with hydraulically connected water-bearing units;
- The thickness of the productive aquifer zone within the upper section varies across the Study Area and can be greater than 50 m thickness towards the west and southwestern parts of the Study Area;
- The depth to the groundwater table or the piezometric water level beneath the Study Area ranges between 5 m and 72 m below ground level. This significant variation is associated mainly with topographical variations but may also be attributed to the unconfined to semi-confined conditions of the aquifer and the development of minor discrete perched aquifer bodies;
- The shallower groundwater is present in the lower-lying areas and adjacent to the main rivers and Lake Albert. It is only in these areas of shallow groundwater that there is a potential for groundwater to support wetland areas;
- Beneath the higher ground in the east of the Study Area, the groundwater level is much deeper, typically at depths exceeding 20m;
- Recharge to the aquifer beneath the Study Area is primarily from rainfall and will likely be taking place across the entire extent of the aquifer by direct downward seepage (or percolation) through the unsaturated zone;
- Where the groundwater is at depth, there is potential for additional groundwater recharge to occur by infiltration from ephemeral watercourses following periods of high rainfall;
- Yields around 2 – 16 m^3/hr have been achieved from boreholes within the Study Area. Higher yields of more than 50 m^3/hr have been reported in the literature;
- An average aquifer transmissivity of 34 m^2/day with an average storage coefficient of 0.1 and hydraulic conductivity between 0.02 m/day and 15 m/day have been reported for the sedimentary aquifer. Transmissivity values of 100 m^2/day and 155 m^2/day were calculated using available pumping test data from boreholes at Ngege and Kasamene within the Study Area;
- Groundwater flow across the Study Area is generally from east to west towards Lake Albert. However, this may vary at certain locations within the Study Area close to the major rivers and due to groundwater abstractions;
- Groundwater quality in the aquifer is variable but generally is of good quality across the Study Area. There is no difference in groundwater quality north and south of the Victoria Nile;
- There is no widespread inorganic water chemistry problem, but elevated iron, manganese and bromide concentrations may be common naturally occurring issues. Elevated arsenic may be an issue with groundwater in some parts of the Study Area;
- There also is evidence of elevated ammonia concentrations, which are attributed to human factors such as pollution from latrines;
- Groundwater vulnerability is potentially a major concern. Due to the largely unconfined and unconsolidated nature of the surface sand aquifer beneath the Study Area, where the water table is shallow, groundwater is likely to be highly vulnerable to both point-based and aerial source pollution from anthropogenic activities. Microbial contamination was detected in some groundwater samples from the 2016 and 2017 ESIA survey campaigns; and
- Where the groundwater level is at depth of more than 10 m, there is a reduced risk to groundwater. However, the permeable nature of the sand provides a pathway for the infiltration of surface contaminants and for contaminants to migrate to the groundwater.

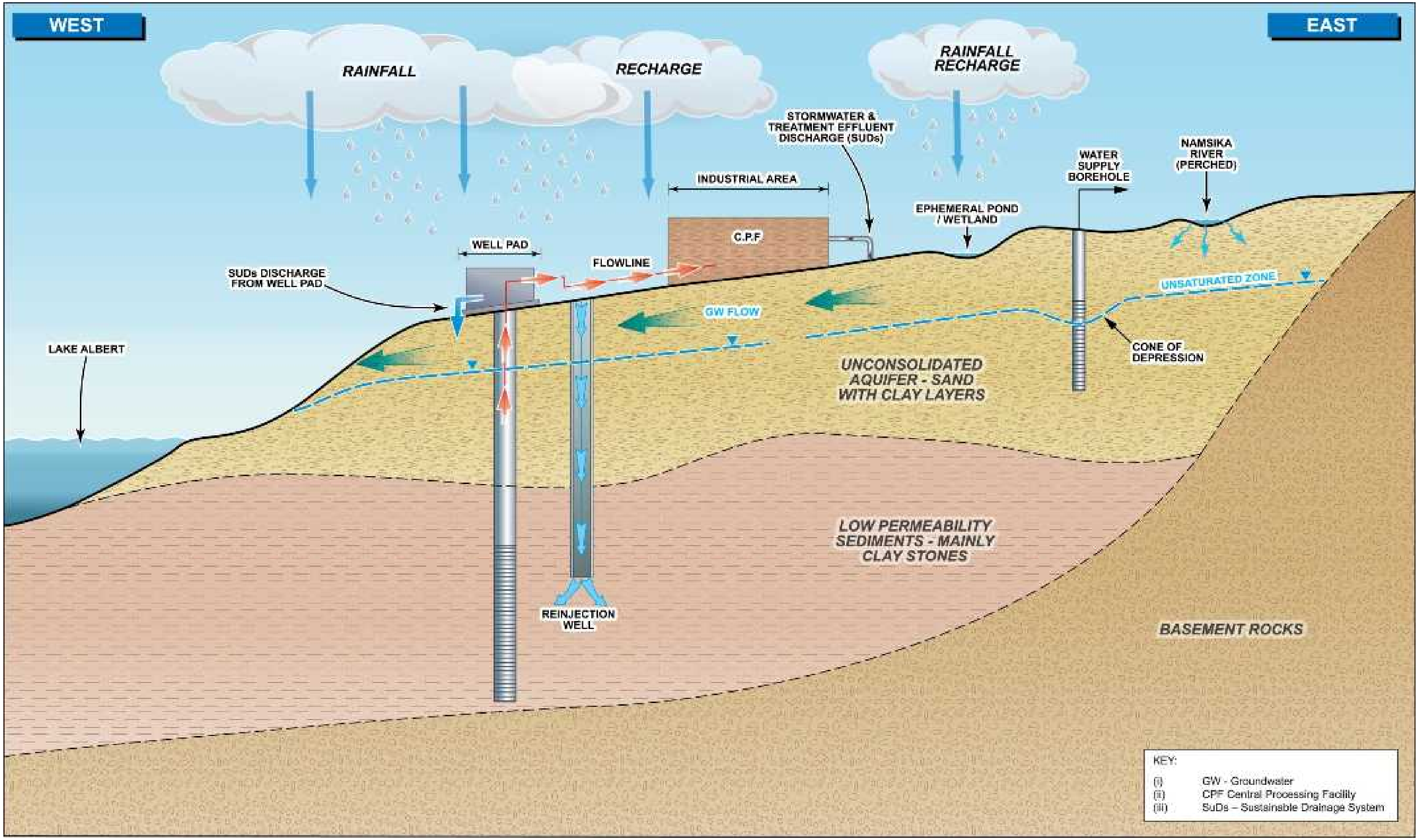

Figure 9-13: Schematic Conceptual Site Model across the Study Area

9.7 Data Assumptions and Limitations

9.7.1 Assumptions

The following assumptions were made during the field survey campaigns and preparation of this Chapter of the ESIA:

- The sampled boreholes are in good condition and the samples collected are considered to represent the groundwater quality at their locations;
- The laboratory results are accurate without any significant laboratory errors;
- The information on the boreholes provided by relevant stakeholders is accurate;
- Third party information/data from previous studies used in preparing this report are accurate; and
- The upper part (150 m) of the sedimentary sequence forms a single aquifer unit, will be used to supply water for the Project and is the main receptor for the groundwater assessment.

9.7.2 Limitations

The following limitations were encountered during the field surveys campaigns and preparation of this Chapter of the ESIA:

- Pumping test data for new boreholes at the CPF was not available at the time of the ESIA submission to facilitate the assessment of the baseline groundwater conditions;
- Some of the data/information taken from third party reports could not be verified to ascertain their accuracy;
- None of the sampled boreholes are deeper than approximately 150 m and the borehole logs for deeper levels are inadequate to confirm the presence of deeper aquifers above the basement bedrock;
- There is very limited pumping test information for boreholes within the Study Area to facilitate determination of the hydraulic properties of the unconsolidated sand aquifer – though a commitment is made by the Project Proponents to gather additional information via a survey which is currently underway as part of the FEED Water Abstraction Feasibility Study. The results of this additional work will be used to up-date the baseline information and to refine a detailed hydrogeological conceptual site model (CSM); and
- Very limited information/details of the design and construction of the sampled groundwater boreholes is provided for both the primary and secondary data sources.

9.8 Impact Assessment and Mitigation

9.8.1 Impact Assessment Methodology

The proposed Project has the potential to cause adverse effects on the groundwater conditions in the vicinity of the Project, both in respect of groundwater level and flow and groundwater quality. Adverse impacts on the groundwater system could result in associated impacts on the surface water system and on groundwater dependent wetlands and other water dependent designated protected areas. Most ephemeral ponds, water holes and ephemeral streams are not directly connected to the groundwater but are surface water components. An assessment of the impacts on surface waters is provided in ***Chapter 10***: ***Surface Water.***

The methodology adopted for the hydrogeology impact assessment is based on the source-pathway-receptor approach. For there to be an identifiable impact, there must be a source i.e. a contaminant or an activity; a receptor; and, a pathway, which allows the source to impact on a receptor. All three elements must be present before a linkage and a potential impact can be realised.

In order to assess the potential impacts of the Project on the hydrogeological conditions, a conceptual hydrogeological model of the Project Area has been prepared. The conceptual hydrogeological model is discussed in Section 9.8.4. The conceptual model together with the source-pathway-receptor approach form the basis of a semi-quantitative risk assessment of the potential impacts of the Site Preparation and Enabling Works, Construction and Pre-Commissioning, Commissioning and Operations and Decommissioning Phases of the Project on groundwater. These potential linkages are assessed for each phase of the Project in the subsequent sections of the Chapter. Figure 9-13 shows the schematic conceptual site model for the Project and Study Area.

The principal *sources* of potential impact are:

- Additional abstraction of groundwater from the sand aquifer for the Project components;
- Release of soluble contaminants from surface activities into the groundwater in the sand aquifer; and
- Release of soluble contaminants from sub-surface activities into the groundwater in the sand aquifer.

The main *receptors* potentially at risk from these sources are:

- Existing water supply boreholes in the Project Area;
- Human health through the loss of a water supply source;
- Human health through contamination of a water supply source;
- New camp, well pads and Industrial Area domestic water supply boreholes;
- Surface water features in hydraulic continuity with groundwater in the sand aquifer, through either a reduction/loss of baseflow discharge or the discharge of contaminated groundwater; and
- Wildlife and other ecosystems reliant on groundwater.

The main *pathways* for the sources to impact on the receptors are:

- Infiltration of surface soluble contaminants and percolation to the groundwater;
- Direct runoff of contaminated drainage to adjacent watercourses;
- Migration of soluble contaminants entering the groundwater and discharging as baseflow to surface water features; and
- Reduction in groundwater flow.

9.8.2 Potential sources of Impact

The impact assessment considers the potential effects on groundwater caused by operational and/or non-routine activities which could result in adverse impacts on groundwater flow or quality, such as the additional groundwater abstraction for the Project and the accidental release of contaminants during scheme operations. Releases that might occur are addressed in this chapter. Unplanned events, such as major failures of equipment, including ruptures of pipelines, tank failures or blow outs, which are unlikely to occur but could have a greater impact on groundwater, are considered in ***Chapter 20: Unplanned Events***.

In respect of hydrogeology, the proposed development could impact on both groundwater levels and flows and on groundwater quality. During the early years of the Project, water is planned to be provided from boreholes drilled at the camps, well pads, the Masindi Vehicle Check Point and in the Industrial Area for a variety of Project activities, including domestic supply.

The assessment of potential groundwater or hydrogeological impacts takes into consideration applicable international standards, Ugandan national standards and recognised Good International Industry Practice (GIIP) regarding the control of activities which potentially pose a risk to water resources. The closest groundwater receptors to the Project activities have been identified and used to define the spatial scope of the assessment. The key activities likely to pose a risk to the groundwater conditions during each of the Project phases are included below in Table 9-14.

The assessment of impacts has been undertaken by identifying and evaluating a range of activities and scenarios that are likely to occur throughout all phases of the Project and for those activities specific to each phase. The principal activities associated with each phase of the Project and embedded mitigation measures are outlined in ***Chapter 4: Project Description and Alternatives***. For the purpose of the Impact Assessment, it is assumed that these embedded mitigation measures are implemented for all relevant phases of the Project as required. The sensitivity or importance of individual receptors has been categorised by their nature using the criteria in Table 9-15 to help determine the potential significance of effects.

Table 9-14: Project Activities which may lead to Potential Impacts

Phase	Activity
Site Preparation and Enabling Works	Clearance of vegetation and soils (Industrial Area, well pads, Water Abstraction System, Masindi Vehicle Check Point, Bugungu Airstrip and Victoria Nile Ferry Crossing Facilities)
	Civil works activities at well pads, Water Abstraction System sites, Industrial Area (including concrete batching and cement washout) and Masindi Vehicle Check Point
	Deliveries of materials and supplies (including fuel and other hazardous substances) to the Project Site
	Storage of fuel and other hazardous substances
	Refuelling of plant and machinery within Project site
	Use of power generation plant (e.g. diesel generators)
	Drilling of water supply boreholes at camps, well pads and Industrial Area
	Abstraction of water from boreholes for domestic, washing and dust suppression purposes
	Discharge of surface water runoff
	Disposal of waste water (grey and black)
	Discharge of sewage effluent on the reed beds at Bugungu Camp, Tangi Camp, Buliisa Camp (and Masindi Vehicle Check Point)

Phase	Activity
	Construction of Victoria Nile Crossing Facility, including piling for the jetties
	Waste generation, storage and disposal (hazardous and non-hazardous)
Construction and Pre-Commissioning	Development drilling activities (oil production, water re-injection and observation wells) at the well pads.
	Abstraction of water (ground and surface) for use at well pads, camps and Masindi Vehicle Check Point for potable, washing and dust suppression purposes
	Abstraction of groundwater for drilling operations
	Deliveries of materials and supplies (including fuel and other hazardous substances) to the Project Site
	Storage of fuel and other hazardous substances
	Refuelling of plant and machinery within Project site
	Use of temporary power generation plant (e.g. diesel generators)
	Containment and storage of drilling fluids and drill cuttings
	Discharge of surface water runoff
	Operation and discharge from temporary SuDS drainage system (including use of storm water facility)
	Discharge of treated waste water from Waste Water Treatment plant and of discharge of sewage effluent on the reed beds at Bugungu Camp, Tangi Camp and Buliisa Camp
	Horizontal Directional Drilling (HDD) activities at the Victoria Nile Crossing Points
	Construction of Production and Injection Network (i.e. Pipelines and Flowlines) and Water Abstraction System from Lake Albert, pipeline Right of Way (RoW) including trenching, welding, storage of material, backfilling etc.
	Hydrotesting – Management of hydrotest water and associated chemicals
	Waste generation, storage and disposal (hazardous and non-hazardous)
Commissioning and Operations	Operation of CPF plant and equipment
	Operation of plant and equipment at the well pads
	Production and Injection Network maintenance (e.g. pigging activities)
	Well pad maintenance activities (including use of work-over rig)
	Delivery of materials and supplies (including fuel and other hazardous substances) to the Project Site
	Storage of fuel and other hazardous substances
	Refuelling of plant and machinery within Project site

Phase	Activity
	Abstraction of water from boreholes for domestic, washing and dust suppression purposes
	Discharge of surface runoff from all permanent facilities via drainage system (SuDS)
	Discharge of treated waste water from Waste Water Treatment plants
	Re-injection of process water
	Use of polymer injection at pilot location.
	Waste generation, storage and disposal (hazardous and non-hazardous)
Decommissioning	Dependent upon Decommissioning strategy - but expected to be similar to those for Site Preparation and Enabling Works and Construction and Pre-Commissioning Project Phases apart from absence of large scale groundwater abstraction.

9.8.3 Impact Assessment Criteria

In assessing the significance of the potential impacts on the hydrogeological conditions due to the Project, three key factors were considered – the type and nature of the impact i.e. adverse, beneficial, temporary, direct, indirect etc.; the sensitivity and/or importance of the receptor; and, the potential magnitude of any effect. The significance criteria are based on a combination of impact magnitude and receptor sensitivity. The impact significance matrix in Table 3-1 of ***Chapter 3: ESIA Methodology*** is used to determine the significance of each impact.

There will be situations using the source-pathway-receptor approach where potential impacts could occur to identified receptors but where realisation of the impact is considered highly unlikely, for example where the receptor is located a significant distance from the source of the potential impact. The likelihood of an impact being realised also is considered using a qualitative and semi-quantitative assessment on a scale of certain, likely or unlikely to assess whether there is a realistic likelihood of any impact, even where a plausible linkage exists. For example, it is considered highly unlikely that effects associated with normal scheme operations will have a significant impact on a receptor located more than 1 km from the source. Table 9-15 considers distance as a factor in determining the receptor sensitivity. To facilitate the assessment of potential impacts, distance drawdown curves have been developed based on the anticipated aquifer properties.

9.8.3.1 Receptor Sensitivity

The sensitivity of the identified receptors is provided in Table 9-15. The sensitivity of individual receptors is based on the ability of the receptor to absorb the impact, such as a reduction in the groundwater level or flow or deterioration in groundwater quality, without any perceptible change in the characteristics of the receptor. The sensitivity also considers the areal relationship between the receptor and the Project element and the importance of the receptor on a local, national or international scale. Table 9-16 identifies the principal groundwater receptors in the Study Area and their appropriate sensitivity. It should be recognised that similar receptors, such as existing community water supply boreholes, will have different sensitivities depending on their proximity to individual elements of the Project.

Table 9-15: Hydrogeology Receptor Sensitivity

Sensitivity	Description
High	Groundwater aquifer(s) and community water supply boreholes. Camp/compound domestic supply boreholes. Potable supply borehole at Tourist Lodges. Water supply boreholes located within 1 km of Project elements. Extensive groundwater dependent wetland areas. Internationally designated biodiversity site with water dependency.
Moderate	Groundwater aquifer(s) and other water supply boreholes not used as the primarily source, used for individual supplies or for non-potable uses located within 1 km of Project elements. Nationally designated protected site with water dependency/wetland. Groundwater dependent wetland areas of limited extent.
Low	Groundwater in unconsolidated sand aquifer more than 1 km from scheme element. Community or other water supply borehole more than 1 km from scheme element. Groundwater dependant wetland/watering hole not designated and not used for potable water supply and Community or other water supply borehole.
Negligible	Groundwater aquifer(s) and boreholes in non-potable use more than 1 km from scheme element. Non-potable quality groundwater, possibly present at depth.

9.8.3.2 Receptor Identification

The principal hydrogeological receptor is the groundwater in the unconsolidated sand aquifer which underlies the entire Project Area and forms a regionally important source of water. The groundwater supports local and community water supply boreholes, wetland areas and the surface water system. Accordingly, the principal receptors are human health and groundwater and surface water resources. Impacts on surface water are assessed in ***Chapter 10: Surface Water***. Other receptors potentially impacted indirectly are wildlife and sensitive ecosystems. These are considered in ***Chapters 14: Terrestrial Wildlife*** and **Chapter *15: Aquatic Life*** respectively.

Table 9-16: Description of Identified Receptors

Receptor	Description	Receptor Sensitivity/Importance
Human health	Community water supply borehole source within 1 km of scheme element, Camp domestic water supply borehole	High
Human health	Other domestic water supply sources within 1 km of Project component e.g. tourist lodges	High
Animal health	Community water supply borehole, watercourses connected to groundwater and used for drinking both in North and South Nile areas	High
Biodiversity	Internationally designated site with water dependency e.g. Ramsar site, MFNP	High
Water resources	Watercourses/wetland areas in hydraulic continuity with groundwater in unconsolidated sand aquifer within 1 km of Project component	High

Receptor	Description	Receptor Sensitivity/Importance
Water resources	Sand aquifer with potable water quality within 1 km of Project component but no active water usage	Moderate
Water resources	Watercourses/wetland areas in hydraulic continuity with groundwater in sand aquifer more than 1 km from Project component	Moderate
Human health	Domestic water supply sources or small scale water sources in infrequent use or non-potable uses within 1 km of Project component	Moderate
Biodiversity	Nationally designated protected site with water dependency/wetlands within 1 km of Project component	Moderate
Human health	Community or other domestic water supply borehole sources more than 1 km from Project component.	Low
Water resources	Sand aquifer with potable water quality more than 1 km from Project component with no active abstraction	Low
Biodiversity	Groundwater dependent wetland/watering hole, not designated and more than 1 km from Project component	Low
Water resources	Aquifer(s) with non-potable water quality more than 1 km from Project component	Negligible
Water resources	Water supply sources for non-potable uses more than 1 km from Project component	Negligible

9.8.3.3 Impact Magnitude

The magnitude of potential and residual impacts considers the likely scale of the predicted changes to the baseline conditions resulting from the potential impacts and takes into account the extent, duration, frequency and reversibility of the impact. Table 9-17 provides an explanation of the impact magnitude criteria for groundwater.

As part of the FEED Study, detailed spill risk assessments are currently being undertaken for the construction and operational phases of the Project to validate the design mitigation measures identified in ***Chapter 4: Project Description and Alternatives*** and hence minimise impacts on groundwater quality from the Project. Additional mitigation measures (if necessary) will be defined as an outcome of these risk assessments.

Table 9-17: Impact Magnitude

Impact Magnitude	Description
High	Pollution of aquifer(s) supporting community potable water supply borehole rendering supply unusable (i.e. water quality fails to meet Ugandan Potable Water Quality Standards). Derogation of existing community water supply borehole/spring due to groundwater abstraction for scheme use. Major, extensive and irreversible adverse impact on internationally or nationally designated area (Ramsar or MFNP), long term impact (>10 years).
Moderate	Pollution of aquifer(s) supporting a water supply borehole, with contaminant concentrations in source exceeding Ugandan standards but where minor treatment only is required for continued potable water use. Temporary and reversible lowering of groundwater level resulting in an adverse impact on existing water supply boreholes requiring minor remedial works, such as lowering pumps, to allow continuation of supply. Minor and localised adverse impacts on designated area. The impact may recover through natural processes and the impact will be medium term (5-10 years).
Low	Minor localised pollution of aquifer(s) supporting water supply borehole, causing a measurable deterioration in water quality in source but with contaminant concentrations remaining below Ugandan standards. Adverse impact on groundwater level due to abstraction for Project use but not affecting ability of borehole/spring to continue to provide adequate water supply. Minor impact on level or quality at groundwater dependant wetland/watering hole not designated and not used for water supply. The impact is predicted to recover rapidly through natural processes and the duration of impact is short term (0-5 years).
Negligible	Minor deterioration in groundwater quality and/or negligible depletion of aquifer(s) supporting potable water supply borehole with negligible increase in contaminant concentrations at source and no adverse impact on groundwater level.

For the purpose of the impact assessment, the impact magnitude on water supplies resulting from Project related groundwater abstraction is supported by the development of distance-drawdown curves that predict the distance away from a Project abstraction well where there will be no influence in the groundwater level. The construction details of community boreholes are not known. However as a conservative measure, a decrease in water level (i.e. drawdown) of 1 m or less is considered not to have a discernible impact. The distance-drawdown curves are discussed in Section 9.8.7.

Using a combination of receptor importance and impact magnitude, the significance of any actual or potential impacts can be defined as high, moderate, low or insignificant. These matrices are presented in Tables 3-1 and 3-2 in ***Chapter 3: ESIA Methodology***. The significance of any impacts is identified both prior to and after the implementation of mitigation measures. Those impacts that are considered high or moderate are considered to be significant and are discussed in more detail.

9.8.4 Conceptual Hydrogeological Model

Operations associated with the Project could pose a risk to the groundwater in the unconsolidated deposits and to existing users of the groundwater. Impacts on groundwater level and flow could arise from the proposed water abstractions. Impacts on groundwater quality could result from the use, storage and uncontrolled discharges of contaminants, such as fuel oils and chemicals and from operations associated with the Project, principally at the well pads and in the Industrial Area/CPF. In order to inform the impact assessment, a conceptual hydrogeological model of the Project Area has been developed.

The hydrogeological conditions in the Project Area comprise a sequence of unconsolidated deposits, consisting of an upper sand layer, underlain by a sequence of interbedded sands, silts and clays. These sequences form the principal water-bearing strata beneath the Project Area and comprise the main aquifer used for water supply in the area. For the purpose of the assessment and based on borehole information for the area, it is assumed that the aquifer is up to 150 m thick. Whilst it is likely that the silt and clay units provide barriers to vertical groundwater flow, it is assumed that regionally the unconsolidated deposits form a single aquifer unit. There is currently no evidence of other aquifers at greater depths. Groundwater in the sand aquifer is the principal source of water supply for the area and will be utilised for the Project.

The depth to groundwater in the unconsolidated deposits varies across the Study Area. Beneath much of the Study Area, the groundwater is at a depth of more than 20 m. It is only adjacent to Lake Albert and the Victoria Nile where shallow groundwater is present and may intercept the ground surface as springs and seepages. Due to the depth to groundwater across the bulk of the Study Area, it is unlikely that there is hydraulic continuity with minor ponds and watercourses, which are often ephemeral and considered to be reliant on rainfall. It is interpreted that regionally groundwater in the sand aquifer flows in a generally westerly direction. South of the Victoria Nile, groundwater provides baseflow discharge to Lake Albert with a component of flow to the southern bank of the Victoria Nile. North of the Victoria Nile, it is considered that groundwater discharges to the northern bank of the Victoria Nile and to the eastern bank of the Albert Nile.

It is likely that the sand has a high intergranular permeability which facilitates groundwater flow and also readily allows infiltration of incident rainfall. Due to these characteristics, the aquifer is considered vulnerable to contamination from surface activities. Whilst the generally thick unsaturated zone provides conditions conducive to the attenuation of contaminants infiltrating from the surface, where the groundwater level is shallow in the vicinity of the main surface water features, there is an increased risk to groundwater. The main surface water features within the Project Area (Lake Albert, the Victoria Nile and the Albert Nile) are expressions of groundwater discharge from the unconsolidated sand aquifer. The abstraction of water from these surface water features will have no impact on groundwater resources or flow, as there is no connection between abstraction from these water features and groundwater availability.

The groundwater in the sand aquifer is of satisfactory quality and generally meets the Ugandan standards for natural potable water.

The groundwater quality results for samples collected in November 2016 and June 2017 are consistent. The groundwater quality was generally within the Ugandan standards in all the sampled boreholes, with generally minor exceedances for arsenic, iron, manganese, bromide and ammonia. In contrast to the data collected in November 2016, concentrations of nitrite were all below the laboratory limit of detection of 0.03 mg/l. Metals and inorganic parameters are likely due to natural conditions as anthropogenic sources have not been identified.

Additional information on the hydrogeological characteristics of the Study Area are provided in Section 9.5.4.

9.8.5 Groundwater Usage associated with Project Activities

Groundwater is planned to form the principal source of water for the early phases of the Project, until the water abstraction system from Lake Albert has been commissioned. In case the FEED Water Abstraction Feasibility Study does not confirm sufficient groundwater quantities, then temporary water abstraction from the Lake Albert will be envisaged. The predicted groundwater usage for the Project life is shown on Figure 9-14 and detailed in Table 9-18.

The maximum groundwater requirement is for Year 1 and 2 when it is estimated that approximately 960,000 m^3/annum (2,630 m^3/day) will be required. The required groundwater abstraction progressively reduces to approximately 249,000 m^3/annum (682 m^3/day) in Year 8 and to 120,000 m^3/annum (330 m^3/day) by Year 18. The groundwater requirement subsequently remains constant until the end of the scheme.

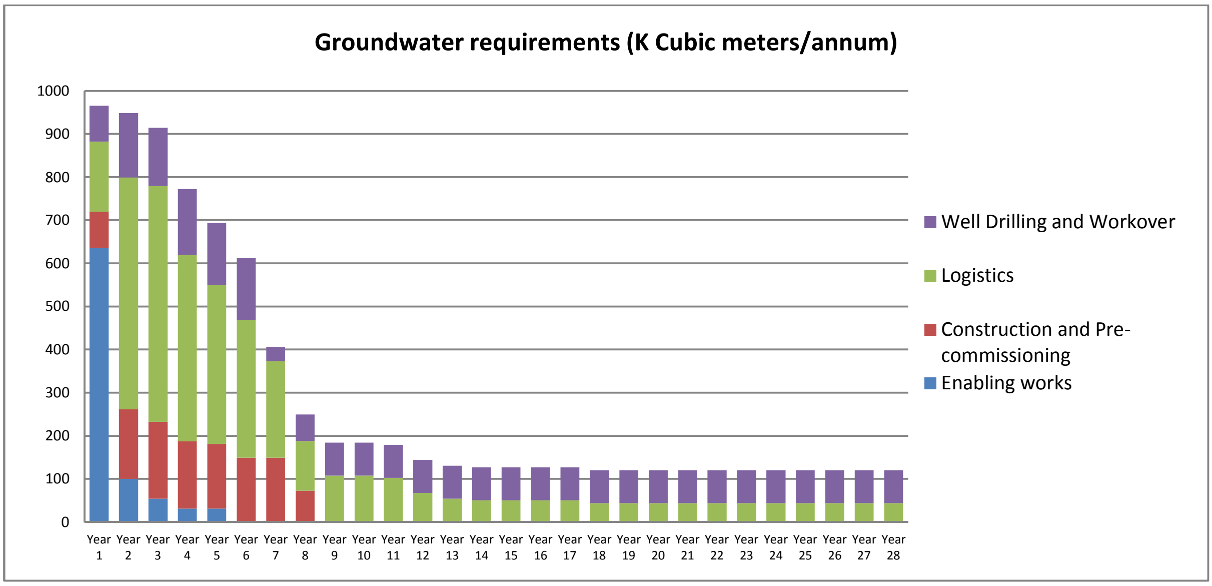

Figure 9-14: Project Groundwater Requirement

During the early years of the Project, the main groundwater requirements are for the enabling works in the Industrial Area and for the construction of infrastructure elements, such as access roads and well pads; for water use at the three permanent camps; at the construction camp; and at the Masindi Vehicle Check Point. From Year 2, groundwater is required for use in the development drilling at the well pads.

From Year 10 onwards, the bulk of the groundwater requirement is used at the Tangi Camp and in the camp in the Industrial Area for domestic supply and road maintenance/dust suppression and for workover.

Table 9-18: Groundwater Requirement during Project Life (km^3/annum)

Year	Site Preparation and Enabling works	Construction and Pre-commissionin g	Logistics	Well drilling and workover	TOTAL
1	636	84	163	83	966
2	100	161	538	149	949
3	55	178	547	135	915
4	31	156	432	153	772
5	31	150	369	143	693
6	-	149	320	143	612
7	-	149	223	34	406
8	-	73	115	62	249
9	-	-	108	77	184
10	-	-	108	77	184
11	-	-	102	77	179
12	-	-	68	77	144
13	-	-	54	77	131
14	-	-	51	77	127
15	-	-	51	77	127
16	-	-	51	77	127
17	-	-	51	77	127

Year	Site Preparation and Enabling works	Construction and Pre-commissionin g	Logistics	Well drilling and workover	TOTAL
18	-	-	44	77	120
19	-	-	44	77	120
20	-	-	44	77	120
21	-	-	44	77	120
22	-	-	44	77	120
23	-	-	44	77	120
24	-	-	44	77	120
25	-	-	44	77	120
26	-	-	44	77	120
27	-	-	44	77	120
28	-	-	44	77	120

9.8.6 Embedded Mitigation

In-built design (embedded) mitigation measures are features of the design of Project components that are intended to preclude adverse impacts to the environment. A list of relevant embedded mitigation measures already built into the design of the Project is outlined within ***Chapter 4: Project Description and Alternatives***. Table 9-19 lists those embedded mitigation measures relevant to the protection of groundwater level and quality. These measures have been taken into account when assessing the significance of the potential impacts.

Embedded mitigation measures will be incorporated to help control and limit available pathways between any contaminant source and the principal receptor (groundwater). During the FEED study, detailed spill risk assessments have been or are currently being undertaken for the construction and operational phases of the Project to validate the design mitigation measures identified in ***Chapter 4: Project Description and Alternatives***. Additional mitigation measures (if necessary) will be defined as an outcome of these risk assessments.

As a result, although many of the potentially-contaminative activities identified in Table 9-14 are common to all four phases of the Project, such as the storage and management of fuels and chemicals and the management of effluent, it is considered that specific assessments of the potential impacts on groundwater quality of these activities are not required.

Table 9-19: Summary of Embedded Mitigation Measures for Hydrogeology

Embedded Mitigation Measures
All fuels and hazardous materials will be stored within appropriate bunds and drip trays, providing appropriate containment, where practicable
Chemicals and hazardous liquids will be supplied in dedicated tote tanks made of sufficiently robust construction to prevent leaks/spills. Dedicated procedures will be developed for fuel and hazardous material transfers and personnel will be trained to respond. Spill kits will be available at all storage locations
Main refuelling facilities will be located within the Industrial Area, the camps and the Masindi Vehicle Check Point. Facilities will be located within bunded areas with appropriate capacity (110% tank containment). The refuelling pumps will be equipped with automatic shut off and there will be dedicated procedures and spill kits available. Bunds will be designed to minimise ingress of surface water, facilities roofed where practicable and any contaminated water collected will be trucked off site for disposal
With the exception of the CPF which has a bespoke drainage arrangement, drainage arrangements for the permanent facilities will be as follows: • Potentially contaminated areas (i.e. fuel and chemical storage areas) will be provided with local effluent collection (sumps, kerbing and bunding) whereby the potentially contaminated water will be collected and removed by road tanker to a licenced waste disposal facility; and • Uncontaminated areas which will drain naturally to the environment via Sustainable Drainage System (SuDS) comprising filter drains and soakaways. The SuDS design is subject to further detailed design. Sampling points will be established for all potentially contaminated areas to enable samples to be collected for analysis
Each well pad will include an emergency pit with capacity for up to 50 cubic metres (m^3) for use should there be an unplanned event i.e. blowout. The pit will be lined and covered to prevent rainwater ingress
The pipelines will comprise carbon steel with adequate corrosion allowance built into material specifications (wall thickness) to prevent leaks
An anticorrosion coating will be applied for external protection and a corrosion inhibitor will be injected for internal protection
The drainage arrangement of the CPF will be designed to segregate clean and potentially contaminated effluent streams. The drainage for the CPF will be segregated as follows: • Continuously Contaminated Drains will collect hazardous fluids from process and utility equipment. All effluent collected in the closed drainage system will be returned back to the oil treatment trains. There will be no discharge to environment from the closed drains system; • Potentially Contaminated Drains will collect rainfall, wash-water or fire water that falls on paved process and equipment areas that could contain contaminants such as hydrocarbons, metals and solids. Drip pans and kerbs will be provided below every process or utility system that may potentially leak or overflow. Any drips or leaks will be routed to the open drain system via a sump. Roofing will be provided where practicable to prevent surface water ingress. During normal operating conditions, rainwater from potentially contaminated areas will be directed to an the oil water separator prior to discharge to environment in accordance with applicable discharge standards as presented in Chapter 10: Surface Water. When the oil-water separator is full, it will overflows to an associated storm basin via an overflow diverter which will act as a buffer. When the level in the separator falls, the water collected in the storm basin will be sent by storm water pumps back to the overflow diverter and on to the separator. The storm water basin will be sized to withstand a 1 in 100 year event. An oil in water analysers will be installed on the discharge point of the potentially contaminated drains to provide continuous monitoring of the discharge; and • Uncontaminated Drains will manage clean surface water from uncontaminated areas via suitably designed SuDS (network of filter drains and soakaways).
Drainage channels will be installed along the edges of the upgraded roads to prevent excessive runoff and cross drainage culverts will be installed, where appropriate. All drainage infrastructure will be designed taking into account the Uganda Ministry of Works and Transport - Road and Bridge Works Design Manual for Drainage (January 2010)
Surface water will be managed via temporary sustainable drainage systems (SuDS) to manage flood and contamination risk. The requirements for construction SUDS will be adapted depending on the nature of the activities utilising the principles as outlined in Chapter 23: Environmental and Social Management Plan
Contaminated run off will be minimised by ensuring adequate storage facilities are in place for materials stockpiles, waste, fuels/chemicals/hazardous materials, vehicles/washing areas, parking facilities

Embedded Mitigation Measures
All dewatering from excavations or isolated work areas will be provided with appropriate level of treatment prior to discharge
Additional water supply boreholes will be installed during the Site Preparation and Enabling Works Phase and will be drilled to target deep water aquifer zones using water and bentonite
All drill cuttings from borehole drilling activities will be collected and disposed of appropriately. Disposal methods will be pre-agreed with NEMA prior to commencement of activities
Flow meters will be installed on all boreholes to measure flow, water level and quality
The Project Proponents are aware of the need to employ water efficiency measures throughout the lifetime of the Project; they will consider water reduction measures, where feasible
The installation of boreholes across the Project Area is subject to the outcome of the Water Abstraction Feasibility Study currently being undertaken by the Project Proponents
Pre-commissioning water (used for pipeline cleaning and hydrostatic tests) will be reused wherever practicable on multiple pipelines. The base case for management of hydrostatic test water is for the treated water to be left in situ until start up. Final disposal will be determined and selected depending on water quality and available discharge options. The base case for ESIA is that water left in the pipeline from hydrotesting will be disposed via the Produced Water Treatment Train and transferred back via the Production and Injection Network to the well pads for re-injection, subject to further technical assessment
All wells will be drilled using a Blow Out Preventer (BOP) system prior to entering hydrocarbons bearing reservoirs to prevent an uncontrolled release of hydrocarbons in the event that well control issues are experienced during drilling
A down-hole safety valve (DHSV) will be fitted on all production wells crossing major fault lines
Synthetic Based Muds will be transferred from the Liquid Mud Plant to the well pads via truck in dedicated sealed containers to reduce the risk of spillage during storage, handling and transportation operations
• Mud Products will comply with Uganda's Health, Safety and Environment Regulations. Only Chemicals ranked E or D in the OCNS (Oil Chemical National Scheme classification) will be allowed to be used; • All products for completion and drilling fluids will be free of chlorides; the upper limit will be 2% by weight; • All Products entering in the mixing of drilling, completion and cementing will be free of aromatic Hydrocarbon, the upper limit is fixed at 300 parts per million (ppm); and • No asphalt, no gilsonite, nor equivalent so called "black" products will be permitted in the drilling fluids and cementing formulations.
Spent muds will be temporary stored in containers prior to removal by a vacuum truck, waste cuttings will collected via augers to the Roll-on Roll-off (Ro-Ro) skips (or equivalent) and transferred off the well pad for treatment and disposal
Disposal of drill cuttings will be in accordance with Ugandan Legislation and IFC Environmental Health and Safety (EHS)
Construction activities will be contained within the permanent RoW which will have a width of 30 m and is designed to accommodate the pipeline trench(s), stockpile areas, laydown, welding, and the movement of construction equipment alongside the trench(s)
Prior to starting HDD activities a risk assessment will be undertaken to identify the necessary design of the HDD tunnels including appropriate tunnelling and slurry management practice to control groundwater ingress and minimise slurry loss from the tunnel into surrounding aquifers/surface waters
Any residues and wastes generated from pre-commissioning activities will be managed in accordance with the site Waste Management Plan
For any chemical usage [with respect to pre-commissioning], a thorough Chemical Risk Assessment will be undertaken and lowest toxicity chemicals will be used wherever possible
Pre-commissioning water (used for pipeline cleaning and hydrostatic tests) will be reused wherever practicable on multiple pipelines
[Decommissioning of Masindi] All wastes will be removed and disposed of at dedicated waste treatment facilities in accordance with the Waste Management Plan. A detailed Decommissioning Plan will be developed for the works during the Site Preparation and Enabling Works Phase of the Project
Commissioning tests will be undertaken using feedstock oil, natural gas, methanol and chemicals. All commissioning fluids will be managed either at CPF or transferred off site for disposal

Embedded Mitigation Measures
A dedicated Pipeline Integrity Management System will be implemented during the Commissioning and Operations Phase. This will include regular preventative maintenance including operational pigging, intelligent pigging and inspection campaigns to monitor the status of pipelines
The chemicals used for polymer injection will be subject to detailed environmental risk assessment prior to use taking into account all chemical /biological properties and the specific requirements for early oil recovery use
A review of relevant studies, if necessary, will be undertaken during the Commissioning and Operations Phase to confirm that the planned decommissioning activities utilise good industry practices and are the most appropriate to the prevailing circumstances and future land use
In general, the following principles will be adopted where practicable and will be subject to detailed assessment prior to decommissioning: • Above ground infrastructure will be removed to 0.5 m below ground level and backfilled and vegetated; • Access roads may be left in place depending upon the subsequent use of the land; • Shallow foundations for infrastructure may be excavated, demolished and disposed of; • Where piled foundations exist, these may be excavated to a depth of 1 m below the existing ground level and removed; • Excavations resulting from the removal of foundations will be backfilled; • It is expected that pipelines will be cleaned, capped and let in situ, to prevent disturbing the reinstated habitats; and • Where the environment assessment identifies it is acceptable, in some locations pipeline sections may be cleaned, reclaimed and re-used.
During the Decommissioning Phase the following assumptions are applicable regarding supporting facilities: • Water will be supplied from dedicated abstraction boreholes; • Localised effluent collection facilities will be provided for chemical storage, hazardous materials storage, liquid waste storage, tanks, and fuelling facilities. Such containment will include impermeable areas, kerbing, bunding and drip trays as appropriate; • Drainage systems will remain until sites are free of contamination. SuDS will also manage flood risk during this phase of work; • No discharge of water used for decommissioning activities will be discharged to the environment; • Sewage will be treated by existing wastewater treatment plants (WWTPs) and discharged in accordance with wastewater treatment standards as presented in Chapter 10: Surface Water or collected and transferred to suitably licensed treatment facilities for processing and disposal; and • Waste will be segregated and managed in accordance with a Waste Management Plan.
Depending on the final land use agreed with the Ugandan authorities, all or part of the site may need to be rehabilitated. In such circumstances, the Project Proponents will also develop a monitoring programme for completion criteria to verify that the sites are being returned to the agreed representative state.
A Waste Management Plan will be developed and maintained to cover the duration of the Project; and will address the anticipated waste streams, likely quantities and any special handling requirements. The Project Proponent's will implement a waste tracking system to ensure traceability of all wastes removed off site.
Prior to transfer offsite to a licensed waste treatment facility, waste materials will be segregated and stored in appropriate containers to prevent: • Accidental spillage or leakage; • Contamination of soils and groundwater; • Corrosion or wear of containers; • Loss of integrity from accidental collisions or weathering; • Theft; and • Odour and scavenging by animals.
The existing camps have operating WWTPs. Sewage produced from the camps will be treated at the WWTPs in compliance with regulatory requirements (refer to Chapter 10: Surface Water). Sewage from other Project Areas (e.g. road work sites) will be collected and transferred to WWTPs and/or suitably licensed treatment facilities for processing and disposal. All sewage sludge will be removed periodically from WWTPs and transferred off site for disposal
A flow meter will be integrated at the discharge point of the WWTPs to record to all discharges and a sample point will be established to collect spot samples for analysis

Embedded Mitigation Measures
For the Masindi Vehicle Check Point, waste will be collected and transferred to an approved waste treatment facility for recycling, treatment, recovery and/or disposal
Sewage produced from the camps and other Project Areas will be treated at the WWTPs located at the camps in compliance with regulatory requirements (refer to Chapter 10: Surface Water). Wastewater from the well pads will be collected and transferred by tanker to the nearest WWTPs
For the Masindi Vehicle Check Point, sewage will either be treated by a wastewater treatment plant on site and discharged in accordance with the wastewater treatment standards presented in Chapter 10: Surface Water or transferred to the Masindi sewage treatment plant for processing (depending on capacity and approval)
During the Commissioning and Operations Phase waste will be stored and processed at the Integrated Waste Management Area located south of Victoria Nile. There will be no waste management facility located north of the Victoria Nile within the MFNP
For the well pads, Victoria Nile Ferry Crossing Facility and the Lake Water Abstraction System, sewage will be collected and transferred to suitably licensed treatment facilities for processing and disposal

9.8.7 Groundwater Abstraction

9.8.7.1 Regional Groundwater Resources Impact Assessment

As shown in Figure 9-14, groundwater is the source of water for the early years of the Project until the abstraction from Lake Albert is commissioned. The maximum annual groundwater abstraction is 960,000 m^3 in Year 1 with a similar, slightly lower volume required in Year 2.

In response to the Scoping Report for the Project, NEMA requested that:

"A comprehensive assessment should be undertaken for the project water needs, the estimated amounts of water to be abstracted from the various sources and the capacity of the available resources to meet these needs without compromising the ecosystem and local and regional demands. This should include detailed hydrological study for the L. Albert and associated systems to inform the design of the project. Options for recycling of water should be assessed and provided in the EIS."

A groundwater resources balance has been carried out to assess the impact of the proposed groundwater abstraction on regional groundwater resources. The water balance compares the predicted rates of groundwater abstraction against the estimated groundwater recharge to the Project Area. For the purpose of the water balance, it is assumed that the only source of groundwater recharge to the aquifer is rainfall, although it is likely that following heavy rainfall, water in ephemeral watercourses infiltrates the sand aquifer. There are locations in the Project Area where surface watercourses are present however the groundwater level is significantly below ground level and hence does not support the watercourse by base flow discharge. In these locations, the water in the rivers may seep into the ground, providing additional recharge to the aquifer.

Information contained in the National Irrigation Masterplan for Uganda, 2010-2035, (2011) DWRM, Uganda (Ref: 9-23) indicates that groundwater recharge in the Project Area is between approximately 19 mm/annum and 40 mm/annum. The estimated groundwater recharge rate is supported by a water resources assessment of Uganda (Ref: 9-27), in which the sustainable groundwater resource for the Study Area is stated as between 23.7 mm/annum for the Albert Nile area and 39.9 mm/annum for the Victoria Nile. Assuming a Project Area on land (i.e. excluding the area over Lake Albert) of approximately 101,700 ha, the total groundwater recharge varies between approximately 19,323,000 m^3/annum for the lowest recharge rate and 30,001,500 m^3/annum, assuming an average recharge of 29.5 mm/annum.

The projected groundwater abstraction rates vary from a maximum 960,000 m^3/annum in Year 1 and a lower rate of 120,000 m^3/annum from Year 18 until the end of the Project.

If the abstraction rates are compared against the groundwater recharge estimates for the Project Area, the maximum rate of groundwater abstraction during the early years of the Project equates to approximately 4.9% of the minimum recharge rate and 3.2% of the average recharge rate. For the lower, longer term abstraction rates, the percentage of the annual recharge due to the abstraction varies between 0.6% and 0.4%.

The groundwater in the unconsolidated aquifer is considered to be of moderate sensitivity (see Table 9-15). Based on the above worst-case scenarios, it is considered that the proposed rates of groundwater abstraction for the Project do not present a significant impact on the regional groundwater resources for the Project Area. Accordingly, it is concluded that the magnitude of the impact of groundwater abstraction for the Project on regional groundwater resources will be negligible and hence the significance of the potential impact will be Insignificant. As the potential impact is assessed to be Insignificant, it is not considered necessary to identify and implement any additional mitigation measures; consequently, the residual impact significance to regional groundwater resources during all phases of the Project is also considered **Insignificant**.

9.8.7.2 Local Groundwater Resources Impact Assessment

Whilst it is concluded that the proposed rates of groundwater abstraction for the Project do not pose an unacceptable risk to regional groundwater resources, groundwater abstraction for the Project can still pose a risk to local groundwater conditions. Figure 9-15, taken from Misstear et al 2006 (Ref 9-28) shows the effect of groundwater abstraction on the surrounding groundwater level. Pumping from the borehole depresses the groundwater level in the vicinity of the borehole. The resultant cone of depression extends away from the borehole, with the amount of depression (drawdown *s*) reducing with increasing distance (*r*) from the pumping borehole. The outer limit of the cone of depression is the point of zero drawdown (r_0). There is the potential for the cone of depression to extend outside of the boundary of the individual elements of the Project. The cone of depression can also be described as the cone of influence. Boreholes located beyond the point where no drawdown is expected will not be affected by the proposed groundwater abstraction. Drawdown of the groundwater level could affect existing boreholes in the vicinity of the proposed abstraction boreholes. Hence, there is a possibility that derogation of existing community water supply boreholes could occur.

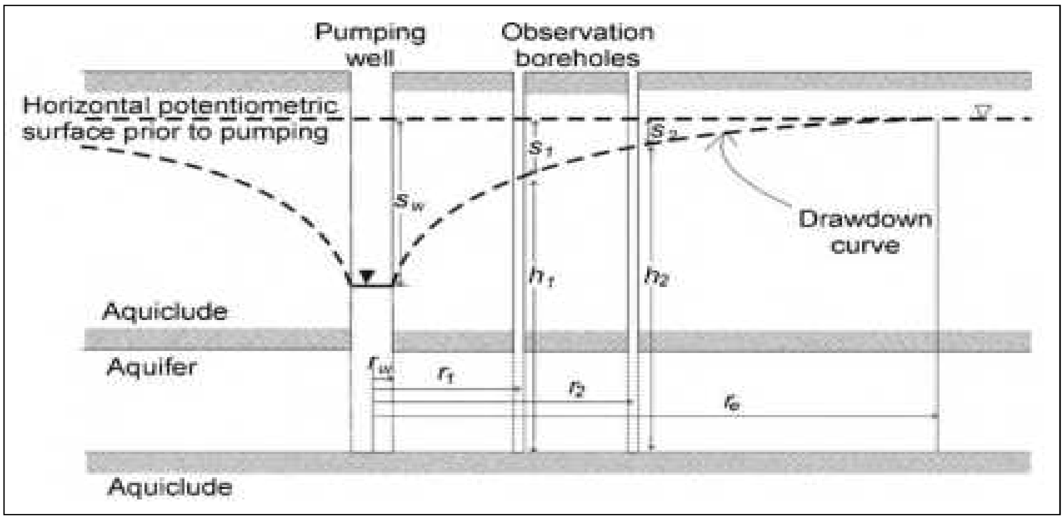

Figure 9-15: Groundwater Level Response to Abstraction

The extent of the cone of depression and the amount of drawdown at varying distances from the abstraction borehole depend on the rate of pumping, the length of the pumping period and the local hydraulic characteristics of the aquifer (transmissivity and storage coefficient). Information on the predicted rate and duration of pumping at various elements of the Project is available. The aquifer characteristics vary across the Project Area resulting from variations in the geological conditions. Reliable transmissivity and storage coefficient values for the unconsolidated sand aquifer in the Project Area are lacking due to limited good quality, pumping test data for boreholes in the Project Area. The current lack of good quality data limits the ability to undertake a robust assessment of the impact of abstraction on the local hydrogeological conditions.

In order to assess the effects of groundwater abstraction on the groundwater level in the vicinity of an abstraction borehole, preliminary estimates of transmissivity and storage coefficient values have been made from the limited available results of pumping tests (Table 9-5). The only Project element where there are site-specific, aquifer properties is borehole DWD 35634 at Bugungu Camp, for which a transmissivity of 35 m^2/day was calculated for an abstraction rate of approximately 236 m^3/day. In this borehole, pumping at this rate resulted in a drawdown of approximately 9 m in the borehole from a rest water level of 40.91 m bgl.

For the proposed abstractions from Buliisa Camp and the Industrial Area, both south of the Victoria Nile, minimum and maximum transmissivity values of 35 m^2/day and 130 m^2/day have been used. The transmissivity values are based on the analysis of pumping tests carried out on boreholes south of the Victoria Nile (Table 9-5).

For other elements of the Project, including the well pads, Tangi Camp and the Masindi Vehicle Check Point, where there is limited information on the aquifer properties in the vicinity of these Project elements, transmissivity (T) values of approximately 25 m^2/day(min); 149 m^2/day (average); and 266 m^2/day(max) have been used with an unconfined storage coefficient of 10% based on pumping test results from boreholes in the sand aquifer across the Study Area.

Using these data, distance-drawdown plots have been prepared for six scenarios, assuming the following maximum predicted abstraction rates (Q) for each scheme element to undertake a conservative assessment of impacts of additional groundwater abstraction:

- Abstraction from the Industrial Area boreholes at 1,595 m^3/day for one year;
- Abstraction from Tangi Camp borehole(s) at 382 m^3/day for five peak years and after will range from 70 m^3/day to 180 m^3/day;
- Abstraction from Bugungu Camp borehole(s) at 289 m^3/day for five peak years and 139 m^3/day for other years until it is decommissioned;
- Abstraction from Buliisa Camp borehole(s) at 160 m^3/day for six years and 80 m^3/day for other years until it is decommissioned;
- Abstraction from well pad boreholes at 37 m^3/day for one year at each well pad; and
- Abstraction at Masindi Vehicle Check Point at 90 m^3/day for four years.

The distance-drawdown plots for the above borehole abstractions are provided as in Figure 9-16 to Figure 9-21. These distance-drawdown plots have been used to predict the potential impacts of groundwater abstraction on water features in the vicinity of each Project element where groundwater abstraction is proposed. For example, Figure 9-16 shows the predicted distance-drawdown curves for an abstraction of 1,595 m^3/day from a borehole in the Industrial Area. Two curves are shown based on the minimum and maximum transmissivity values derived from pumping tests in the area south of the Victoria Nile. The curve (blue) for the lower transmissivity value shows greater drawdowns in the vicinity of the abstraction borehole but a smaller extent of the cone of depression, with an r_0 of 536 m; indicating that beyond this distance there will be no measureable drawdown. For the higher transmissivity case (i.e. green curve), the extent of the cone of depression (r_0) is 1,033 m but the predicted drawdown in the vicinity of the abstraction borehole is much lower. To further illustrate the data shown in the graph, if another well is located 100 m from the abstraction borehole, it is expected that a drawdown of 12 m would be experienced at the lower transmissivity however a drawdown of only 3 m would be experienced assuming the higher transmissivity of the geological unit. A similar analysis can be carried out for the predicted distance-drawdown curves for the other Project elements in Figure 9-17 to Figure 9-21.

The distance-drawdown plots assume that the water supply requirement is provided by a single borehole at each location. Where more than one borehole is used, potential impacts may be lower depending on the relative locations of the boreholes. When the abstraction boreholes are drilled, it is recommended that a pumping test is carried out on each borehole to confirm whether additional boreholes are needed to supply the required yield and to confirm the local hydrogeological characteristics of the aquifer. If necessary, the distance-drawdown plots should be refined based on the findings of the pumping test analysis.

A FEED Water Abstraction Feasibility Study is currently being undertaken to confirm the availability of groundwater for use in the Project. Information from this study will be used to refine the predicted effects of groundwater abstraction from the Project boreholes, where necessary. The FEED study will involve collation of pump test data for the Project Area, updating the water balance model and defining the sustainable yield across the Project Area taking into account site specific information to address the current lack of data.

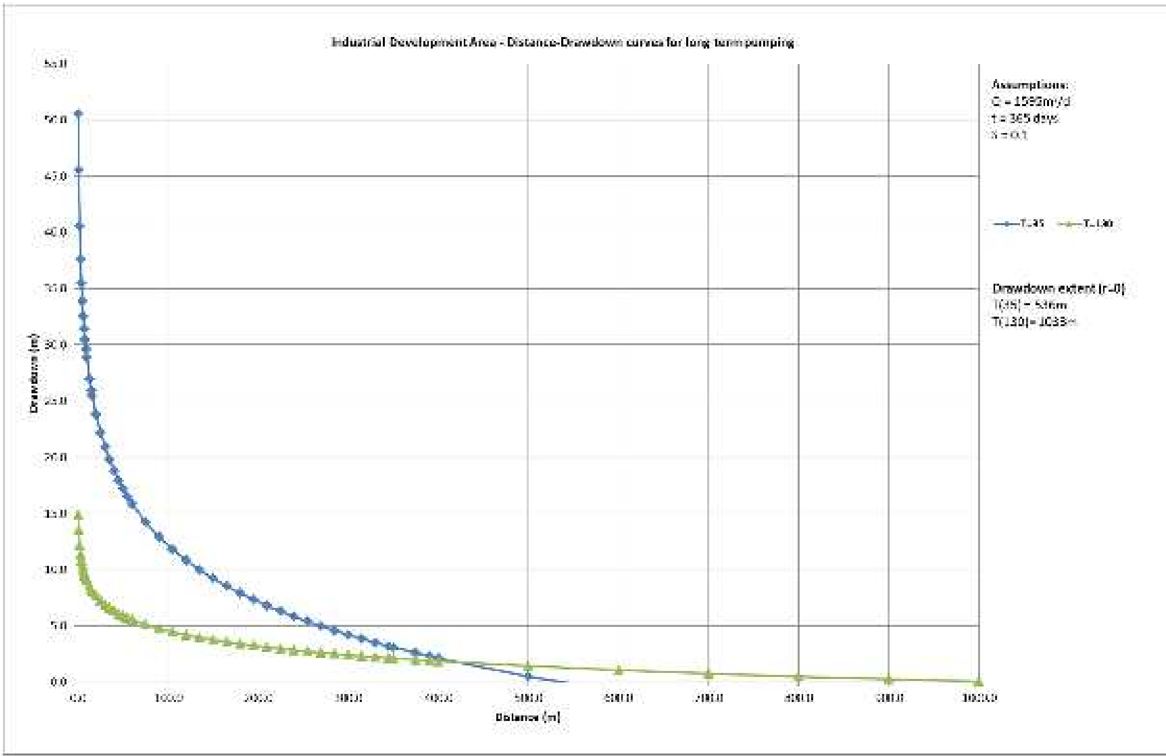

Figure 9-16: Industrial Area – Distance-Drawdown Curves

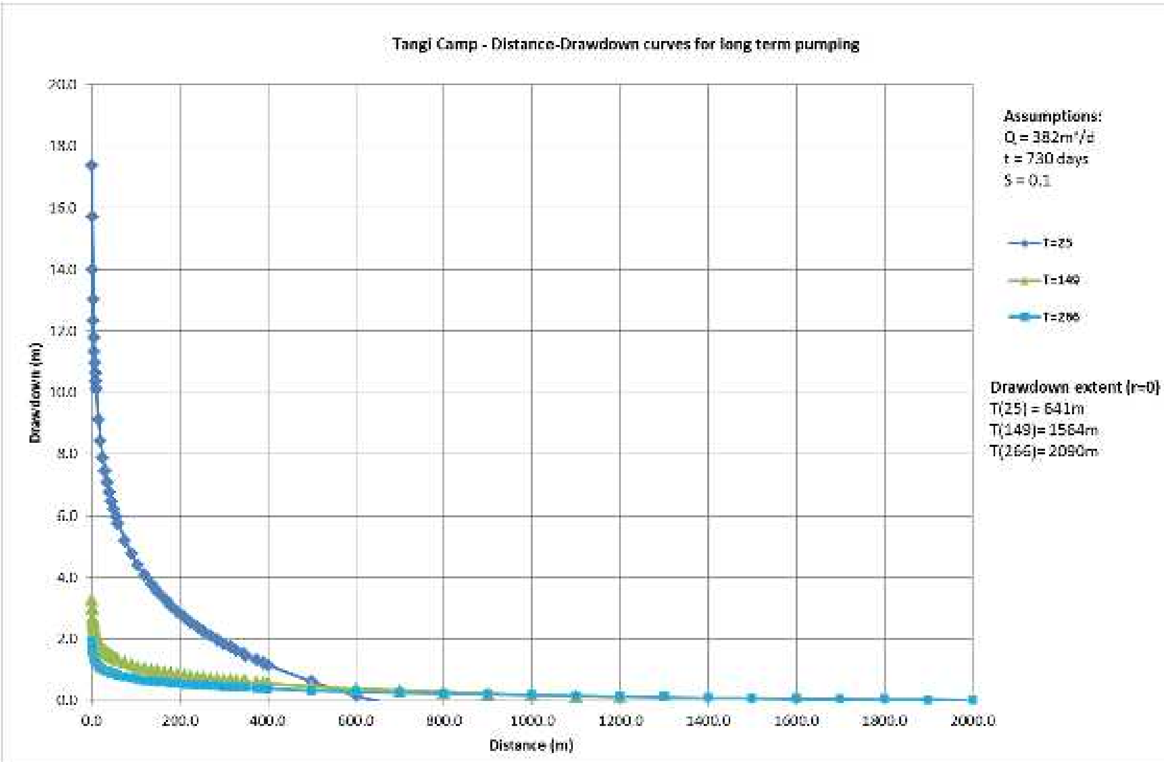

Figure 9-17: Tangi Camp – Distance-Drawdown Curves

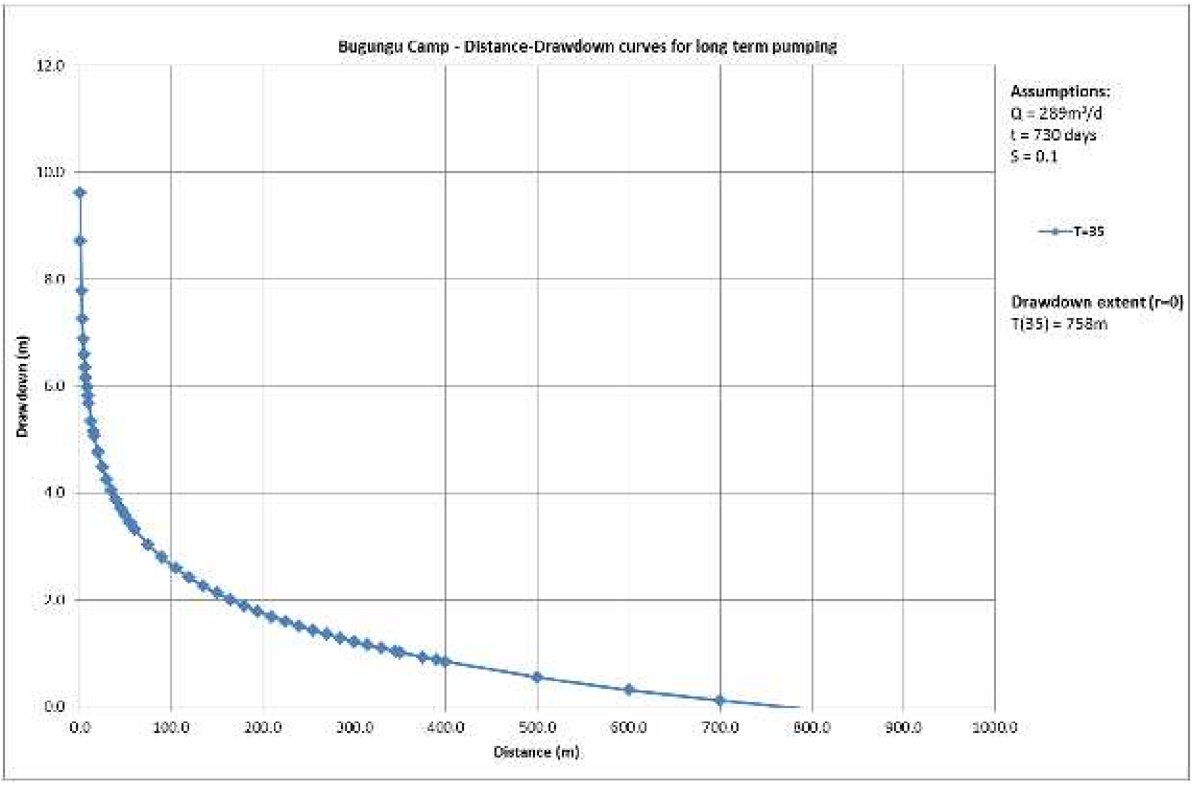

Figure 9-18: Bugungu Camp – Distance-Drawdown Curves

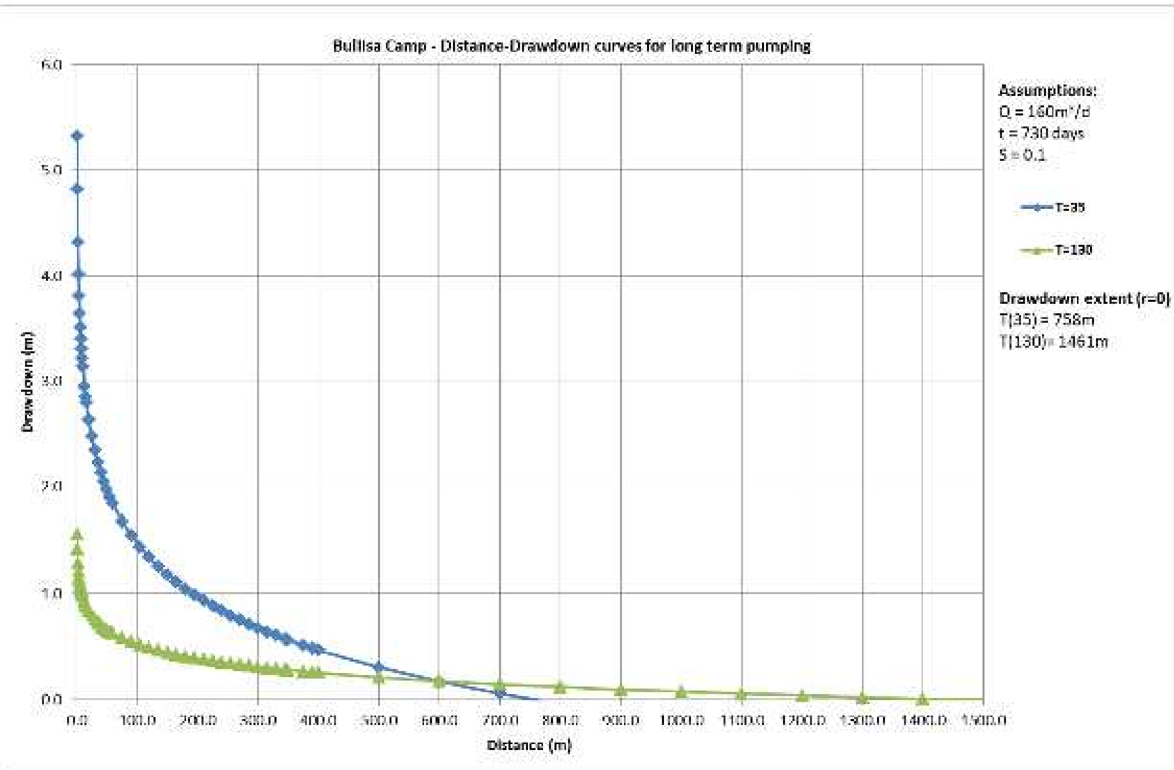

Figure 9-19: Buliisa Camp – Distance-Drawdown Curves

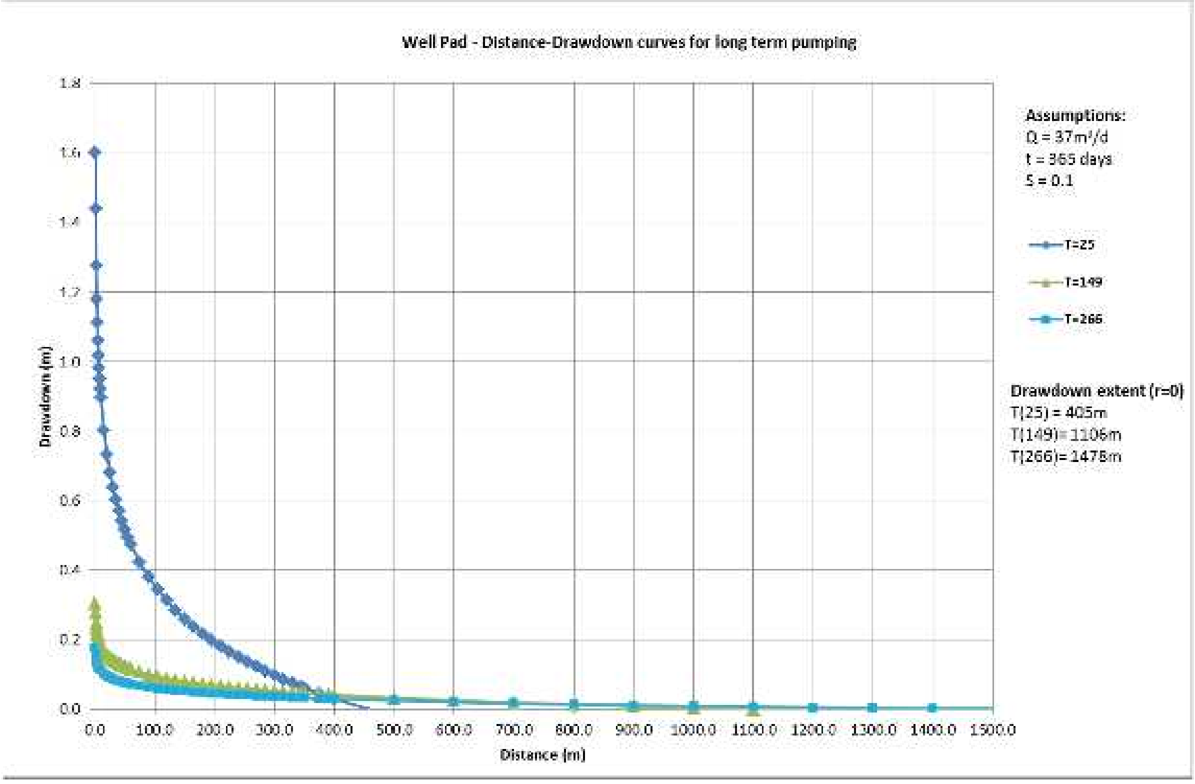

Figure 9-20: Well Pad – Distance Drawdown Curves

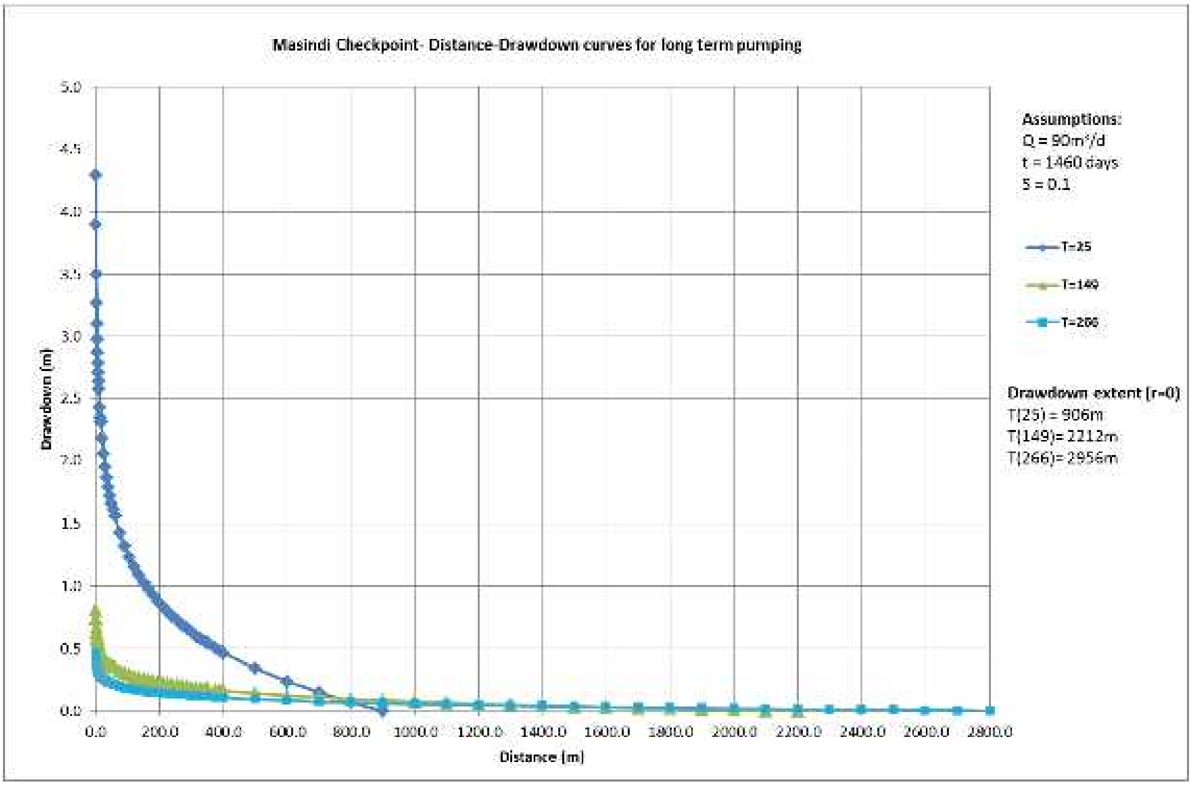

Figure 9-21: Masindi Vehicle Check Point – Distance-Drawdown Curves

Abstraction from the new water supply boreholes for the Project will lower the groundwater level in the vicinity of the pumping boreholes. The groundwater level in existing boreholes in the vicinity of the Project elements also may be lowered as a result of this additional abstraction, as shown in Figure 9-15. Most groundwater abstraction boreholes can withstand a small lowering of the groundwater level without affecting the yield from the borehole, as natural fluctuations in the groundwater level of 1 m to 2 m are common.

There is limited data on variations in the groundwater level. However, any suitably drilled boreholes will be finished at a depth considerably below the rest groundwater level to allow for the effects of abstraction from the borehole and with a sufficient margin to allow for natural variations in the groundwater level. Accordingly, it is a reasonable conclusion that a drawdown of up to 1 m (the trigger drawdown) as a result of pumping from the Project will not impact on the ability of the borehole to continue to operate. For the purpose of the assessment, it is assumed that existing boreholes which may suffer a lowered groundwater level as a result of the proposed abstraction can withstand a drawdown of 1 m without affecting the ability of the borehole to maintain its current abstraction. Therefore, if the predicted drawdown in an existing supply borehole is less than 1 m, it is concluded that there will be no adverse impact on the borehole. The assessment only considers those impacts on existing boreholes, where the predicted drawdown exceeds 1 m. Table 9-20 shows the predicted extent of the cone of depression and the 1 m drawdown for different elements of the Project based on the distance-drawdown curves.

Where a greater drawdown is predicted, individual assessments have been carried out or will be as part of the FEED study to establish whether the borehole is capable of continuing to operate without any adverse effects. The assessment shall include establishing the borehole depth, accurate groundwater levels in the pumping boreholes and monitoring boreholes, the pumping water level and the depth of pump suction. If it is concluded that the borehole is not capable of continuing to operate as a result of the predicted drawdown, remedial measures shall be implemented, such as lowering the pump suction depth where practical, or installing a deeper, replacement borehole.

Table 9-20: Predicted impact of new abstractions on groundwater level

Project element	Maximum extent of predicted drawdown (m)	Extent of predicted 1m drawdown (m)
Well pads	1480	<10
Industrial Area/CPF	1030	600
Tangi Camp	2100	400
Bugungu Camp	760	345
Buliisa Camp	1460	200
Masindi Vehicle Check Point	2950	165

For each of the well pads, the camps and the Industrial Area, maps of the main features including existing boreholes and other water features within an approximate 1 km radius of the Project element have been prepared. The maps are provided within the Project Component Factsheets within Appendix B.

The distance-drawdown graphs for groundwater abstraction at the well pads, provided in Figure 9-20, indicate that based on the minimum and maximum calculated transmissivity values, the effect of the groundwater abstraction of 37 m^3/day extends to up to approximately 1.5 km from the abstraction borehole, subject to the specific hydrogeological conditions in the area of each well pad. A drawdown of greater than 1 m is predicted only within 10 m of the well pad boreholes.

Accordingly, while an existing potable water supply borehole located within 1 km of the well pad abstraction borehole is considered to be of high sensitivity (Table 9-15), the effect of the predicted drawdown of the groundwater level at the borehole is considered not to pose a risk of derogation. It is concluded that abstraction of groundwater from the water supply boreholes at the well pads will have an **Insignificant** impact on groundwater resources.

A similar approach has been adopted to assess the risk to known existing boreholes in the vicinity of other Project elements, based on a conservative drawdown prediction of 1 m. For the Project elements the 1 m drawdown trigger is estimated at a distance of 600 m for the Industrial Area; 400 m for Tangi camp; 345 m for Bugungu camp; 200 m for Buliisa camp; and 165 m for the Masindi Vehicle check point.

For each of the four Project phases an assessment has been made of the impact of the proposed groundwater abstractions for the Project on existing boreholes in the vicinity of the individual Project elements. The existing abstraction boreholes which are located within the predicted areas of a drawdown of more than 1 m are highlighted and assessed in the following sections.

9.8.7.3 Groundwater Quality

The principal potential impacts on the groundwater quality in the sand aquifer are associated with uncontrolled releases of fuel oils and chemicals stored and used on the site during all phases of the Project; leaks and spills of product at the well pads and from the pipelines; and, from the processing operations at the CPF. Implementation of the standard in-built (embedded), operational measures will be adopted to minimise the potential impacts to groundwater as defined in Section 9.8.6.

Impacts of the Project on the quality of groundwater in the unconsolidated sand aquifer are based on a qualitative assessment of the main contaminants of concern associated with the various phases of the Project and the local groundwater conditions, in particular the depth to groundwater and the lithology of the shallow deposits. In those areas where the groundwater level is shallow and the overlying strata consist of permeable sands, the groundwater would be vulnerable to surface contamination reaching the groundwater.

In contrast, where the groundwater level is at depth, which includes the majority of the Project Area, and the surface strata comprise mainly lower permeability silt and clay, the groundwater is less vulnerable. In combination with the implementation of the embedded mitigation measures and the geological and hydrogeological conditions, the risk to groundwater quality from individual Project elements has been assessed.

9.8.7.4 Human health

Impacts on human health from a groundwater point of view relate to two main issues – (1) derogation of an existing domestic water supply by drying up the source through the additional groundwater abstraction required for the Project, and (2) derogation of an existing domestic water supply through pollution of the source as a result of the Project activities.

The assessment of the impact of the additional groundwater abstraction in Section 9.8.7.1 shows that the proposed abstraction will not significantly affect regional groundwater resources. Accordingly, it is concluded that the Project will not have a significant impact on the ability of the local population to continue to abstract water from the area. Local impacts on groundwater levels are considered in the following sections for each of the Project phases.

The impacts on human health are closely linked to the impacts on groundwater quality and the significance of any impacts will be similar.

9.8.8 Assessment of Impacts: Site Preparation and Enabling Works

9.8.8.1 Introduction

The main elements of this phase of the Project which potentially could impact on groundwater are listed in Table 9-14.

During the Site Preparation and Enabling Works Phase water will be supplied from both existing boreholes and new boreholes for domestic and general use. The proposed boreholes will be located as close as possible to the infrastructure to reduce the length of temporary piping where possible to a maximum of 500 m. The number of boreholes required in north and south Nile will be identified following the FEED Water Feasibility Study. Volumes of water required for each site are summarised in ***Chapter 4: Project Description and Alternatives***. Groundwater will be used for the Industrial Area site preparation and dust suppression, access road construction and road upgrades, concrete works, well pad site preparation, airstrip earthworks (Bugungu and Masindi) and the Victoria Nile Ferry Crossing Facility construction. For the purposes of this assessment, it is assumed that the water requirement for the roads construction and road upgrades and dust suppression will be sourced from either the well pad, camps or Industrial Area boreholes.

During this phase the construction camp in the Industrial Area and at the Masindi Vehicle Check Point will be established and will require water from new boreholes drilled on the sites. The existing camps, Tangi camp (North Nile) and the Bugungu and Buliisa camps (South Nile) may each require the installation of additional boreholes to meet the anticipated increase in water demand for domestic use. Table 9-21 identifies the presence of known boreholes located within 1 km of each camp, the Industrial Area/CPF and the Masindi Vehicle Check Point. Open water features within 1 km of each Project element are considered in ***Chapter 10: Surface Water***.

Table 9-21: Water Features within 1 km of Project Infrastructure

Project Component	Existing boreholes within 1 km of Project element	Borehole details	Number of boreholes within 1 m drawdown trigger zone
South of the Victoria Nile - Well Pads			
GNA-01	2	Kisomere Community BH – 790m DWD 16550 - 216m	Nil
GNA-02	1	DWD 21635 – 221m	Nil
GNA-03	1	DWD 17683 – 237m	Nil
GNA-04	3	DWD 31403 - on site DWD 16038 – 385m DWD 29476 – 777m	Nil
NGR-01	Nil		Nil
NGR-02	2	DWD 29474 – 270m DWD 29577 – 825m	Nil
NGR-03A	2	DWD 16551 -374m DWD 21024 – 440m	Nil
NGR-05A	5	DWD 25974 – 837m DWD 25975 – 749m DWD 25977 – 800m DWD 33437 – 917m DWD 33449 – 917m	Nil
NGR-06	Nil	N/A	Nil
KGG-01	Nil	N/A	Nil
KGG-03	Nil	N/A	Nil
KGG-04	1	DWD 16040 – 676m	Nil
KGG-05	2	DWD 25893 – 406m DWD 30263 – 833m	Nil
KGG-06	Nil	N/A	Nil
KGG-09	Nil	N/A	Nil
KW-01	Nil	N/A	Nil
KW-02A	2	DWD 16552 – 880m DWD 21665 – 749m	Nil
KW-02B	3	DWD 16552 – 839m DWD 33438 – 374m CD 2219 – 449m	Nil

Project Component	Existing boreholes within 1 km of Project element	Borehole details	Number of boreholes within 1 m drawdown trigger zone
NSO-01	Nil	N/A	Nil
NSO-02	2	Ngwedo-2 – 626m DWD 25893 – 626m	Nil
NSO-03	Nil	N/A	Nil
NSO-04	Nil	N/A	Nil
NSO-05	3	DWD 30264 – 970m VpPL3054 – 965m CD 2245 – 972m	Nil
NSO-06	Nil		Nil
North of the Victoria Nile - Well Pads			
JBR-01	1	DWD 28633 – on site	Nil
JBR-02	Nil	N/A	Nil
JBR-03	1	DWD 35655 – 517m	Nil
JBR-04	Nil	N/A	Nil
JBR-05	2	DWD 25308 – 981m DWD 35662 – 683m	Nil
JBR-06	1	DWD 25308 – 654m	Nil
JBR-07	1	DWD 35657 – 421m	Nil
JBR-08	Nil	N/A	Nil
JBR-09	1	DWD 29473 – 607m	Nil
JBR-10	1	DWD 40971 – 297m	Nil
Other Infrastructure and Camps			
Industrial Area/Construction camp	1	DWD 25901(Kayese) – 397m	1
Northern Nile Tangi camp	3	DWD 29472 – 80m DWD 35646 – on site DWD 35670 – on site	3
Bugungu camp	2	DWD 29475 – on site DWD 35634 – on site	2
Bugungu Airstrip	Nil	N/A	Nil
Buliisa camp	2	DWD 21665 – on site DWD 29942 – on site	2
Masindi Vehicle Check Point	Nil	N/A	Nil

Potential impacts on groundwater quality could result from spillages and leaks of fuels and chemicals from bulk storage and vehicle and plant refuelling; the management of concrete lorry washout water; and poor management of effluent and wastes generated at the camps and in the Industrial Area and during water borehole drilling. For the purpose of the impact assessment, it is assumed that the embedded mitigation measures in the Project design will be implemented to minimise the risk to groundwater quality in the underlying sand aquifer.

For the purpose of the hydrogeology impact assessment, it is assumed that operations associated with the construction of new roads, the upgrading of existing roads and the borrow pit excavations will have no impact on the groundwater flow and level or on groundwater quality other than general impacts from accidental spillages and leaks of fuels and chemicals, which will be managed through the embedded mitigation measures. Accordingly, these activities have not been considered further in this assessment.

9.8.8.2 Potential Impacts - Site Preparation and Enabling Works

9.8.8.2.1 Groundwater level and flow – Well Pads

During this phase of the Project, the water abstraction boreholes will be drilled at the well pads. It is understood that a borehole will be drilled at each well pad to provide a water supply during earthworks, civil works and construction of roads during this phase of the Project.

Abstraction of water poses a potential risk to existing water supply sources in the vicinity of the borehole, although the distance-drawdown curve in Figure 9-20 shows that a drawdown of more than 1 m is limited to within 10 m of the abstraction borehole. As shown in Table 9-21, the only well pads with existing wells are GNA-04 and JBR-01. However these boreholes are located within the footprint of the well pad and it is expected that these will not be used as a community water source. As there are existing water supply boreholes within 1 km of several of the well pads, the sensitivity of the groundwater is high. As only a negligible potential impact is predicted, there will be **Insignificant** impacts on groundwater level and flow.

9.8.8.2.2 Groundwater level and flow – Camps and Masindi Vehicle Check Point

The water supply to the Bugungu, Buliisa and Tangi camps will be provided from on-site boreholes. The maximum water requirement at each camp is needed for the Site Preparation and Enabling Works phase of the Project. For the purpose of the impact assessment, the following maximum daily abstraction rates are assumed – 382 m^3/day at the Tangi camp; 289 m^3/day at the Bugungu camp; and 160 m^3/day at the Buliisa camp. At the Masindi Vehicle Check Point, there is a water requirement only for the early part of the Project (Years 2-5) at a maximum projected rate of 90 m^3/day.

For the Tangi and Bugungu camps, there are no known community boreholes within 1 km of the camps, although there are existing boreholes located at the camps. Table 9-20 shows that based on the proposed abstraction rates, the predicted distance for the 1 m drawdown is 400 m and 345 m respectively from the proposed abstraction wells. Accordingly, there are no existing water supply sources at risk from the proposed abstractions. In the absence of an existing community water supply borehole within 1 km of the two camps, groundwater in the sand aquifer is of moderate sensitivity. A slight drawdown of the groundwater level in the vicinity of the camps will have only a negligible impact on regional groundwater resources as shown in Section 9.8.7.1. Accordingly, the potential impact significance is considered **Insignificant** and no mitigation measures are required.

At the Tangi camp there are two boreholes (DWD 35670 and DWD 35646) both owned by TEP Uganda. Currently, it is understood that only borehole DWD 35646 is in use. It is assumed that one or both boreholes will provide the water supply for the camp. The combined permitted abstraction from the two boreholes is 330 m^3/day. A pumping test on borehole DWD 35670 gave a yield of 278 m^3/day for a drawdown of 13.2 m. The rest water level in the borehole is approximately 9 m bgl.

In order to meet the maximum water requirement for the camp of 382 m^3/day, it will be necessary to amend the permit to allow a slightly higher abstraction rate. Based on the findings of the pumping test, it is likely that the combined use of both boreholes will meet the abstraction rate required. There are no other identified boreholes within 1 km of the Tangi camp and hence there are no receptors at risk from the abstraction. Figure 9-17 shows the predicted distance-drawdown curves for the proposed abstraction at Tangi camp. As indicated in Section 9.8.7.1 a slight drawdown of the groundwater level in the vicinity of the camp will only have a negligible impact on regional groundwater resources and in the absence of other water abstractions within 1 km of the camp, no existing water supply boreholes are at risk of derogation. Accordingly, the potential impact significance of the proposed abstraction on groundwater resources is considered to be **Insignificant**.

There is a similar situation at the Buliisa camp where there is an existing abstraction borehole (DWD 35633) owned by TUOP. This has a valid permit for an abstraction rate of 150 m^3/day, slightly below the required abstraction rate. It is assumed that the borehole will provide the water supply for the camp, subject to increasing the permitted abstraction rate to 160m^3/day. There is one identified existing borehole within 1 km of the Buliisa camp. However it is beyond the 1 m drawdown extent of 200 m. The community borehole is approximately 520 m from the camp and it is estimated that the proposed abstraction could lower the water level by less than 0.5 m depending on the aquifer characteristics at the site. It is unlikely that the predicted minimal drawdown will have a significant adverse impact on the ability of the borehole to continue to operate and hence the magnitude of impact would be negligible. The borehole would be considered as being of high sensitivity and the resulting potential impact significance would be **Insignificant**.

At the Bugungu camp, the only identified boreholes within 1 km are the existing camp boreholes (DWD 29475 and 35634) operated by TEP Uganda. The permit for borehole DWD 29475 allows an abstraction rate of 100 m^3/day from this borehole, below the maximum abstraction rate required for this phase of the Project of 289 m^3/day. A pumping test on borehole DWD 35634 gave a yield of 236 m^3/day for a drawdown of approximately 9 m from a rest water level of approximately 41 m bgl. Based on the results of the pumping test, it is considered that the boreholes on the site will provide the required water supply for the camp, including for domestic use. It will be necessary to increase the permitted abstraction rate from this borehole, if the borehole is capable of providing the extra water; to utilise borehole DWD 35634 in combination; or, to drill additional boreholes on the site. In the absence of any other boreholes within 1 km of the camp, there are no groundwater receptors at risk from the additional abstraction. It is considered that additional drawdown of the groundwater level in the vicinity of the camp will only have a negligible impact on groundwater resources. Accordingly, the significance of the potential impact of the proposed abstraction is considered **Insignificant**.

Based on the DWRM borehole database, the closest existing water supply borehole is approximately 5 km from the Masindi Vehicle Check Point. It is estimated that effects of abstraction from the proposed borehole on the site at a maximum rate of 90 m^3/day will extend a maximum of approximately 3 km from the borehole, with the 1 m drawdown distance 165 m from the abstraction borehole. In the absence of existing boreholes within approximately 5 km of the site, no adverse impacts are predicted. The sand aquifer is of moderate sensitivity at this location and accordingly, the significance of any potential impact will be **Insignificant**.

When the new abstraction borehole(s) are drilled at the sites, a pumping test should be carried out to confirm whether additional boreholes are needed to supply the required yield and the local hydrogeological characteristics of the aquifer. If necessary, the distance-drawdown plots should be refined based on the findings of the pumping test analysis.

9.8.8.2.3 Groundwater level and flow – Industrial Area

During the Site Preparation and Enabling Works phase of the Project, the maximum water requirement is for the preparation of the Industrial Area/CPF. There are currently no abstraction boreholes on the site and hence new boreholes will need to be drilled to provide the required water demand of up to 1,595 m^3/day. In the absence of site-specific information on the hydrogeological conditions in this area, it is not possible to confirm how many abstraction boreholes will be required to provide the required volume. However, based on the results of pumping tests from the sand aquifer and the approved quantities on the abstraction permits, it is considered that the maximum yield from a borehole in the sand aquifer is in the order of 400 m^3/day and hence it may be necessary to drill a minimum four boreholes on the Industrial Area/CPF.

An existing borehole (DWD 25901) for Kayese village has been identified approximately 400 m southeast of the Industrial area. From the distance-drawdown curves for the Industrial Area in Figure 9-16, it is inferred that the anticipated drawdown at this distance is between approximately 2.5 m and 5.0 m. If the borehole is an existing potable supply, it is of high sensitivity. The borehole is 76.5 m deep and the groundwater level is approximately 40 m bgl. It is understood that this borehole has been non-functional since January 2018. Accordingly, the borehole is no longer a receptor and the proposed abstraction of groundwater at the Industrial Area does not pose a risk of derogating this borehole. In the absence of existing boreholes in the area, groundwater in the sand aquifer is of moderate sensitivity and the significance of potential impact is **Insignificant**. However, if the borehole becomes functional in the future, additional mitigation measures will be identified if required.

9.8.8.2.4 Groundwater level and flow – Bugungu Airstrip

During Year 1, the airstrip at Bugungu will be extended. Water for use in the works will be sourced from a new borehole drilled on the site. A maximum abstraction rate of 25 m^3/day is required with the demand continuing for approximately one year. There are no existing boreholes in the vicinity of the airstrip and hence there are no adverse impacts predicted for the new abstraction. The potential impacts can be classified as **Insignificant.**

9.8.8.2.5 Groundwater level and flow – Nile Ferry Crossing

As part of the construction of the Nile Ferry Crossing, jetties will be constructed on both banks of the Victoria Nile. Details of the jetties are provided in ***Chapter 4: Project Description and Alternatives***. It is proposed that the jetties are formed on piled foundations driven into the bed of the river. The piles will form a local low permeability barrier to groundwater flowing to the river and cause a local change in the direction of groundwater flow. However, it is considered that the impact on groundwater level and flow will be negligible and that no mitigation measures are required. There are no existing water supply boreholes within 1 km of crossing facilities on the northern and southern banks of the Nile and in accordance with Table 9-15, groundwater in the sand aquifer is of moderate sensitivity. The potential impact of the construction of the jetties on groundwater level and flow is **Insignificant**.

9.8.8.2.6 Groundwater level and flow - Water Supply boreholes

A number of boreholes will be drilled in this phase of the Project to provide a source of water for the Project activities. The assessment of the impact of the additional groundwater abstraction in Section 9.8.7.1 shows that the proposed abstraction will not significantly affect regional groundwater resources and a review of the anticipated impacts of the additional abstraction shows that there will be no significant impacts on existing water supply boreholes. The sensitivity of the sand aquifer and the boreholes is high. However, as no adverse impacts are predicted from the additional groundwater abstraction, the potential impact is considered **Insignificant.**

9.8.8.2.7 Groundwater quality -Well Pads

Other than the site clearance and preliminary construction works for the well pads and the drilling of the water supply borehole at each well pad, no other activities will take place at the well pads during this phase of the Project which pose a risk to groundwater quality. The potential impacts can be classified as **Insignificant.**

9.8.8.2.8 Groundwater quality - Camps and Masindi Vehicle Check Point

The potentially polluting activities associated with the camps and the Masindi Vehicle Check Point are similar to those for the well pads, principally related to the storage and use of fuels and chemicals. In respect of groundwater quality impacts, the water supply boreholes for the camps are themselves receptors of a high sensitivity. At the Bugungu and Buliisa camps, it is anticipated that the groundwater level is at a significant depth, in excess of 30 m (Figure 9-9 and Figure 9-11), which provides an opportunity for attenuation for any contaminants percolating from the surface of the site. At the Tangi site, the groundwater level is shallower at approximately 9 m and hence there is a reduced opportunity for attenuation of any contaminants.

In respect of groundwater quality impacts, the water supply borehole for the Masindi Vehicle Check Point is a receptor of high sensitivity. It is likely that the groundwater level at the Masindi Vehicle Check Point is at depth, which provides an opportunity for the attenuation of any contaminants percolating from the surface. There is currently limited information on the groundwater conditions at the Masindi Vehicle Check Point, although it is recommended that ongoing FEED Water Abstraction Feasibility Study will include gathering more information on the groundwater conditions for the Masindi Vehicle Check Point location.

Implementation of embedded mitigation measures outlined in ***Chapter 4: Project Description and Alternatives*** and in Table 9-19 will minimise the uncontrolled discharge of contaminants to the underlying groundwater, thereby minimising the risk to the groundwater and the camp water supply boreholes. Monitoring of site activities for potential impacts will allow for timely maintenance, remediation and restoration to minimise potential direct and indirect impacts on the underlying groundwater. The magnitude of the impact is therefore classed as being negligible/low and hence the significance of the potential impact **Low** to **Moderate Adverse**, depending on the relationship between the borehole location and the location of potential contaminants.

The existing Bugungu, Buliisa and Tangi camps have operating waste water treatment plants, which have sufficient capacity to process and treat waste water generated during the Site Preparation and Enabling Works Phase. Waste water will be transferred by tanker from other Project areas to the closest plant for processing and discharge in line with national requirements and the site licence.

Sewage effluent from the camps will be directed through the treatment plants, if required prior to discharge to subsurface soakaway. The sewage treatment plants will receive black waters from other elements of the Project for treatment prior to disposal. The effluent discharge areas will be located as remote as possible from the locations of the domestic water supply borehole(s) and consideration shall be given to the ground conditions with respect to suitability and design of the soakaway system. All discharges will be permitted and will comply with the waste water quality criteria in Table 9-3 and Table 9-4. A programme of regular water quality monitoring of the effluent discharges will be implemented and will form part of the Environmental Monitoring Plan. The thick unsaturated zone beneath the soakaway areas provide conditions for the attenuation of the effluent such that there should be no adverse impact on groundwater quality in the sand aquifer or on the site domestic water supply borehole(s). Potential impacts on the domestic water supply boreholes will be **Insignificant** to **Low Adverse**, depending on the proximity of the boreholes to sources of potential contamination including the treated sewage effluent soakaway areas.

With the implementation of the embedded mitigation measures designed to minimise the release of contaminants, the magnitude of the impact is classed as being negligible/low and hence the significance of the potential impact **Insignificant** to **Moderate Adverse**, depending on the relationship between the domestic water supply borehole location and the location of potential contaminants and discharges.

9.8.8.2.9 Groundwater quality - Industrial Area

The development of the Industrial Area/CPF includes the establishment of a temporary construction camp, which will be supplied by an on-site borehole(s), which are of high sensitivity. For this phase of the development, the main activities at the Industrial Area will be related to enabling earthworks although concrete production also will be carried out on the site.

A recent ground investigation carried out in this area has shown that the groundwater beneath the site is at depth at approximately 42 m bgl, providing a substantial unsaturated zone for the attenuation of any contaminants percolating to the groundwater table. It is likely that the ground conditions of a mixture of sand, silt and clay also provide conditions conducive to the attenuation of any contaminants.

For this phase of the Project, the potentially polluting activities in the Industrial Area are similar to those already assessed for the camps, such as the storage and use of fuels and chemicals and sewage effluent disposal, with the on-site water supply borehole(s) being the principal receptor of high sensitivity. With the implementation of the embedded mitigation measures, a negligible impact is predicted and the significance of the potential impact is classed as being of **Insignificant** to **Low Adverse.** The actual significance depends on the relationship between the borehole location(s) and the location of potential contaminants**.**

9.8.8.2.10 Groundwater quality – Bugungu airstrip

The main receptor at Bugungu airstrip to sources of contamination is the new domestic water supply borehole on the site. The potentially polluting activities at the Bugungu are similar to those for the well pads, principally related to the storage and use of fuels. Provided the embedded mitigation measures are implemented to control the potential escape of contaminants, a negligible impact is predicted and it is considered that the significance of the potential impact is classed as being **Insignificant.**

9.8.8.2.11 Groundwater quality – Victoria Nile Ferry Crossing

The construction works for the Victoria Nile Ferry Crossing pose a negligible risk to groundwater quality. The potentially polluting activities are similar to those for other activities, principally related to the storage and use of fuels and chemicals. In addition the use of piled foundations to form the two jetties, poses a minor risk of the escape of cement, subject to the piling method used. A minor release of cement into the groundwater or the adjacent Victoria Nile would have a negligible impact on groundwater quality. The significance of the potential impact is **Insignificant.**

9.8.8.2.12 Groundwater quality – Water Supply Boreholes

The boreholes drilled for this phase of the Project for domestic water supply in the Industrial Area, at the camps and at the Masindi Vehicle Check Point are receptors of high sensitivity. Potential impacts to water quality are associated with similar operations to those previously assessed for these elements of the Project. With the implementation of the embedded mitigation measures designed to minimise the release of contaminants, the magnitude of the impact is classed as being negligible/low and hence the significance of the impacts are **Low** to **Moderate Adverse**, depending on the relationship between the domestic water supply borehole location and the location of potential contaminants and discharges.

9.8.8.2.13 Human Health

Impacts to water quality from the release of contaminated materials (solid and liquid) to soils that may leach into the groundwater potentially also impact on the health of domestic water users through the abstraction and use of untreated, contaminated water.

The sensitivity of receptors for potable water is summarised in Table 9-15 and the magnitude of impacts is discussed in Table 9-17. The sensitivity of domestic, potable water receptors is primarily a function of distance, where receptors within 1 km of a source of contaminated groundwater would be of high sensitivity and those beyond 1 km would be of low sensitivity. The water supply boreholes drilled on the sites for domestic use are of high sensitivity.

The magnitude of a potential impact to human health is similar to that for groundwater quality and is classified in relation to the Ugandan potable water quality standards; where a high impact magnitude would be associated with water quality having contaminants in exceedance of the Ugandan potable water quality standards. Impact to groundwater with contamination levels below the Ugandan potable water quality standards would be considered to have a low magnitude. In the unlikely event of pollution of groundwater supporting community potable water supply boreholes rendering the water quality unacceptable for continued use, the potential impact significance would be **Moderate Adverse,** due to a pollutant linkage being present between contaminated groundwater and humans. For less significant contamination levels, the potential impact significance would be **Low Adverse.**

9.8.8.3 Additional Mitigation and Enhancement

Chapter 4: Project Description and Alternatives outlines the embedded mitigation measures which will be implemented to minimise potential adverse impacts on groundwater quality. In order to further reduce any potential impacts on the groundwater conditions, including the groundwater quality of existing and new potable supply boreholes, it is considered that the additional mitigation measures outlined in Table 9-22 should be implemented.

Table 9-22: Additional Mitigation Measures

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
GW.1	Majority of coating and painting activities shall be done at the Construction Support Base in dedicated buildings	X	X		
GW.2	On site painting and coating shall be limited to touch up and roller application	X	X		
GW.3	Implementing a **Grievance Management Procedure**, to allow recording and follow up of any complaints related to Project activities, in a timely manner	X	X	X	X
GW.4	Regular inspection, servicing and maintenance of vehicles and plant to ensure they are operating as per manufacture's specification. Use manufacturer approved parts to minimise potentially serious accidents caused by equipment malfunction or premature failure	X	X	X	X
GW.5	Vehicle/equipment maintenance should only be done in designated areas	X	X	X	X
GW.6	Allow only trained and accredited (as required) personnel in the use of machines	X	X	X	X
GW.7	An **Environmental Monitoring Programme** to be established. It shall include a comprehensive groundwater quality and level monitoring networks to ensure that the site condition is monitored throughout each project phase. The location of groundwater monitoring points and criteria for monitoring shall be selected based on receptor sensitivity and impact magnitude	X	X	X	X
GW.8	Educate workers (as part of training provided) about the potential for environmental contamination and communicate expectation that suspected areas of potential contamination should be reported	X	X	X	X
GW.9	Develop and implement a **Spill Prevention Plan**, incorporating secondary containment as far as practicable for liquids contained on site	X	X	X	X
GW.10	An **Oil Spill Contingency Plan** to be established. This will define notification procedure, response strategy, means, and post-spill actions such as clean-up, monitoring, etc. in the event of uncontrolled/accidental discharge		X	X	
GW.11	Plan site layouts so storage and refuelling areas are located away from the nearest ground and surface water receptors, as far as is practicable	X	X	X	X
GW.12	Remove contaminated soils that result from recent spills from work site for storage and subsequent treatment and/or disposal at an appropriate licensed facility	X	X	X	X
GW.13	Ensure spill response equipment (including sampling and personal protective equipment) is readily available on site to contain and clean any spillages as soon as reasonably practicable after the event	X	X	X	X
GW.14	Undertake regular site inspections and audits, including chemical storage tanks to identify early signs of failure	X	X	X	X
GW.15	Abstraction and discharge permits will be obtained, as required	X	X	X	X

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
GW.16	Ensuring compliance to the abstraction and discharge limits permitted. Records for the abstraction and discharge to be maintained	X	X	X	X
GW.17	Implement efficient water use by sensitising workers (as part of training) about the importance of efficient water use, adopting suitable water conservation techniques such as water re-use measures and training all contractors working on the Project to implement working methods that control water consumption and ensure water is used efficiently during the Project life	X	X	X	X
GW.18	The **Environment Monitoring Programme** will draw on the results of other ongoing studies and will include: 1. review of the suitability of existing water quality baseline information and whether there is need to update it; 2. establishment of water monitoring in the Project Area and implementation of an 'early warning' system when the concentration of certain pollutants rises above a threshold value; and 3. assessment of the effectiveness and success of water conservation measures.	X	X	X	X
GW.19	Testing of new abstraction boreholes. For all new groundwater abstraction boreholes, it is recommended that pumping tests are undertaken to provide site-specific hydrogeological properties of the sand aquifer and refine distance-drawdown estimates. If necessary, the impact assessment on existing water supply boreholes in the area should be repeated to identify the need for any additional mitigation	X	X		
GW.20	Drilling fluids are to be stored in tanks. Drilling fluids will not be stored in below ground pits		X		
GW.21	Have adequate sumps and drainage around construction areas which are subject of possible pollution to capture spills	X	X		X
GW.22	Design, management and monitoring of hydrotest carried out in line with the appropriate Hydrotest Specification for Pipeline hydrotesting		X		
GW.23	Halt hydro-testing if leakage is detected and remediate as far as practicable any pollution of soil or water		X		
GW.24	Before decommissioning, a **Decommissioning Management Plan** will be prepared and agreed with NEMA and other relevant agencies prior to the commencement of any on-site works. It will include details on the methods and activities associated with the decommissioning of the infrastructure, including the transportation and final disposal or re-use strategy for Project components and wastes. Completion criteria will be detailed in the management plans				X
GW.25	Prior to decommissioning, an intrusive ground investigation will be carried out as deemed necessary based on historical site data and monitoring data done throughout the life of the field				X

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
GW.26	Construction techniques will allow unimpeded shallow groundwater and surface water flow where they have to cross seasonal watercourses (for example between JBR-01 & JBR-10/Nile crossing; JBR-03 & JBR-04; around JBR-09; between JBR-08 and JBR-09), through use of culverts and permeable layers, avoiding compaction of soils	X	X		X
GW.27	Pipeline trenches will be designed to ensure that they do not become preferential flow paths for groundwater, particularly where they cross seasonal wetland areas or terrain, which comprises catchment for wallows or waterholes. This could comprise placement of impermeable backfill (clay or similar) at certain locations within the trench to prevent lateral movement of water within the pipeline alignment		X		

9.8.8.4 Residual Impacts - Site Preparation and Enabling Works

A summary of the identified residual impacts during the Site Preparation and Enabling Works phase is presented below. There are a number of instances where a residual impact significance of **Insignificant** to **Low Adverse** is predicted. For the purpose of the assessment of residual impacts, a conservative approach has been adopted and a residual impact of **Low Adverse** has been assumed.

9.8.8.4.1 Groundwater level and flow

The potential impacts for groundwater level and flow have been identified as Insignificant for all Project components, consequently the residual impacts are also classed as **Insignificant.**

The additional mitigation measure provided by the FEED Water Abstraction Feasibility Study will confirm whether there are sufficient groundwater reserves to allow extraction of the required amount of water, without having a significant effect on any nearby boreholes

9.8.8.4.2 Groundwater quality – Well Pads, Bugungu Airstrip and Victoria Nile Ferry Crossing

The potential impacts for groundwater quality have been identified as Insignificant for well pads, Bugungu Airstrip and Victoria Nile Ferry Crossing, consequently the residual impacts are also classed as **Insignificant.**

9.8.8.4.3 Groundwater quality – Camps and Masindi Vehicle Check Point

The domestic water supply boreholes at the camps and at the check point are sources of high sensitivity. With the implementation of the embedded measures to protect groundwater quality and additional mitigation measures, including suitable locations for effluent discharges, it is considered that residual impacts on the potable supply boreholes will be **Insignificant** to **Low Adverse**, depending on the proximity of the boreholes to sources of potential contamination.

9.8.8.4.4 Groundwater Quality – Industrial Area

With the implementation of the embedded and additional mitigation measures to protect groundwater quality, including regular monitoring of the water quality of the water supply boreholes, it is considered that construction of the Industrial Area poses no significant residual impact on the quality of groundwater in the unconsolidated sand aquifer, resulting in an **Insignificant** impact. It is also considered that residual impacts on the new supply boreholes in the Industrial Area will be **Insignificant** to **Low Adverse**, depending on the proximity of the boreholes to sources of potential contamination.

9.8.8.4.5 Water Supply Boreholes

Impacts on groundwater level and flow and on groundwater quality of the water supply boreholes drilled for the Project are identical to those for the camps. With the implementation of the embedded and additional mitigation measures designed to minimise the release of contaminants, the significance of the impact is **Insignificant** to **Low Adverse**, depending on the relationship between the water supply borehole location and the location of potential contaminants and discharges.

9.8.8.4.6 Human Health

Based on the implementation of the additional mitigation measures identified in Table 9-22, the residual impacts to human health, in particular to the water supply boreholes drilled on the sites for domestic use, have been classified as being of **Insignificant** to **Low Adverse** significance.

A summary of the potential impacts of the activities associated with the Site Preparation and Enabling Works phase of the Project on Hydrogeology, pre and post-mitigation is provided in Table 9-23 to Table 9-25.

Table 9-23: Site Preparation and Enabling Works: Residual Impacts on Groundwater Level and Flow

Project Component	Well Pads			Camps and Masindi Vehicle Check Point			Industrial Area			Bugungu Airstrip			Victoria Nile Ferry Crossing			Project Water Supply Boreholes		
Groundwater level and flow	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	N	H	**I**	N	M	**I**	N	M	**I**	N	M	**I**	N	M	**I**	N	H	**I**
Residual	N	H	**I**	N	M	**I**	N	M	**I**	N	M	**I**	N	M	**I**	N	H	**I**

Note: H is High, M is Moderate, L is Low, N is Negligible and I is Insignificant

Table 9-24: Site Preparation and Enabling Works: Residual Impacts on Groundwater Quality

Project Component	Well Pads			Camps and Masindi Vehicle Check Point			Industrial Area			Bugungu Airstrip			Victoria Nile Ferry Crossing			Project Water Supply Boreholes		
Groundwater quality	**Magnitude**	**Sensitivity**	**Magnitude**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	N	H	**I**	L	H	**M**	N	H	**L**	N	M	**I**	N	M	**I**	L	H	**M**
Residual	N	H	**I**	N	H	**L**	N	H	**L**	N	M	**I**	N	M	**I**	N	H	**L**

Note: H is High, M is Moderate, L is Low, N is Negligible and I is Insignificant

Table 9-25: Site Preparation and Enabling Works: Residual Impacts on Groundwater Level, Flow and Quality - Human Health

Project Component	Well Pads			Camps and Masindi Vehicle Check Point			Industrial Area			Bugungu Airstrip			Victoria Nile Ferry Crossing			Project Water Supply Boreholes		
Human Health	**Magnitude**	**Sensitivity**	**Magnitude**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	L	H	**M**	L	H	**M**	L	H	**M**	L	M	**L**	L	M	**L**	L	H	**M**
Residual	N	H	**I**	N	H	**L**	N	H	**L**	N	M	**I**	N	M	**I**	N	H	**L**

Note: H is High, M is Moderate, L is Low, N is Negligible and I is Insignificant

9.8.9 Assessment of Impacts: Construction and Pre-Commissioning

9.8.9.1 Introduction

The main elements of this stage of the Project which potentially could impact on groundwater are listed in Table 9-14. Many are similar to those already considered for the Site Preparation and Enabling Works phase. There is an overlap of several activities between the Site Preparation and Enabling Works and the Construction and Pre-Commissioning Phases regarding groundwater as shown in ***Chapter 4: Project Description and Alternatives***. The overlap will occur between Year 2 and Year 5 as the construction of the access roads to well pads and well pad construction initiated during the Site Preparation and Enabling Works phase continues into the Construction and Pre-Commissioning Phase. The requirement for groundwater supplies is highest in Year 2 decreasing thereafter as the amount of water required decreases. There is a significant reduction in the volume of groundwater required for the remainder of this phase of the Project as the Lake Albert water abstraction facility will have been commissioned and will provide the majority of the water requirements for the Project. The Water Abstraction System will be installed to provide water for the Commissioning and Operations Phase of the Project, including for re-injection, potable and firewater uses. If the FEED Water Abstraction Feasibility study confirms that groundwater water resources in the Project Area are not sufficient, then water will be temporary abstracted from Lake Albert.

9.8.9.2 Potential Impacts – Construction and Pre-Commissioning

9.8.9.2.1 Groundwater Resources

The overall impact of groundwater abstraction for the Project on regional groundwater resources has been addressed in Section 9.8.7.1 and shown to be negligible for the maximum rates of groundwater abstraction. For this phase of the Project, groundwater abstraction will reduce from approximately 2,506 m^3/day in Year 3 to 682 m^3/day by Year 8. The majority of this reduction results from the absence of a major groundwater requirement in the Industrial Area. The requirement for a water supply at the Masindi Vehicle Check Point will have ceased by Year 6. Accordingly, in respect of regional groundwater resources, impacts will be less than those during the Site Preparation and Enabling Works phase of the Project, as the volume of groundwater abstracted will be substantially lower. The significance of the potential impact on regional groundwater resources will remain **Insignificant**.

9.8.9.2.2 Groundwater level and flow – Well Pads

Table 9-18 provides an estimate of the groundwater requirement for the well pads during this phase of the Project, which is assumed to continue for seven years. It is projected that approximately 37 m^3/day of water will be required at each well pad during well drilling.

Based on the available information summarised in Table 9-21, existing boreholes have been identified within 1 km of seven of the 10 well pads in the North Nile area (JBR01-JBR10). In the South Nile area, existing boreholes have been identified within 1 km of 13 of the 24 well pad locations. In both the North and South Nile areas, none of the boreholes are within the 1 m drawdown zone from the well pad abstraction boreholes. Groundwater in the sand aquifer is designated as being of high sensitivity in accordance with Table 9-15.

The 1 m drawdown trigger is estimated at a distance of 10 m from the well pad boreholes. As there are no existing water supply boreholes this close to the water supply boreholes at any of the well pads, there are no existing water supply sources at risk of derogation from the proposed groundwater abstraction at the well pads. The potential impact of the additional abstraction on existing groundwater supply boreholes is considered to be **Insignificant**.

9.8.9.2.3 Groundwater level and flow – Camps and Masindi Vehicle Check Point

The abstraction of water from boreholes at the camps and at the Masindi Vehicle Check Point will be similar to that for the Site Preparation and Enabling Works phase. There will be no additional impacts on groundwater level and flow and hence the potential impact remains **Insignificant**.

9.8.9.2.4 Groundwater level and flow – Industrial area

Domestic water supply at the Industrial Area/CPF will continue to be sourced from on-site boreholes which were drilled and operational during the previous phase of the Project. However, for this phase of the Project the majority of the water used in the Industrial Area/CPF will be sourced from the Lake Albert water abstraction system, which will be commissioned during this phase of the Project. As the volume of groundwater abstraction at the Industrial Area/CPF will reduce significantly during construction from approximately 1,520 m^3/day to approximately 390 m^3/day, any impacts will be substantially less than those predicted for the Site Preparation and Enabling Works phase. In the Site Preparation and Enabling Works phase, the significance of the impact on groundwater level and flow was classed as insignificant due to the absence of any existing water supply borehole in close proximity. Accordingly, it is considered that potential impacts on groundwater level and flow from the Construction and Pre-Commissioning phase would remain **Insignificant**.

9.8.9.2.5 Groundwater level and flow – Production and Injection Network

The pipelines for the production and injection network will be installed in trenches typically at depths of 0.8 m to 2 m. Other than at the crossing for the Victoria Nile, there will be a significant thickness of unsaturated ground below the pipelines. Installation of the majority of the pipelines will be significantly above the groundwater level. As a result, there will be no impact on the groundwater level and the impact will be **Insignificant**.

9.8.9.2.6 Groundwater level and flow – HDD crossing of Victoria Nile

In order to deliver product from the wells north of the Victoria Nile to the CPF, a pipeline crossing will be constructed below the river at a depth of between 15 m and 20 m below the river bed. Three crossings will be formed using a HDD technique, two of each will be of 30” diameter and the third one of 9” diameter, one containing the production pipeline, one the water injection pipeline and the other electrical and fibre optic cabling. Although it is likely that the groundwater level in the sand aquifer is shallow on both banks of the Victoria Nile, no dewatering of the aquifer is required for the pipeline crossing.

The majority of the length of the crossing will be below the groundwater level in the sand aquifer. The pipelines will form low permeability barriers to groundwater flow. However, as sand is present above and below the pipelines, it is considered that these will not significantly disturb groundwater flow and will not change the groundwater level. Groundwater in the sand aquifer is of moderate sensitivity in this situation and only a negligible impact magnitude is predicted. It is considered that the significance of the potential impact on groundwater level and flow of the three pipelines will be **Insignificant**.

9.8.9.2.7 Groundwater quality

Impacts of this phase of the Project on groundwater quality are similar to those assessed for the previous phase as the potential contaminant sources are very similar. The only additional sources of potential contamination are associated with the construction of the crossing below the Victoria Nile, testing of the pipelines and the commissioning of various operations in the Industrial Area. The results of the assessment for the previous phase are provided in Section 9.8.8.2. Major non routine events are considered within ***Chapter 20: Unplanned Events***.

9.8.9.2.8 Groundwater quality – Well Pads

Drilling operations at the well pads pose a potential risk to groundwater quality in the underlying unconsolidated sand aquifer and to existing water supply boreholes. Spillages and leakage of fuel oils and chemicals stored on the site; and from vehicle and plant usage and from drilling muds and drilling returns pose a potential risk to the quality of the groundwater in the underlying aquifer. Embedded mitigation measures are in place to minimise the impacts of such incidents. A summary list is provided in Table 9-19 and a full list is provided in ***Chapter 4: Project Description and Alternatives***. All of these measures are designed to disrupt or break the contaminant pathway between the contaminant source and the groundwater.

The groundwater in the underlying aquifer is of moderate sensitivity, in the absence of potable supply boreholes within 1 km of the well pads, or of high sensitivity, where potable supply boreholes are present within this radius. Water feature surveys around the well pads where well drilling will be undertaken during this phase of the Project have identified existing potable supply boreholes within 1 km at 20 of the well pads as shown in Table 9-21. The water supply boreholes drilled at the well pads to facilitate the well drilling will be used as a source of domestic water supply and form a receptor of high sensitivity.

Measures at the well pads to control the escape of potential contaminants during oil well drilling will minimise the uncontrolled discharges of contaminated water and drilling muds, thereby reducing the potential impact to the underlying groundwater quality and to the scheme water supply borehole at each well pad. These measures would ensure that the significance of the potential impact on groundwater quality would be **Insignificant**.

There is currently limited information on the groundwater conditions around the well pads. As part of the abstraction borehole installation, pumping tests will be carried out on all new abstraction boreholes to confirm the local aquifer characteristics and the depth of groundwater, which plays an important role in the assessment of the vulnerability of the aquifer to pollution.

The oil production wells will be lined with solid lining, below which the wells will be screened, as shown in Figure 4-22 of ***Chapter 4: Project Description and Alternatives***. Other sections of solid lining will be placed to depths of approximately 30 m and 150 m. These will be grouted in place and will seal off the sand aquifer from the oil drilling operations. This well construction will ensure that the risk of cross contamination of the sand aquifer will be prevented. Accordingly, the risk to the groundwater quality in the upper sand aquifer from oil well drilling operations is considered negligible and the potential impact on groundwater quality is **Insignificant**.

In addition, once the well pads have been completed, a drainage scheme based on the Sustainable Drainage Strategy (SuDS) will be installed for use during the construction and operational phases. Drainage from the well pad will be conveyed to a gravel-filled trench, which is connected to a soakaway with filter drains from where water will infiltrate into the underlying sand aquifer. The gravel trench will provide a facility to collect and allow removal of trace contaminants (suspended solids, hydrocarbons) prior to discharge from the site. In the event of contaminated drainage entering the SuDS system, the material will be excavated and removed off-site for treatment at the CPF or to a landfill for disposal. Clean gravel will be replaced in the trench. In order to monitor the discharge of site drainage and runoff, groundwater monitoring boreholes will be installed at appropriate locations.

Accordingly, it is considered that the proposed SuDS system and regular groundwater quality monitoring will ensure that risks to groundwater in the vicinity of the well pads are minimised. The groundwater in the aquifer is of moderate sensitivity and it is considered that any impact on groundwater quality will be negligible and the potential impact is **Insignificant**.

9.8.9.2.9 Groundwater quality – Camps and Masindi Vehicle Check Point

The potentially polluting activities associated with the camps and the Masindi Vehicle Check Point are similar to those for the previous phase of the Project, principally related to the storage and use of fuels and chemicals and the discharge of sewage effluent from the sites.

With the implementation of embedded mitigation and regular water quality monitoring of the effluent discharges as part of the Environmental Monitoring Plan, potential impacts on the domestic water supply boreholes will be **Low** to **Moderate Adverse**, depending on the proximity of the boreholes to sources of potential contamination including the treated sewage effluent soakaway areas.

9.8.9.2.10 Groundwater quality - Industrial Area/CPF

The principal receptors to sources of contamination in the Industrial Area/CPF are the on-site borehole(s) drilled for domestic water supply as part of early phase of the Project. Based on currently available information, there are no existing abstraction boreholes in the vicinity of the Industrial Area. For this phase of the Project, the potentially impacting activities in the Industrial Area are similar to those already assessed for the well pads and camps with the on-site domestic water supply borehole(s) being the principal receptor of high sensitivity. As it is possible that these boreholes will be in close proximity to the pollutant sources, there is a plausible risk to the groundwater quality and to the boreholes. With the implementation of the embedded mitigation measures the significance of the potential impact is classed as being **Moderate Adverse**.

9.8.9.2.11 Groundwater quality – Production and Injection Network

During this phase of the Project, the production and injection network will be constructed and tested for its integrity prior to use to convey product from the oil production wells and injection water back to the well pads. Testing of the pipelines will be carried out using water treated with chemicals. This water will be re-used wherever possible. It is assumed that no testing water will be discharged to the environment. Following satisfactory testing of each pipeline, the pipelines will be filled with water to preserve the conditions prior to operations. All testing and preservation water will be directed to the CPF and then by the pipelines to the well pads for re-injection. As there is no discharge of the testing water to groundwater in the sand aquifer, the potential impact of these operations are considered **Insignificant**.

9.8.9.2.12 Groundwater Quality – HDD crossing of Victoria Nile

The proposed HDD beneath the Victoria Nile will be carried out in accordance with the details in ***Chapter 4: Project Description and Alternatives***. To minimise the risk of collapse of the boreholes, drilling will be carried out using a water-based bentonite mud flush which will be maintained under pressure to counteract the potential for borehole collapse without significant loss of flush into the surrounding strata.

It is likely that there will be a negligible loss of drilling mud into the surrounding strata which will cause a local reduction in the permeability of the material. The bentonite mud flush will have a high pH typically above pH10 in comparison to the background pH of the groundwater of approximately 6 to 7.5. It is considered that the impact on groundwater quality of the HDD below the Victoria Nile will be negligible and that the significance of the potential impact on groundwater will be **Insignificant.**

The potential and significance of unplanned events during the HDD is discussed in ***Chapter 20: Unplanned Events***.

9.8.9.2.13 Groundwater Quality – Water Supply Boreholes

The polluting activities which pose a potential risk to the quality of groundwater abstracted by the on-site domestic water supply boreholes are similar to those considered above, principally related to the storage and use of fuels and chemicals and the discharge of sewage effluent from the sites. As it is possible that these boreholes will be in close proximity to the pollutant sources, there is a plausible risk to the groundwater quality and to the boreholes. With the implementation of the embedded mitigation measures the significance of the potential impact is classed as being **Low** to **Moderate Adverse.**

9.8.9.2.14 Human Health

The potential impacts to human health would be similar to that described in Section 9.8.8.2.13 with the additional potential impact on the domestic water supply wells at the well pads and in the Industrial Area from the Project activities, which pose a plausible risk to potable groundwater. With the implementation of the standard embedded measures the significance of the potential impact is considered to be **Low** to **Moderate Adverse.**

9.8.9.3 Additional Mitigation and Enhancement

Chapter 4: Project Description and Alternatives outlines the embedded mitigation measures which will be implemented to minimise potential adverse impacts on groundwater flow and quality. The additional mitigation measures required to manage potential impacts on groundwater level and quality during the Construction and Pre-Commissioning phase are outlined in Table 9-22.

9.8.9.4 Residual Impacts - Construction and Pre-Commissioning

A summary of the identified residual impacts during the Construction and Pre-Commissioning phase is presented below. There are instances where a residual impact significance of **Insignificant** to **Low Adverse** is predicted. For the purpose of the assessment of residual impacts, a conservative approach has been adopted and a residual impact of **Low Adverse** has been assumed.

9.8.9.4.1 Groundwater level and flow

The potential impacts for groundwater level and flow have been identified as Insignificant for all Project components, consequently the residual impacts are also classed as **Insignificant.**

The additional mitigation measure provided by the FEED Water Abstraction Feasibility Study will confirm whether there are sufficient groundwater reserves to allow extraction of the required amount of water, without having a significant effect on any nearby boreholes

9.8.9.4.2 Groundwater quality – Well Pads, Production and Injection Network and HDD Crossing of Victoria Nile

The potential impacts for groundwater quality have been identified as Insignificant for the well pads, Production and Injection Network and HDD Crossing of Victoria Nile, consequently the residual impacts are also classed as **Insignificant.**

9.8.9.4.3 Groundwater quality – Camps, Masindi Vehicle Check Point, Industrial Area and Project Water Supply Boreholes

The domestic water supply boreholes at the camps, Masindi Vehicle Check Point and Industrial Area are sources of high sensitivity. With the implementation of the embedded measures to protect groundwater quality and additional mitigation measures, including suitable locations for effluent discharges, it is considered that residual impacts on the potable supply boreholes will be **Insignificant** to **Low Adverse**, depending on the proximity of the boreholes to sources of potential contamination.

9.8.9.4.4 Human Health

Based on the implementation of the embedded and additional mitigation measures identified in Table 9-19 and Table 9-22, the residual impacts to human health have been classified as being of **Insignificant** to **Low Adverse** significance.

A summary of the potential impacts of the activities associated with the Construction and Pre-Commissioning phase of the Project on Hydrogeology, pre and post-mitigation is provided in Table 9-26 to Table 9-28.

Table 9-26: Construction and Pre-Commissioning: Residual Impacts on Groundwater Level and Flow

Project Component	Well Pads			Camps and Masindi Vehicle Check Point			Industrial Area			Production and Injection Network			HDD Crossing of the Victoria Nile			Project Water Supply Boreholes		
Groundwater level and flow	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	N	H	**I**	N	M	**I**	N	M	**I**	N	M	**I**	N	M	**I**	N	H	**I**
Residual	N	H	**I**	N	M	**I**	N	M	**I**	N	M	**I**	N	M	**I**	N	H	**I**

Note: H is High, M is Moderate, L is Low, N is Negligible and I is Insignificant

Table 9-27: Construction and Pre-Commissioning: Residual Impacts on Groundwater Quality

Project Component	Well Pads			Camps and Masindi Vehicle Check Point			Industrial Area			Production and Injection Network			HDD Crossing of the Victoria Nile			Project Water Supply Boreholes		
Groundwater quality	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	N	H	**I**	L	H	**M**	L	H	**M**	N	M	**I**	N	M	I	L	H	**M**
Residual	N	H	**I**	N	H	**L**	N	H	**L**	N	M	**I**	N	M	I	N	H	**L**

Note: H is High, M is Moderate, L is Low, N is Negligible and I is Insignificant

Table 9-28: Construction and Pre-Commissioning: Residual Impacts on Groundwater Level, Flow and Quality - Human Health

Project Component	Well Pads			Camps and Masindi Vehicle Check Point			Industrial Area			Production and Injection Network			Project Water Supply Boreholes		
Human Health	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	N	H	**L**	L	H	**M**	L	H	**M**	N	M	**I**	L	H	**M**
Residual	N	H	**I**	N	H	**L**	N	H	**L**	N	M	**I**	N	H	**L**

Note: H is High, M is Moderate, L is Low, N is Negligible and I is Insignificant

9.8.10 Assessment of Impacts: Commissioning and Operations

9.8.10.1 Introduction

The main elements of this stage of the Project which potentially could potentially impact on groundwater are listed in Table 9-14. Many are similar to those already considered for the previous phases of the Project. For this phase of the Project, the principal water supply will be sourced from Lake Albert. Groundwater usage will be restricted to the provision of domestic water supply at the Industrial Area and Tangi camp for potable supply and other ancillary uses and from the water supply boreholes at the well pads for maintenance purposes.

The groundwater requirement for this phase of the Project is estimated as 180,000 m^3/annum (490 m^3/day) during the peak three years and then will decrease and remain at 120,500 m^3/annum (330 m^3/day) for the majority of the phase, less than half the requirement for the Construction and Pre-Commissioning phase. Accordingly, the potential impact on the availability of groundwater resources will be substantially less than for the two preceding phases of the Project.

The major implications to groundwater quality in the unconsolidated aquifer from this phase of the Project are associated with the commencement of operations in the Industrial Area/CPF and with the operation of the pipelines. The main elements of the Industrial Area and the CPF are described in ***Chapter 4: Project Description and Alternatives***. The Industrial Area, including the CPF, covers an area of 307 ha. Following construction, the area will contain several activities which pose a risk to groundwater quality. These comprise principally the CPF, which will process oil from the well pads; bulk storage of processed oil; several diesel generators; oil processing trains and associated pipelines.

9.8.10.2 Potential Impacts – Commissioning and Operations

9.8.10.2.1 Groundwater Resources

A detailed assessment of the potential impacts on regional groundwater resources of groundwater abstractions required for the Project is provided in previous sections of this Chapter and the significance of the impact shown to be Insignificant for the maximum rate of groundwater abstraction. A substantially reduced rate of groundwater abstraction is required for this phase of the Project and no additional groundwater abstraction is required. Accordingly the significance of impacts on groundwater resources remains **Insignificant**.

9.8.10.2.2 Groundwater level and flow

During the Commissioning and Operations phase of the Project, the majority of the water requirement will be sourced from Lake Albert. Groundwater will only be abstracted for use in the remaining camps, principally for domestic use, dust suppression and general camp usage and from the water supply boreholes at the well pads for domestic use and well work-over purposes. The total projected water requirement for this phase of the Project is approximately 330 m^3/day, with a domestic water requirement of approximately 69 m^3/day at the Tangi camp and approximately 52 m^3/day in the Industrial Area. There is no water requirement for the Bugungu camp and the Buliisa camp as both camps will have been decommissioned at the beginning of this phase. The Masindi Vehicle Check Point will also have been closed prior to this phase of the Project and hence will no longer require a groundwater supply. At the well pads, the water requirement will have reduced from 37 m^3/day to 10 m^3/day during workover operations. These are significantly lower abstraction rates than for previously assessed phases of the Project.

An assessment of the impact of abstraction from the camp boreholes on groundwater resources and on adjacent water supply boreholes has been undertaken in previous sections of this Chapter. It has been concluded in the previous assessments that the significance of the abstraction from the camp boreholes on existing water supply boreholes in the area is insignificant.

Previous assessments of the impacts of groundwater abstraction from the boreholes at the well pads for the earlier phases of the Project, has shown that impacts are insignificant. As the rate of abstraction is lower for this phase of the Project, the significance of any potential impact remains **Insignificant**.

9.8.10.2.3 Groundwater quality – Well Pads

The extraction of oil from the wells presents an additional potential source of groundwater contamination to the underlying unconsolidated aquifer. Standard operational procedures at each well pad designed to protect the quality of the underlying groundwater in the event of any leaks from the wells and the delivery pipelines to the CPF will be adopted.

As discussed in Section 9.8.9.2.8, drainage from the hardstanding areas at the well pads will be conveyed to a soakaway as part of a SuDS approach adopted for the well pads. Based on the assessment, it is considered that any impact on groundwater quality during this phase at the well pads will be negligible and the potential impact is **Insignificant.**

The re-injection of process water will be carried out through deep boreholes drilled into the reservoir at the well pads and in the Industrial Area. The boreholes have been designed to isolate the upper unconsolidated sand aquifer by strings of solid lining as shown in ***Chapter 4: Project Description and Alternatives***. The injection of polymer also will be through deep boreholes drilled into the reservoir. The borehole design will prevent process water and polymer entering the freshwater aquifer and the potential impact will be **Insignificant**.

9.8.10.2.4 Groundwater quality – Tangi Camp

The activities at Tangi Camp are similar to those for the previous phase of the Project, principally related to the storage and use of fuels and chemicals and the discharge of sewage effluent from the sites. However, the extent of the activities at the camp will be reduced during this phase of the Project as part of the camp will have been decommissioned.

With the implementation of regular water quality monitoring of the effluent discharges as part of the Environmental Monitoring Plan, potential impacts on the domestic water supply boreholes will remain **Insignificant** to **Low Adverse**, depending on the proximity of the water supply borehole to sources of potential.

9.8.10.2.5 Groundwater quality – Industrial Area

The increase in operations in the Industrial Area/CPF for this phase of the Project poses a risk to groundwater quality in the unconsolidated sand aquifer. Drainage schemes are proposed to isolate potentially contaminated surface water within the CPF and to separate this water from drainage of areas which pose a negligible risk of contamination. No contaminated water will be discharged off-site. The principal receptors are the domestic water supply boreholes on the site, which are of high sensitivity.

As it is possible that these boreholes will be in close proximity to the pollutant sources, there is a plausible risk to the groundwater quality and to the boreholes. With the implementation of the embedded mitigation measures the significance of the potential impact is classed as being **Moderate Adverse.**

9.8.10.2.6 Groundwater quality - Production and Injection Network

Operation of the pipelines is the main additional activity in this phase of the Project which has the potential to impact on groundwater, in particular groundwater quality. The potential impact on groundwater quality from testing of the pipelines has been assessed in Section 9.8.9.2.11. Leaks from the pipelines pose a potential risk to the groundwater quality in the unconsolidated aquifer, particularly where there is an absence of low permeability silt and clay at a shallow depth, allowing contaminants readily to infiltrate to the groundwater. The groundwater in the underlying aquifer is of moderate to high sensitivity depending whether there are existing potable water supply boreholes in close proximity to the pipelines. Potential pipeline failure is considered an Unplanned Event and assessed in ***Chapter 20: Unplanned Events****.* There is a risk of impact to groundwater quality from localised spillages of fuel during maintenance activities on the RoW. The impact magnitude for normal operations is considered to be negligible and the potential impact significance **Insignificant**.

9.8.10.2.7 Groundwater quality - Water Supply Boreholes

The potential impacts on the on-site domestic water supply boreholes are similar to those considered previously for earlier phases of the Project in Section 9.8.9.2.13. As it is possible that these boreholes will be in close proximity to the pollutant sources, there is a plausible risk to the groundwater quality and to the boreholes. With the implementation of the embedded mitigation measures the significance of the potential impact is classed as being **Low** to **Moderate Adverse** depending on the proximity of the boreholes to sources of potential contamination.

9.8.10.2.8 Human Health

The potential impacts to human health would be similar to that described in Section 9.8.9.2.14 with the domestic water supply boreholes being the principal receptors. With the implementation of the standard embedded measures the significance of the potential impact is considered to be **Low** to **Moderate Adverse.**

9.8.10.3 Additional Mitigation and Enhancement

Chapter 4: Project Description and Alternatives outlines the embedded mitigation measures which will be implemented to minimise potential adverse impacts on groundwater flow and quality. The additional mitigation measures identified to manage potential impacts on groundwater level and quality during the Commissioning and Operations phase are outlined in Table 9-22.

9.8.10.4 Residual Impacts – Commissioning and Operations

A summary of the identified residual impacts during the Commissioning and Operations phase is presented below.

9.8.10.4.1 Groundwater level and flow

An assessment of the impacts of groundwater abstraction for earlier phases of the Project has concluded that there are no significant adverse residual impacts on groundwater level or flow. As the volume of groundwater abstracted for this phase of the Project is expected to be lower than for the previous two phases the significance of the residual impact remains **Insignificant**.

9.8.10.4.2 Groundwater quality – Well Pads and Production and Injection Network

The potential impacts for groundwater quality have been identified as Insignificant for the well pads and Production and Injection Network, consequently the residual impacts are also classed as **Insignificant.**

9.8.10.4.3 Groundwater quality – Tangi Camp, Industrial Area and Project Water Supply Boreholes

The domestic water supply boreholes at Tangi Camp and the Industrial Area are sources of high sensitivity. With the implementation of the embedded measures to protect groundwater quality and additional mitigation measures, it is considered that residual impacts on the potable supply boreholes will be **Insignificant** to **Low Adverse**, depending on the proximity of the boreholes to sources of potential contamination.

9.8.10.4.4 Human Health

Based on the implementation of the embedded and the additional mitigation measures identified in Table 9-19 and Table 9-22, the residual impacts to human health have been classified as being of **Insignificant** to **Low Adverse** significance.

A summary of the potential impacts of the activities associated with the Commissioning and Operations phase of the Project on Hydrogeology, pre and post-mitigation is provided in Table 9-29 to Table 9-31.

Table 9-29: Commissioning and Operations: Residual Impacts on Groundwater Level and Flow

Project Component	Well Pads			Tangi Camp			Industrial Area			Production and Injection Network			Project Water Supply Boreholes		
Groundwater level and flow	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	N	H	**I**	N	M	**I**	N	M	**I**	N	M	**I**	N	H	**I**
Residual	N	H	**I**	N	M	**I**	N	M	**I**	N	M	**I**	N	H	**I**

H is High, M is Moderate, L is Low, N is Negligible and I is Insignificant

Table 9-30: Commissioning and Operations: Residual Impacts on Groundwater Quality

Project Component	Well Pads			Tangi Camp			Industrial Area			Production and Injection Network			Project Water Supply Boreholes		
Groundwater quality	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	N	H	**I**	N	H	**L**	L	H	**M**	N	H	**I**	L	H	**M**
Residual	N	H	**I**	N	H	**L**	N	H	**L**	N	H	**I**	N	H	**L**

H is High, M is Moderate, L is Low, N is Negligible and I is Insignificant

Table 9-31: Commissioning and Operations: Residual Impacts on Groundwater Level, Flow and Quality - Human Health

Project Component	Well Pads			Tangi Camp			Industrial Area			Production and Injection Network			Project Water Supply Boreholes		
Human Health	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre- mitigation	N	H	**I**	N	H	**L**	L	H	**M**	N	M	**I**	L	H	**M**
Residual	N	H	**I**	N	H	**L**	N	H	**L**	N	M	**I**	N	H	**L**

H is High, M is Moderate, L is Low, N is Negligible and I is Insignificant

9.8.11 Assessment of Impacts: Decommissioning

9.8.11.1 Introduction

As described in ***Chapter 4: Project Description and Alternatives,*** the expected service lifetime of the Project is 25 years. The decommissioning programme will be developed during the Commissioning and Operations Phase of the Project. Decommissioning activities will be undertaken in accordance with the international and national legislation and regulations prevailing at that time, and in liaison with the relevant regulatory authorities, and will seek to have as little impact on the environment as possible. A review of relevant studies if necessary will be undertaken during the Project operations to confirm that the planned decommissioning activities utilise good industry practices and are the most appropriate to the prevailing circumstances and future land use.

An ESIA may be required before decommissioning commences in order to confirm that the planned activities are the most appropriate to the prevailing circumstances. This will be agreed with Ugandan regulatory authorities responsible at the time. In addition, it is envisaged that the process of developing detailed decommissioning management plans may be staged, initially outlining potential options and studies required for discussion with the regulatory authorities, and finally leading to agreed plans prior to the commencement of decommissioning.

Prior to undertaking decommissioning activities, the Project Proponents will undertake a review of historical monitoring data and incidents on site that might have caused ground and/or groundwater contamination. Project Proponents will also develop a monitoring programme for completion criteria to verify that the sites are being returned to the agreed representative condition. Aspects of the Decommissioning Management Plan to safeguard groundwater resources will include:

- Chemical and hazardous substance management;
- Waste management;
- Soils management; and
- Spill contingency.

The main activities of this phase of the Project which potentially could impact on groundwater are associated with the decommissioning of the well pads, camps, pipelines and the Industrial Area/CPF. Generally it is expected that pipelines will be cleaned, capped and left in situ to prevent disturbing the reinstated habitats; and where the environment assessment identifies it is acceptable, in some locations pipeline sections may be cleaned, reclaimed and re-used.

It is likely that there will be very limited water requirement for this final phase of the Project other than for use at the camps.

9.8.11.2 Potential Impacts - Decommissioning

9.8.11.2.1 Groundwater level and flow

It is envisaged that the decommissioning operations will not require any abstraction of groundwater other than as a source of domestic water supply at the camps. The impact of the groundwater abstraction at the camps has been assessed previously and is shown to be insignificant. As the decommissioning operations will not increase the groundwater requirement, it is concluded that the significance of the potential impact of this phase of the Project on groundwater level and flow remains **Insignificant**.

9.8.11.2.2 Groundwater quality

Potential impacts to groundwater quality would be expected to be similar to those identified during the Construction and Pre-Commissioning phase of the Project. Potential impacts to groundwater quality during this phase are considered to be **Insignificant** to **Moderate Adverse** Significance.

9.8.11.3 Human health

The potential impacts to human health would be expected to be similar to those described in Section 9.8.9.2.14 with the domestic water supply boreholes being the principal receptors. With the implementation of the standard embedded measures the significance of the potential impact is considered to be **Low** to **Moderate Adverse.**

9.8.11.4 Additional Mitigation and Enhancement

Chapter 4: Project Description and Alternatives outlines the embedded mitigation measures which will be implemented to minimise potential adverse impacts on groundwater flow and quality. The additional mitigation measures required to manage potential impacts on groundwater level and quality for the Decommissioning phase are outlined in Table 9-22.

For this phase of the Project, it is likely that groundwater abstraction is only required at the camps. There is potential that the boreholes at the camps may be transferred for use by the local community as a source of potable water supply following completion of decommissioning. This will provide a beneficial impact of the Project.

9.8.11.5 Residual Impacts - Decommissioning

A summary of the identified residual impacts during the decommissioning phase is presented below.

9.8.11.5.1 Groundwater level and flow

An assessment of the impacts of groundwater abstraction for earlier phases of the Project has concluded that residual impacts on groundwater level or flow are Insignificant. As the volume of groundwater abstracted for this phase of the Project is lower than for the previous three phases of the Project, the **Insignificant** residual impact remains valid.

9.8.11.5.2 Groundwater quality

With the embedded mitigation measures to protect groundwater quality and the additional measures outlined above, it is considered that the residual impact significance for groundwater quality is classed as **Insignificant**.

9.8.11.5.3 Human health

Following implementation of embedded and additional mitigation measures, residual impact significance to human health has been classified as **Insignificant**.

9.9 In-Combination Effects

As described in ***Chapter 4: Project Description and Alternatives***, the Project has a number of supporting and associated facilities that are being developed separately (i.e. they are subject to separate permitting processes and separate ESIAs or EIAs). These facilities include:

- Tilenga Feeder Pipeline;
- East Africa Crude Oil Export Pipeline (EACOP);
- Waste management storage and treatment facilities for the Project;
- 132 Kilovolt (kV) Transmission Line from Tilenga CPF to Kabaale Industrial Park; and
- Critical oil roads.

The in-combination impact assessment considers the potential joint impacts of both the Project and the supporting and associated facilities. This is distinct from the Cumulative Impact Assessment (CIA) which consider all defined major developments identified within the Project's AoI (and not just the associated facilities) following a specific methodology which is focussed on priority Valued Environmental and Social Components (VECs) (see ***Chapter 21: Cumulative Impact Assessment***). The approach to the assessment of in-combination impacts is presented in ***Chapter 3: ESIA Methodology*****,** Section 3.3.5.

The EACOP and waste management storage and treatment facilities for the Project; are largely located remote from the Project Area and it is considered that these are at a sufficient distance from the elements of the Project that there are no in-combination impacts in respect of hydrogeology. The Tilenga Feeder Pipeline and critical oil roads are within the Project Area. Impacts to hydrogeology from pipeline and the oil roads would be the same for similar components of the Project. However, activities associated with these facilities are spatially removed from the proposed Project infrastructure and may not coincide with Project related activities; hence there are **no** significant in-combination impacts with respect to hydrogeology. Additionally, the other identified projects would be subject to their own design controls and additional mitigation measures which would be developed to help avoid or minimise any adverse impacts and thus would also help to prevent any in-combination impacts.

The influx of people (induced by the numerous developments as outlined above) into the area may also result in an increased demand for groundwater within the region. At this stage it is not possible to confirm where and what additional water resource will be needed, but it is assumed that the supply will be from groundwater. It is considered likely that any demand will be localised to new population centres. Should these locations be close to any Project water abstraction boreholes, consideration will be given to increased groundwater level monitoring to determine any changes in groundwater level.

9.10 Unplanned Events

There are possible scenarios associated particularly with oil well drilling and scheme operations where adverse impacts on hydrogeology could occur in the event of an unplanned event. An assessment of the impact of unplanned events on the groundwater conditions relevant to the Project is detailed in ***Chapter 20: Unplanned Events***.

9.11 Cumulative Impact Assessment

Chapter 21: Cumulative Impact Assessment provides an assessment of the potential cumulative effects of the Project together with other defined developments in the Project Area of Influence (AoI). The CIA focussed on VECs that were selected on the basis of set criteria including the significance of the effects of the Project, the relationship between the Project and other developments, stakeholder opinions and the status of the VEC (with priority given to those which are of regional concern because they are poor or declining condition). On the basis of the selection process, *Access to Safe Drinking Water Resources* was considered to be a priority VEC and is therefore considered further in the CIA.

9.12 Conclusions

Impact assessment criteria were developed and utilised for assessing the potential impacts to hydrogeology from the Site Preparation and Enabling Works, Construction and Pre-Commissioning,

Commissioning and Operations; and Decommissioning phases of the Project, and include impact magnitude and receptor sensitivity. The assessment of potential impacts has been undertaken by identifying and evaluating a range of activities and scenarios that are likely to occur throughout the four phases of the Project. Impacts to regional groundwater resources, local groundwater level and flow, groundwater quality and human health were assessed, and the significance of impacts was established for the pre-mitigation and post mitigation scenarios. The residual impacts for each phase of the Project after the implementation of mitigation measures are summarised in Table 9-32 and below:

- The maximum groundwater demand of 2,630 m^3/day will be required in Years 1 and 2 prior to the commissioning of the Lake Albert Water Abstraction System, and will reduce substantially during the lifetime of the Project with a required groundwater abstraction rate of only 330 m^3/day by Year 18. The overall impact of groundwater abstraction for the Project on regional groundwater resources has been assessed to be Insignificant for all phases of the Project;
- Abstraction of groundwater for use at the camps, the Masindi Vehicle Check Point, the Industrial Area and the well pads could pose a risk to local groundwater level and flow, particularly where there are existing water supply boreholes in close proximity to the Project elements. Based on an assessment of the hydrogeological characteristics of the sand aquifer, it is concluded that residual impacts on local groundwater resources, including existing water supply boreholes, are Insignificant;
- The domestic water supply boreholes installed at the camps, well pads and in the Industrial Area are the principal receptors to any contamination resulting from Project activities. With the implementation of the embedded and additional mitigation measures including groundwater monitoring, it is concluded that the residual impacts on groundwater quality will be Insignificant to Low Adverse; and
- Impacts on human health from a groundwater point of view relate to derogation of existing domestic water supplies by drying up the source through the additional groundwater abstraction required for the Project, and / or potential contamination of the source as a result of the Project activities. Following implementation of the embedded and additional mitigation measures identified, residual impacts on human health are assessed to be Insignificant to Low Adverse.

Table 9-32: Residual Impacts significance to Groundwater

Potential Impact	Residual Impact Significance			
	Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
Derogation of Regional Groundwater Resources	Insignificant	Insignificant	Insignificant	Insignificant
Impacts to Groundwater Level and Flow	Insignificant	Insignificant	Insignificant	Insignificant
Impacts to Groundwater Quality	Insignificant to Low Adverse	Insignificant to Low Adverse	Insignificant to Low Adverse	Insignificant
Impacts to Human Health	Insignificant to Low Adverse	Insignificant to Low Adverse	Insignificant to Low Adverse	Insignificant

9.13 References

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Ref. 9-2 GoU, 1995, National Environment Act, Chapter 153. National Environment Act, Chapter 153.

Ref. 9-3 GoU, 1999, National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations, 1999 (S.I. No. 4 of 1999).

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Ref. 9-5 Uganda National Bureau of Standards: (UNBS) US EAS 12: 2014, Potable Water – Specification.

Ref. 9-6 Guidelines for Environmental Impact Assessment in Uganda (NEMA 1997) (National Environment Management Authority, 1997).

Ref. 9-7 Environmental Impact Assessment Guidelines for Water Resources Related Projects in Uganda (MWE 2011) (Ministry Water and Environment, 2011).

Ref. 9-8 Operational Waste Management Guidelines for Oil and Gas Operations (NEMA 2012).

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Ref. 9-22 Albertine Rift Development Project Injection Water Supply Study: Groundwater Review (Atkins 2010)

Ref. 9-23 National Irrigation Masterplan for Uganda, 2010-2035. (DWRM, 2011).

Ref. 9-24 Managed Groundwater Development in Uganda: Contribution to the Water Resources Assistance Strategy. 2012.

Ref. 9-25 Block EA-1 Environmental Baseline Study for Block EA-1 in Uganda (AECOM, 2015).

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Ref. 9-27 Nsubuga et al. Water Resources of Uganda: An Assessment and Review. Journal of Water Resource and Protection. 2014. Vol 6. Pp 1297-1315.

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TILENGA PROJECT

10 – Surface Water

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10 Surface Water

10.1 Introduction

This Environmental and Social Impact Assessment (ESIA) chapter presents an assessment of the impacts of the Project on the existing surface water conditions (i.e. surface water quality, resources and flood risk) within the Project Area. It includes a detailed overview of the current surface water resources, wetlands and the natural hydrological environment and the associated baseline conditions which are found within the Project Area and surrounding area. Addressed in the assessment are the potential impacts on the surface water environment associated with the Site Preparation and Enabling Works, Construction and Pre-Commissioning, Commissioning and Operations and Decommissioning phases of the Project. It also identifies mitigation measures required to avoid or minimise potential adverse impacts on the surface water environment.

Surface water is an important socio-economic resource and forms part of the fresh water supply sources in Uganda. As at 2015, about 8% of the total population of Uganda rely on surface water resources to meet their water supply demand (Ref. 10-1). Lake Albert, the Victoria Nile River and the Albert Nile River and a few wetlands, named and unnamed rivers and streams are the surface water bodies within the Project Area and surrounding area (i.e. any area within or outside the Project Area with surface water bodies/watercourses and water features that are likely to be impacted by the proposed Project) hereafter referred to as the Study Area. Primarily, these water bodies are used for irrigation and agriculture; including fisheries, livestock farming and a small proportion for domestic purposes. Surface water is also used for navigation, recreation, tourism and wildlife sectors, and also provides raw water for various industrial activities including, mining, and hydro-electric power generation.

It is planned that surface water will be the primary source of water supply for construction and re-injection purposes and groundwater to be used for other domestic and industrial uses. The primary water source for the initial Site Preparation and Enabling Works phase will be groundwater pending results of the Front-End Engineering Design (FEED) Water Abstraction Study. If the feasibility study does not confirm that sufficient groundwater resources are available, the Project Proponents will investigate a further option for installation of a temporary surface water abstraction station until the permanent Water Abstraction Station is in place (see ***Chapter 4: Project Description and Alternatives***). The purpose of this facility will be to service the water needs for the Site Preparation and Enabling Works; and the Construction and Pre-Commissioning phases until Water Abstraction is functional and water abstraction boreholes are installed. During the Construction and Pre-Commissioning phase water demand will be met by both groundwater and surface water. Until the permanent water abstraction station is operational, surface water will be sourced from the Lake Albert and the Victoria Nile using temporary pumps and tankers. Similarly, during the Commissioning and Operations phase the water demand will be met by both groundwater and surface water from the Lake Albert Water Abstraction station. No surface water abstraction is anticipated during the Decommissioning phase; it is assumed that water requirements will be met by groundwater. Any land use activities that directly or indirectly have an impact on water flow or might have the potential to affect the quality of the surface water bodies in the area can lead to social-economic and environmental challenges. In the context of the proposed Project, surface water is, therefore, a critical component for consideration for this ESIA.

It is also important to consider the existing surface water conditions and how they might influence the scope or design of the development. There may be specific surface water influence on the landscape, for example, flood zones, which will limit the developable area. Development in vulnerable surface water areas could alter the surface water dynamics and may lead to flood risk.

10.2 Scoping

The scoping process identified the potential impacts to surface water bodies that could occur as a result of the construction, operation and decommissioning of the Project. These potential impacts are summarised in Table 10-1. It is worth noting that the Project phasing and identified list of potential impacts have evolved during the completion of this ESIA and consequently build and expand on those potential impacts initially identified during the Scoping phase.

Table 10-1: Potential Hydrological Impacts identified during Scoping

Potential Impact	Potential Cause	Surface Water Receptor	Phase
Potential for changes in surface water flow regimes.	Construction activities leading to the removal of vegetation, compaction of surfaces, removal of natural surface depressions and all Project facilities that will result in new impermeable surfaces.	Rivers, ponds and lakes (including the Victoria Nile River and Lake Albert) and other surface water bodies located within or hydrologically connected to the Project Footprint.	Construction Operation Decommissioning
The potential for erosion as a result of a change in run-off rates and extreme rainfall events.	Construction activities leading to the removal of vegetation, compaction of surfaces, removal of natural surface depressions and all Project facilities that will result in new impermeable surfaces. During the operation of the Project's components.	Rivers, ponds and lakes (including the Victoria Nile River and Lake Albert) and other surface water bodies located within or hydrologically connected to the Project Footprint.	Construction Operation Decommissioning
Potential reduction in the catchment area, which feeds local water resources.	The physical presence of the Project facilities along with the need for collection and treatment of water at specific locations.	Rivers, ponds and lakes (including the Victoria Nile River and Lake Albert) and other surface water bodies located within or hydrologically connected to the Project Footprint.	Construction Operation Decommissioning
Potential for impacts on surface water quality.	Construction activities with the potential to discharge contaminants (e.g. spillage of oils, fuel and chemicals) and process water and foul water (i.e. used water or storm water, discharged to sewers linked to surface water bodies) from operational camps.	Rivers, ponds and lakes (including the Victoria Nile and Lake Albert) and other surface water bodies located within or hydrologically connected to the Project Footprint.	Construction Operation Decommissioning
Potential impacts on watercourses (banks, beds and hydraulic flow).	Construction of Project components adjacent to or crossing a watercourse (including new roads).	Watercourses located within or hydrologically connected to the Project Footprint.	Construction Decommissioning
Potential for increased flooding risk.	Construction, operation and decommissioning activities which require alteration of terrain, removal of vegetation and increased impermeable surfaces. Natural events such as extreme rainfall and climate change.	The Project's facilities and surface water bodies, residential, commercial and agricultural receptors located within or hydrologically connected to the Project Footprint.	Construction Operation Decommissioning

10.3 Legislative Framework

10.3.1 Introduction

All relevant environmental standards prescribed by the National Environment Act Cap 153 (Ref. 10-2) and national regulations shall apply to the Project. From a water resources, quality and flood perspective, the relevant Ugandan national standards take pre-eminence as they are consistent with other stringent international standards. However, in the absence of specific parameters within the Ugandan national standards, other relevant international standards such as the World Health Organisation (WHO), the International Finance Corporation (IFC), Environmental Health and Safety (EHS) standards, United States Environmental Protection Agency (USEPA), whichever is stricter, shall be applied for such specific parameters. This approach has been used throughout this ESIA Chapter in evaluating the surface water baseline data and impact assessment.

10.3.2 National Legislative Framework

There are several national policies, laws and regulations relevant to surface water and applicable to the ESIA of the proposed Project and its environmental aspects. Details of these are presented in ***Chapter 2: Policy, Regulatory and Administrative Framework***.

The following policies and regulations apply to surface water:

- The National Environment Management Policy (NEMP) (1994);
- The National Water Policy (1999);
- National Policy for the Conservation and Management of Wetland Resources (1995);
- The Constitution of the Republic of Uganda, 1995 (as amended);
- The National Environment Act, Cap. 153;
- The Water Act, Cap 152;
- The Environmental Impact Assessment Regulations, 1998; and
- The National Environment (Wetlands, River Banks and Lake Shores Management) Regulations, 2000.

10.3.3 National Standards Related to Surface water

The applicable national standards related to surface water and relevant to the proposed Project and its water resources and environmental aspects are prescribed by the Water Act Cap 152 (Ref. 10-3), Section 107 of the National Environmental Act Cap 153 and include the following:

- Ugandan Natural Potable Water Standard (UPWS) East African Standard (EAS) 12:2014 (Ref. 10-4);
- National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations, S.I. No 5/1999 (Republic of Uganda, 1999) (Ref. 10-5);
- The National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations (1st Revised Draft), 2014 (Ref. 10-6);
- The Water (Waste Discharge) Regulations, 1998; and
- National Environment (Wetlands; River Banks and Lake Shores Management) Regulations, 2000.

10.3.3.1 Potable Water

The Ugandan Natural Potable Water Standard (UPWS) EAS 12:2014 (Ref. 10-6) which is identical with and has been reproduced from the EAS 12:2014 Potable Water — Specification is mostly consistent with other stringent international standards such as the WHO drinking water standard (Table 10-2). The

UPWS EAS 12:2014 includes standards for Natural Potable, Potable and Treated drinking water. From a baseline water quality perspective and for the proposed Project, the stipulated standards for natural potable water (Table 10-2) have been used for the assessment of all potential surface water quality impacts from the Project. The water quality results from surface water samples collected during the various ESIA field surveys campaigns have been compared against the Ugandan Natural Potable Water Standard (UPWS).

Table 10-2: Ugandan Natural Potable Water Standard and WHO Guidelines

Water Quality Parameter	Unit	UPWS (EAS – 12:2014) (Natural Potable Water)	WHO Guidelines (4th Edition 2011)
Metals			
Aluminium (Al)	mg/l	0.2	0.2
Arsenic (As)	mg/l	0.01	0.01
Barium (Ba)	mg/l	0.7	0.7
Uranium (U)	µg/l	-	0.03
Cadmium	mg/l	0.003	1.003
Chromium (Cr)	mg/l	0.05	0.05
Copper (Cu)	mg/l	1	2
Iron (Fe)	mg/l	0.3	-
Mercury (Hg)	mg/l	0.001	0.006
Manganese (Mn)	mg/l	0.1	-
Nickel (Ni)	mg/l	0.02	0.07
Lead (Pb)	mg/l	0.01	0.01
Zinc (Zn)	mg/l	5	-
Mono Aromatic Hydrocarbons			
Benzene	µg/l	10	10
Toluene	µg/l	700	700
Ethylbenzene	µg/l	-	300
Xylenes (sum)	µg/l	500	500
BTEX (sum)	µg/l	-	-
Physical and Chemical Analyses			
pH	mg/l	6.5 – 9.5	-
Conductivity	µS/cm	2500	
Suspended Matter	mg/l	Not detectable	
Inorganic Compounds			
Chloride	mg/l	250	-
Fluoride	mg/l	1.5	1.5
Sulphate	mg/l	400	
Inorganic Compounds			
Ortho-Phosphate (PO_4-P)	mg P/l	2.2	-
Nitrate (NO_3)	mg/l	45	50
Nitrite (NO_2)	mg/l	0.003	3
Miscellaneous Research			
Turbidity	NTU	25	-
Total Coliform	cfu/100ml	Absent	-

(pink) Denotes difference in standards

(blue) Denotes no equivalent EAS value

10.3.3.2 Effluent discharge

The applicable national standards related to the discharge of treated effluent wastewater to surface water bodies and relevant to the Project are also prescribed by the Ugandan Water Act Cap 152 (Ref. 10-3). A summary of the wastewater standards is presented in Table 10-3 (also known as the National Standards for the discharge of effluent or wastewater). This Uganda effluent or wastewater discharge standard is considered to be stringent as it is consistent with other international standards. In 2014, draft legislation was produced to replace the existing regulations. The draft legislation provides delimiting maximum concentrations of physical, chemical and biological parameters for various types of discharges including standards for unspecified effluent discharges (5th Schedule) and sector specific oil and gas exploration and production effluents (8th Schedule). The unspecified effluent discharge standards (5th Schedule) are applicable to wastewater discharges and are presented in Table 10-4 below.

Table 10-3: Ugandan Effluent Discharge Water Standard

Parameter	Standard 1999	Standard (Draft) 2014	Parameter	Standard 1999	Standard (Draft) 2014
1,1,1 - Trichloroethane	3.0 mg/l	3.0 mg/l	Iron	10 mg/l	5.0 mg/l
1,1,2 - Dichloroethyelene	0.2 mg/l	0.2 mg/l	Lead	0.1 mg/l	0.01 mg/l
1,1,2 - Trichloroethane	0.06 mg/l	0.06 mg/l	Magnesium	100 mg/l	-- mg/l
1,2 - Dichloroethane	0.04 mg/l	0.04 mg/l	Manganese	1.0 mg/l	1.0 mg/l
1,3 - Dichloropropene	0.2 mg/l	0.2 mg/l	Mercury, total	0.01 mg/l	0.001 mg/l
Aluminium	0.5 mg/l	0.5 mg/l	Nickel	1.0 mg/l	1.0 mg/l
Ammonia Nitrogen	10 mg/l	5.0 mg/l	Nitrate N	20 mg/l	5.0 mg/l
Arsenic	0.2 mg/l	0.01mg/l	Nitrite N	2.0 mg/l	1.0 mg/l
Barium	10 mg/l	10 mg/l	Nitrogen Total	10 mg/l	10 mg/l
Benzene	0.2 mg/l	Nil	Oil and Grease	10 mg/l	5.0 mg/l
BOD5	50 mg/l	30 mg/l	pH	6.0-8.0	6.0-9.0
Boron	5 mg/l	0.25 mg/l	Phenols	0.2 mg/l	0.02 g/l
Cadmium	0.1 mg/l	0.10 mg/l	Phosphate (total)	10 mg/l	1.0 mg/l
Calcium	100 mg/l	100 mg/l	Phosphate (soluble)	5.0 mg/l	1.0 mg/l
Chloride	500 mg/l	250 mg/l	Selenium	1.0 mg/l	0.02 mg/l
Chlorine	1 mg/l	0.2 mg/l	Silver	0.5 mg/l	1.0 mg/l
Chromium (total)	1 mg/l	1 mg/l	Sulphate	500 mg/l	50 mg/l
Chromium (VI)	0.05 mg/l	0.05 mg/l	Sulphide	1.0 mg/l	1.0 mg/l
Cis 1,2 – Dichloroethylene	-- mg/l	0.4 mg/l	TDS	1200 mg/l	1200 mg/l
Cobalt	-- mg/l	0.1 g/l	Temperature	20-350°C	+/- 3°C of ambient
COD	100 mg/l	60 mg/l	Tetrachloroethylene	0.1 mg/l	0.3 mg/l
Coliforms	10,000 counts/100ml	<400 counts/100ml	Tetrachloromethane	0.02 mg/l	0.02 mg/l
Colour	300 TCU	50 TCU	Tin	5 mg/l	5.0 mg/l
Copper	1.0 mg/l	0.5 mg/l	Total Suspended Solids, TSS	100 mg/l	100 mg/l
Cyanide	0.1 mg/l	0..05 mg/l	Tricholoroethylene	0.3 mg/l	0.3 mg/l
Detergents	10 mg/l	10 mg/l	Turbidity	300 NTU	30 NTU
Dichloromethane	0.2 mg/l	0.2 mg/l	Zinc	5 mg/l	5.0 mg/l

Note: Standards for Pesticides, PCBs and Radioactive materials have not been included in the table; refer to the Draft Standards for discharge limits. The sector specific draft regulations have proposed maximum permissible limits for storm water drainage – Oil & Grease (10 mg/l) and Process Oil (nil).

The Project Proponents have developed environmental optimum requirements to be adopted for the Tilenga Project for the next phases (FEED phase, construction, and drilling, commissioning, operation, decommissioning, abandonment and site restitution) (Ref. 10-36). The 2014 draft legislation for effluent discharges has been adopted.

Table 10-4 provides the effluent standards specified under the 1999 Regulations and the proposed maximum permissible limits provided in the 2014 draft legislation. Table 10-4 also presents the specific standards for wastewater discharges adopted for the Project.

Table 10-4: Standard for sanitary effluent discharges

Pollutants	Units	Regulation 1999	Regulation 2014	IFC EHS Guidelines	Standards for Project
pH	pH	6-8	6-9	6-9	6-8
BOD	mg/l	50	30	30	30
COD	mg/l	100	60	125	100
Total nitrogen	mg/l	10	10	10	10
Total phosphorus	mg/l	10	5	2	2
Oil and grease	mg/l	10	5	10	10
Total suspended solids	mg/l	100	100	50	50
Total coliform bacteria	MPN/100ml	10,000	400	400	400

10.3.3.3 Surface Water Permits and Licensing Policy

The regulation of surface water abstraction and the control of wastewater discharge to surface water bodies in Uganda is regulated by the Directorate of Water Resources Management (DWRM) and is provided for within the Water Act Cap 152 and 153, the National Water Policy and the Water Action Plan. The regulation aims to protect water resources (i.e. both surface water and groundwater resources) from over-exploitation and pollution.

According to the regulation, the use of a motorised or powered pump to abstract (extract) water from any surface water body requires a Surface Water Abstraction Permit (SWAP). Also, a SWAP or a Hydraulic Works Construction Permit (HWCP) is required for constructing or operating any works for impounding, damming, diverting or conveying any surface water or draining any land in Uganda.

Furthermore, according to the National Environment Regulations (1999) (Ref. 10-5), a Wastewater Discharge Permit (WDP) is required for the discharge of any waste that comes in contact with surface water bodies or piece of land without adequate treatment of the waste.

In addition, an Easement Certificate (EC) is required for accessing a water body for either abstraction or discharge of pre-treated effluent or wastewater through the land of a disagreeing neighbour (i.e. any landlords/landowners or stakeholders owning land that provides easement or access to a water body to be used for abstraction or discharge).

A discharge licence is required under the Water (Waste Discharge) Regulations, 1998 (No. 32 of 1998). These regulations outline wastewater discharge and standards for treated effluent water. The regulatory authority establishes the standards of any treated effluent before discharge to a water body in consultation with the lead agency under Section 27 of the Environment Statute of 1995. Section 4 prohibits discharge without a permit issued by the Director of Water Resources.

10.3.3.3.1 Permits and Licensing Policy – Working in Wetlands Areas

The regulation of wetlands and their management in Uganda is regulated by the Ministry of Water (MWE) through the Wetland Management Department (WMD) and is provided under Section 107 of the National Environmental Act Cap 153. The regulation aims to conserve and ensure proper use of wetland resources in the country. This regulation decrees that a permit is required for any activity carried out within a wetland area.

10.3.3.3.2 Permits and Licensing Policy – Operation of Sewage Treatment Plant Areas

The operation of a plant for the treatment of sewage is referenced under Sections 53(2) and 107 of the National Environment Act which provides for the handling and disposal of sewerage waste. Under these regulations, a licence is required if human waste or sewage is treated at a waste treatment plant or disposal site before disposal.

10.3.4 International Standards and Guidance

The majority of the international standards relevant to surface water are similar to those for groundwater. The international standards that apply to both surface water and groundwater are presented in ***Chapter 9: Hydrogeology***. However, additional international standards of relevance and specific to surface water, such as the USEPA Water Quality Criteria for Human Health and Aquatic Life criteria (2000) (Table 10-5) have been considered and used to compare water quality results particularly in the absence of an applicable national standard.

10.3.4.1 IFC Performance Standards and Guidelines

The International Finance Corporation (IFC) Performance Standards (PSs) (Ref. 10-9) are directed towards project developers, providing guidance on how to identify risks and impacts, and are designed to help avoid, mitigate, and manage risks and impacts as a way of doing business in a sustainable way. The standards include stakeholder engagement and disclosure obligations for the Project. IFC PS that are applicable to surface water resources include:

- IFC PS 1: Assessment and Management of Environmental and Social Risks and Impacts - establishes requirements for social and environmental performance management throughout the life of a project;
- IFC PS 3: Resource Efficiency and Pollution Prevention - defines an approach to pollution prevention and abatement in line with current internationally disseminated technologies and good practice. There is a requirement to address potential adverse impacts on ambient conditions such as surface water; and
- IFC PS 4: Community Health, Safety and Security – requires that adverse impacts on water resources in use by communities are avoided or minimised.

10.3.4.2 IFC Guidelines

The IFC guidelines that are applicable to surface water resources are the following:

- IFC Environmental Health and Safety (EHS) General Guidelines (IFC, 2007a) (Ref. 10-10);
- IFC EHS Guidelines for Onshore Oil and Gas Development (IFC, 2007b) (Ref. 10-11); and
- IFC EHS Guidelines for Water and Sanitation (IFC, 2007c) (Ref. 10-12).

The General EHS Guidelines address discharges to surface water, wastewater management including wastewater treatment, storm water management, wastewater and water quality monitoring and water conservation. This IFC guideline applies to projects that have either direct or indirect discharge of process wastewater, wastewater from utility operations or storm water to the environment. These guidelines are also applicable to industrial discharges to sanitary sewers that discharge to the environment without any treatment. Projects with the potential to generate process wastewater, sanitary (domestic) sewage, or storm water should incorporate the necessary precautions to avoid, minimise, and control adverse impacts to human health, safety, or the environment.

More specifically, and under the guidelines, discharges to surface water should not result in contaminant concentrations more than local ambient water quality criteria or, in the absence of local standards, other sources of ambient water quality criteria (e.g. USEPA, WHO). Under the IFC water conservation requirement, potential adverse impacts on water resources in use by communities should be avoided or minimised. The IFC water conservation program also should be implemented commensurate with the magnitude and cost of water use. These programs should promote the continuous reduction in water consumption and achieve savings in water pumping, treatment and disposal costs. Water conservation measures may include water monitoring/management techniques; process and cooling/heating water recycling, reuse and other technologies; and sanitary water conservation techniques.

The sector-specific guidelines include information relevant to production drilling; development and production activities; transportation activities including pipelines; other facilities including pump stations, metering stations, pigging stations, compressor stations and storage facilities; ancillary and support operations; and decommissioning. These industry-specific Guidelines were scheduled to be updated in 2017. However, at the time of submission of this ESIA, there has been no update. These guidelines address management of the following EHS issues that are relevant to surface water; wastewater/effluent discharges; solid and liquid waste management; and spills (Ref. 10-8).

The IFC EHS Guidelines for Water and Sanitation recommend measures to prevent, minimise and control environmental impacts associated with surface water abstractions and to protect water quality.

When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever regulation is more stringent. Furthermore, the IFC Performance Standards on Environmental and Social Sustainability (IFC, 2012) suggest that, where none exist nationally, internationally recognised standards should be used (Ref. 10-6).

10.3.4.3 WHO Guidelines

WHO has published Guidelines for Drinking Water Quality, which is kept up to date through a process of rolling revision. The most recent version of the guidelines is found in the 4th Edition, published in 2011 (Ref. 10-13).

Tables of guideline values are presented in the 4th Edition of the Guidelines for chemicals of health significance in drinking water. Where there is no Ugandan standard for a particular parameter, the WHO guideline value has been adopted as listed in Table 10-2. The WHO guidelines values are provided at Appendix L Annex 02.

10.3.4.4 USEPA Water Quality Criteria

USEPA recommended water quality criteria for human health and aquatic life were developed in accordance with Section 304(a)(1) of the Clean Water Act (Ref. 10-14), and are based on data and scientific judgments on pollutant concentrations and environmental or human health effects. The USEPA aquatic life criteria were developed for surface waters of the US and may not apply to all types of aquatic life and surface water resources in Uganda (Ref. 10-15). These criteria were established to guide adopting water quality standards for the protection of aquatic life and human health. The human health criteria are the highest concentration of a pollutant or parameter in water that is not expected to pose a significant risk to people Ref. 10-16). An aquatic life criterion represents the highest concentration of a parameter in water that is not expected to pose a significant risk to the majority of species in a given environment. These scientific-based recommended criteria are relevant for evaluating the potential risk of surface waters to human health and the environment (aquatic life). While the USEPA criteria may not apply to all aquatic life in all water bodies; they have been widely used internationally where necessary, particularly for both human and aquatic life protection. For the ESIA, they have been used for comparison of the water quality field data in the absence of a relevant Ugandan national standard or other international standard or where the USEPA standard is the most stringent standard. In particular, the USEPA criteria has been used to compare ESIA baseline water quality results for Chromium and Benzene with set USEPA values of 0.01 milligrams per litre (mg/l) and 2.2 micrograms per litre (µg/l) respectively as against the WHO and Ugandan standards set at 0.05 mg/l and 10 µg/l respectively (See Table 10-2 and Table 10-5).

Table 10-5: International Surface Water Quality Standards

Water Quality Parameter	Unit	USEPA Water Quality Aquatic Life Criteria (2000)	USEPA Water Quality Human Health Criteria (2000)
Metals			
Aluminium (Al)	mg/l	0.75	-
Arsenic (As)	mg/l	0.34	1.8 x10^{-5}
Barium (Ba)	mg/l	-	0.1
Cadmium	mg/l	0.0018	
Chromium (Cr)	mg/l	0.0074	0.01
Copper (Cu)	mg/l	-	1.3
Iron (Fe)	mg/l	1	-
Mercury (Hg)	mg/l	0.0014	-
Manganese (Mn)	mg/l	-	0.05
Nickel (Ni)	mg/l	0.47	0.61
Lead (Pb)	mg/l	0.065	-
Zinc (Zn)	mg/l	0.12	7.4
Mono Aromatic Hydrocarbons			
Benzene	µg/l	-	2.2
Toluene	µg/l		57
Ethylbenzene	µg/l	-	68
Inorganic Compounds-			
Chloride	mg/l	230	-
Inorganic Compounds			
Nitrate equivalent NO3-N	mg N/l	-	10

Notes: (1) USEPA – Freshwater CMC – (Criteria Maximum Concentration) – acute exposure. (2) There is no CMC for iron. However, there is a CCC (Criterion Continuous Concentration) – chronic of 1000 µg/l.

10.3.4.5 Sediment Screening Values

Published lists of screening values have been developed by various sources to assist with evaluating whether the presence of chemicals in sediments could present potential risks to freshwater biota. In the absence of national standards or criteria, these screening values can be used to evaluate the potential environmental threat posed by measured levels of chemical constituents in sediments. Conservative low screening values are often used for initial screening of sediment concentration data to determine where they could have a possible effect on biota. Secondary screening levels are less conservative and used to determine where it is likely/probable that biota could be affected by measured levels of chemical constituents. USEPA Freshwater Sediment Screening Benchmarks. are consensus-based threshold effect concentrations (TEC) commonly used for initial screening of sediments for inorganic and organic constituents to identify possible effects on freshwater biota, and has been used in assessing river bed sediment quality analyses results and potential impacts within the Project Area (Ref. 10-17). Sediment initial screening values are presented in Table 10-6 and are also provided in Appendix L Annex 03.

Table 10-6: Sediment Initial Screening Concentrations

Parameter	Units	EPA Sediment Screening Value
Metals		
Arsenic (As)	mg/kg	9.8
Antimony (Sb)	mg/kg	2
Barium (Ba)	mg/kg	-
Beryllium (Be)	mg/kg	-
Cadmium (Cd)	mg/kg	0.99
Chromium (Cr)	mg/kg	43.4
Cobalt (Co)	mg/kg	-
Copper (Cu)	mg/kg	31.6
Mercury (Hg)	mg/kg	0.18
Lead (Pb)	mg/kg	35.8

Parameter	Units	EPA Sediment Screening Value
Molybdenum (Mo)	mg/kg	-
Nickel (Ni)	mg/kg	22.7
Selenium (Se)	mg/kg	2
Tin (Sn)	mg/kg	-
Vanadium (V)	mg/kg	-
Zinc (Zn)	mg/kg	121
Mono Aromatic Hydrocarbons		
Benzene	mg/kg	-
Toluene	mg/kg	-
Ethylbenzene	mg/kg	1.1
m-Xylene & p-Xylene	mg/kg	0.0252
o-Xylene	mg/kg	-
Xylenes, total	mg/kg	-

10.4 Spatial and Temporal Boundaries

The Project is part of the broader oil and gas development being undertaken in the Lake Albert region of the Albertine Graben. It has an area of approximately 110,000 hectares (ha). Figure 10-1 shows the Project Area and key elements of the Project.

The ESIA Project Area includes Contract Area CA-1, Exploration Area EA-1A and Licence Area LA-2 North and environs. It is defined to include surface water features and receptors that may be affected by the Project throughout all of the Project's phases (i.e. from site preparation to decommissioning). However, to evaluate surface water resources, a Study Area has been defined by the extent of the network of the surface water bodies (river, streams wetlands, lakes and ponds) within and beyond the Project Area. These include surface water bodies and their local catchment/sub-basin as well as areas prone to flooding that may be affected by the proposed Project activities. Figure 10-2 shows the principal surface water catchments and sub-basins within the Study Area and the region.

The surface water and flood risk impact assessments are further defined by the location of all surface water features which are hydrologically or hydrogeologically connected within a defined 1 kilometre (km) radius of the key Project Components. Taking into account a number of factors including the network of the surface water bodies, their interactions with groundwater bodies, and the regional surface water and groundwater flow directions, the southern, eastern and western extents of the Study Area are defined by the southern, eastern and southwestern boundary line of the Project Area in Figure 10-1. The northern and north western boundary of the Study Area extends beyond the northern boundary of the Project Area and includes the area up to the Panganyo flow monitoring station north of the Project Area (Figure 10-6).

The temporal boundaries for the baseline characterization are based on the available primary and secondary data. River flows and lake levels are primarily dependent upon meteorological conditions; hence the characterization of the rivers and stream flows in the project area and of Lake Albert are based on the available data and take into consideration long term trends where practicable. Water quality data collected between 2014 and 2017 is used to provide indicative background surface water quality.

The proposed timescales for the different phases of the Project are set out in ***Chapter 4: Project Description and Alternatives***. A brief summary of the timescales are provided below:

- Site Preparation and Enabling Works Phase expected to take approximately 5 years;
- Construction and Pre-Commissioning is expected to take up to 7 years;
- Commissioning and Operations is expected to commence approximately 36 months after effective date of the main construction contract award. The lifetime of the Project is 25 years; and

- Decommissioning is planned for the end of the 25 year operation.

The phases overlap and in total the duration through all phases will be approximately 28 years. The duration of activities which may lead to potential surface water impacts differ between short and long term episodes, all of which are described within the assessment.

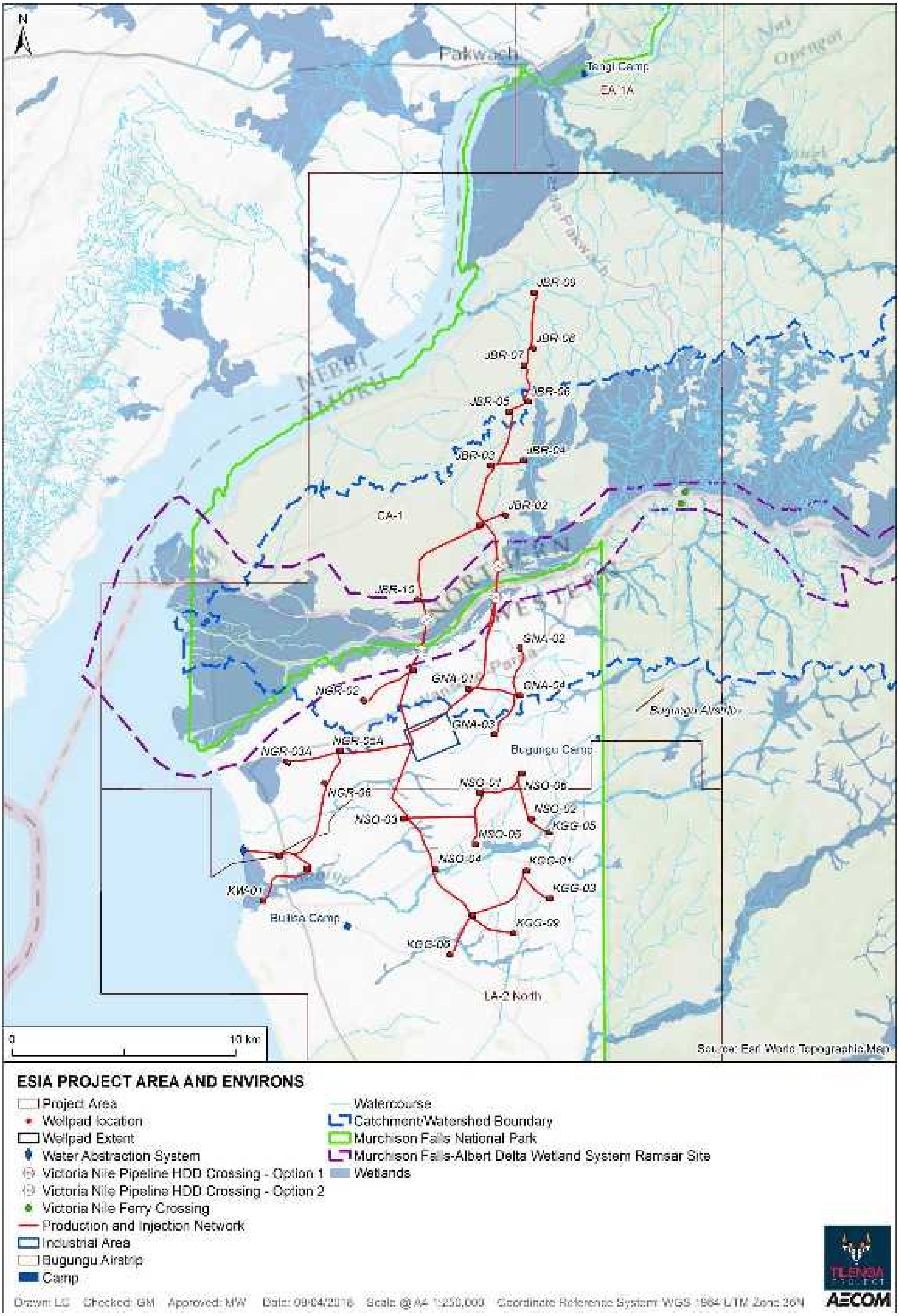
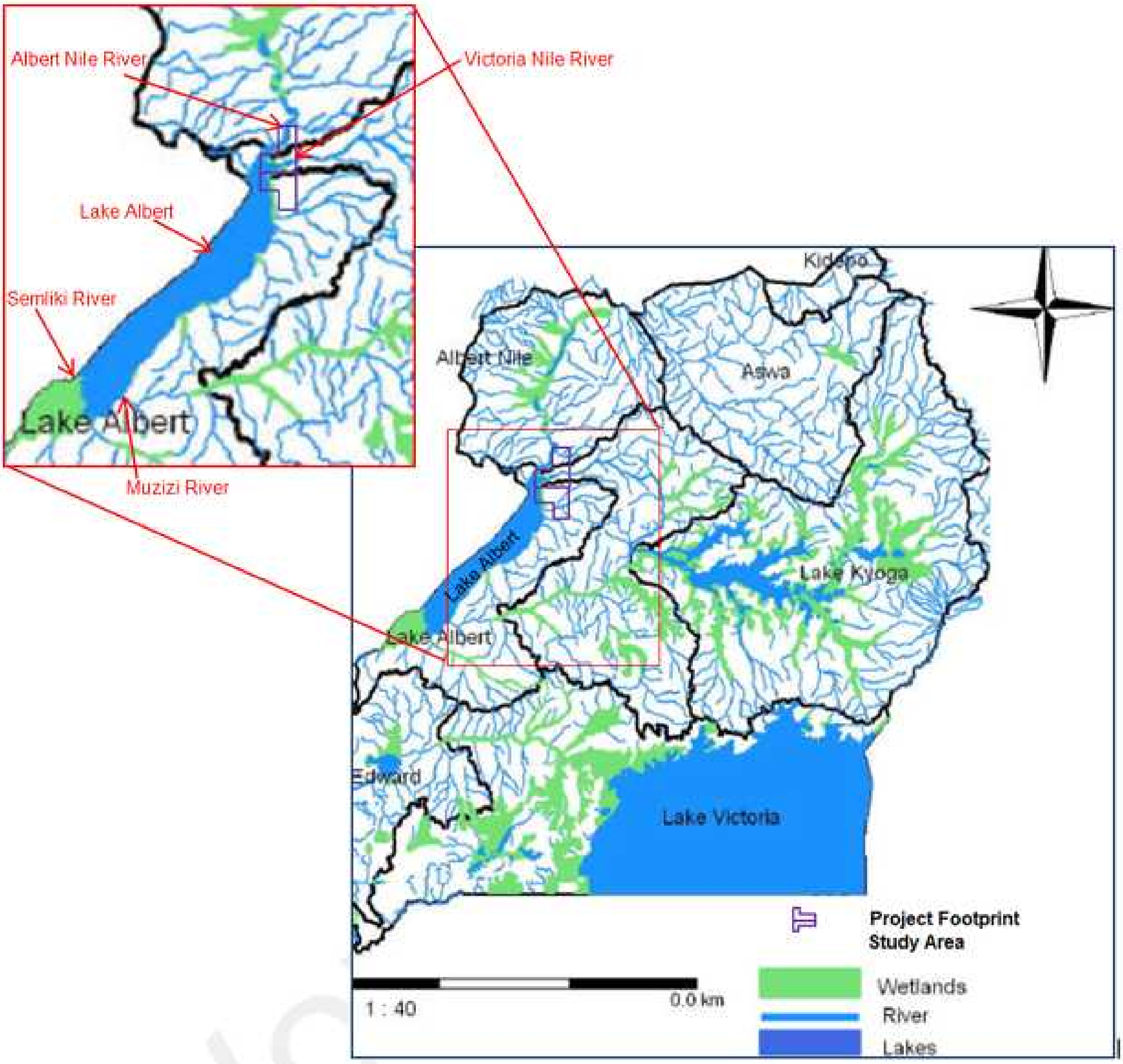


Figure 10-1: **ESIA Project Area and Environs Showing Streams and Wetlands**



Source: Otim, Moses, 2005

Figure 10-2: Basins, Lakes, Main Rivers and Drainage Systems of Uganda and the Study Area

10.5 Baseline

10.5.1 Introduction

Information on surface water quality was gathered from numerous sources, both primary and secondary, and used to identify the prevailing baseline conditions. Readily available surface water data were collected, reviewed and evaluated for relevance. Based on the evaluation, the existing baseline surface water conditions of the Study Area were characterised and data gaps identified were used to inform subsequent targeted qualitative surveys. The principal secondary information sources included reports, Geographic Information System (GIS) data and raw data sets, such as:

- Total Exploration & Production (E&P) Uganda B.V (TEP Uganda) GIS datasets and reports;
- Tullow Uganda Operations Pty Ltd (TUOP) GIS datasets and reports;
- Other GIS data;
- Satellite images;
- Literature with information and data relevant to the Project published by NEMA and DWRM;
- Other readily available published books, reports and scientific literature; and
- Internet websites.

The TEP Uganda and TUOP reports include various Environmental Impact Assessments (EIAs) for the exploration phase activities within the Study Area and environs as well as Project briefs, interim reports and draft reports of studies and the scopes of work for planned studies. Many of the reports held in the libraries of TEP Uganda and TUOP have been produced by a broad range of public and private organisations, institutions and government ministries and consulting firms.

10.5.2 Data Gap Analysis

An extensive data gap analysis was carried out as part of the Environmental Baseline Study (EBS) EA-1 (now known as CA-1) (AECOM, 2015) (Ref. 10-18) and EBS EA-2 (now known as LA-2) (AECOM, 2012) (Ref. 10-19). Data gaps were identified for surface water under various sub-topics. A summary of the surface water data gaps is provided in Table 10-7.

The data gap analysis helped guide planning of the ESIA baseline field survey activities, as well as determining the selection of the surface water sampling locations.

Table 10-7: Relevant Surface Water Data Gap Analysis Summary

Sub-Topic	Information Available	Gaps Identified	Actions to Fill Gaps
Hydrology and surface water resources	Surface water monitoring stations exist in each of the sub-basins in the Albertine Graben. The data from these stations are digitised and stored in the national databases. Catchment management plans have been developed for critical rivers in blocks 1 and 2 by the Ministry of Water and Environment in collaboration with the regional and district water authorities. Lakes Edward and Albert fisheries (LEAF) pilot project and various studies commissioned by TUOP provide information on the aquatic environment of Lake Albert, including characteristics of the catchment area and its degradation, hydrological regime and water resources, water quality and pollution.	Only limited general information is available for surface water vulnerability in the Study Area and specific information about the flooding risk is not available.	Consult with NEMA on the status of the monitoring data collated under the Environmental Monitoring Plan for the Albertine Graben. Analyse existing data to gain a better understanding of hydrological regime and water availability and vulnerability within the Study Area, and to inform the flood risk assessment.

Sub-Topic	Information Available	Gaps Identified	Actions to Fill Gaps
Surface water quality	There is no known national surface water quality monitoring programme in Uganda. Surface water quality data is available from the surveys conducted for exploration and appraisal phases within Blocks 1 and 2. Surface water quality data collected during the EBS_EA-1 (CA-1) field survey campaigns expanded the inventory of water quality locations and physical and chemical characteristics. For LA-2 the most extensive freshwater study was conducted in the Kasamene area Water quality data is available for Lake Albert within the potential area for water abstraction (Atkins, 2010 and AECOM, 2015).	Limited understanding of temporal and spatial coverage, consistency and quality across various datasets.	Consult with NEMA on the status of the water monitoring data collated under the Environmental Monitoring Plan for the Albertine Graben. Analyse and synthesise relevant information from the available reports and maps. Conduct surface water surveys to collect additional water quality data to increase spatial coverage within the Study Area, targeting surface water resources that can be potentially affected by the development and are sensitive or considered as valued ecosystem components.

These gaps have now been addressed following a desk-based study and targeted baseline qualitative field surveys (2014 – 2017) carried out as part of this ESIA and via a review of other recently published key literature as detailed in Table 10-15.

Details of the surface water survey findings including data analysis and characterisation of the baseline surface water quality condition of the Study Area are presented in the subsequent sections of this chapter. Sections 10.5.3 to 10.5.9 provide details of the baseline surveys. Table 10-21 provide a summary of the combined 2014 - 2017 surface water quality data. The full results are presented in Appendix L - Annex 2. Section 10.6 provides details of the surface water baseline conditions. Section 10.7 summarises the surface water quality characteristics of the Project Area, including morphological features, based on the baseline water quality results and findings from the targeted ESIA baseline surveys and the literature.

10.5.3 Surface Water Quality Baseline Surveys Overview

The baseline surveys of the surface water environment in the Study Area was designed to address the gaps identified from previous studies are summarised in the following sections.

The data sampling locations were selected to target Project-specific areas where relevant data gaps were identified. A two-stage data collection method comprising desk-based research and targeted field surveys was used to collect both qualitative and quantitative data.

The desk-based studies were aimed at gathering relevant published data covering the Study Area and local catchments. The data acquired included surface water hydrology, water resources management and monitoring data, and review of various EIA reports and water resources and catchment management projects' reports. The study also included a review of relevant information on water quality and management, including water quality, water quantity, flood risk and morphological data from previous, recently concluded and existing management projects and from various data sources such as NEMA, DWRM etc.

The targeted field surveys were aimed at enabling professional observation of the physical environment and an assessment of surface water bodies and their morphology within the Study Area. The surveys included the collection of water and river bed sediment samples to enable acquisition of new surface water data to fill the data gap identified from previous studies and to establish the baseline surface water condition and characterisation of the ESIA Study Area. In particular, the survey collected water quality data from both the northern and southern part of the Victoria Nile River. Sediment samples were also collected from the Victoria Nile River.

10.5.3.1 Primary Data and Baseline Surveys – 2014

The surface water quality data collected as part of the Environmental Baseline Study (EBS) for CA-1 expands the inventory of physical characteristics and chemical concentrations of surface water found within this part of the Study Area. The dataset included locations affected by human development as well as virgin lands and relatively pristine areas such as the Ramsar Site (i.e. Albertine Graben Murchison Falls-Albert Delta Wetland System - Ramsar Site No. 1640) between Murchison Falls National Park (MFNP) and the Victoria Nile Delta, as well as a survey of the Lake Albert waters. The surface water sampling locations are shown on Figure 10-3. Four rounds of sampling were conducted in 2014 to capture dry and wet seasons (i.e. February, April, July and September).

A summary of the key findings of the water quality baseline data obtained as part of the EBS study for Block CA-1 is presented below. Full details are provided in the EBS report (Ref. 10-18) while the laboratory analytical results are presented in Appendix L - Annex 02. The results were interpreted in light of the site characteristics and sampling date (i.e. wet or dry season), taking into account historical results from previous studies and literature review.

10.5.3.2 Primary Data and Baseline Surveys – November 2016 and June 2017

Surface water quality data from the previous surveys listed above, conducted within CA-1/EA-1A and LA-2 North indicate the overall status of surface water quality in the Study Area. The data does not cover all of the Study Area and does not adequately characterise surface water quality in the vicinity of all Project elements and sensitive receptors. Additional surface water field survey work was therefore carried out to inform the present ESIA to ensure sufficient spatial information is available to accurately characterise the existing surface water quality conditions within the Study Area and to highlight any potential impacts associated with the proposed development plan that should be assessed and addressed. The key focus is the vicinity of the proposed Project footprint boundary, the affected catchments, as well as potential downstream surface water receptors. The Project footprint boundary includes well pad locations, pipeline corridors, access roads, Industrial Area and camps, ferry crossing, as well as the proposed Lake Albert water abstraction station locations, as shown in Figure 10-3.

The ESIA surface water survey consisted of two field campaigns carried out in November 2016 (Campaign 1) and June 2017 (Campaign 2) involving measurement and sample collection at selected locations, including flowing watercourses (rivers, streams), lakes, ponds and pools. Survey activities included the measurement of field parameters, followed by the collection of surface water samples. The same survey locations were sampled in both campaigns.

10.5.4 Primary Data Survey Locations

10.5.4.1 Baseline Survey 2014

Samples were collected from selected surface water locations within LA-2 North and CA-1 for physical and chemical analysis. Of the 16 locations initially selected for the EBS, 14 locations in the North Nile and South Nile areas are within the Study Area for the ESIA. Within the North Nile area 8 locations were selected and the South Nile 6 locations were selected. Locations were chosen to include a variety of both permanent and ephemeral surface water resources such as rivers, streams, ponds and wetlands. Preliminary locations were selected based on review of aerial imagery, historical data, local land and water resource use, and findings of prior studies including due diligence investigations of prior oil exploration activities. Final locations were selected following a visual reconnaissance of each location in December 2013.

The surface water sampling locations and site selection rationale are shown in Table 10-8.

Table 10-8: Surface Water Sampling Locations and Selection Rationale 2014

Survey Point	Location	Site Selection Rationale
North Nile		
SW01	Tangi River near Tangi Gate in MFNP	Characterise water quality within MFNP.
SW02	Opengor/Ajai River in MFNP	Characterise water quality within MFNP.
SW03	Kituna River in MFNP	Characterise water quality within MFNP.
SW04	Victoria Nile near the delta in MFNP	Characterise water quality within MFNP.
SW05	Victoria Nile near the Paraa Ferry Landing	Characterise water quality within MFNP.
SW06	Victoria Nile 4 km upstream of Paraa Ferry, MFNP	Characterise water quality within MFNP.
SW12	Albert Nile and Pakwach Village	Characterise water quality within MFNP.
SW17	Shallow pool in MFNP near Tangi River near a documented location of a natural oil seep	Characterise water quality within MFNP near an oil seep
South Nile		
SW07	Victoria Nile downstream of Murchison Falls, MFNP – south bank	Characterise water quality within MFNP.
SW08	Victoria Nile near Murchison Falls, MFNP – south bank	Characterise water quality within MFNP.
SW09	Victoria Nile at Wanseko Village inside Ramsar Area	Characterise water quality within MFNP near communities
SW10	Season stream near Bugungu Camp	Characterise water quality in season stream
SW14	Season stream in MFNP	Characterise water quality in season al stream
SW16	Shallow hand dug well in a rural community south of Wanseko	Characterise water quality in community

Sediment samples were not collected during the EBS program.

10.5.4.2 Baseline Survey 2016 and 2017

Surface water and sediment samples were collected during 2016 and 2017. Surface water samples were collected in November 2016 and June 2017. Most sediment samples were collected in November 2016; sediment samples at the ferry crossing were collected in June 2017. The locations and the rational for the selection of the sampling locations are presented in Table 10-9. The water sampling survey locations are shown in Figure 10-3.Two sample points (SW1 and SW2) located at watering holes north of the Victoria Nile within the MFNP – CA-1:

- Two sample points (SW4 and SW5) located in the Sambiye catchment south of the Victoria Nile in LA-2 North near proposed well pads and pipeline corridors. SW4 is co-located with an Aquatic Life survey location;
- Two sample points (SW6 and SW7) located in Lake Albert in LA-2 North, near the shore and offshore near the proposed water intake/abstraction facility location;
- One sample point (SW8) located in a watercourse near JBR-09 in CA-1 and co-located with an Aquatic Life Survey location;
- Two sample points (SW9 and SW10) located in the upstream and downstream areas of the Victoria Nile River main delta in CA-1, respectively;
- Two sample points (SW11 and SW12) located in watercourses within the Ngazi and Waiga catchments south of the Victoria Nile in LA-2 North;
- One sample point (SW13) located in a wildlife watering hole north of the Victoria Nile in CA-1; and
- Two sample points (SW14S and SW14N) located on the northern and southern banks of the Victoria Nile River at the pipeline route crossing in CA-1.

One of the planned survey locations (SW3) north of the Victoria Nile River within MFNP could not be safely reached by vehicle and was therefore not sampled during either campaign. Table 10-9 provides an overview of the surface water sampling locations, including the coordinates, rationale and characteristics of each sampling location and the locations are shown in Figure 10-3. Photographs of each survey location are presented in Appendix L– Annex 01.

The sediment sampling locations (Figure 10-3) within the Study Area were selected as detailed in Table 10-9; summarised as follows:

- Three sediment samples were collected in the Victoria Nile at locations where aquatic life samples were also collected (SE1, SE2 and SE3):
- One sediment sample was collected in the vicinity of the water abstraction station offshore in Lake Albert; and

Two sediment samples were collected near the proposed Victoria Nile Ferry Crossing.

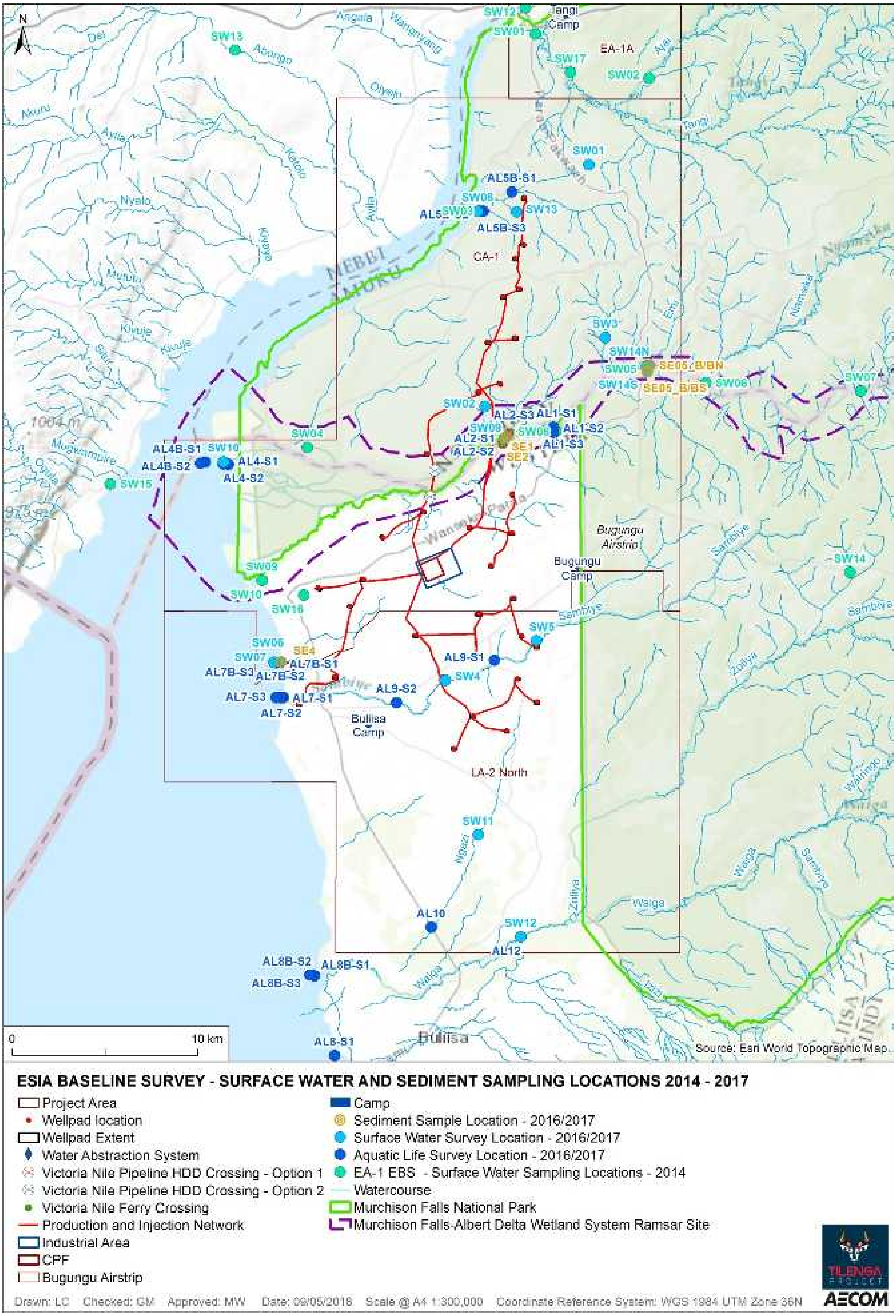


Figure 10-3: Baseline Surveys – Surface Water and Sediment Sampling Locations (2014 to 2017)

Table 10-9: Surface Water and Sediment Sampling Locations and Selection Rationale 2016 and 2017

Block	Survey Point	Location	Rationale and intended receptor
Surface Water Sampling Locations			
CA-1	SW1	Wildlife watering hole north of Victoria Nile in MFNP southeast of exploratory well Jobi East-2.	Characterise water quality of important ecological feature, i.e. pond or watering hole, used by sensitive wildlife within MFNP.
CA-1	SW2	Wildlife watering hole north of Victoria Nile in MFNP south of exploratory well Rii-1 near planned location of JBR-01 and associated pipeline.	Characterise water quality of important ecological feature, i.e. pond or watering hole, used by sensitive wildlife within MFNP.
CA-1	SW3 Note 1	Near oil seep location at Songe River north of Victoria Nile River in MFNP.	Characterise surface water near natural oil seep.
LA-2 North	SW4 Note 2	Sambiye River watercourse southeast of Ngwedo Village, west of Kigogole-2. Co-located with Aquatic Life survey location.	Near proposed Sambiye River pipeline crossing and well pad NSO-04.
LA-2 North	SW5 Note 2	Sambiye River watercourse at road crossing east of Kibambura, north of Kigogole-1.	Near proposed Sambiye River pipeline crossing and well pads NSO-02 and KGG-05.
LA-2 North	SW6	Near shore at Lake Albert water abstraction facility.	Determine baseline lake quality at shore near water abstraction facility.
CA-1	SW7	Offshore at possible water intake location for Lake Albert water abstraction facility.	Determine baseline lake quality at shore near water abstraction facility.
CA-1	SW8	Watercourse near JBR-09. Co-located with Aquatic Life survey location AL5B.	Determine baseline river water quality.
CA-1	SW9	Victoria Nile River at pipeline crossing, Option 1. Located 160m southwest of Aquatic Life survey location AL2-S1.	Determine baseline river water quality near pipeline crossing.
CA-1	SW10	Victoria Nile main delta at Lake Albert. Co-located with Aquatic Life survey location.	Determine baseline river water quality near the confluent area of the Victoria Nile and Lake Albert.
LA-2 North	SW11 Note 2	Ngazi catchment south of proposed KGG-02 well pad. Co-located with Aquatic Life survey location.	Determine baseline watercourse quality.
LA-2 North	SW12	Waiga River southeast of proposed KGG-02 and southwest of exploration well Ngara-1. Co-located with Aquatic Life survey location AL12.	Determine baseline watercourse quality.
CA-1	SW13	Wildlife watering hole north of Victoria Nile in MFNP near JBR-09.	Characterise water quality of important ecological feature, i.e. pond or watering hole, used by sensitive wildlife in MFNP.
CA-1	SW14	Ferry crossing on the south bank of the Victoria Nile.	Determine baseline watercourse quality.
CA-1	SW14	Ferry crossing on the north bank of the Victoria Nile.	Determine baseline watercourse quality.
Sediment Sampling Locations			
CA-1	SE1	Near mid-channel of Victoria Nile in MFNP at proposed pipeline crossing, Option 1. Co-located with Aquatic Life survey location AL2-S2.	Determine baseline sediment quality near proposed pipeline crossing.
CA-1	SE2	Near southern bank of Victoria Nile in MFNP at proposed pipeline crossing, Option 1. Co-located with Aquatic Life survey location AL2-S2.	Determine baseline sediment quality near proposed pipeline crossing.
CA-1	SE3	Near northern bank of Victoria Nile at proposed pipeline crossing, Option 1. Co-located with Aquatic Life survey location AL2-S3.	Determine baseline sediment quality near proposed pipeline crossing.
LA-2 North	SE4	Near shore near Lake Albert water abstraction facility.	Determine baseline lake sediment quality at shore near alternate location of water abstraction facility.
CA-1	SE5 BN	Ferry crossing on the north bank of the Victoria Nile, sampled in second campaign only.	Determine baseline sediment quality near proposed ferry crossing.
CA-1	SE5 BS	Ferry crossing on south bank of the Victoria Nile, sampled in second campaign only.	Determine baseline sediment quality by proposed ferry crossing.

10.5.5 Baseline Data Collection Methods –Surface Water

Baseline surveys were conducted in 2014 and 2016/2017. Observation notes were made at each selected location to record appropriate local conditions at the time of sampling. Field parameters were measured and surface water samples collected following established professional protocols and procedures to ensure accuracy and completeness. Physical and chemical parameters were measured by a calibrated multi-parameter water quality meter in field in a water-filled bucket. Samples in deep water (e.g. Lake Albert and rivers) were collected using a Van dorn sampler and in shallow water (e.g. water holes and streams) a bucket. Water quality parameters measured in the field included:

- pH, temperature, electrical conductivity (EC), oxygen reduction potential (ORP), dissolved oxygen (DO), resistivity, salinity, and total dissolved solids (TDS).

With the exception of Lake Albert water quality samples collected in 2014, all surface water and sediment samples were analysed by Eurofins Analytico BV (Analytico) in the Netherlands

10.5.5.1 Baseline Surveys - 2014

All surface water samples were collected for laboratory analysis for chemical constituents and physical content including:

- Total petroleum hydrocarbons (TPH);
- Mono-aromatic hydrocarbons (BTEX);
- Metals, major anions and cations; and
- Total suspended solids (TSS).

Laboratory analysis was completed for the chemical parameters shown in Table 10-10. The inclusion of parameters such as ammoniacal nitrogen allowed for assessment of where water may be polluted by untreated sewage.

Table 10-10: Chemical Analytical Testing Suite for Surface Water Samples - 2014

Analytical Parameters	
Metals	**Mono Aromatic Hydrocarbons**
Arsenic (As)	Benzene
Barium (Ba)	Toluene
Calcium (Ca)	Ethylbenzene
Cadmium (Cd)	o-Xylene
Cobalt (Co)	m,p-Xylene
Chromium (Cr)	Xylenes (sum)
Copper (Cu)	BTEX (sum)
Iron (Fe)	**Petroleum Hydrocarbons**
Lead (Pb)	TPH (C10-C12)
Manganese (Mn)	TPH (C12-C16)
Magnesium (Mg)	TPH (C16-C21)
Mercury (Hg)	TPH (C21-C30)
Nickel (Ni)	TPH (C30-C35)
Zinc (Zn)	TPH (C35-C40)
Polycyclic Aromatic Hydrocarbons	TPH Sum (C10-C40)
PAH (16 EPA)	**Inorganic Compounds**
Inorganic Compounds	Ortho-phosphate (PO4)
Ammonium ((NH_4-N)	Ortho-phosphate (PO4-P)
Bromide	Nitrate equivalent NO3-N

Analytical Parameters	
Chloride	Nitrate (NO3)
Fluoride	Nitrite as NO2-N
Sulphate	Nitrite (NO2)

Sampling was carried out in Lake Albert along the two transects over the course of two field survey campaigns - in February 2014 during the dry season and in September 2014 during a supplementary field survey. Field measurements were taken as described above for the surface water features. All the Lake Albert water samples collected were analysed by accredited CSA Laboratories in Italy. CSA performed the analyses in accordance with the national and international methods for the parameters shown in Table 10-11

Table 10-11: Lake Albert Water Analytical Programme - 2014

Analytical Parameter	
Total Suspended Solids	Barium
Particle size (total solids-TS)	Calcium
SDI (Silt Density Index)	Potassium
Chlorine demand	Manganese
Dissolved oxygen	Strontium
Salinity	Silica
pH	Silica (SiO_2)
Total Organic Carbon (TOC)	Iron
Turbidity	Phosphate (PO_4)
Ammoniacal nitrogen (NH_{4+})	Nitrate (NO_3)
Carbonates (carbonate ion)	Nitrite (NO_2)
Bicarbonates (bicarbonate ion)	Fluoride (F)
Sulphide (sulphide ion)	Sulphate (SO_4)
Cyanides (CN)	Chlorides (Cl)
TPH	Magnesium
PAH	Sodium
Phenols	

10.5.5.2 Baseline Surveys – 2016/2017

All surface water samples were collected for laboratory analysis for chemical constituents and physical content including:

- Total petroleum hydrocarbons (TPH);
- Mono-aromatic hydrocarbons (BTEX);
- Metals;
- Major anions and cations;
- Total suspended solids (TSS) and turbidity.

The analytical parameters are summarised in Table 10-12.

Table 10-12: Chemical Analytical Testing Suite for Surface Water Samples - 2016/2017

Analytical Parameters	
Metals	**Mono Aromatic Hydrocarbons**
Aluminum (Al)	Benzene
Arsenic (As)	Toluene
Barium (Ba)	Ethylbenzene
Cadmium (Cd)	o-Xylene
Cobalt (Co)	m,p-Xylene
Chromium (Cr)	Xylenes (sum)
Copper (Cu)	BTEX (sum)
Iron (Fe)	**Petroleum Hydrocarbons**
Manganese	TPH (C10-C12)
Nickel (Ni)	TPH (C12-C16)
Lead (Pb)	TPH (C16-C21)
Zinc (Zn)	TPH (C21-C30)
Inorganic Compounds	TPH (C30-C35)
Bromide	TPH (C35-C40)
Chloride	TPH Sum (C10-C40)
Fluoride	**Physical and chemical analyses**
Sulphate	Total suspended solids
Ortho-phosphate (PO4-P)	Turbidity
Ortho-phosphate (PO4)	
Nitrate equivalent NO3-N	
Nitrate (NO3)	
Nitrite as NO2-N	
Nitrite (NO2)	

The results have been compared against the UPWS to determine exceedances. In the absence of a UPWS standards, the results were compared against other international standards such as the WHO Drinking Water Guidelines and USEPA standard for Aquatic Life and Human Health Water Quality Criteria to determine any exceedances. The exceedances reported are highlighted in red and orange in Appendix L – Annex 2.

Descriptions of the main findings from the 2014 to 2017 results are presented in Section 10.5.7 to Section 10.5.9 below.

10.5.6 Baseline Data Collection Methods –Sediments

Sediments were collected using a grab sampler. Sediment samples were collected at six surface water survey locations in November 2016 and June 2017. All six sediment sample locations (SE1, SE2, SE3, SE4, SE5 BS and SE5 BN) are shown in Figure 10-3. Table 10-9 provides an overview of the chosen sampling locations, including the coordinates, rationale and characteristics of each sampling location. Photographs of each survey location are presented in Appendix L – Annex 01. The following parameters were analysed for the sediment samples:

- Physical – particle size; and
- Chemical - pH, BTEX, total organic carbon (TOC), polycyclic aromatic hydrocarbons (PAH) and metals.

Sediment samples were analysed in Eurofins Analytico in The Netherlands. The full laboratory analytical results from both field campaigns (i.e. November 2016 and June 2017) are presented in Appendix L - Annex 02.

Conservative, consensus-based benchmark screening values derived from freshwater biota are presented for comparison, with exceedances highlighted in red. (Ref. 10-17). The TEC screening values are shown in Table 10-6. Sediment laboratory results taken in November 2016 and June 2017 are summarised in Appendix L – Annex 03. A description of the main findings is presented in Section 10.7.

10.5.7 Primary Data: Baseline Surveys 2014

10.5.7.1 Water Quality North Nile Area

Surface water resources in the North Nile area (i.e. in the northern parts of the Project Area) include a small section of the northern end of Lake Albert, the Victoria Nile River, Albert Nile River and major tributaries such as the Tangi River and Opengor/Ajai River as well as seasonal streams (Kituna River) and isolated wetlands, as shown in Figure 10-1.

The water quality analyses results for samples collected from this part of the Study Area were generally satisfactory as most water quality parameters analysed were below the Uganda standard.

Where substances were not detected i.e. concentrations were below the laboratory Limit of Detection (LOD) they were reported as less than (<) the LOD value (see Appendix L - Annex 02). For example, the limit of detection for most of the fractions of petroleum hydrocarbons is 10 µg/l and the results are reported as <10 µg/l. This signifies that the substances were not found in the baseline water quality samples. This concentration therefore sets a level against which further samples can be compared. Furthermore, where the LOD is less than the water quality standard and the method is accredited, this implies that the water quality meets the specified standards.

Low concentrations of TPH were detected in surface water samples from the Tangi River, the Opengor/Ajai River, Victoria Nile River, and the Albert Nile River at Pakwach village. The highest concentrations of TPH of 93 µg/l (TPH sum C1-C40) occurred in the Victoria Nile upstream of Paraa Ferry, near the reported location of a natural oil seep. Most reported concentrations of TPH were below the laboratory detection limit of 10 µg/l. There are no UPWS, WHO or USEPA for TPH. TPH is a gross measure of petroleum contamination, although non-petroleum hydrocarbons sometimes appear in the analysis. TPH results simply show that hydrocarbons of possible petroleum origin are present in the sampled media and, therefore, the relative potential for human health effects. The TPH concentrations measured in EBS surface water samples are unlikely to pose a potential concern to human health.

Other hydrocarbons (BTEX – benzene, toluene, ethylbenzene and xylenes) were detected, at three locations in the North Nile – the Tangi and Kituna Rivers, and in the Victoria Nile River near a reported natural oil seep. BTEX is a standard indicator of hydrocarbons. There is no standard for the sum of BTEX, however, there was no exceedance of UPWS or WHO limits (Table 10-2) for the individual determinands. BTEX is typically found in petroleum products, such as gasoline and diesel fuel, and is a potential indicator of fuel or petroleum related contamination. However, BTEX is relatively volatile and susceptible to aerobic biodegradation, which limits its persistence in surface water. Therefore, the detections of BTEX in the Tangi River, Kituna River, and Victoria Nile are difficult to explain because there are no known or suspected sources of BTEX near these sample locations.

Concentrations of PAH compounds were detected slightly above the laboratory limit of detection of 0.20 µg/l in only one sample collected from the Kituna River. Because PAH compounds are ubiquitous and associated with anthropogenic (i.e. petroleum processing) as well as natural sources (i.e. wildfire), the origin of PAH in this sample is uncertain, but may be from natural sources given its location and the frequent occurrence of grass fires within MFNP.

The major cations (calcium, magnesium and sodium) analysed in the surface water sample in the North Nile area were below the UPWS of 150 mg/l, 100 mg/l and 200 mg/l respectively. The maximum concentrations of these cations were 83 mg/l, 42 mg/l and 83 mg/l, respectively. Manganese concentrations were detected at concentrations above the Ugandan Potable Water Standard of 0.1 mg/l in 8 of the twenty-eight samples collected. The common cations calcium, magnesium, manganese, potassium and sodium detected in every surface water sample collected in the South Nile area during the EBS field survey campaigns, and are likely from natural origins.

At several sampling locations, barium was present at concentrations above the laboratory limit of detection of 50 µg/l, but concentrations remained below the UPWS of 0.7 mg/l. Iron was detected above the UPWS of 0.3 mg/l in all samples collected north of the Victoria Nile River in the Tangi, Opengor/Ajai and Kituna rivers, as well as at the reported natural oil seepage point near the Tangi River. There was an exceedance of iron (Fe) in 22 of the 28 samples for iron. Iron and manganese are indigenous constituents commonly found in both surface water and groundwater. The elevated levels in these samples may therefore be of natural cause and a reflection of the geochemistry of the local and regional geology of the Study Area.

Trace concentrations of chromium and copper were also found in the Tangi, Opengor/Ajai and Kituna Rivers at maximum concentrations of 0.0036 µg/l, 0.0071 µg/l and 0.0034 µg/l respectively for chromium and 0.0067 µg/l, 0.0052 µg/l and 0.016 µg/l respectively for copper. The most frequent and highest concentration of metals was found in an isolated pool of the Kituna River and at a natural oil seepage point near the Tangi River. These concentrations of chromium and copper may in part be attributed to the accumulation of the metals as a result of surface water evaporation. The Kituna River and near the oil seep location on the Tangi River are within the MFNP and suggest the elevated concentrations are likely to be of natural origin. The reported concentrations of chromium and copper at the isolated pool of the Kituna River remain well below the UPWS of 0.05 mg/l and 1 mg/l respectively.

The major anions (i.e. sulphate, chloride and fluoride) analysed in surface water samples from the North Nile area were below the UPWS of 400 mg/l, 250 mg/l and 1.5 mg/l respectively, with maximum concentrations of 53 mg/l, 220 mg/l and 1.1 mg/l respectively. The highest level of chloride detected amongst all the samples was 220 mg/l in one sample collected at a small pool near the Tangi River in the MFNP. Another sample collected at the Opengor/Ajai River in MFNP report chloride level of 48 mg/l. This chloride value is well below the Ugandan limit of 250 mg/l. Nitrate (i.e. Nitrate equivalent (NO_3-N) was detected at most locations with the highest reported at 4.1 mg/l, which is below the USEPA limit of (10 mg/l) for human health criteria. There is no prescribed limit for Nitrate equivalent (NO_3) within the UPWS. However, the UPWS limit for Nitrate (i.e. NO_2-N) is 45 mg/l. Nitrate (i.e. NO_3-N) was not detected in all of the samples analysed. The highest concentration of Phosphate (i.e. PO_4 – P) detected at the Tangi, Opengor/Ajai River and Kituna River at 0.59 mg/l, 0.41 mg/l and 0.34 mg/l were all below the UPWS limit of 2.2 mg/l. The full results are provided in Appendix L - Annex 02.

10.5.7.2 Water Quality South Nile Area

Surface water resources in the South Nile area include the Victoria Nile River, Lake Albert, Sambiye River, Waiga River, Biraizi River and other seasonal streams and isolated wetlands. The pH of one sample from the shore of the Victoria Nile at Wanseko village (i.e. pH of 5.33) was less than the minimum UPWS set at 5.5. TPH was sporadically detected at concentrations ranging between 5.9 µg/l and 16 µg/l in surface water samples from the South Nile area, including the Victoria Nile near a natural oil seepage point close to Murchison Falls Lodge. Trace concentrations of other hydrocarbons (BTEX) were detected at Wanseko village and in a seasonal stream in the MFNP. Iron was detected above the UPWS of 0.3 mg/l in 16 of the 18 samples collected south of the Nile River. The source of TPH detections in these samples is uncertain. The source of the detected BTEX in at both locations is uncertain. While the occurrence at Wanseko Village could be attributed to surface runoff contaminated with fuels, this explanation is less likely to explain BTEX in the MFNP seasonal stream.

Iron was the only metal detected in concentrations exceeding a USEPA aquatic life water quality criterion. Iron concentrations measured in the seasonal stream within MFNP (SW14) ranged from 9.6 to 14 mg/L, compared to the criterion of 1 mg/L. The elevated levels of iron may be attributed to naturally occurring colloidal or complex forms of insoluble ferric iron hydroxide.

Barium and cobalt were found in every sample from the seasonal stream in MFNP (SW14). Trace concentrations of copper and mercury were also detected once in samples from the Victoria Nile at Wanseko village (SW09). Barium and cobalt were detected in soils samples therefore their presence can be attributed to natural causes.

The highest concentration of zinc was detected in surface waters in the South Nile area within Wanseko village was reported at 0.095 mg/l, although at levels below the UPWS of 5 mg/l. The highest reported concentration of ammonium of 0.4 mg/l in surface water in the South Nile area was also at Wanseko village, below the UPWS of 0.5 mg/l which may be attributed to community activities at or near the sample location. Trace amounts of copper and mercury were also reported in surface water at this location. The source of the zinc and copper is unknown however both were detected in soil samples collected in undisturbed areas in both the north and south Nile therefore its presence in the surface water may be attributed to natural causes. The source of mercury is unknown; it was only sporadically detected in soil samples hence the likely source is anthropogenic.

Nitrate (i.e. nitrate equivalent (NO_3-N) was reported at two locations on the Victoria Nile, including below Murchison Falls (SW07 and SW08) at 1.8 mg/l and 5.2 mg/l respectively. However, the levels were below the USEPA limit of (10 mg/l) for human health criteria. There is no prescribed limit for nitrate equivalent (NO_3-N) within the UPWS. Nitrate (i.e. NO_3-N) was not detected in any of the samples analysed in the South Nile Area. The highest and only detected concentration of Phosphate (i.e. PO_4 – P) was from a sample (SW14) collected at a seasonal stream in MFNP next to the road at 0.074 mg/l which was below the UPWS limit of 2.2 mg/l. The full results are provided in Appendix L - Annex 02. The source of nitrate is unknown. Nitrogen compounds in the soil are converted by bacteria into nitrates. Anthropogenic sources of nitrite and nitrate include infiltration from fertiliser use and/or leakage from septic systems. Phosphorus occurs naturally in rocks and other mineral deposits. The source of phosphate is unknown however during the natural process of weathering, the rocks gradually release the phosphorus as phosphate ions which are soluble in water and the mineralize phosphate compounds breakdown.

10.5.7.3 Lake Albert

To expand and improve on available Lake Albert water resource and quality information, the EBS CA-1 study conducted by AECOM in 2014 determined the Silt Density Index (SDI) and total suspended solids (TSS) concentration in the Lake Albert water to inform the design of the water abstraction and water treatment facilities, and general water quality at two transect positions for the water abstraction facilities. Some of the key findings are summarised below:

- In September the temperature was higher than in February and was higher in the shallower water;
- Electrical conductivity, pH, TDS and salinity measured in September and in February indicated similar results; and
- Turbidity had similar depth profiles in February and in September.

Current meter measurements registered similar values in current speed on the first and second field survey campaigns. The current direction showed wide variability in all the monitored locations with a prevalent northwest-southeast trend.

The analytical parameters showed modest variations during both field survey campaigns and most parameters analysed where generally within the limit. The 2014 results were also consistent with the 2016 – 2017 ESIA survey results.

10.5.8 ESIA Baseline Survey (November 2016)

10.5.8.1 Water Quality Results Evaluation

A total of 14 surface water samples were collected in November 2016 from the sampling locations shown in Figure 10-3. The results are tabulated and compared against the UPWS and in the absence of a Uganda standard, against other relevant international standards such as the WHO standard. The analytical results for parameters above the laboratory reporting limit are presented in Table 10-13. The full results are presented in Appendix L – Annex 02. The majority of the parameters analysed were reported at concentrations below the Ugandan standard. Parameters with exceedances of the standard are highlighted in red .The source of elevated levels of constituents is most likely due to natural process and not anthropogenic in nature based on the land use in the vicinity of the sampling locations.

Parameters that exceeded the UPWS Standard in one or more samples included aluminium, iron, manganese, lead and nitrate. Parameters that exceeded the USEPA Water Quality Aquatic Life Criteria in one or more samples included iron, lead and nickel. The only parameter that exceeded the USEPA Water Quality Human Life Criteria was chromium in one sample.

Aluminium was detected in five samples above the UPWS standard of 0.2 mg/L collected from a watering hole in MFNP (SW02), Lake Albert near shore (SW06), seasonal watercourse near JBR-09 (SW08), Nile River (SW-09) and the Waiga River (SW12) at concentrations ranging from 0.22 mg/L to 4.1 mg/L. The source of the aluminium is unknown but it is likely to be attributed to natural causes.

Barium exceeded the USEPA Water Quality Criteria of 0.1 mg/L in one sample, SW08 collected in a watercourse near JBR-09 at concentration of 0.5mg/L. The source of barium is unknown but likely due to natural processes as it was also detected in locations where there are no known anthrophonic sources.

Chromium was detected in one sample, SW02, at a concentration of 0.016 mg/L which exceed the USEPA Water Quality Human Health Criteria limit of 0.01 mg/L. Chromium has been detected in soil samples and there are no apparent anthropological sources the presence of this metal are likely due to natural processes.

Iron was detected above the UPWS standard of 0.3 mg/L in seven samples collected from SW02, SW06, SW08, SW09, SW12, wetland in MFNP (SW01) and the Nile River at the delta of Lake Albert (SW10). Concentrations ranged from 0.38mgL to 9.8 mg/L. Iron concentrations in SW01, SW02, SW08 and SW12 also exceeded the USEPA Water Quality Standard for Aquatic Life limit of 1 mg/L. The elevated levels of iron may be attributed to naturally occurring colloidal or complex forms of insoluble ferric iron hydroxide.

Manganese was detected in four samples, SW01, SW02, SW08 and SW12 at concentrations ranging 0.14 mg/L to 1.2 mg/L; the UPWS standard is 0.1mg/L.

Nickel was detected in two samples SW02 and SW08 at concentrations of 0.009 mg/L and 0.011 mg/L, respectively which exceed the USEPA Water Quality Aquatic Life Criteria limit of 0.0052 mg/L.

Lead was detected in three samples, SW01, SW02 and SW08 at concentrations ranging from 0.0051 mg/L to 0.25 mg/L; all concentrations reported are above the USEPA Water Quality Aquatic Life Criteria limit of 0.0025 mg/L. The lead concentrations in SW01 and SW08 also exceeded the UPWS standard and the WHO drinking water guideline of 0.01 mg/L. The two water samples from small isolated water bodies (SW01 and SW08) in the North Nile area recorded lead concentrations however they are not sources of potable drinking water.

The sources of manganese, nickel and lead are no known. Their presence in water collected from watering holes and wetlands where no anthropogenic sources have been identified suggest that they are a result of natural processes.

SW06 and SW07 reported nitrite concentrations of 0.46 mg/l and 0.32 mg/l respectively which exceeded the UPWS limit of 0.003 mg/l. It should be noted that the UPWS limit for nitrite may be erroneous as this limit falls below the detection limit of all nitrite analytical methods. It is considered that the WHO limit of 3 mg/l may be a more appropriate standard for comparison. However, the results have been compared against the Uganda limit. If the results are compared against the WHO limit, the nitrite concentration for all of the samples would not exceed the limit.

The baseline surveys provide characterisation of the current status of water quality.

10.5.8.2 Sediment Sample Evaluation (2016)

Evaluation of the sediment analytical results found that, with one exception, none of the measured constituent concentrations in any of the samples collected exceeded consensus-based TEC freshwater sediment screening criteria. The analytical results for parameters above the laboratory reporting limit are presented in Table 10-14. Chromium was detected in all sediment samples collected,

One sediment sample (SE3) collected 10 m off the northern bank of the Victoria Nile near the proposed pipeline crossing reported a slightly elevated chromium value of 50 mg/kg, which exceeds the TEC criterion of 43.4 mg/kg. It is not possible to directly compare the sediment samples analyses results with the nearby surface water sampling results. However, it is worth mentioning that chromium was reported at <0.001 mg/l and 0.0016 mg/l at the closest surface water monitoring point, SW09, which is below the UPWS of 0.05 mg/l. This result contrasts with the concentrations of 7.8 mg/kg (i.e. at sample point SE1) and 9.1 mg/kg (i.e. at sample point SE2) in sediment samples collected near the centre of the channel and 10 m off the southern bank, respectively.

The two sediment samples collected from Lake Albert near shore and 500m offshore near the proposed water abstraction facility contained 15 mg/kg chromium. Elevated chromium in the sediment samples is an indication of possible natural contamination of the river bed sediments which may contribute to sediment toxicity of the lake and river. As the chromium levels in the water are well below the Ugandan standard, it is likely that the chromium in the sediments is not in a form that is readily available for release to water.

The sediment sample near the northern bank of the Nile also contained 22 mg/kg nickel, close to the EPA criterion of 22.7 mg/kg. Nickel concentrations in the other sediment samples from the Victoria Nile and Lake Albert were roughly an order of magnitude less than this result. The metals concentrations in sediments are likely to be reflection of the local geology rather than an indication of potential contamination.

Table 10-13: Surface Water Analytical Results (2016-2017)

Surface Water Results		Location ID and Description				SW01 Wetland in North Nile MFNP		SW02 Watering hole in North Nile MFNP		SW06 Lake Albert near shore		SW07 Lake Albert offshore		SW08 Watercourse near JBR09		SW09 Nile River		SW10 Nile River at Lake Albert		SW12 Waiga River		SW13 Wildlife watering hole in north of Nile	SW14 Nile Ferry Crossing (N)
		Date sampling				11/4/2016	12/06/2017	11/4/2016	12/06/2017	11/5/2016	14/06/2017	11/5/2016	14/06/2017	12/16/2016	12/06/2017	11/5/2016	14/06/2017	11/5/2016	14/06/2017	12/16/2016	13/06/2017	12/06/2017	14/06/2017
Parameter	Unit	USEPA Water Quality Human Health Criteria	USEPA Water Quality Aquatic Life Criteria	WHO Guideline (4th Edition 2011)	EAS 12:2014	SW1-161104	SW1-1706-12	SW2-161104	SW2-1706-12	SW6-161105	SW6-1706-14	SW7-161105	SW7-1706-14	SW8-1612	SW8-1706-12	SW9-161105	SW9-1706-14	SW10-161105	SW10-1706-14	SW12-1612	SW12-1706-13	SW13-1706-12	SW14-1706-14
Metals																							
Aluminum (Al)	mg/L	-		0.2	0.2	0.15	15	5	5.9	0.27	<0.10	0.18	<0.10	4.1	2.2	0.48	<0.10	0.16	<0.10	0.22	0.31	1.2	<0.10
Arsenic (As)**	mg/L	0.018	0.15	0.01	0.01	<0.005	0.0078	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Barium (Ba)**	mg/L	0.1		0.7	0.7	0.08	2	0.081	0.35	0.087	0.078	0.084	0.077	0.5	0.29	< 0.05	<0.05	< 0.05	<0.05	0.096	0.087	0.24	<0.05
Cadmium (Cd)**	mg/L	0.005	0.00025	.003	0.003	< 0.0004	0.00055	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
Cobalt (Co)	µg/L	-		-	-	< 3	170	6.4	29	< 3	<3.0	< 3	<3.0	17	5.2	< 3	<3.0	< 3	<3.0	4.3	3.3	14	<3.0
Chromium (Cr)**	mg/L	0.01	0.0074	0.05	0.05	<0.001	0.023	0.016	0.015	<0.001	<0.001	<0.001	<0.001	0.0044	0.0037	0.0016	<0.001	<0.001	<0.001	<0.001	<0.001	0.0017	<0.001
Copper (Cu)**	mg/L	1.3		2	1	<0.005	0.22	0.01	0.033	<0.005	<0.0016	<0.005	<0.0016	0.023	0.013	<0.005	<1.6	<0.005	<0.0016	<0.005	0.027	0.069	<0.0016
Iron (Fe)	mg/L	-	1	-	0.3	4.2	110	7.5	43	0.39	<0.050	0.26	<0.050	9.8	9.6	0.82	0.27	0.38	0.27	9.6	5.8	17	0.3
Manganese	mg/L	50		-	0.1	0.14	8.8	0.18	1.1	0.016	<0.010	< 0.01	<0.010	1.2	0.17	0.036	0.027	0.026	0.027	0.6	0.39	1.7	0.028
Nickel (Ni)**	mg/L	0.61	0.0052	0.07	0.02	<0.005	0.075	0.009	0.019	<0.005	<0.005	<0.005	<0.005	0.011	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0051	<0.005
Lead (Pb)**	mg/L	-	0.0025	0.01	0.01	0.25	0.094	0.0051	0.028	<0.005	<0.005	<0.005	<0.005	0.015	0.014	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0098	<0.005
Zinc (Zn)**	mg/L	7.4	0.12	-	5	< 0.01	0.088	0.015	0.021	< 0.01	<0.005	< 0.01	<0.005	0.017	0.0083	< 0.01	0.0051	< 0.01	0.0065	< 0.01	<0.005	0.0065	<0.005
Mono Aromatic Hydrocarbons																							
Toluene	µg/L	1300		700	700	< 0.2	0.79	< 0.2	<0.20	0.33	<0.20	< 0.2	<0.20	< 0.2	<0.20	< 0.2	0.52	< 0.2	<0.20	< 0.2	<0.20	<0.20	<0.20
Ethylbenzene	µg/L	530		300	-	< 0.2	0.96	< 0.2	0.55	0.29	0.46	< 0.2	1.3	< 0.2	1.6	< 0.2	0.96	< 0.2	1.1	< 0.2	0.72	0.81	0.51
BTEX (sum)	µg/L	-		-	-	< 1	1.8	< 1	<1.0	< 1	<1.0	< 1	1.3	< 1	1.6	< 1	1.5	< 1	1.1	< 1	<1.0	<1.0	<1.0
Petroleum Hydrocarbons																							
TPH (C16-C21)	µg/L	-			-	< 10	<10	< 10	<10	< 10	<10	< 10	<10	< 10	<10	< 10	<10	11	<10	< 10	<10	<10	<10
TPH (C21-C30)	µg/L	-			-	< 15	<15	< 15	<15	< 15	<15	< 15	<15	< 15	<15	< 15	<15	27	<15	< 15	<15	<15	<15
TPH (C30-C35)	µg/L	-			-	< 10	<10	< 10	<10	< 10	<10	< 10	<10	< 10	<10	< 10	<10	12	<10	< 10	<10	<10	<10
TPH Sum (C10-C40)	µg/L	-			-	< 38	<38	< 38	<38	< 38	<38	< 38	<38	< 38	<38	< 38	<38	61	<38	< 38	<38	<38	<38
Physical and chemical analyses																							
Turbidity	NTU				25	20.8	35.2	685	514	19	<1.0	13.7	<1.0		129.8	37.5	<1.0	6.93	<1.0		35.9	17.6	<1.0
Total suspended solids	mg/L	-			-	27	5200	430	2500	37	<3.8	18	<3.8	2800	960	92	15	12	14	120	86	450	14
Inorganic Compounds																							
Bromide	mg/L	-				< 0.05	0.14	< 0.05	<0.050	0.051	0.068	0.058	0.068	< 0.3	<0.050	< 0.05	<0.050	< 0.05	<0.050	< 0.3	<0.050	<0.050	<0.050
Chloride	mg/L	-	230		250	0.31	24	1.3	1.6	20	19	20	19	0.54	0.45	4.8	4.6	5	4.6	0.89	0.28	2.3	4.7
Fluoride	mg/L	-		1.5	1.5	0.4	0.3	0.093	0.21	0.78	0.76	0.78	0.76	0.19	0.42	0.33	0.32	0.34	0.31	0.15	0.16	0.25	0.32
Sulphate	mg/L	-			400	0.75	15	4.2	3.3	12	11	12	10	1.1	2.1	1.4	2.7	1.5	2.4	0.89	1.4	1	2
Inorganic Compounds																							
Ortho-phosphate (PO_4-P)	mg P/L	-		-	2.2	< 0.06	0.13	0.38	0.16	0.061	<0.020	0.086	<0.020	0.11	0.021	< 0.06	<0.020	< 0.06	<0.020	0.33	0.082	0.029	<0.020
Ortho-phosphate (PO_4)	mg PO4/L	-		-		< 0.02	0.39	0.12	0.49	0.02	<0.060	0.028	<0.060	0.036	0.064	< 0.02	<0.060	< 0.02	<0.060	0.11	0.25	0.089	<0.060

Surface Water Results			Location ID and Description			SW01 Wetland in North Nile MFNP		SW02 Watering hole in North Nile MFNP		SW06 Lake Albert near shore		SW07 Lake Albert offshore		SW08 Watercourse near JBR09		SW09 Nile River		SW10 Nile River at Lake Albert		SW12 Waiga River		SW13 Wildlife watering hole in north of Nile	SW14 Nile Ferry Crossing (N)
			Date sampling			11/4/2016	12/06/2017	11/4/2016	12/06/2017	11/5/2016	14/06/2017	11/5/2016	14/06/2017	12/16/2016	12/06/2017	11/5/2016	14/06/2017	11/5/2016	14/06/2017	12/16/2016	13/06/2017	12/06/2017	14/06/2017
Parameter	Unit	USEPA Water Quality Human Health Criteria	USEPA Water Quality Aquatic Life Criteria	WHO Guideline (4th Edition 2011)	EAS 12:2014	SW1-161104	SW1-1706-12	SW2-161104	SW2-1706-12	SW6-161105	SW6-1706-14	SW7-161105	SW7-1706-14	SW8-1612	SW8-1706-12	SW9-161105	SW9-1706-14	SW10-161105	SW10-1706-14	SW12-1612	SW12-1706-13	SW13-1706-12	SW14-1706-14
Nitrate equivalent NO3-N	mg N/L	10		-		0.44	<0.20	0.85	<0.20	0.21	<0.20	< 0.2	<0.20	< 0.2	<0.20	0.33	0.31	0.33	0.33	< 0.2	<0.20	<0.20	<0.20
Nitrate (NO_3)	mg/L			50	45	1.9	<0.90	3.8	<0.90	0.93	<0.90	< 0.9	<0.90	< 0.9	<0.90	1.5	1.4	1.5	1.5	< 0.9	<0.90	<0.90	<0.90
Nitrite as NO_2-N	mg N/L			-		0.013	<0.010	0.02	0.012	0.14	<0.010	0.097	<0.010	< 0.01	0.036	< 0.01	<0.010	< 0.01	<0.010	< 0.01	<0.010	0.015	<0.010
Nitrite (NO_2)	mg/L			3	0.003	0.043	<0.030	0.066	0.039	0.46	<0.030	0.32	<0.030	< 0.03	0.12	< 0.03	<0.030	< 0.03	<0.030	< 0.03	<0.030	0.049	<0.030

Notes:

** Results converted µg/L to mg/L

Exceedance of EAS 12:2014

Exceedance of USEPA Criteria

Note: USEPA standard applied where no EAS12:2014 standard exists

Table 10-14: Sediment Analytical Results (2016-2017)

Sediment Results	Location ID and Description		SE1 Victoria Nile central channel	SE2 Victoria Nile 8 m from south bank	SE3 Victoria Nile 10 m from north bank	SE4 Lake Albert near shore	SE5 Nile Ferry crossing on the north bank of the Nile	SE5 B/BN Nile Ferry crossing on the south bank of the Nile
	Sample ID		SE2-1612	SE3-1612	SE1-1612	SE4-161106	SE5-170614 B/BS	SE5-170614 B/BN
	Sample Date		12/16/2016	12/16/2016	12/16/2016	11/6/2016	14-06-2017	14-06-2017
Parameters	Units	EPA 2006						
Metals								
Barium (Ba)	mg/kg	-	11	29	140	58	230	<15
Beryllium (Be)	mg/kg	-	<1.0	<1.0	1.2	<1.0	<1.0	<1.0
Chromium (Cr)	mg/kg	43.4	7.8	9.1	50	15	110	27
Cobalt (Co)	mg/kg	-	<2.0	<2.0	11	2.1	21	2.4
Copper (Cu)	mg/kg	31.6	<3.0	<3.0	13	<3.0	32	<5.0
Mercury (Hg)	mg/kg	0.18	<0.050	<0.050	<0.050	<0.050	0.05	<0.050
Lead (Pb)	mg/kg	35.8	<3.0	<3.0	7.5	<3.0	14	<13
Molybdenum (Mo)	mg/kg	-	<1.0	<1.0	<1.0	<1.0	<1.5	<1.5
Nickel (Ni)	mg/kg	22.7	2.3	2.3	22	2.1	43	4.8
Selenium (Se)	mg/kg	2	<5.0	<5.0	<5.0	<5.0	8.9	1
Vanadium (V)	mg/kg	-	3.9	4.2	41	18	96	15
Zinc (Zn)	mg/kg	121	<10	<10	30	<10	55	<17
Total Petroleum Hydrocarbons								
C30-C35 Petroleum Hydrocarbons	mg/kg	-	6.4	6	8.9	<6.0	<24	<6.0
Mono Aromatic Hydrocarbons								
Toluene	mg/kg	-	<0.050	<0.050	0.13	<0.050	<0.050	<0.050

Sediment Results	Location ID and Description		SE1 Victoria Nile central channel	SE2 Victoria Nile 8 m from south bank	SE3 Victoria Nile 10 m from north bank	SE4 Lake Albert near shore	SE5 Nile Ferry crossing on the north bank of the Nile	SE5 B/BN Nile Ferry crossing on the south bank of the Nile
	Sample ID		SE2-1612	SE3-1612	SE1-1612	SE4-161106	SE5-170614 B/BS	SE5-170614 B/BN
	Sample Date		12/16/2016	12/16/2016	12/16/2016	11/6/2016	14-06-2017	14-06-2017
Parameters	**Units**	**EPA 2006**						
Polycyclic Aromatic Hydrocarbons, PAH								
Fluorene	mg/kg	0.0774	<0.010	<0.010	0.012	<0.010	N/A	N/A
Phenanthrene	mg/kg	0.204	<0.010	0.022	0.018	<0.010	N/A	N/A
Anthracene	mg/kg	0.0572	<0.010	0.017	<0.010	<0.010	N/A	N/A
Fluoranthene	mg/kg	0.423	<0.010	0.012	0.015	<0.010	N/A	N/A
Pyrene	mg/kg	0.195	<0.010	<0.010	0.011	<0.010	N/A	N/A
Benzo(a)anthracene	mg/kg	0.108	<0.010	<0.010	<0.010	<0.010	N/A	N/A
Chrysene	mg/kg	0.166	<0.010	<0.010	0.011	<0.010	N/A	N/A
Benzo(b)fluoranthene	mg/kg	0.240	<0.010	<0.010	0.012	<0.010	N/A	N/A
Physical and chemical analyses								
Acidity (pH-$CaCl_2$)	Std units	-	7.6	8	5.2	N/A	5.5	8.5
Calcium (Ca)	mg/kg	-	N/A	N/A	N/A	N/A	4200	650
Potassium (K)	mg/kg	-	N/A	N/A	N/A	N/A	2700	100
Magnesium (Mg)	mg/kg	-	N/A	N/A	N/A	N/A	4600	200
Sodium (Na)	mg/kg	-	N/A	N/A	N/A	N/A	210	40
Phosphorus total (P)	mg/kg	-	N/A	N/A	N/A	N/A	0.55	0.061
Phosphorus total (PO_4)	mg/kg	-	N/A	N/A	N/A	N/A	1.7	0.19
Phosphorus total (P_2O_5)	mg/kg	-	N/A	N/A	N/A	N/A	1.2	0.14

Note: N/A – Not Analysed

10.5.9 ESIA Baseline Survey (June 2017)

10.5.9.1 Water Quality Results Evaluation

The second of two survey campaigns associated with the Tilenga ESIA was conducted in June 2017. This survey campaign involved the sampling of surface water at the same locations as in November 2016. The analytical results for parameters above the laboratory reporting limit are presented in Table 10-13. The complete surface water laboratory analytical results are presented in Appendix L – 02 and have been compared with the UPWS and WHO Guidelines, and the USEPA Aquatic Life and Human Health Criteria. The majority of the parameters analysed were reported at concentrations below the Ugandan standard. Parameters with exceedances of the Ugandan standard are highlighted in red in all tables.

Aluminium concentrations were detected above the UPWS limit of 0.2 mg/l in five of the ten samples (SW01, SW02, SW08, SW12 and SW13) ranging between 0.31 mg/l and 15 mg/l with the highest concentration detected at SW01. There are no USEPA Water Quality Criteria for aluminium. The source of the aluminium is unknown; as there are no anthropogenic sources the presence is attributed to natural causes.

Barium was above the UPWS of 0.7 mg/l in one sample location (SW01) at 2 mg/l. Barium concentrations exceeded the USEPA Water Quality Human Health Criteria of 0.1 mg/L in samples collected from SW01, SW02, SW08 and SW13 at concentrations ranging from 0.24 mg/L to 2 mg/L. Three of the four samples were collected from watering holes therefore the source is likely to be from natural processes.

Cadmium was detected in only one sample, SW01 from a wetland in MNFP at a concentration of 0.00055 mg/L which exceeds the USEPA Water Quality Aquatic Life Criteria of 0.00025 mg/L. The source is unknown but likely to be attributed to natural processes.

Chromium concentrations exceeded both the USEPA Water Quality Criteria limits for Human Health and Aquatic Life limits of 0.01 mg/L and 0.0074 mg/L, respectively in water samples from SW01 and SW02. The chromium concentration in SW01 was 0.023 mg/L and in SW0 0.015 mg/L. Both sampling locations are in MFNP therefore the source is likely to be from natural processes.

The UPWS limit for iron of 0.3 mg/l was exceeded in six of the samples (SW01, SW02, SW08, SW12, SW13 and SW14) in the range of 0.3 mg/l and 110 mg/l. Of the six samples, only the sample from SW14 did not exceed the USEPA Water Quality Aquatic Life Criteria limit of 1 mg/L. The highest iron exceedances were recorded at SW01 (110 mg/l) and SW02 (43 mg/l) at a wetland north of the Victoria Nile within the MFNP and a watering hole, north of the Victoria Nile respectively. The source of the iron can be attributed to natural processes.

Manganese was detected above the UPWS limit of 0.1 mg/l in five of the samples (SW01, SW02, SW08, SW12 and SW13) ranging between 0.17 mg/l and 8.8 mg/l. The maximum manganese level of 8.8 mg/l was reported for the sample collected from the wetland north of the Victoria Nile in the MFNP. The source is unknown but is likely to be attributed to natural processes.

Nitrite was detected above the UPWS limit of 0.003 mg/l in three samples (SW02, SW08 and SW13) ranging between 0.039 mg/l and 0.12 mg/l. The remainder of the samples were reported as being less than the laboratory detection limit of 0.03 mg/l. As noted earlier, the UPWS limit for nitrite falls below the detection limit of all nitrite analytical methods. If the results are compared against the WHO limit, the nitrite levels for all of the samples would not exceed the limit. However, as this laboratory limit is above the UPWS limit of 0.003 mg/l, it is not known if the remainder of the samples exceeded the limit. Nitrite is commonly formed as an intermediate product in bacterially mediated nitrification and denitrification of ammonia and other organic nitrogen compounds. The occurrence can also be linked to water from fertilisers and can also be found in sewage and wastes from humans and farm animals. Accordingly, the elevated nitrite in the samples may be of natural occurrence or linked to waste from humans and farm animals using these water bodies. The potential source of the elevated levels of nitrite is not known but may be attributed to both natural and/or anthropogenic causes and animals.

There are no Ugandan standards for TPH. The laboratory limit of detection for TPH C10 – C40 is less than 10 µg/l. Petroleum hydrocarbons were not detected above the laboratory detection limit any of the surface water samples. However, BTEX was reported in five of the ten samples (SW01, SW07, SW08, SW09 and SW10) ranging in concentration between 1.1 µg/l and 1.8 µg/l. However, there is no exceedance of the individual component determinants benzene, toluene, ethylbenzene and xylene which have UPWS and WHO limits of 300 µg/l, 500 µg/l, 10 µg/l and 700 µg/l respectively. It is not known if these detections are the result of naturally occurring oil seepage in the Study Area or due to anthropogenic sources.

10.5.9.2 Sediment Sample Evaluation (2017)

Sediment samples were collected at two additional sampling locations - SE05 N/B and SE05 S/B along the Victoria Nile River Figure 10-3. Analytical results for parameters detected above the laboratory reporting limits are shown in Table 10-14. The full suite of sediment laboratory results is presented in Appendix L - Annex 03. The results have been compared against conservative, consensus-based USEPA screening values derived for freshwater biota.

Concentrations of 110 mg/kg and 43 mg/kg were reported for chromium and nickel respectively, for additional samples collected at SE5 at the propose Nile Ferry Crossing along the Victoria Nile River. These exceed the USEPA limits for chromium and nickel of 43 mg/kg and 23 mg/kg respectively. Comparatively lower concentrations of chromium reported at 27 mg/kg and nickel reported at 1 mg/kg were detected in the sample collected at location SE5 at the northern bank of the River at the same sampling location. Comparatively, the results for chromium and nickel reported for the sediment sample taken at SE5 are significantly higher than that reported for the samples taken at SE3 further downstream of the Victoria Nile River. The source of chromium and nickel are not known however they were detected in all sediment samples collected and is therefore attributed to natural causes

10.5.10 Secondary Data

10.5.10.1 Data sources

The baseline surface water environment of the Study Area has been determined using a wide range of data sourced from both the literature and EBS field survey campaigns carried out in the area by AECOM since 2014. Findings from these surveys and the literature review have been used to characterise the surface water environment of the Study Area as presented in the sections below.

The secondary information and data related to the surface water environment directly relevant to the baseline characterisation of the Study Area and the ESIA process, were obtained from a number of sources as listed in Table 10-15, including the recently published Albertine Graben Environmental Baseline Monitoring (AGEBM) Report (NEMA 2017) (Ref. 10-21) following the Albertine Graben Environment Monitoring Plan. The AGEBM report draws on the data and information collected or held by the various relevant stakeholders.

Table 10-15: Relevant Secondary Source Surface Water Related ESIA Components

Document Title	Source and Format	Date of Information	ESIA-Relevant Content
Environmental and Social Impact Assessments for exploration and appraisal phases in Blocks 1 and 2. Prepared by various consultants (Atacama, AWE, Eco & Partner, BIMCO and so forth) between 2007 and 2013	TEP Uganda Reports	2007-2013	Multiple ESIAs have been prepared for seismic and drilling projects that took place in the area where the proposed Buliisa development Project is planned. Each report describes the physical environment baseline conditions at the regional level and reports field survey data specific to the Project Footprint.
Albertine Rift Development Project (ARDP) Injection Water Supply Study. Groundwater review. (Atkins, 2010) (Ref. 10-22)	TUOP Report	Groundwater data 2007 - 2010	This study provides information on regional groundwater issues and investigates water supply options for the provision of injection of water for the Kasamene oil field development and the broader basin development. The report analyses the geology, groundwater yields and quality.

Document Title	Source and Format	Date of Information	ESIA-Relevant Content
Albertine Rift Development Project (ARDP) Injection Water Supply Study. Hydrology of Lake Albert (Atkins, May 2010) (Ref. 10-23)	TUOP Report	Groundwater data 2007 - 2010	This study provides information on the regional hydrology of Lake Albert and investigates the availability of water at Lake Albert for oil extraction, now and in the future. The study also provides some general information about surface water bodies including the Lake Albert physiography and hydrology.
National Water Supply Database Uganda Ministry of Water and Environment (MWE) (Ref. 10-24)	Uganda Ministry of Water and Environment public website. GIS files, pdf files	Various	A web-based public database that allows users to extract data, including operational status, for safe water supply sources in 112 Uganda districts, including piped water systems, protected springs, shallow wells, deep boreholes, rainwater harvesting tanks, dams, and valley tanks, with the exception obtain water quality data.
Albertine Graben Environmental Baseline Monitoring (AGEBM) Report 2017 (Ref. 10-21)	NEMA Report	2017	The AGEBM is a product of high-level consultation and collaboration with the relevant sectors and partners involved with the management of water resources in Uganda. The report draws on the data and information collected or held by the various stakeholders including data from the Graben Environment Monitoring Plan that was prepared under the coordination of NEMA. The baseline monitoring report helps to measure the degree and quality of change of the valued ecosystem components outlined in the Albertine Graben Environmental Monitoring Plan (AGEMP). Furthermore, it provides a clear picture of the current state of the ecosystem components, the drivers of change and the indicators that will be used to measure the extent/degree of change. The report also includes targeted baseline qualitative water quality and ecological monitoring data taken from a network of monitoring stations located in the region and the ESIA Study Area.
Albertine Rift Development Project (ARDP) Water Monitoring Data Report Round 1 October –November 2010 (Ref. 10-25)	TUOP Report	2009	Water quality results for one round of sampling in Lake Albert and the Victoria Nile.
Lakes Edward and Albert Fisheries (LEAF) ESMP Final Report (2011) (Ref. 10-26)	Nile Basin Initiative (NBI)/	2011	Provides details of baseline water quality monitoring data in Lake Albert.
Lake Overview Report Final Report: Strategic Environmental and Social Overview of Lake Albert, Uganda. Unpublished report for Tullow Oil PLC (Ref. 10-27)	ERM/Tullow Report	2007	Provides morphometric baselines and water resources supply potential of Lake Albert and its usage by local community. Also provides some details of the Lake's water quality and potential water quality issues including flooding, potential impacts from current and future land use activities with the local catchment of the lake. Highlight the need for water quality and sediment quality baseline data to be captured prior to exploration and consideration for water quality monitoring.
Uganda Categorised Flood Hazard Map (Ref. 10-28)	Website https://oasishub.co/dataset/uganda-categorised-flood-hazard-ssbn/resource/	Accessed 25 September 2017	A flood hazard map indicating the location of various flood events including 1 in 20 years, 1 in 50 years, 1 in100 years, 1 in 1,000 years.

Document Title	Source and Format	Date of Information	ESIA-Relevant Content
Environmental Sensitivity Atlas for the Albertine Graben – 2nd Edition (NEMA 2010) (Ref. 10-20)	Website http://www.nemaug.org/atlas/Sensitivity_atlas_2010.pdf	2010	Provides environmental planners with tools to identify resources at risk, establish protection priorities and identify timely appropriate response and clean-up strategies. The Atlas enables oil companies and authorities to incorporate environmental consideration into exploration and contingency plans. It also provides an overview of such aspects as the occurrence of biological resources, human resource use (fishing and hunting) and archaeological sites that are particularly sensitive to oil spill. Furthermore, it contains information regarding the physical environment, lakeshore and bathymetry of Lake Albert and the climate of the region and the Study Area.
Consolidated Hydrological Yearbook for Uganda 1978 – 2014 (DWRM, 2014) (Ref. 10-29)	Website http://www.mwe.go.ug/library/manuals-guidelines-and-forms	2014	The yearbook describes and illustrates the climatic zones covering the ESIA Study Area and provides information about the water resources, drainage system and surface water monitoring network within the ESIA Study Area and environs. It also provides information on the hydrological processes affecting major hydrological basins including the Lake Albert, Albert Nile and Victoria Nile Basin which the Study Area falls within. Furthermore, it highlights the potential water resources availability challenges that may affect the Study Area and environs. It also includes representative hydrographs of river flow, water balance (i.e. of Victoria Nile, Lake Albert etc.) and groundwater level data of the Study Area which are beneficial to the present ESIA. The yearbook is based on the collection of all available hydrological and meteorological time-series data from the DWRM database.

10.5.10.2 Previous EIA and Other Surveys

Baseline surface water quality analyses from previous studies have been reviewed and used to inform the characterisation of the baseline water environment of the Study Area. Surface water quality data available from surveys conducted for exploration and appraisal phases within Blocks 1 and 2 have been used. These include those performed in support of the seismic, geophysical and geotechnical surveys.

In November 2007, baseline water quality studies were conducted in Lake Albert as part of the Lake Albert Offshore Exploration Drilling ESIA (Ref. 10-27). These studies included surface water and sediment sampling at 13 stations in Lake Albert within the Ngassa-Nzizi area and the Kingfisher-Pelican area. Findings from these studies provided a small amount of additional information of Lake Albert's water quality baseline condition. In summary, the pH values at all sampling sites ranged from 7.6 to 8.8. Electrical conductivity at all the sites ranged from 671 to 686 micro Siemens per centimetre (µS/cm), increasing with depth. These indicate the possible conductivity values ranges in Lake Albert, especially at areas located south of the confluence with the Victoria Nile at Wanseko.

10.5.10.3 Lakes Edward and Albert Fisheries (LEAF) ESMP Final report (2011)

The LEAF ESMP Final report (NBI, 2011) (Ref. 10-30) includes a description of baseline water quality in Lake Albert. Further details can be found in the Lakes Edward and Albert Fisheries Pilot Project, Feasibility Report (NBI/NELSAP, 2008) (Ref. 10-31). This section summarises the key findings of that study.

The water quality data indicates that some physical, bacteriological and chemical parameters exceed the Ugandan Potable Water Standards, especially along the Victoria Nile River, Albert Nile River and near the Tangi River. This deviation of the water quality from the UPWS can be attributed to anthropogenic activities such as runoff and nutrients loads from agriculture and livestock. In general, measurements of DO, temperature, electrical conductivity, pH, chlorophyll levels, turbidity and total faecal coliform counts indicate low levels of contamination, although there are some localised pollution “hot spots”.

The bottom offshore waters of Lake Albert were found to be devoid of oxygen. High algal concentrations (11-18 grams per litre (g/l)) were noted in the shallow areas at the entrance of Victoria Nile River near Wanseko Fish Landing. These may be due to pollution from anthropogenic activities from urban, domestic and industrial wastewaters, including runoff, as well as sediment loads and nutrients from agriculture and livestock areas, which enter the lake through numerous river systems from the upper catchment. Consequently, as the lake acts as a repository to discharges from numerous rivers, the discharge of polluted effluents into the lake increases the Chemical Oxygen Demand (COD) and concentrations of total Phosphorus (TP), total Nitrogen (TN), and Chlorophyll, resulting in eutrophication and growth of plant and algae.

10.5.10.4 Strategic Environmental and Social Overview of Lake Albert (2007)

The Report of the Strategic Environmental and Social Overview of Lake Albert (2007) (Ref. 10-27) discusses the hydrochemistry of Lake Albert and summarises the chemical composition of major inorganic elements in the lake from several data sources. Although the Victoria Nile River controls the level of Lake Albert and provides approximately 90% of the water entering the lake, it has a more limited effect on the relative concentrations of the major ions. The major chemistry of most of the lake (away from the direct influence of the Victoria Nile River inflow and outflow) is quite similar to Lake Edward and has much higher concentrations of the major ions than the Victoria Nile River flowing out of Lake Victoria.

The discussion notes that Lake Albert has a relatively high pH level and unusual nutrient chemistry especially in regards to total phosphorus and dissolved reactive silicon (SiO_2) and that phosphorous concentrations rose over time from the 1960s through the 1990s. A possible explanation is that the eutrophication of Lake Victoria during the same period led to an increase in total phosphorus, and consequently, the Victoria Nile may have become the most important source of phosphorous input to Lake Albert. The major ion chemistry of the lake's water was reported from between 1960 – 1995. The variation in the chemistry was attributed to the mixing of two major source waters of quite different composition.

10.5.10.5 Albertine Rift Development Project (ARDP) Water Quality Monitoring (SWS, 2010)

Schlumberger Water Services conducted water monitoring of Lake Albert and the Victoria Nile in October and November 2009 (Ref. 10-32). Surface water monitoring included three transects extending into the Lake with vertical water quality profiles sampled at several points along each transect and a vertical profile at Paraa on the Victoria Nile River. Of the three transects, only Transects 1 and 2 are within the Project Area. The aims of the study were:

- to characterise the suspended particulate material in the lake in order to design the water intakes and filtration equipment;
- to characterise the water composition in order to evaluate the interaction between injection water and formation water; and
- to provide baseline environmental data.

To establish baseline environmental water quality, one near surface sample (0.5 m) from halfway along each transects and one sample from the Victoria Nile River was collected for chemical analysis. The water quality sample locations are provided in Table 10-21. The analytical results were compared to the US EPA Water Quality for Aquatic Life Criteria. There were no exceedances of the criteria. Although there are no standards, TPH was detected as follows:

- TPH C_6-C_{40} detections : Sample location VN-1A (64 µg/l), LA-2E (91 µg/l);
- TPH C_{16}-C_{24} detections: SVN-1A (20 µg/l), LA-2E (10 µg/l); and
- TPH C_{24}-C_{40} detections: VN-1A (44µg/l), LA-2E (81 µg/l).

The source of the TPH is not known. However, the results are consistent with the samples collected from the Victoria Nile River at Paraa (SW05D in 2014) and at the Lake Albert/Victoria Nile confluence (SW10 2016) sampling locations during the 2014 – 2017 ESIA surveys which reported TPH C1-C40 detections of 91 and TPH C1-C40 of 61 respectively.

10.5.10.6 Albertine Rift Development Project Injection Water Supply Study (2010)

The Albertine Rift Development Project Injection Water Supply Study prepared by Atkins in 2010 (Ref. 10-23) includes limited Lake Albert water quality data for two offshore transects in the vicinity of the proposed intake structure (SWS 2009). This involved vertical profiling of 14 locations with a total of 24 samples collected. The resulting Secchi disc visibility measurements indicate the lake waters are likely to be eutrophic, with limited light penetration potentially due to the presence of phytoplankton. Average turbidity levels were very low, suggesting limited, suspended material. pH levels were alkaline but stable, as were the ranges in electrical conductivity, temperature, salinity and TDS. This suggested the water was well mixed with no stratification. DO levels were greatest between 1.0 m and 1.5 m depth, decreasing with depth. The ORP increased with water depth towards the lake bed, indicating more reducing conditions as is expected at the interface between the lake bed and water column. The TDS values were low and alongside the electrical conductivity levels, indicate freshwater with limited dissolved material.

10.5.10.7 Albertine Graben Monitoring Plan and Baseline Monitoring Report (2017)

The National Environment Management Authority (NEMA) in partnership with other stakeholders from the Environmental Information Network produced an Environmental Monitoring Plan for the Albertine Graben (AG EMP 2012) (Ref. 10-33). The objective of the AG EMP is to track the impact which oil and gas-related developments have on the environment of the Albertine Graben. As such, the monitoring plan lists some environmental monitoring indicators that will be used to monitor a defined list of major valued ecosystem components, including aquatic and physical/chemical indicators. Over time, the monitoring indicators are intended to demonstrate progress and changes in the ecosystem components and provide an indication of the effectiveness of ongoing environmental management.

The AG EMP includes plans for monitoring surface water quality through a network of surface water monitoring stations existing in each of the sub-basins in the Albertine Graben. Water level data is collected by observers from both groundwater and surface water stations on a daily basis. River flow discharge measurements are also carried out by staff from DWRM on a quarterly basis. The data from these stations are digitised and stored in the national databases from where it can be retrieved for further analytical purposes.

Following the preparation of the AG EMP, the Albertine Graben Environmental Baseline Monitoring (AGEBM) Report (NEMA, 2017) (Ref. 10-21) was published. The AGEBM report is a product of a high-level consultation and collaboration with the relevant sectors and partners. The parameters reported on in the report were identified in the Albertine Graben Environment Monitoring Plan prepared under the coordination of NEMA. The report draws on the data and information collected or held by the various stakeholders. The Environment Information Network (EIN) institutions represent the five themes namely Aquatic, Terrestrial, Physical and Chemical, Society and Business and Management, all of which form the core of the contributing institutions and constitute the authorship of the report. Findings from these reports have also been used to inform the characterisation of the baseline water environment of the Study Area.

10.6 Baseline Surface Water Conditions

10.6.1 Transboundary Catchment Systems

The Study Area falls within the Lake Albert, Victoria Nile River and the Albert Nile River Catchments, all of which are part of the Nile River which is a transboundary catchment running across several countries from Uganda to Egypt. The Uganda section of the Nile basin is divided into eight main drainage sub-basins. These are; Lake Victoria, Lake Kyoga, River Kafu, Lake Edward, Lake Albert, River Aswa, Albert Nile and Kidepo Valley. Figure 10-4 shows that most of the Project Area falls within the hydrological/water catchment of Lake Albert and Victoria Nile River with a small proportion of the Northern Boundary of the Project Area within the Albert Nile Catchment (Ref. 10-34).

Uganda has adopted an Integrated Water Resources Management (IWRM) strategy. In Uganda, the institutional IWRM is represented by the DWRM at the national level, which operates under the Ministry of Water and Environment. At the regional level, there are four Water Management Zones (WMZ) of the DWRM, responsible for facilitating the creation and implementation of catchment-based water resource management in association with Catchment Management Organisations (CMO). The Study Area falls within northern end of the Albert Water Management Zone as shown in Figure 10-5.

The Study Area lies at the northern end of the Lake Albert sub-basin catchment and the southern part of the Albert Nile sub-basin catchment area. The yield from these sub-basins, though small compared with the total Nile River flow, dominates the water resources potential of the Study Area. The yield from these sub-basins, though small compared with the total Nile River flow, dominates the water resources potential of the Study Area. The Lake Albert and Albert Nile sub-basin catchments are the most prominent within the Study Area and are also considered to be transboundary catchments shared by Uganda, the Democratic Republic of Congo (DRC) and South Sudan. A small section of the eastern part of the Study Area also falls within the Victoria Nile River sub-basin catchment.

Source: Nsubuga, 2014

Figure 10-4: Main Drainage Sub-Basins in Uganda

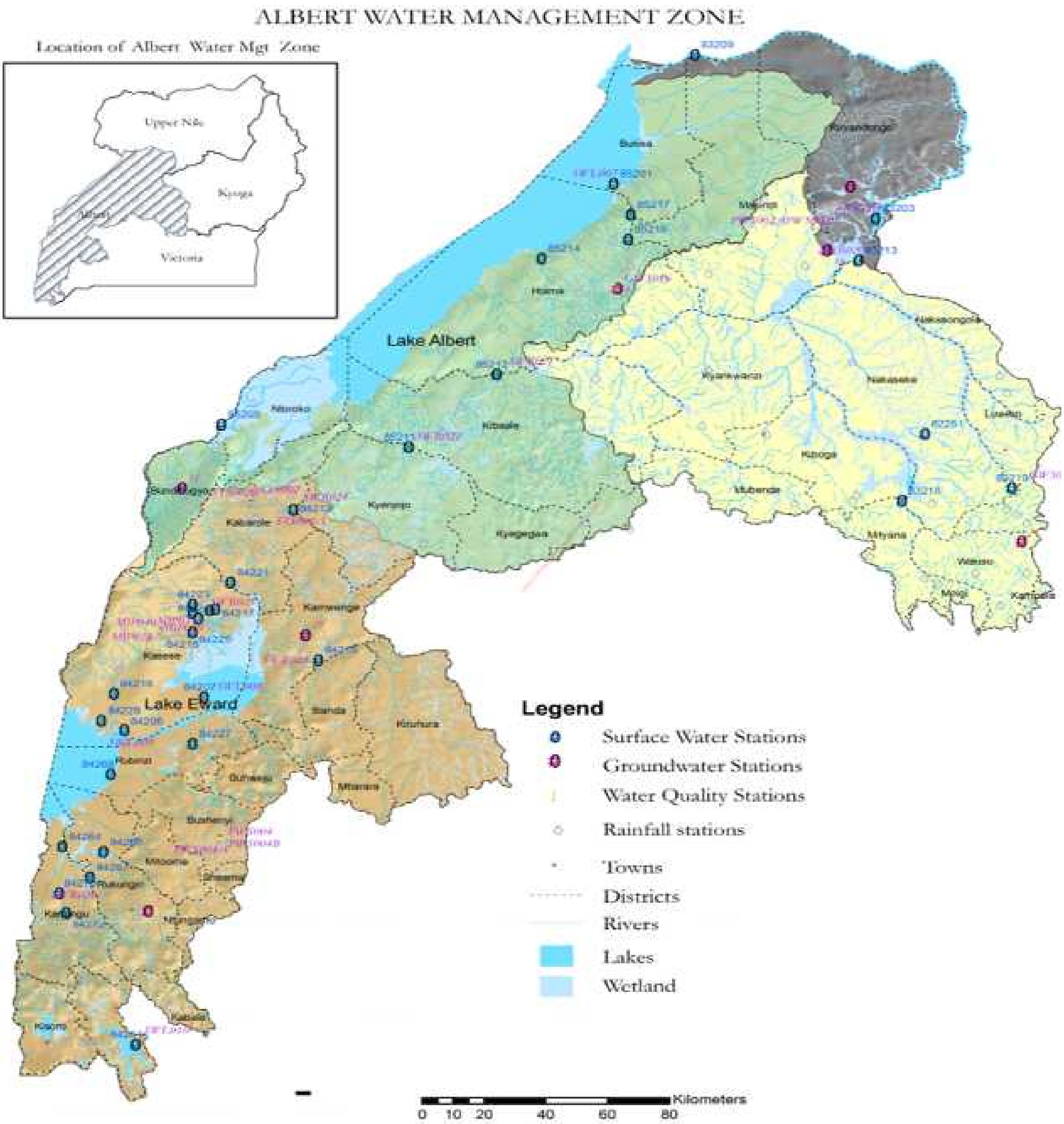


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Figure 10-5: Lake Albert Water Management Zone (WMZ)

10.6.2 Surface Water Bodies in the Study Area

The Project Area is separated by the Victoria Nile River that flows westerly from the eastern part of the Study Area towards Lake Albert. The Victoria Nile River forms a delta front around the area where it discharges and converges with Lake Albert (Figure 10-1).

Most of the Project Area falls within the hydrological/water catchment of Lake Albert and the Victoria Nile River with a small proportion of the northern part of the Project Area within the Albert Nile River catchment.

The North Nile area, located between the two branches of the Nile, is characterised by low hills. The Tangi River flows generally westward through the North Nile area into the Albert Nile near Pakwach. Major tributaries of the Tangi River include the Ajar and Opengor. The Albert Nile is also fed from the East by several short, seasonally inundated riverine floodplains in the North Nile area. Several named ephemeral streams also originate in the North Nile area and flow southward into the Victoria Nile River near Paraa, including the Songe, Emi, and Nyamsika.

The South Nile area is bounded by the Victoria Nile to the North and Lake Albert to the West. The Murchison River flows West/Northwest through the South Nile area and has its confluence with the Victoria Nile River near Murchison Falls. Similar to the North Nile area, ephemeral drainages convey surface water northward into the Victoria Nile through the South Nile area.

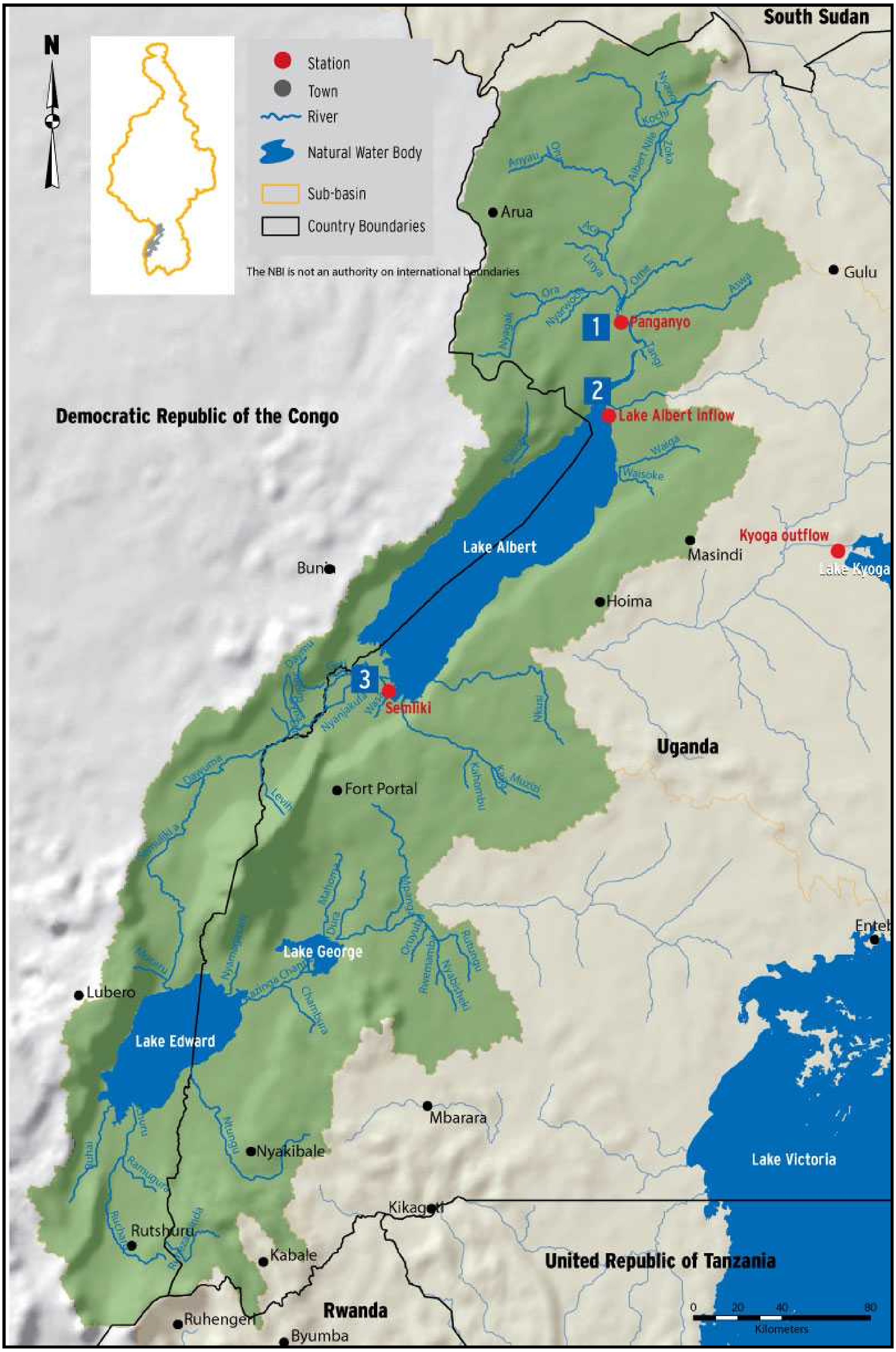
The surface water environment is endowed with many watercourses that form part of the water resources and drainage network of the region and the Study Area (Figure 10-2). These watercourses include streams/rivers, wetlands and lakes that straddle a large part of the region and the Study Area. For the ESIA surface water baseline study and impact assessment, the watercourses within the Study Area have been categorised as being either "main" or “ordinary" watercourses as defined below.

10.6.2.1 Main Water Bodies

The “Main" surface water bodies are defined as large ***permanent*** surface water bodies/watercourses such as rivers and lakes that are of regional (i.e. transboundary ***international*** water bodies), national and local importance in terms of their water resources supply potential and ecological importance. They are the most prominent and principal water bodies within the drainage network that drain the Study Area. Taking into account their water resources supply potential and ecological importance to the region, they are also considered to be of high sensitivity within the water environment and they are in most cases hydrologically connected to each other. Based on this definition, Lake Albert, the Albert Nile River and the Victoria Nile River have been identified as the main surface water bodies within the Project Area and environs. Both Lake Albert and the Albert Nile River are transboundary surface water bodies (i.e. water bodies in the Study Area that cross at least one international political border or boundary).

10.6.2.1.1 Lake Albert

Lake Albert (Figure 10-5) is the dominant surface water body within the Study Area. It is a typical Rift Valley lake lying at an altitude of about 615 m between two parallel escarpments, that on the western side rising abruptly to nearly 2,000 m above the water surface. The lake is about 150 km long, with an average width of about 35 km, and a maximum depth of 56 m within 7 km of the mid-western shore. Its main inflows are from Lake Victoria which reaches it via the Semliki River at its southern end and by the Victoria Nile River that flows into it at its northern end. Table 10-16 provides details of the key characteristic features of the lake. The bathymetry of Lake Albert (Figure 10-7) shows that the lake is shallower in the north and south where the Victoria Nile River and Semliki River drain into the lake respectively. The maximum depth of the northern area of the lake within the Project Area is between 19 – 24 m. Typical fluctuation in the water level of Lake Albert is approximately 0.5 m.

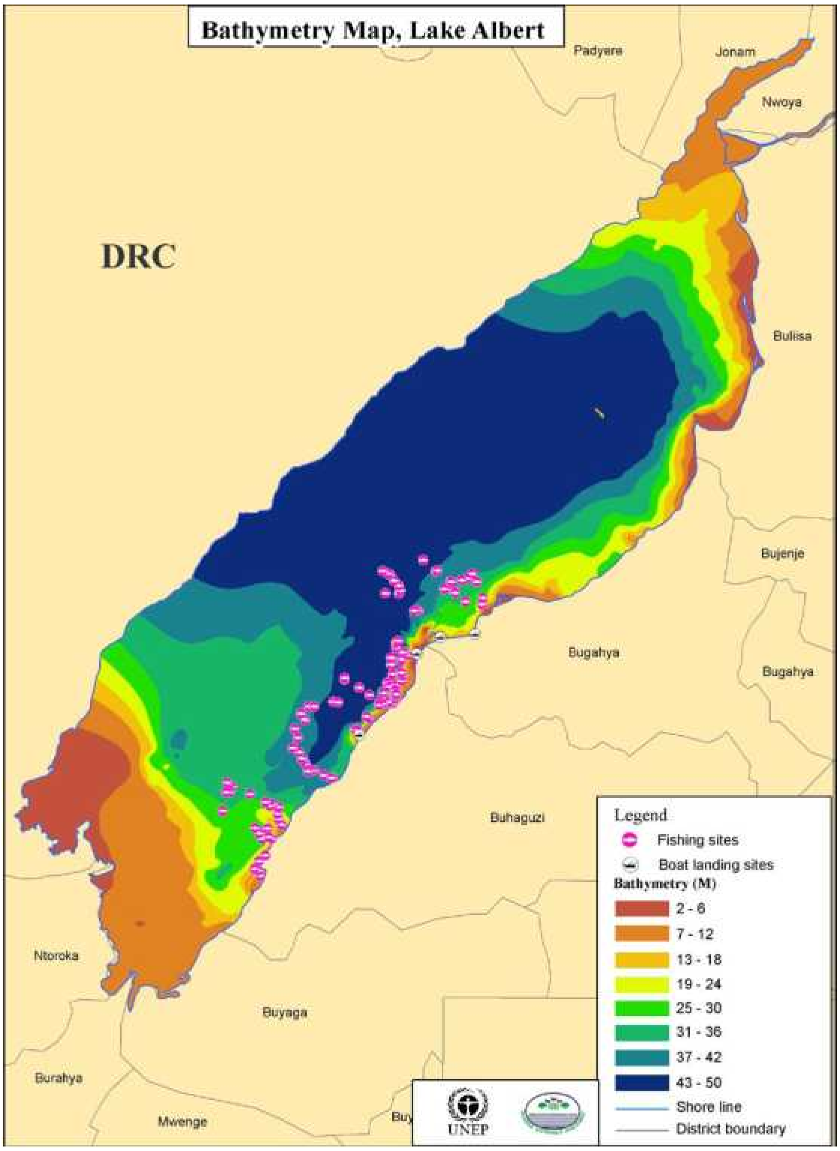


Source: Nile Basin Initiative, 2008

Figure 10-6: Flow Monitoring Stations in Lake Albert Catchment and Study Area

Table 10-16: Characteristics and Water Resource Potential of Lake Albert

Parameter	Value/Status
Total Surface Area (km²)	5300
Total Length (km)	150
Total Volume (km³)	280
Total Catchment (i.e. Eastern Catchment Area) (km²)	4,230
Maximum Depth (m)	56
Average Depth (m)	25
Normal range of actual water fluctuation (m)	0.5
Orientation and Flow Direction	South to North
Altitude (m)	615
Part of Uganda (%)	55
Average Electrical Conductivity (µS/cm)	650
Water pH	8.8



Source: NEMA 2009

Figure 10-7: Bathymetric Map of Lake Albert

10.6.2.1.2 Albert Nile River

The Albert Nile River issues from the northern end of Lake Albert north of the mouth of the Victoria Nile (Figure 10-6). It flows from the northern boundary of the Study Area about 130 miles (210 km) north past Pakwach to the South Sudanese border at Nimule, where it becomes the Al-Jabal River or White Nile River. The Albert Nile River forms the main surface water outflow from Lake Albert and the Study Area.

10.6.2.1.3 Victoria Nile River

The Victoria Nile River forms the upper section of the Nile River, flowing some 300 miles (480 km). It issues from the northern end of Lake Victoria at Ripon Falls (now submerged), west of Jinja, and flows northwest over the Nalubaale and Kiira dams at Owen Falls, through Lake Kyoga, and past Masindi Port and Atura. In its lower course the Victoria Nile is impeded by a series of rapids culminating in the Murchison Falls on the eastern edge of the Western Rift Valley. At the northern end of Lake Albert it flows westerly through the Project Area and forms a swampy estuary in the Study Area (Figure 10-8).

There are no bathymetry data for the Victoria Nile River and the Albert Nile River. Flow within the watercourses varies over the year and is controlled by seasonal rainfall variation. The direct flow of the Victoria Nile is from east to west while that of Lake Albert and the Albert Nile River is from south to north. Flow measurement taken at Panyango (Figure 10-6) at the downstream end of the Study Area on the Albert Nile indicated an average monthly outflow from Lake Albert of about 3 Billion m^3/month.

10.6.2.2 Ordinary Water Bodies

The "Ordinary" surface water bodies are defined as small to medium size ***permanent, perennial, intermittent and ephemeral*** surface water bodies/watercourses that are of national and local importance in terms of their water resources supply potential and ecological importance as well as those wetlands that are not prominent and not important in any form. In comparison with the main surface water bodies, they are less prominent and are part of the tributaries to the main surface water bodies/watercourses within the drainage network on a national or local scale. In some cases, they are isolated and are not hydrologically connected to any ordinary or main surface water bodies. The Tangi River in the north of the Project Area and the Waisoke, Waiga, and Sambiye Rivers (Figure 10-8) in the south of the Study Area are named ordinary surface water bodies identified within the Project Area.

Intermittent streams - have flowing water periods during the wet season (wet seasons) but are generally dry during hot summer months. Intermittent streams do not have continuous flowing water year-round and are not "relatively permanent waters."

Ephemeral streams - have less flow than intermittent streams, are typically shallow, and have flowing water for brief periods in response to rainfall. Ephemeral streams and ditches are generally dry for most of the year. Most of the streams, wetlands, ponds and ditches within the Study Area have the flow characteristics of an ephemeral stream.

Some of the permanent ordinary surface watercourses are hydrologically connected to the main surface watercourses and contribute to the overall flow of the main surface watercourses they discharge to. Also, depending on their location, the seasonal watercourses are either directly or indirectly connected to the permanent and/or main surface watercourses. In any case they form part of the overall hydrological water cycle of the Study Area.

The rivers that drain into Lake Albert from the east, south of the Victoria Nile, include the Waisoke, Waiga and Sambiye rivers. To the north of the Victoria Nile, the Tangi River drains to the White Nile. The flow path of each river is consistent with a Meandering River system. The exact nature of these designated ordinary surface watercourses and morphology including their depth and flow is not known. However, it is anticipated that flow in these rivers will be highly variable depending on the seasonal weather patterns.

10.6.2.2.1 Tangi River

The Tangi River flows generally westward through the North Nile area into the Albert Nile near Pakwach. The river drains to the White Nile to the north of the northern Project boundary. The habitat survey location AL14, located on this river, is recorded as having heavily turbid water, silty substrate, with water levels less than 1m and slow flows during the wet season. The River Tangi flows through an extensive floodplain delta.

10.6.2.2.2 Sambiye River

The Sambiye River flows westwards and discharges to Lake Albert near the southern boundary of the Project Area. The habitat survey location AL9 reported the river as being dry during the 2016 and 2017 field campaign.

10.6.2.2.3 Waiga River

The Waiga River flows westwards and discharges of Lake Albert. The habitat survey location AL12 reported that the River at this point is shallow, relatively fast flowing river running through a narrow ravine, with different stream morphological features, including riffles and glide sections. The wetted width was noted as approximately 4 m and a depth of less than 0.5 m. Also, it is noted that there was a brisk current; hard bottom with coarse sandy gravel, plus pebbles some smooth stones.

10.6.2.2.4 Waisoke River

The Waisoke River flows westwards and discharges to Lake Albert.

10.6.2.2.5 Unnamed Intermittent, Ephemeral and Perennial Streams

As shown in Figure 10-8 there are also a number of unnamed ordinary surface water courses within the Study Area many of which have characteristics of intermittent and ephemeral streams and a few with perennial characteristics. No information is available of the morphology of these ordinary water bodies.

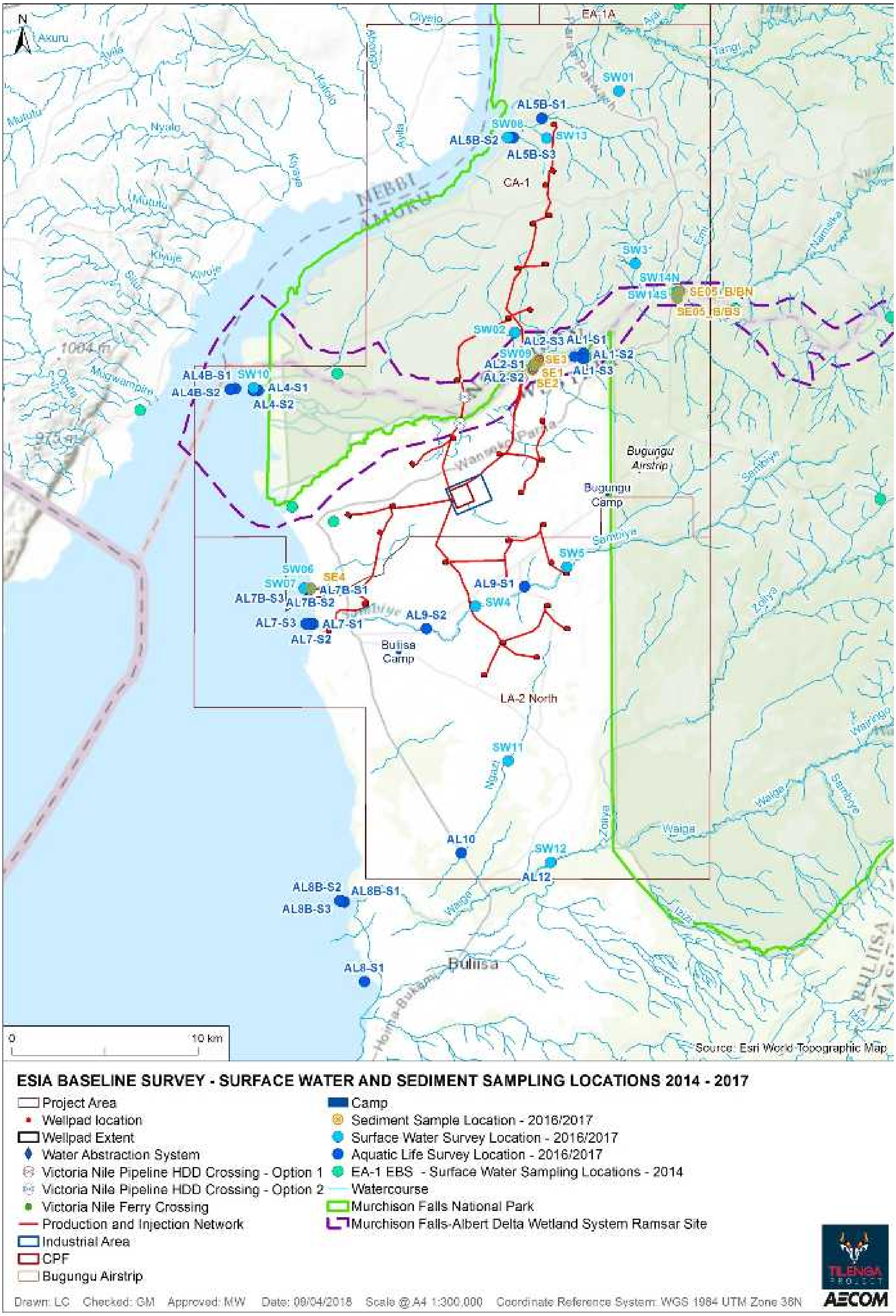
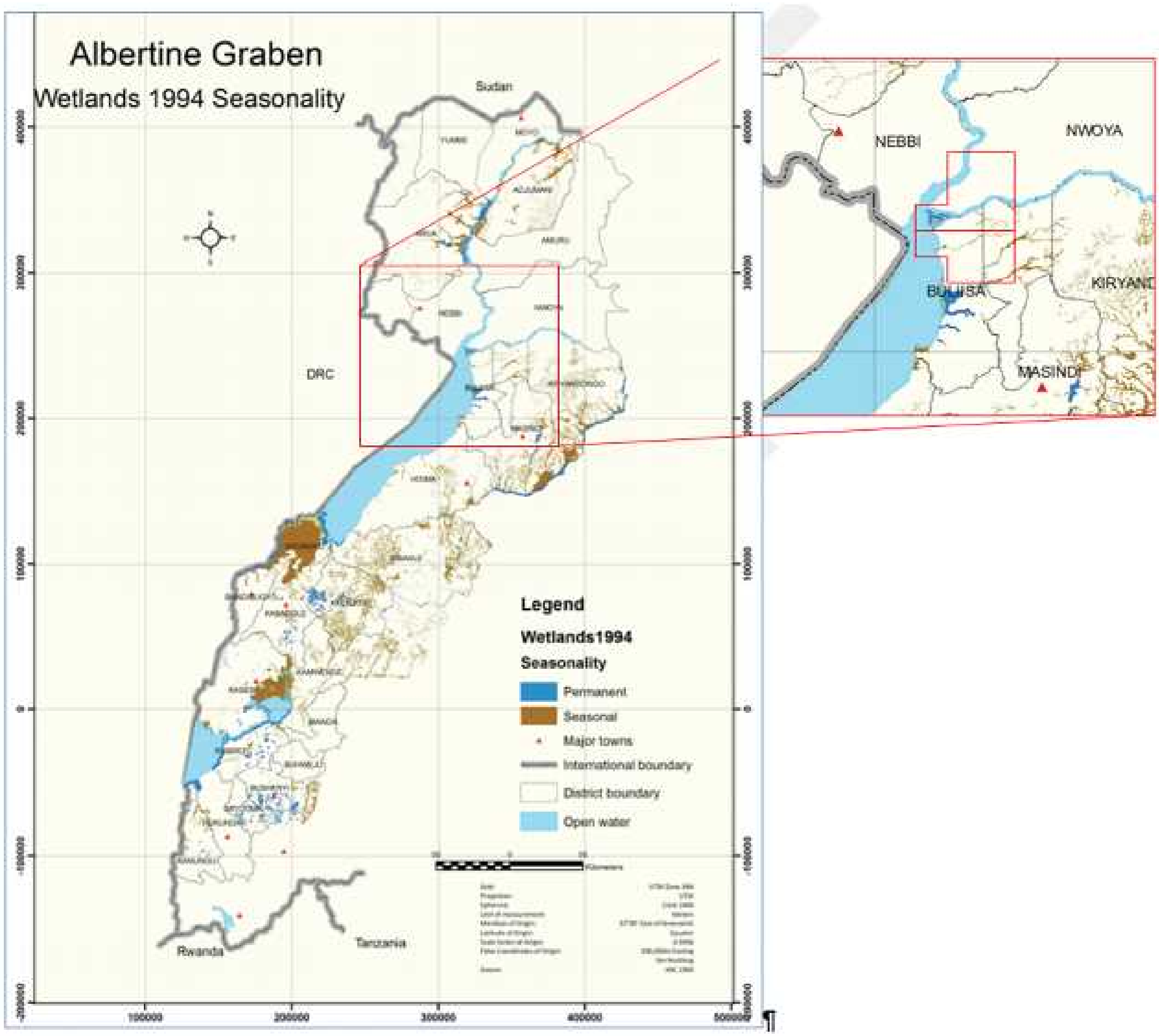


Figure 10-8: Ordinary Streams and Wetlands in the Study Area

10.6.2.3 Wetlands

The Murchison Falls-Albert Delta Wetland System at the confluence of the Victoria Nile River and Lake Albert (Figure 10-1) is the only and most prominent permanent wetland system within the Study Area. It is also a designated Ramsar site (Ramsar No. 1640). The wetland systems at Buliisa and Masindi (Figure 10-9) are other prominent permanent wetland systems in the region. These other wetlands are located upstream of the Study Area and are not designated Ramsar sites. Limited information relevant to the ESIA is available in the literature about the Buliisa and Masindi wetland systems. All of the remaining non-prominent individual wetlands are also not Ramsar designated site, but may be linked to other wetlands through a complex network of permanent and seasonal streams, rivers and lakes, making them an essential part of the drainage system across the region (UNWWAP and DWD, 2005). Further information on wetlands systems is provided in ***Chapter 13: Terrestrial Vegetation***, ***Chapter 14: Terrestrial Wildlife*** and ***Chapter 15: Aquatic Life***.



Source: WMD, 1994

Figure 10-9: Wetlands in the Albertine Graben and the Study Area

10.6.3 River Flows within the Study Area

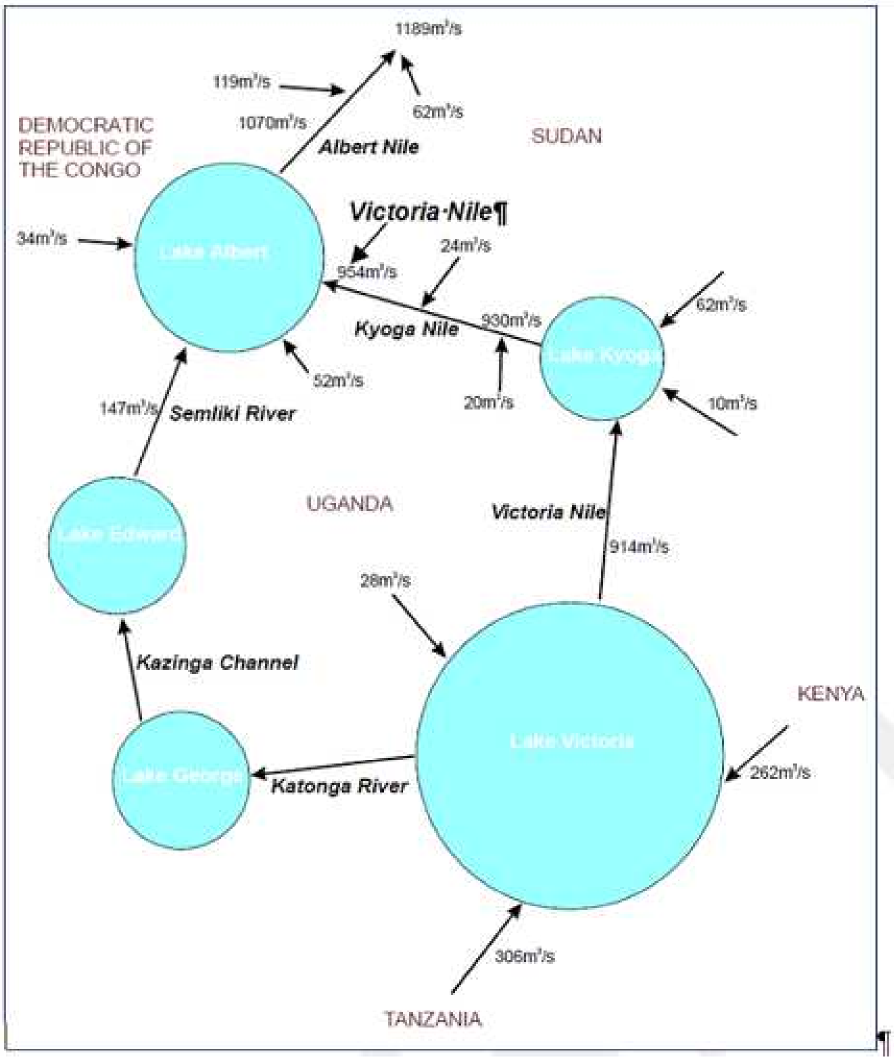
Lake Victoria, located approximately 300 km southeast of the Study Area (and which drains a total area of about 184,000 km^2 in Rwanda, Burundi, the United Republic of Tanzania, Kenya and the entire southern part of Uganda, has its outlet at Jinja. Passing the Owen Falls Dam, the water flows into Lake Kyoga and subsequently through Karuma Falls where a dam is currently under construction for a hydroelectric power station (i.e. Karuma Hydroelectric Power Station) then through the Victoria Nile River into the northern end of Lake Albert. The other branch of the Victoria Lake system, i.e. Lake

George and Lake Edward, is connected via the Semliki River, which flows into the southern end of Lake Albert (Figure 10-10). Lake Victoria is the main source of inflows to Lake Albert. From Lake Albert, the Albert Nile River flows northwards towards South Sudan.

Historical data (Figure 10-11) shows that the outflow from Lake Victoria since the 1800s varied between 345 cubic metres per second (m^3/s) and 840 m^3/s before it increased significantly in the 1960s to a maximum of around 1,720 m^3/s (Ref. 10-34). Outflows from both Lake Victoria and Lake Albert also show a similar trend which increased significantly in 1961 from about 600 m^3/s to close to 2,000 m^3/s in 1965. The flows subsequently fluctuated between 1,000 and 2,000 m^3/s with an average outflow of about 1,250 m^3/s (107 million cubic metres per day (m^3/d)). The data also show that there is a strong correlation between inflows, in this case from Lake Victoria to Lake Albert and outflows from Lake Albert since the 1800s and this has been relatively constant over time. Despite the well-marked significant increase in inflows and outflows since the 1960s, the data still correlate well, indicating a constant mass balance between inflows and outflows over the period of the dataset.

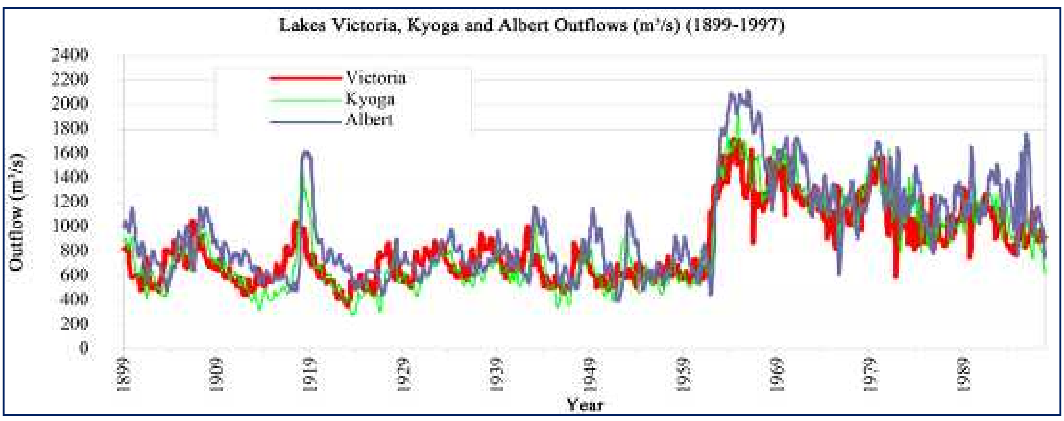
Studies show that the storage capacities of Lake Albert and Lake Victoria play an important role in regulating flows in the Albert Nile. This means that the variability in flows is significantly less than would occur in a catchment without such large lake storage and flow balancing capacity. Local studies show that inflows from the Victoria Nile River help to maintain the level of water in Lake Albert and that its rate of flow is considerably higher than that of the Semliki River, which has annual flows between five and thirty times less than the corresponding annual flows in the Victoria Nile River. Studies also revealed that the rivers (e.g. Waisoke and Waiga River) in the Lake Albert basin catchment area (i.e. south of the Victoria Nile River) have relatively stable dry season flows compared to rivers (e.g. Tangi River) in the Albert Nile sub-basin catchment area (i.e. North of the Victoria Nile) which exhibit seasonal variation. This information is important for the establishment of projects for consumptive water use (MWE, 2013) (Ref. 10-35). Historical flow rates between 1999 and 2009 of the Albert Nile River, Victoria Nile River and the Semliki Rivers are shown in Figure 10-12, Figure 10-13 and Figure 10-14 respectively. Figure 10-15 shows the monthly inflows to Lake Albert and the outflow in the Albert Nile.

In the case of Lake Victoria, recent data shows a well-marked increase in water levels (to within about 0.5 metres below the historical maximum) which is mainly attributed to increased rainfall over the lake as well as regulation of the lake's outflows Figure 10-16 (MWE, 2016) (Ref. 10-36). In comparison to Lake Victoria's water levels, both the Kyoga Nile and Lake Albert levels do not show a similar trend of rising levels over the period 2010 – 2016, as shown in Figure 10-17 and Figure 10-18. These are also consistent with the daily outflows from the Kyoga Nile River discharge (Figure 10-19) to the Victoria Nile River over the period 2010 – 2016. The Kyoga flow provides an indication of the amount of discharge from the Victoria Nile River into the Lake Albert.



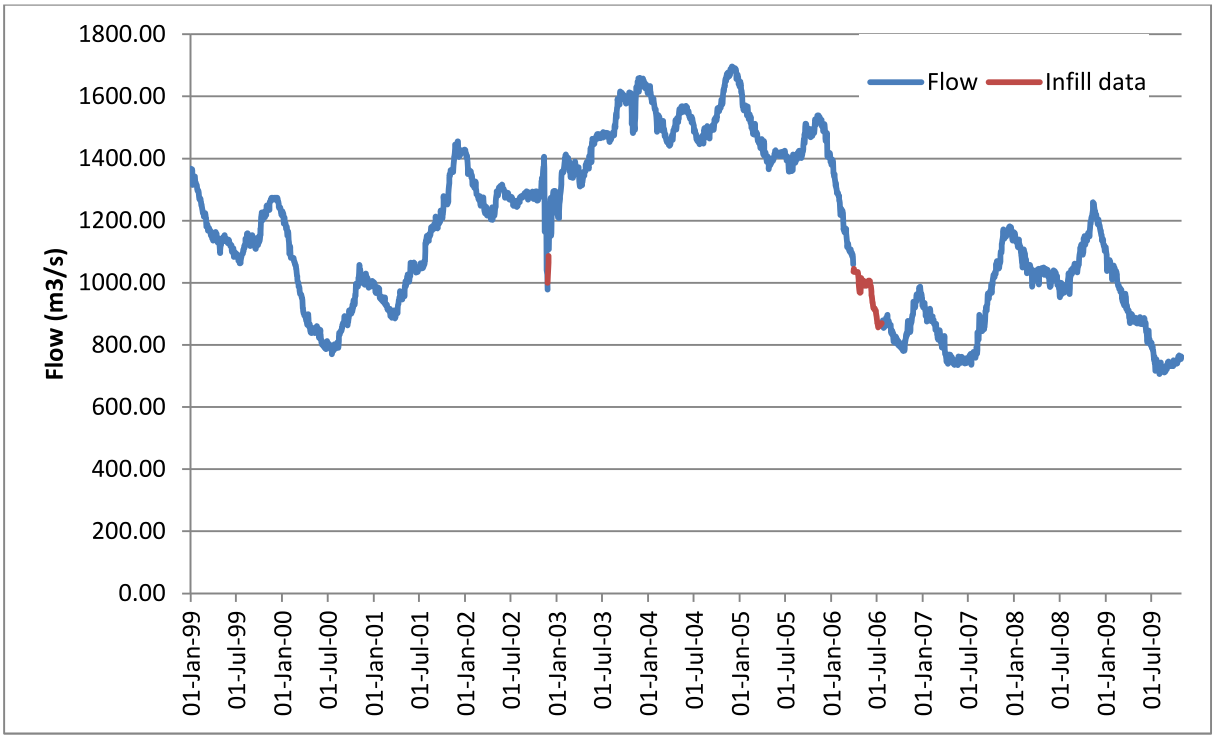
Source: JDIH Envireau, 2009

Figure 10-10: Inflows and Outflows from Lake Albert



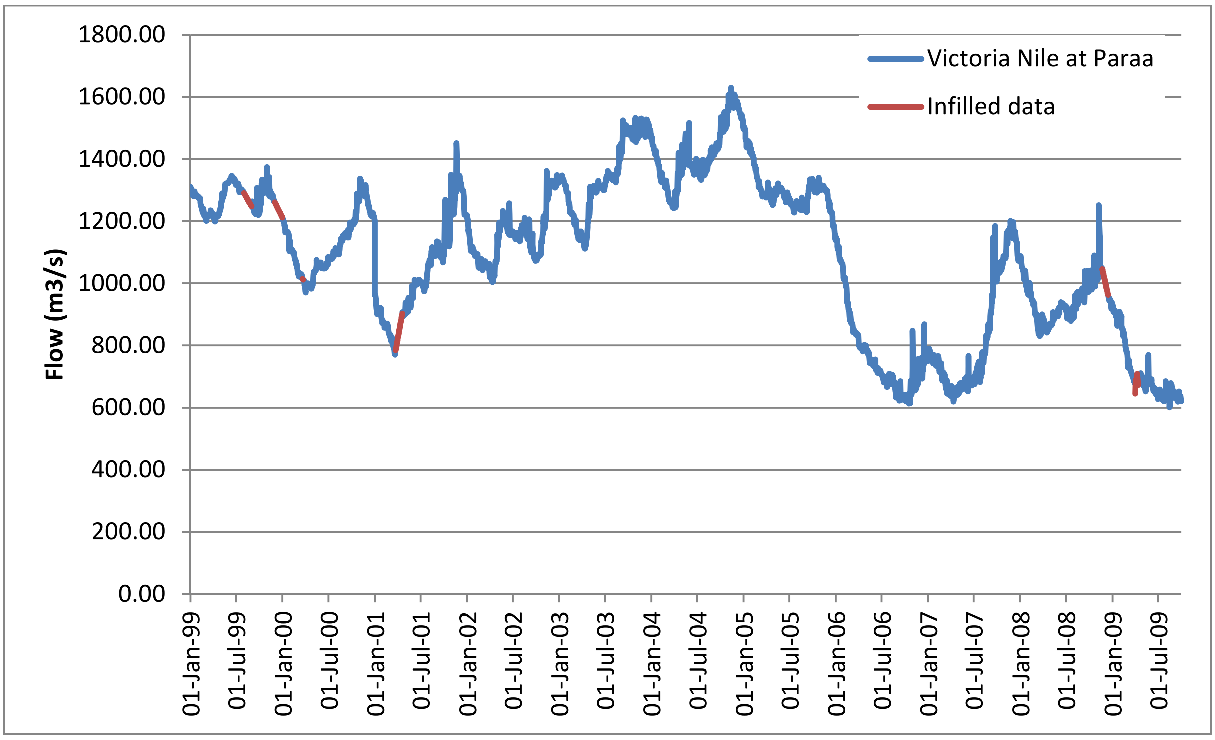
Source: Nsubuga et al 2014

Figure 10-11: Historical outflows from Lake Albert, Lake Victoria and Lake Kyoga for the period 1899 – 1989



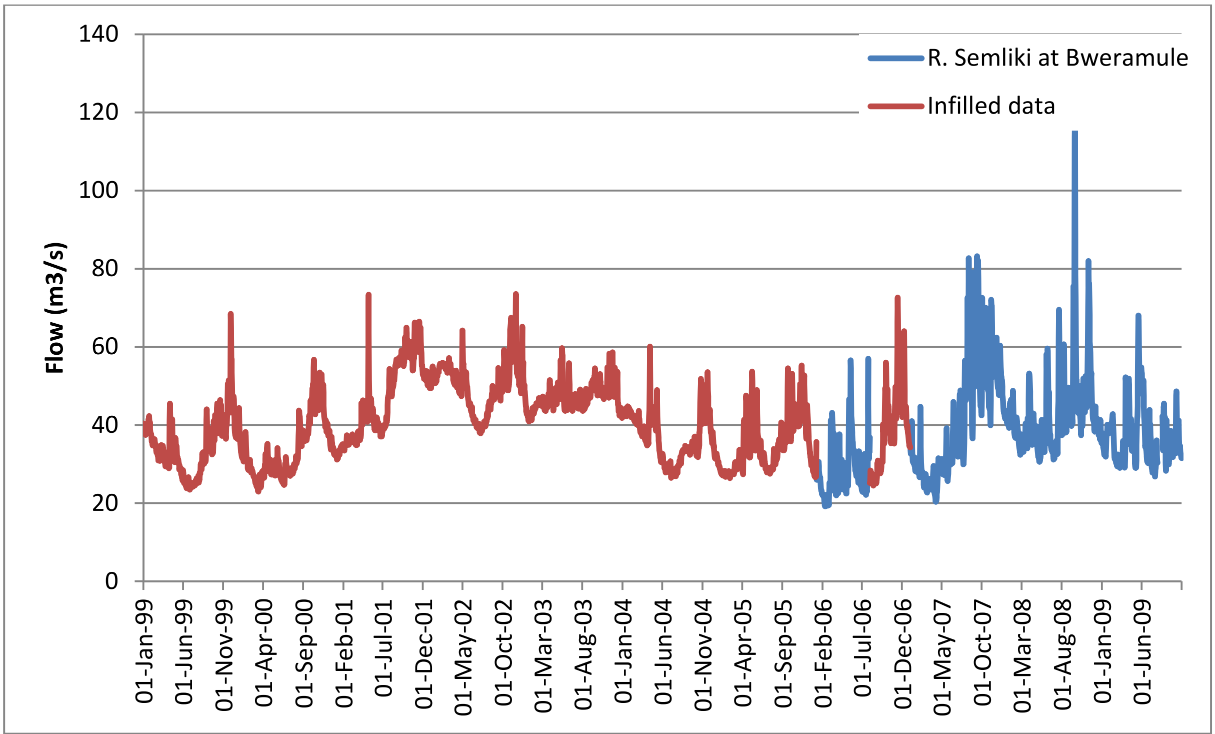
Source: AECOM 2014

Figure 10-12: Flow rate of Albert Nile River 1999-2009



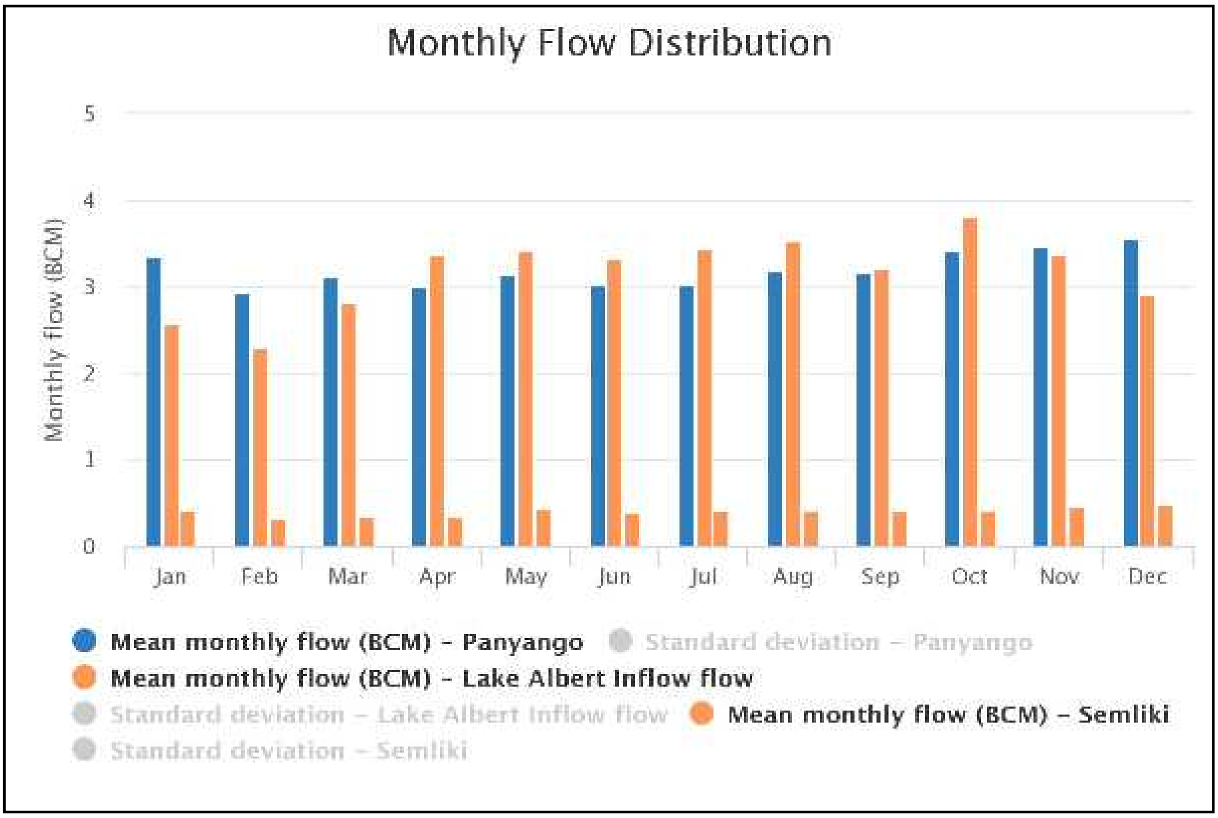
Source: AECOM 2014

Figure 10-13: Flow rate of Victoria Nile from 1999-2009



Source: AECOM 2014

Figure 10-14: Flow rate of Semliki River 1999-2009

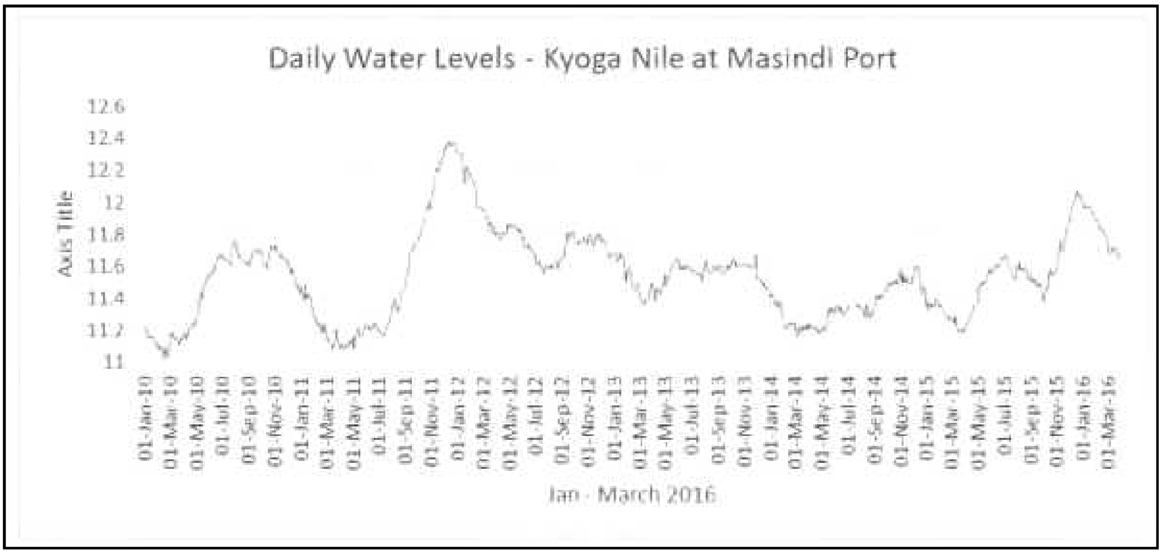


Source: NBI 2018

Figure 10-15: Monthly inflows to Lake Albert and outflow from the Study Area

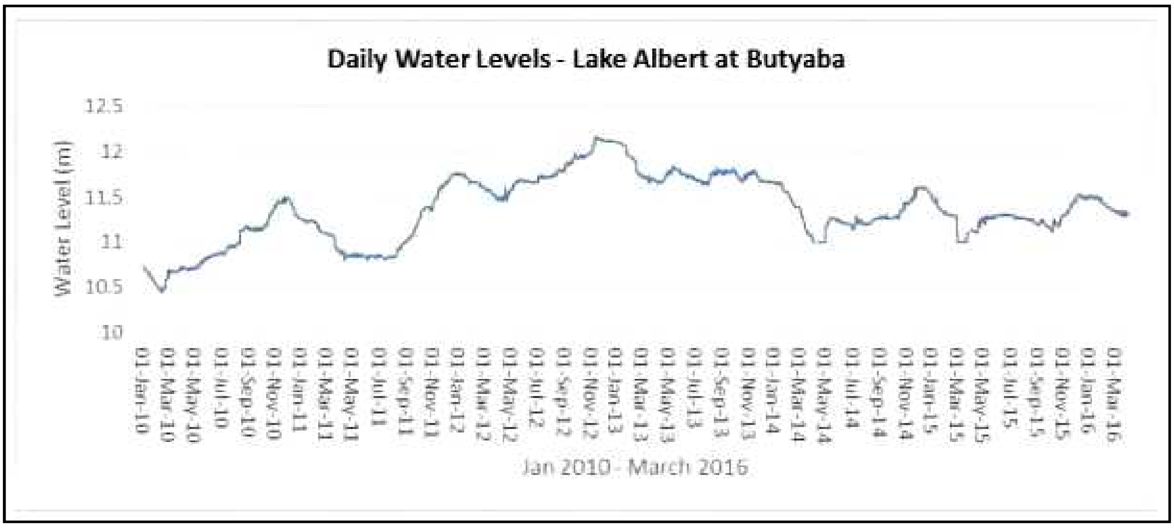
Source: MWE 2016

Figure 10-16: Fluctuation pattern of Lake Victoria from 2010 – 2016



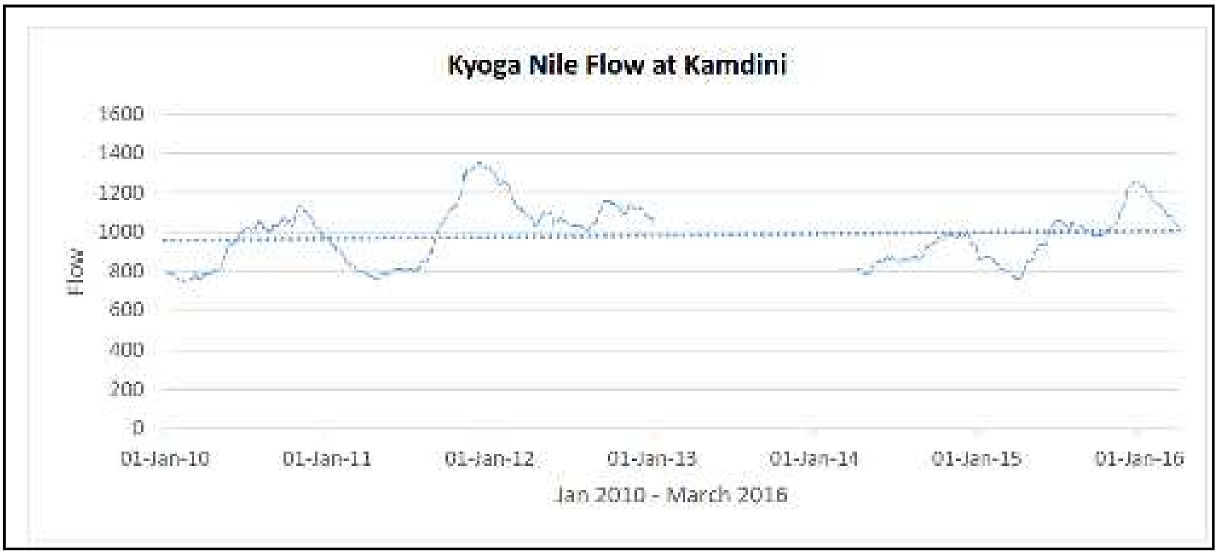
Source: MWE 2016

Figure 10-17: Daily Water Levels of Kyoga Nile Measured at Masindi Port 2010 – 2016



Source: MWE 2016

Figure 10-18: Daily Water Levels of Lake Albert Measured at Butyaba 2010 – 2016



Source: MWE 2016

Figure 10-19: Kyoga Nile Flow (m^3/s) at Kamdini 2010 - 2016

10.6.4 Fluvial Geomorphology (River morphology) within the Study Area

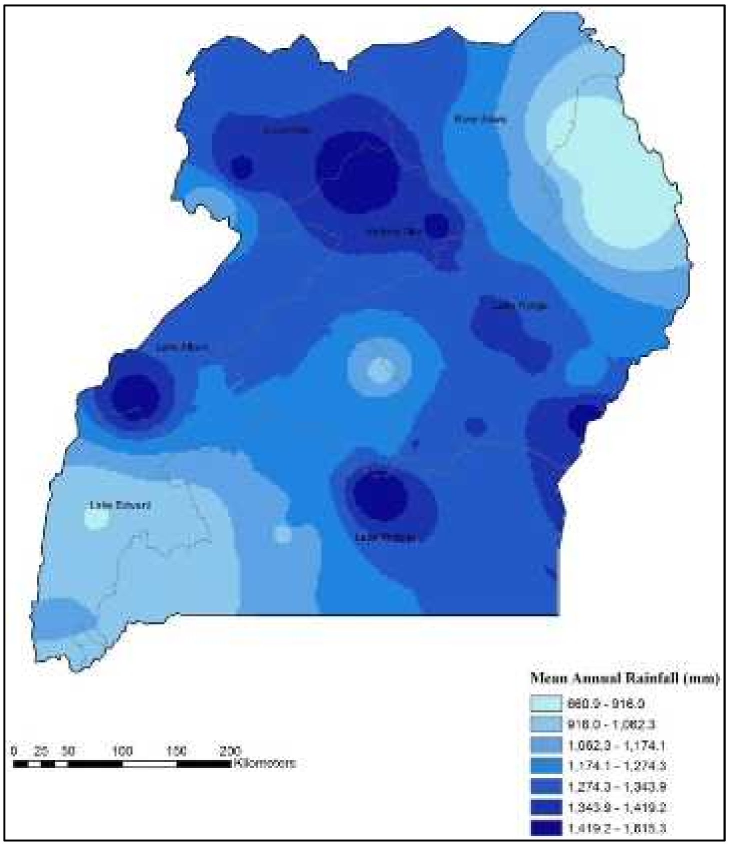
The fluvial geomorphology (i.e. river morphology) of the main and ordinary water courses in the Study Area are controlled by a number of primary factors including: geology of the area, the drainage basin, hydrology (discharge) and climatic. These factors in turn determine the channel pattern and characteristics, flood plain and biota. Further influences include human impact such as engineering structures and land use.

The outcrop geology of the Study Area consists of Quaternary Sedimentary rock. The evolution of the modern drainage network and morphology of the rivers in the Study Area and wider area is a reflection of both natural and anthropogenic changes in erosion and sedimentation regime, in addition to the natural river level changes and major shift in climate and vegetation during the Quaternary Period.

10.6.5 Surface Resources Availability in the Study Area

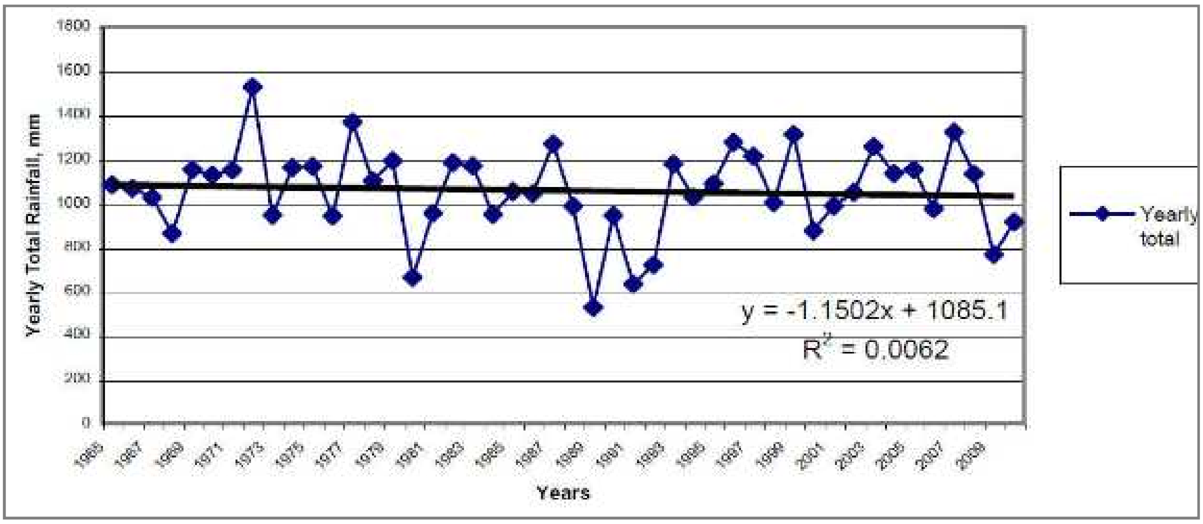
The Study Area falls within the rift valley floor of the Albertine Graben Rift system which lies in a rain shadow of both the escarpment and mountains. Rainfall is controlled by sharp variation in topography of the Study Area with mean annual rainfall between 900 millimetres (mm) and 1,100 mm (Figure 10-20). The areas on the escarpment to the east of the Study Area receive an annual rainfall of approximately 1,400 mm. Rainfall events in the Study Area occur throughout the year, but conditions are wetter between March and May. The period between August and November and February is drier. Figure 10-21 and Figure 10-22 show rainfall data recorded at the Wadelai Weather Station located in CA-1, north of the Victoria Nile River (AECOM, 2015) (Ref. 10-18). Short-term rainfall data collected at the Bugungu station in 2017 are shown in Figure 10-23.

The maximum temperature in the Study Area is above 30 degrees Celsius (°C) which can sometimes reach 38°C. Average minimum temperatures are relatively consistent and vary between 16°C and 18°C.



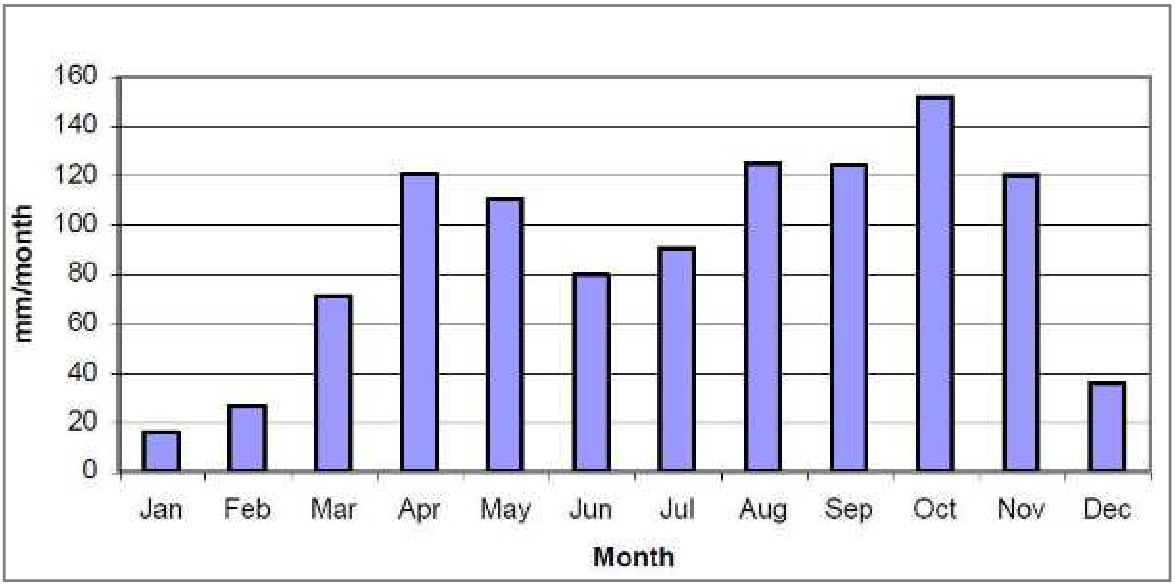
Source: Nsubuga et al., 2014

Figure 10-20: Rainfall Distribution in Uganda



Source: AECOM 2014

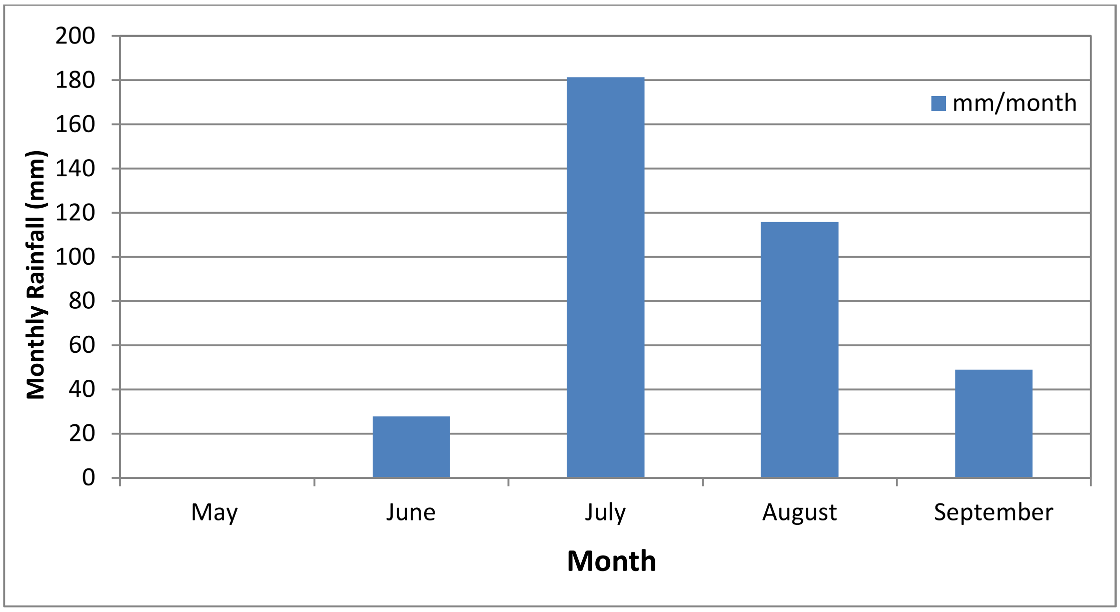
Figure 10-21: Wadelai yearly total rainfall trend (1965 - 2010)



Source: AECOM 2014

Figure 10-22: Wadelai average monthly rainfall (1965 - 2010)

Rainfall is the primary source of water to all the surface water bodies and groundwater systems in Uganda. Rainfall also constitutes the primary source of renewable water in Uganda and the Study Area. Mean annual rainfall in the Study Area ranges between 900 mm – 1,100 mm depending on climatic conditions. In context of the hydrological cycle, it is estimated that about 7 - 20% of the annual rainfall that falls directly on land provides recharge to the groundwater systems by direct infiltration, while the remainder flow as direct runoff to surface water bodies, with a significant proportion returning to the atmosphere via evapotranspiration.



Source: AECOM 2014

Figure 10-23: Bugungu Total Rainfall (2017)

Internal renewable surface water resources in Uganda, most of which comes from direct rainfall precipitation are estimated to be 39 km^3/year (39 Billion m^3/year). This provides runoff directly to surface waters and recharge to groundwater. There is also an additional external water resource estimated to be 21.1 km^3/year (21.1 Billion m^3/year) which comprises inflow from Lake Victoria. The total renewable water resource for the whole country is therefore approximately 60 km^3/year. It is understood that currently only about 1% of the total renewable water resources is used in the country and only about 8% of the country's population relies on surface water resources, mainly for irrigation, agriculture, livestock, and hydroelectric power generation and a small amount for domestic supply (FAO, 2017) (Ref. 10-37).

The outflow of surface water leaving the country through Lake Albert and subsequently via the Albert Nile and White Nile in South Sudan is estimated at 37 km^3/year (37 Billion m^3/year).

10.6.6 Recharge to Surface Water Bodies and Groundwater Systems in the Study Area

As noted above, rainfall is the primary source of water supplies in Uganda. The climate of Uganda is classified as tropical and is hot and humid, with an average humidity of between 70% and 100%. There is a sharp variation in rainfall amounts across Uganda, mainly due to variations in the landscape (NEMA, 2010) (Ref. 10-20). There are two peak wetter seasons between March - May and August - November. Temperatures are slightly higher during the wet seasons. Average annual precipitation in the north is around 600 mm, while in the south it is more than 1,600 mm particularly around the highlands of Mount Elgon in the east, the Rwenzori Mountains in the southwest, Masindi in the west and Gulu in the north of the Study Area respectively.

Studies show that groundwater recharge in the Study Area averages in the order of 90 – 220 mm/year (Nsubuga et al 2014) (Ref 10 – 34). Conservatively, sustainable recharge for the Study Area is put at 19 – 39 mm/year. Studies also show that recharge is more dependent on the number of heavy rainfall events than the total annual volume of rainfall and that substantial recharge occurs during the most torrential rains of the monsoons.

10.6.7 Surface Water/Groundwater Interaction

The majority of the watercourses rise to the east of the Project Area where the basement rocks outcrop. The basement rocks have a low permeability and contain limited groundwater. Accordingly, the streams are dependent principally on incident rainfall with negligible groundwater discharge as base flow.

It is likely that the main watercourses – the Victoria Nile and the Albert Nile, together with Lake Albert receive groundwater discharge as base flow from the unconsolidated sand aquifer, which overlies the basement rocks across the whole of the Project Area. Across the remainder of the Project Area, the groundwater level in the sand aquifer typically is several metres (up to 70 m) below ground level and hence there is no direct hydraulic continuity between the surface water and groundwater systems. It is likely that watercourses flowing over these areas are effluent as they flow across the sand aquifer, losing water to the underlying groundwater system. Locally, the streams may be supported, perched above the main groundwater level, by lower permeability clay units within the sand aquifer, which limit the loss to groundwater. Consequently, surface water-groundwater interaction is less likely in the highland areas (i.e. >650 m elevation) and more likely in the lowland areas (<650 m elevation), where the water table intercepts with or is in hydraulic connection with permanent surface water bodies.

The Victoria Nile River, Albert Nile River and Lake Albert are areas of groundwater discharge from the sand aquifer. Accordingly, abstraction of water from these water bodies will have no impact on the groundwater system.

Further details of the groundwater on the hydrogeological conditions in the Project Area are provided in ***Chapter 9: Hydrogeology***.

10.6.8 Drainage Pattern and Flow Direction

The drainage pattern of the surface water bodies within the Study Area is dendritic (Figure 10-24). The pattern is controlled mainly by the landscape which ranges from the low-lying rift valley floor to the rift's escarpment, and the raised mountain ranges formed by the regional geology of the area. Of the open surface water bodies that make up the drainage system in the Study Area, there are both permanent and seasonal wetlands that contribute to the overall water resources of the area. Drainage from all of the flowing water bodies flows in a generally westerly direction in the Study Area and discharges either to Lake Albert or the Albert Nile River which flows from south to north towards South Sudan.

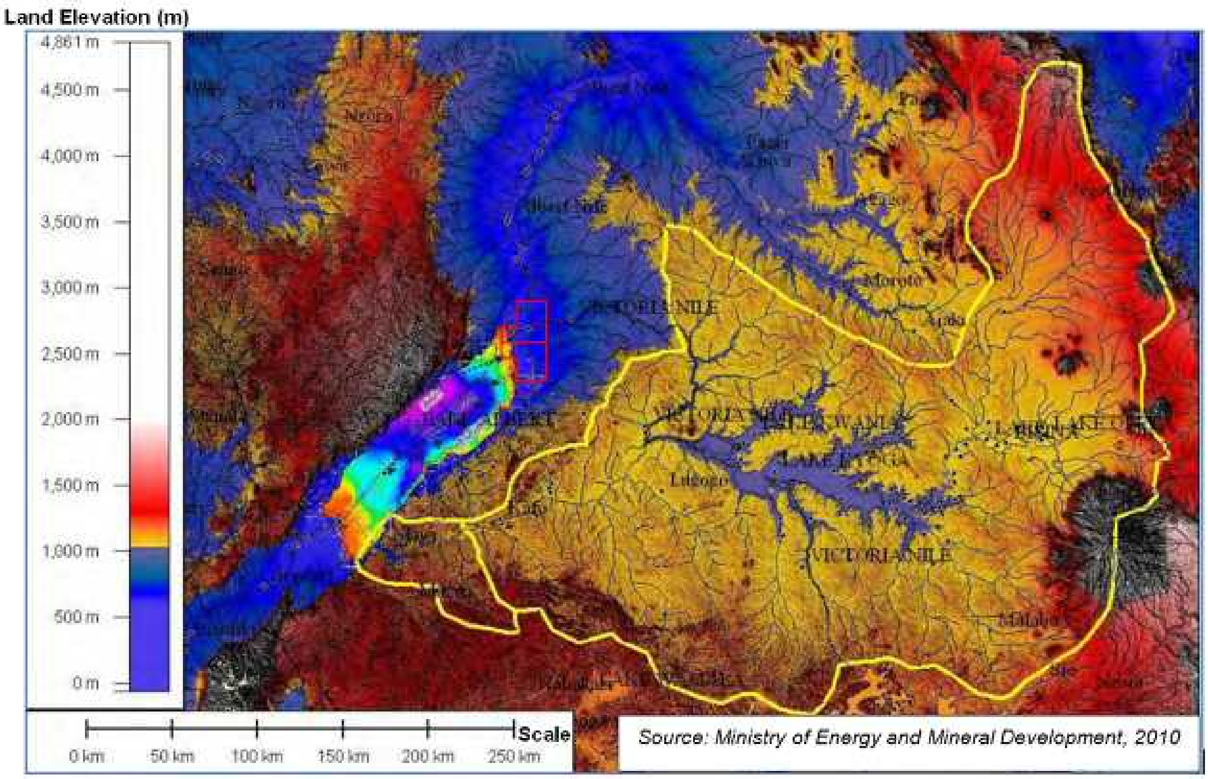
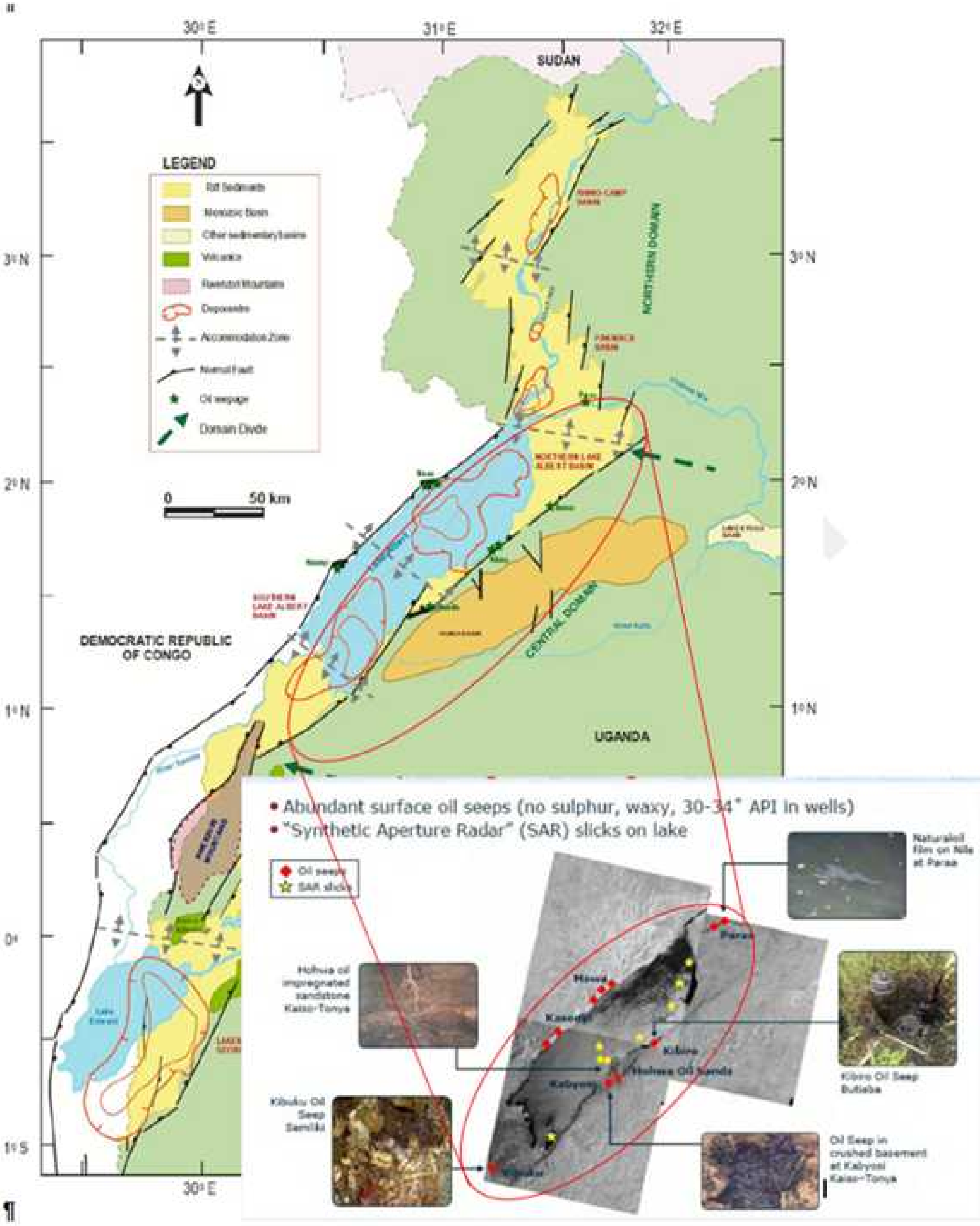


Figure 10-24: Drainage Pattern of the Study Area and Environs

10.6.9 Oil Seeps

Oil (Petroleum) seepages phenomena have been observed along the Lake Albert fault margins and in the Lake Albert Catchment and specifically in Paraa (Figure 10-25) in the Study Area. The effect of natural oil seepages on the surface water quality and the impact on humans and aquatic life depending on this resource currently is not known.



Source: Abeinomugisha, D. 2004 and PEPD, 2004

Figure 10-25: Oil Seepages along the Lake Albert Margin and within the Study Area

10.7 Surface Water Quality Characterisation Summary

The characterisation of the surface water chemistry for the Study Area has been derived from analysis of primary and secondary data analysis as detailed in Section 10.5 and Section 10.6

It should be noted that only the sample results with the parameters that exceeded the UPWS limit are presented. Also as highlighted in Section 10.3.3.1 and Section 10.5.8.1 the UPWS limit (0.003 mg/l) set for nitrite is considered incorrect when compared with the WHO limit of 3 mg/l. Notwithstanding, all the results for nitrite have been compared against both the UPWS and the WHO limit. If the results are compared against the WHO, nitrite in all of the samples complies with the WHO limit.

10.7.1 Lake Albert

Baseline water quality data indicate that the water of Lake Albert is more saline than that of Victoria Nile River and other surface water bodies within the Study Area. This difference in conductivity was evident in the field measurements of electrical conductivity taken during the ESIA field campaigns with average EC values of about 650 microSiemens per centimetre (µS/cm) and laboratory analytical values of chloride reaching 20 mg/l compared with EC values of about 110 µS/cm and chloride of about 5 mg/l recorded for most of the water bodies within the Study Area. Studies using conductivity measurements show that even in times of flood the Victoria Nile River inflow does not affect the lake's water quality beyond about 10 km from the inflow of the river.

Physio-chemical water quality analysis results of water samples taken from near-shore and off-shore locations in Lake Albert during the 2014 – 2017 ESIA survey field campaigns demonstrate that most of the parameters analysed comply with the UPWS except for aluminium, iron, and nitrite which exceeded the UPWS limit. Table 10-17 shows the water quality parameters that exceeded the UPWS in the lake. The full water quality analysis results are given in Appendix L - Annex 02.

Table 10-17: Lake Albert Physico-Chemical Water Quality Summary

Location ID and Description		Water Quality Standards				SW06 Lake Albert near shore		SW07 Lake Albert offshore	
Parameter	**Unit**	**USEPA Water Quality Human Health Criteria**	**USEPA Water Quality Aquatic Life Criteria**	**WHO Guideline (4th Edition 2011)**	**UPWS EAS 12:2014**	**SW6-161105**	**SW6-1706-14**	**SW7-161105**	**SW7-1706-14**
Aluminium (Al)	mg/L	-		0.2	0.2	0.27	<0.10	0.18	<0.10
Iron (Fe)	mg/L	-	1	-	0.3	0.39	<0.050	0.26	<0.050
Nitrite (NO_3 - N)	mg/L	-		3	0.003	0.46	<0.030	0.32	<0.030

In summary, the following observations are made:

- The exceedances are generally slightly above the UPWS;
- Elevated iron and aluminium exceedances were detected only in the near-shore samples. This can be linked to the water quality of inflows from the Victoria Nile River, other watercourses draining the area and groundwater, as elevated iron and aluminium were also detected in samples taken from these water bodies and groundwater boreholes;
- The UPWS standard for nitrite may not be correct hence the WHO criteria has been applied and no exceedances are noted;
- No petroleum hydrocarbons were detected in any samples above the laboratory detection limits. There are no water quality standards for this parameter;
- Trace concentrations of toluene and ethylbenzene were noted but at levels ranging from three to four levels of magnitude lower than UPWS, WHO and USEPA Water Quality Human Health Criteria.

These compounds occur naturally in crude oil and can be found in aquatic environments in the vicinity of natural gas and petroleum deposits. Other natural sources of BTEX compounds include gas emissions from forest fires; and

- Overall, except for the parameters that exceeded the limits (UPWS), the water in Lake Albert is considered to be of good quality, but cannot be used as potable water supply without treatment for these parameters.

10.7.2 Surface Water Bodies (i.e. Watercourses, Watering Holes) North of the Victoria Nile – (Project Footprint CA-1)

The main surface water bodies to the north of the Victoria Nile River within the Study Area comprise watering holes, watercourses and some permanent and perennial streams. Together, these water bodies form part of the local watershed drainage systems in the north of the Study Area. These water bodies are used mainly for wildlife watering and support biological species within the local environment.

Physico-chemical water quality analysis results of samples taken from the surface water bodies north of the Nile River during the 2014 – 2017 ESIA survey field campaigns detected elevated levels of trace metals. Elevated levels of nitrite were also detected in some of the samples. However, the UPWS value of 0.003 mg/L does not align with the WHO value of 3 mg/L. The WHO standard has been adopted for the assessment hence the nitrate concentrations would not exceed the WHO standard. Except for the exceedances, other physio-chemical parameters analysed complied with the UPWS limits. Table 10-18 shows the parameters that exceeded the limits from each sampled water body. The full water quality analysis results are given in Appendix L - Annex 02.

In summary, the following observations are made:

- Elevated iron, manganese and aluminium were reported at values several times above the UPWS limits in all samples analysed. Lead also was reported above the UPWS limit in five of the seven samples. Nickel exceeded the UPWS standard in one sample. Some of these exceedances may be linked to the indigenous constituent of the water associated with the local geology or as a result of pollution from anthropogenic activities, although these are expected to be limited within MFNP;
- Nitrite was detected above the UPWS limit in five of the samples analysed. However, when compared to the WHO limit, all samples were three orders of magnitude below the limit. The nitrite in the samples may be of natural occurrence linked to waste from animals using these water bodies or microbial action;
- Petroleum hydrocarbons were not detected in any of the water samples;
- Toluene and ethyl benzene were detected in some samples at concentrations three to four orders of magnitude lower that the USEPA Water Quality Criteria. These compounds occur naturally in crude oil and can be found in aquatic environments in the vicinity of natural gas and petroleum deposits. Other natural sources of BTEX compounds include gas emissions from forest fires.
- The water in the samples from the watering hole (SW2) and along an unnamed watercourse (SW8) was highly turbid with values up to 685 Nephelometric Turbidity Unit (NTU) and 129.8 NTU compared to a turbidity value for water from the wetland with a maximum value of 35.2 NTU. Elevated NTU level in the watering hole sample may be due to disturbance of the water by animals or during sampling; and;
- Overall, the water in these sampled water bodies is of poor quality and is therefore considered not suitable for direct human consumption without treatment for the parameters that exceeded the prescribed limits.

Table 10-18: Surface Water Bodies Quality Summary – North of Victoria Nile (CA-1)

Parameter	Unit	USEPA Water Quality Human Health Criteria	USEPA Water Quality Aquatic Life Criteria	WHO Guideline (4th Edition 2011)	UPWS (EAS 12:2014)	Watering Hole North of Victoria Nile (SW01)		Watering Hole Near the MFNP (SW02)		Watercourse Near JBR-09 (SW08)		Wildlife Watering Hole (SW13)	Number exceeding UPWS Limits	Number exceeding USEPA Limits
Aluminium (Al)	mg/l	-	-	0.2	0.2	0.15	15	5	5.9	4.1	2.2	1.2	6	N/A
Barium (Ba)	mg/l	0.1	-	0.7	0.7	0.08	2	0.81	0.35	0.5	0.29	0.24	2	6
Cadmium (Cd)	mg/l	0.005	0.00025	0.003	0.003	0.0004	0.00055	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	0	2
Chromium (Cr)	mg/l	0.01	0.0074	0.05	0.05	<0.001	0.023	0.016	0.015	0.0044	0.0037	0.0017	0	3
Iron (Fe)	mg/l	-	1	-	0.3	4.2	110	7.5	43	9.8	9.6	17	7	7
Lead (Pb)	mg/l	-	0.0025	0.01	0.01	0.25	0.094	0.0051*	0.028	0.015	0.014	0.0098*	4	7
Manganese (Mn)	mg/l	50	-	-	0.1	0.14	8.8	0.18	1.1	1.2	0.17	1.7	7	0
Nickel (Ni)	mg/l	0.61	0.0052	0.07	0.02	<0.005*	0.075	0.009*	0.019*	0.011*	<0.005*	0.0051*	1	4
Nitrite (NO_2)**	mg/l	-	-	3	0.003	0.043	<0.030*	0.066	0.039	<0.03*	0.12	0.049	0	N/A
Turbidity	NTU	-	-	-	25	20.8*	35.2	685	514	-	129.8	17.6*	4	N/A

10.7.3 Victoria Nile River and Nile Delta (Wetlands) – (CA-1)

Baseline water quality data indicate that the water from the Victoria Nile River and Victoria Nile Delta area at Lake Albert is generally of good quality and safe for fisheries and falls in the category of fresh water (MWE, 2010), but is not suitable for direct human consumption without treatment. Results from other studies also show that the water in the Victoria Nile River and around the Ramsar wetlands within the Delta is moderately hard (NEMA, 2017) (Ref. 10-31). The wetlands in the MFNP and the Albertine Delta areas are some of the most productive wetlands in the area and have been listed as Ramsar sites since 2006 (Ref. 10–32).

Physico-chemical water quality analytical results of samples taken from the Victoria Nile River and at the Nile Delta (i.e. Project Footprint CA-1) during 2016 – 2017 demonstrate that most parameters analysed comply with the UPWS limit except for aluminium, iron and turbidity that were above the acceptable limits. Table 10-19 shows the parameters that exceeded the limit. The full water quality In summary, the following observations are made:

- Elevated aluminium above the acceptable limit was detected in one sample taken upstream of the Victoria Nile Delta near the proposed Project pipeline crossing. Aluminium was not detected in samples taken at the Nile Delta area;
- Elevated iron was detected above UPWS limit in two samples. However, the other sample results were slightly below the UPWS limit;
- Petroleum hydrocarbons were detected at very low concentrations in only one sample. The source is uncertain but this could have been due to entrainment of fluids from the boats or natural causes;
- Toluene and ethyl benzene were detected in some samples at concentrations three to four orders of magnitude lower that the USEPA Water Quality Criteria. These compounds occur naturally in crude oil and can be found in aquatic environments in the vicinity of natural gas and petroleum deposits. Other natural sources of BTEX compounds include gas emissions from forest fires. These compounds are not attributed to the petroleum hydrocarbons as the samples found to have toluene and ethyl benzene present did not have petroleum hydrocarbons above the laboratory detection limit.
- Elevated turbidity was detected in one sample taken up-stream along the Victoria Nile River. All other samples analysed were within UPWS acceptable limit.

Some of these exceedances may be linked to the indigenous constituent of the water associated with the local geology or as a result of pollution from anthropogenic activities.

10.7.4 South of the Victoria Nile: (LA-2 North)

Baseline water quality data indicates that the water in the Waiga River and other rivers in the south of the Study Area are acidic with pH less than 6.5 (NEMA, 2017) (Ref. 10-16). Physico-chemical water quality analytical results for other parameters analysed were below the UPWS acceptable limit except for iron, manganese, aluminium and turbidity. The full water quality analysis results are given in Appendix L– Annex 02. The parameters having concentrations that exceed water quality standards are shown in Table 10-20.

In summary, the following observations are made:

- Elevated aluminium slightly above the UPWS acceptable limit was detected in both samples taken from the Waiga River (SW12). The source of elevated aluminium in the water may be natural;
- Elevated iron and manganese above the UPWS acceptable limit was detected in both samples taken from the Waiga River. This is linked to the natural chemistry of the river water. Naturally elevated levels of iron and manganese were also detected above the UPWS acceptable limit in groundwater samples collected from boreholes within the south of the Nile and the Waiga river catchment – a reflection of the geology and groundwater chemistry of the area;

Table 10-19: Victoria Nile and Nile Delta (Wetlands) Quality Summary

Parameter	Unit	USEPA Water Quality Human Health Criteria	USEPA Water Quality Aquatic Life Criteria	WHO Guideline (4th Edition 2011)	UPWS (EAS 12:2014)	Victoria Nile River (SW09)		Nile Delta at Lake Albert (SW10)		Nile Ferry Crossing North bank of Nile (SW14)	Number exceeding UPWS Limits	Number exceeding USEPA Limits
Aluminium (Al)	mg/l	-	-	0.2	0.2	0.48	<0.10*	0.16*	<0.10*	<0.10	1	N/A
Iron (Fe)	mg/l	-	1	-	0.3	0.82	0.27*	0.38	0.27*	0.3	2	
Turbidity	NTU	-	-	-	25	37.5	<1.0	6.93	<1.0	<1.0	1	N/A

Table 10-20: Waiga River Water Quality Summary – South of Nile (LA-2 North)

Parameter	Unit	USEPA Water Quality Human Health Criteria	USEPA Water Quality Aquatic Life Criteria	WHO Guideline (4th Edition 2011)	UPWS (EAS 12:2014)	Waiga River (SW12)		Number exceeding UPWS Limits	Number exceeding USEPA Limits
Aluminium (Al)	mg/l	-	-	0.2	0.2	0.22	0.31	1	N/A
Iron (Fe)	mg/l	-	1	-	0.3	9.6	5.8	2	N/A
Manganese (Mn)	mg/l	50	-	-	0.1	0.6	0.39	2	0
Turbidity	NTU	-	-	-	25	-	35.9	1	N/A

Note: N/A – Not Applicable

- Elevated turbidity was detected in the only sample taken from the river. This may be due disturbance of the river water under flowing conditions at the time the sample was collected; and
- Apart from the acidic nature of the Waiga River water, the water is considered to be of fresh water category with the ability to support most aquatic species.

10.7.5 Baseline Surface Water Characterisation Summary

In summary, the quality of the surface water bodies within the Study Area and environs is generally good except for trace metals aluminium, iron, manganese, nickel and lead, and a few other constituents which slightly exceeded the limit. Iron, manganese and aluminium were the predominant trace metals detected in most of the surface water bodies in the Study Area. These are linked to the geology of the area.

Table 10-21 provides an overall summary of the surface water quality results. With exception of iron and manganese, the results suggest that the water quality of the surface water bodies within the Study Area is generally good.

Baseline water quality monitoring of the area (Ref. 10-16) also used ecological species such as Oligoneuridae, Perlidae (Stoneflies) and Heptagenidae (Mayflies) found in some water bodies in the Study Area to demonstrate the quality of the surface water bodies, as these organisms can only survive in the most pristine water condition. The presence and abundance of these biological species can also provide a quick indication of the status of the water quality as well as indicator species for future monitoring of habitat alterations that may arise as a result of the Project.

Table 10-21: Selected Surface Water Quality Analysis Results from 2014 – 2017

Parameter	Units	Min	Max	No of sample locations	No. of samples	Ugandan standard (EAS 12:2014	No. of exceedances
pH		5.33	9.17	23	58	5.5 - 9.5	1
Electrical Conductivity	µS/cm	54	1,187	23	58	2,500	0
Calcium	mg/l	3.5	83	13	46	150	0
Aluminium	mg/l	0.1	15	10	18	0.2	10
Chromium	mg/l	0.001	0.023	23	64	0.05	0
Iron	mg/l	0.05	110	23	64	0.3	52
Magnesium	mg/l	0.99	42	13	46	100	0
Manganese	mg/l	0.01	8.8	23	64	0.1	23
Potassium	mg/l	1.4	20	10	46	-	-
Sodium	mg/l	2.5	190	10	46	200	0
Ammonia	mg/l	0.066	0.52	10	46	0.5	1
Chloride	mg/l	0.28	220	23	64	250	0
Nitrate (NO3)	mg/l	0.9	5.2	23	64	45	0
Nickel (Ni)	mg/l	0.005	0.075	10	64	0.02	1
Lead (Pb)	mg/l	0.094	0.25	10	64	0.01	2
Barium	mg/l	50	2,000	23	64	0.7	1
Zinc	mg/l	5	380	23	64	5	
PAH 16 EPA (sum)	µg/l	< 0.205	< 0.205	13	46	0.7*	0
BTEX, summation	µg/l	<1	5.4	23	64	-	-
TPH Sum (C10-C40)	µg/l	38	150	23	64	-	-

Note: Table includes surface water quality data from ESIA surveys carried out from 2014 - 2017, Exceedances refer to Ugandan standards limits only, standards presented in Column 7

10.7.6 River Bed Sediment Analysis

A total of six river bed sediment samples were collected at specific locations across the Study Area during the 2016 – 2017 ESIA field survey campaigns. The sampling locations are shown in Figure 10-3. Each sample was analysed for a wide range of trace metal parameters as well as petroleum hydrocarbons and other relevant physio-chemical parameters.

Except for chromium and nickel, the values of all the parameters analysed were within the acceptable limit (Ref. 10-12). A summary of the parameters that exceeded the limit is presented in Table 10-22. The full laboratory analytical results are presented in Appendix L – Annex 03.

Table 10-22: River Bed Sediment Sample Analyses Result Summary

Parameter	Unit	EPA Sediment Screening Levels	Sample Locations/ID		Total Number of Samples	Total Number of Exceedances
			Victoria Nile 10 m from north bank (SE3)	Ferry crossing on the north bank of the Nile (SE5)		
Chromium (Cr)	mg/kg	43	50	110	6	2
Nickel (Ni)	mg/kg	23	22*	43	6	1

Note: (*) Below the acceptable TEC limit.

In summary, the following observations are made:

- Elevated chromium detected at the Victoria Nile sediment sample is only minor and may be an indication of natural contamination of the river bed sediments;
- Elevated chromium and nickel detected at the ferry crossing are significantly above the acceptable limit and may be indication of potential contamination from either natural or anthropogenic sources. However, these cannot be concluded with detection from only one sample;
- Petroleum hydrocarbons were detected in some samples at very low concentrations; the source is unknown but likely to be non-anthropogenic; and
- The elevated nickel and chromium levels in the water are not in a form that is readily available for release to water.

10.8 Hydrology and Flood Risk

The Project Area and its components lie across three drainage sub-basins: The Victoria Nile drainage basin, Albert Nile River drainage basin and Lake Albert drainage basin. The Victoria Nile divides the Project Area and outfalls to Lake Albert on its western edge. The hydrology and flood characteristics of these large drainage basins need to be carefully considered as the water bodies will have a significant influence on the environment and may be particularly susceptible to changes.

The Project Area lies within the rift valley floor of the Albertine Graben Rift system. To the east of the Study Area, the ground elevation reaches an altitude of about 720 m above mean sea level (aMSL), while towards the west; it declines to around 620 m aMSL where the landscape intercepts the floodplains of Lake Albert and the Victoria Nile River.

The Study Area, therefore, lies within the rain shadow of the escarpment and mountains. There are many perennial streams throughout the Study Area, and localised flooding can occur in addition to the floodplains of the main rivers.

Fluvial floods occur when the drainage basin experiences an unusually intense or prolonged rainfall event, and streamflow exceeds the capacity of the river channel. Pluvial surface water flooding occurs when rainfall collects in topographical depressions, drainage routes are obstructed and ground conditions do not permit a fast enough rate of infiltration.

Floods can be natural phenomena that arise from natural streams, but can also be the result of hydraulic modification within a catchment (Ref. 10-38).

Human activities can cause or increase the severity of flooding. Some examples of this are deforestation, which can increase the intensity of surface runoff, or the construction of in-channel structures that change the river's flow regime.

Possible flood hazards associated with the proposed Project should be assessed to identify any specific risks and to identify whether further analysis of the hazards should be undertaken.

There are several potential sources of flooding which could impact the proposed Project, including:

- Fluvial;
- Pluvial;
- Groundwater; and
- Other surface waterbodies (e.g. Lakes).

There is little information available on flooding from these sources in the Study Area. This means it is difficult to determine the extent and magnitude of flooding exactly. There are many factors which influence flooding, including topography, rainfall frequency and durations, land cover and land use.

The probability of a flood occurring is often expressed as a return period. The flood hazard map of Uganda (Figure 10-26) shows a record of where certain storm events have occurred, which helps to determine the likelihood of flooding in a particular location. The probability gives the estimated time interval between events of similar size or intensity. The return period for flooding for bank areas along Lake Albert is 1:50 which means that in any given year there is a 2 % chance that flooding will occur. Along the Victoria Nile River, the return period is 1:20 or 5 % chance that flooding will occur.

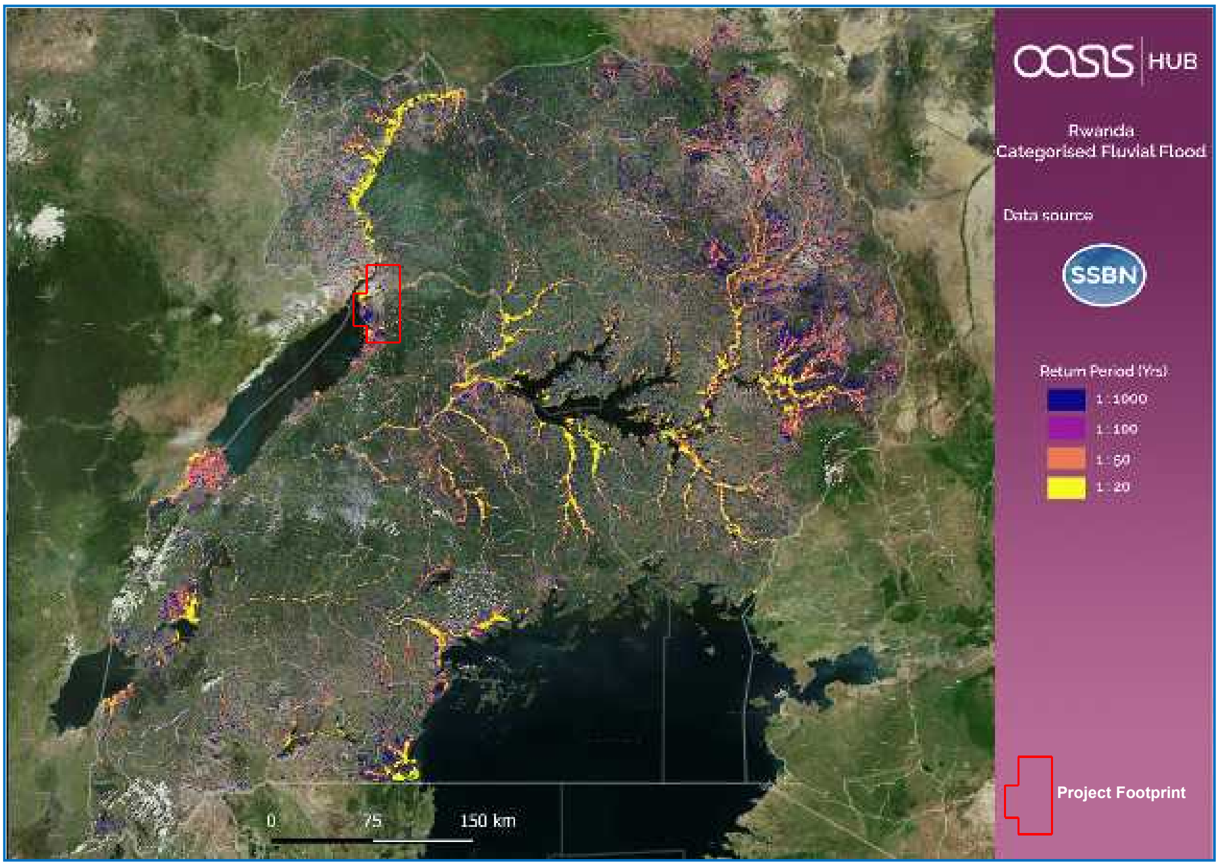
Climate change is expected to increase variability by shifting and intensifying extremes, which could lead to more severe flood events. Studies suggest that increased variability in rainfall patterns can lead to shorter wet periods and heavier, more violent rains with extreme events becoming more frequent (Ref. 10-39). Additionally, the growing variability of inter-annual rainfall is projected to continue, including increased rainfall during the dry season (Ref. 10-33). Climate change allowances should be considered to gain an insight into the future viability of a site or development.

Characteristics of the Study Area also need to be considered. There are areas of wetland habitat in the Project Area which contribute significantly to flood attenuation and protection. Increasing impervious cover (e.g. compacted ground or tarmac) can increase runoff amounts and rates which can flood low-lying areas and so any impediments or alterations to natural drainage patterns as a result of the development need to be understood and properly mitigated.

There is also great variability in seasonal surface water features, which need to be understood when designing the Project to ensure that all potential flood risk is accounted for and mitigated. The hydrological response of a catchment may depend on several factors including its size, the slopes of the stream and land surface, the density of the drainage network, the soils covering the catchment and the underlying geology. Intermittent and ephemeral streams may be dry for most of the year, but provide a significant flood risk during the wet season.

In summary, the flood risk of the Project Area is difficult to determine accurately based on a range of factors including data gaps and high environmental variability. Embedded design mitigation measures will ensure that the existing conditions of the Project Area and surrounding locations are not compromised, and a sustainable, future-proof development is provided.

Possible flood hazards associated with the proposed Project should be assessed to identify any specific risks and to identify whether further analysis of the hazards should be undertaken.



Source: Flood Risk Uganda – Accessed 25 September 2017 https://oasishub.co/dataset/uganda-categorised-flood-hazard-ssbn/resource/

Figure 10-26: Flood Hazard Map of Uganda and the Study Area

10.9 Conceptual Hydrological Model

A conceptual hydrological model to characterise and categorise the surface watercourses and drainage network pattern of the Study Area has been developed to inform the impact assessment. The conceptual model has also helped in defining the sensitivity of the relevant surface water receptors identified within the Project Area and surrounding. Based on these factors, the designation of the surface water bodies are as described in detail in Section 0 and summarised below.

By definition, the model assumes that surface water flooding is flooding that occurs as a direct result of heavy rainfall on the ground surface, leading to flooding before the water reaches watercourses. It includes overland flow as well as flooding that results from drainage systems being overwhelmed, thereby preventing any more “surface water” from entering the drainage system. The model, therefore, excludes any form of tidal flooding as the location of the Project components and the Project Areas are well above extreme tide levels, and upstream of the tidal limits of any main or ordinary rivers in the vicinity of each Project component.

10.9.1 Watercourse Classification

Surface water bodies within the Project Area and the Study Area are designated as either “Main” or “Ordinary” watercourses. The designation is based on hydromorphological position/order within the drainage network and the water resources supply potential on a local, regional and international scale.

“Main” surface water bodies/watercourses are sizeable, permanent features that are of regional (i.e. transboundary international water bodies), national and local importance as a water resource and ecologically. They are considered to be of high sensitivity within the water environment and can be hydrologically connected to one another. They are the most prominent and principal water bodies within the drainage network that drain the Study Area.

The “Main" surface water bodies within the Study Area are:

- Lake Albert;
- Albert Nile River; and
- Victoria Nile River.

The "Ordinary" surface water bodies are defined as small to medium size permanent, perennial, intermittent and ephemeral surface water bodies/watercourses. These features can include rivers, streams, ponds, watering holes and wetlands that are of national and local importance in terms of their water resources supply potential and ecological significance. They are less prominent and are tributaries to the main surface water bodies/watercourses within the drainage network of the Study Area. However, some are isolated and are not hydrologically connected to any ordinary or main surface water bodies.

The “Ordinary” surface water bodies identified within the Study Area are:

- Tangi River (North of the Nile);
- Sambiye River (South of the Nile);
- Biraizi River (South of the Nile);
- Waiga River (South of the Nile);
- Wanseko River (North of the Nile); and
- Unnamed perennial streams, intermittent streams, ephemeral streams and wetlands, North and South of the Victoria Nile River.

10.9.2 Drainage Characteristics

- The Study Area is classified as having a Dendritic Drainage Pattern, and is characteristic of the geology and geological history of the landscape;
- Surface water flow direction across the Project Area and in the surrounding landscape is generally from south to north. However, the Victoria Nile River, and its associated tributaries and ordinary watercourses, generally flow in a westerly direction towards Lake Albert and the Albert Nile River;
- Flows of the main surface watercourses within the Study Area are sustained mainly by surface water flows that originate from Lake Victoria - located approximately 300 km southeast of the Study Area (Figure 10-6 and Figure 10-11);
- Rainfall recharges the surface watercourses, including Lake Victoria;
- In-flow contribution from Lake Victoria which eventually arrives at Lake Albert via the Victoria Nile River and the Semliki River is estimated at 21.1 km3/year (21.1 Billion m3/year);
- Out-flow from Lake Albert through the Albert Nile River is estimated at 37 km3/year (37 Billion m3/year) – this represents the mass balance of the in-flow and out-flows from the region and the Project Area; and
- Outflow via the Albert Nile River accounts for the combined surface water drainage discharge and also indicates the renewable surface water available from the Project Area and surroundings.

10.9.3 Receptor Connectivity

- The drainage network and its Main / Ordinary watercourses flow downstream to the North. The watercourses such as Lake Victoria and other ordinary water bodies to the south and east of the Project Area are considered to be upstream of the Project Area and are not likely to be impacted by the Project; and
- The upstream surface water bodies are not considered in the impact assessment in Section 10.11.

10.9.4 Permanent Watercourses

- The conceptual hydrological model assumes that the permanent ordinary watercourses within the Project Area support the drainage network of the Study Area and are hydrologically or hydraulically (i.e. via groundwater base flow) connected and discharge to the main surface water bodies; and
- The conceptual hydrological model also assumes that most of the perennial watercourses within the Project Area are less likely to be hydrologically or hydraulically connected.

10.9.5 Surface Water Bodies

- Surface water baseline information shows that the main surface water bodies, as designated within the hydrological model, are valuable water resources to the Project and the entire region;
- Any potential contamination or pollution from the Project into inter-connected main and/or ordinary watercourses could impact on surface water within and/or outside the Project Area downstream, posing a risk to the region; and
- The severity of risk is dependent on many factors including the nature and type of contamination and the water body assimilative capacity - which could be either water quality and/or quantity related.

10.10 Data Assumptions and Limitations

10.10.1 Assumptions

The following assumptions were made during the field survey campaigns and preparation of this Chapter of the ESIA:

- Appropriate sampling methods and sample storage and transportation procedures were used;
- The laboratory results interpreted and used in establishing the baseline surface water quality conditions are accurate without laboratory errors; and
- The third party information/data from previous studies used in preparing this report is accurate.

10.10.1.1 Limitations

The following limitations were encountered during the field survey campaigns and preparation of this Chapter of the ESIA:

- Access to some planned sample locations was impossible due to safety constraints;
- The data/information taken from third party reports has not been verified to ascertain their accuracy;
- The physio-chemical water quality samples and results reviewed for each sampling points were insufficient to establish long term trends of the surface water quality stability in the Study Area;
- Elevated concentrations of some constituents, especially metals detected in some of the samples may be as a result of the impact of samples unfiltered in laboratory. Ideally, water samples for trace metals analyses should be filtered at the time of sampling to determine chemical speciation and fractionation of trace elements; and
- Possible flood hazards identified with respect to the proposed Project have been done at a high level.

10.11 Impact Assessment and Mitigation

10.11.1 Impact Assessment Methodology

The impact assessment methodology follows the general methods as set out in ***Chapter 3: ESIA Methodology*** and is based on recognised good practice and guidelines. It takes into account the methods prescribed in the Ugandan Environmental Impact Assessment (EIA) policy document for oil and gas exploration (Ref. 10–34). This assessment is further supplemented with guidelines specified in the Draft IFC Environmental, Health and Safety (EHS) guidelines for onshore oil and gas development projects (Ref. 10–8).

The baseline on which the potential impact is considered is derived from a combination of the desk-based study of relevant literature, published and unpublished, as well as field-based environmental condition data acquired during the ESIA field survey campaigns to the Study Area between 2014 and 2017. The main findings from these studies, data analyses results and interpretation for surface water and potential flood risks are discussed and presented in the preceding baseline section including the conceptual hydrological model presented in Section 10.9 above.

The methodology adopted for the impact assessment is similar to that for the hydrogeology assessment in ***Chapter 9: Hydrogeology*** and follows the source-pathway-receptor approach. For there to be an impact, there must be a source i.e. a contaminant or an activity; a receptor; and, a pathway, which allows the source to impact on a receptor. All three elements must be present before a plausible linkage, and a potential impact on the surface water condition can be realised.

In order to assess the potential impacts of the Project on the surface water conditions, a conceptual hydrological model of the Project Area has been prepared. The conceptual hydrological model is discussed in Section 10.9. The conceptual hydrological model is used to characterise and categorise the surface watercourses and drainage network pattern of the Study Area and has been developed to inform the impact assessment. The conceptual model is also used in defining the sensitivity of the relevant surface water receptors identified within the Project Area and surrounding. The conceptual hydrological model together with the source-pathway-receptor approach form the basis of a qualitative risk assessment of the potential impacts of the Site Preparation and Enabling Works, Construction and Pre-Commissioning, Commissioning and Operations and Decommissioning phases of the Project on surface water. These potential linkages are assessed for each phase of the Project in the subsequent sections of the Chapter.

The principal *sources* of potential direct and/or indirect impacts are:

- Abstraction of surface water from Lake Albert for the Project components;
- Disturbance of water bodies during construction;
- The release of soluble contaminants from surface activities into surface water bodies;
- The release of soluble contaminants from sub-surface activities into the groundwater in the sand aquifer and migration to surface water features;
- The discharge of sediment rich or turbid surface water run-off from site activities into nearby surface watercourses; and
- Loss of flood water storage and increased flood risk.

The main *receptors* potentially at risk from these sources are:

- Existing Main and Ordinary surface watercourses in the Project Area;
- Surface water features in hydraulic continuity with groundwater in the sand aquifer, through either a reduction/loss of baseflow discharge or the discharge of contaminated groundwater; and
- Wildlife, livestock, humans and ecosystems reliant on surface water.

The main *pathways* for the sources to impact on the receptors are:

- Infiltration of surface soluble contaminants and groundwater percolation;

- Direct runoff of contaminated drainage to adjacent watercourses; and
- Migration of soluble contaminants entering the groundwater and discharging as base flow to surface water features.

10.11.2 Sources of Impact

This section assesses the potential impacts of the Project on surface water bodies and watercourses (such as lakes, wetlands, ponds, named and unnamed rivers/streams, both perennial and permanent and watering holes etc.) identified within the Study Area. This assessment includes potential impacts that can, directly and/or indirectly impact on the water environment; as a result of various activities (Table 10-23) over the different phases of the Project development. Flood risk and impacts on morphology are also assessed within this section.

The impact assessment considers the potential effects on surface water caused by operational and/or non-routine activities which could result in adverse impacts on water flow or quality, such as the additional water abstraction for the Project from Lake Albert and the accidental release of small volumes (e.g. 50 – 100 litres) of contaminants during scheme operations. Accidental releases of small volumes of contaminants are addressed in this chapter. Unplanned events, such as ruptures of pipelines, tank failures or blow outs at production wells, which are unlikely to occur but could have a major impact on surface water, are considered in ***Chapter 20: Unplanned Events***.

The Project development has been divided into four phases for the impact assessment, comprising:

- Site Preparation and Enabling Works;
- Construction and Pre-commissioning;
- Commissioning and Operations; and
- Decommissioning.

This assessment addresses impacts that have the potential to cause effects and changes to the established baseline characteristics of surface water quality, hydrology and water availability, surface water drainage patterns, flood risk and river morphology.

As discussed in ***Chapter 9: Hydrogeology*** there is an interrelationship between surface water and groundwater, with groundwater in the unconsolidated sand aquifer providing base flow discharge to the Victoria Nile, Albert Nile and Lake Albert. However, the majority of the other watercourses in the Project Area are not in direct hydraulic continuity with the groundwater and do not receive any base flow support from the groundwater, which typically is present several metres (20 m – 50 m) below the watercourse. ***Chapter 9: Hydrogeology*** provides a detailed assessment of the impacts of the proposed Project on groundwater.

The Victoria Nile, Albert Nile and Lake Albert are the discharge points and receptors for groundwater in the sand aquifer. While there is direct hydraulic continuity between these waterbodies and the groundwater, abstraction of water from these waterbodies will have no impact on the groundwater flow or groundwater resources or on any other ordinary surface water courses hydraulically connected to these main water bodies. Where necessary, inter-related effects on groundwater are discussed in this chapter especially where significant impacts have the potential to affect surface water features that are in hydraulic connection with groundwater systems beneath the Study Area. The assessment takes into account the sensitivity of water environmental features/receptors identified with respect to their regional, national, and local importance, their proximity to the Project components, the potential impact magnitude and significance of impacts as well as mitigation measures either embedded into the design (as outlined in ***Chapter 4: Project Description and Alternatives***) or proposed as additional measures outlined within this chapter.

The assessment of potential surface water impacts has taken into consideration applicable national and international standards. Consideration is given to other accepted standards specifically relevant to the nature of the proposed Project, such as the internationally recognised Good International Industry Practice (GIIP) regarding the control of onshore oil and gas exploration activities and the preparation of environmental health and social impact assessments.

The assessment evaluates Project activities during each phase of the Project that have the potential to impact on the surface water environment and related effects to groundwater within the Study Area. The key Project activities having the potential to impact surface water and flood risk during each Project phase based on the Project construction and operation assumptions are summarised in Table 10-23 and have been used in undertaking the assessment.

Table 10-23: Project Activities which may lead to potential impacts on Surface Water

Phase	Activity
Site Preparation and Enabling Works	• Mobilisation of plant and construction vehicles to the Project Site; • Clearance of vegetation and soils (Industrial Area, well pads, Water Abstraction System, Masindi Vehicle Check Point, Bugungu Airstrip and Victoria Nile Ferry Crossing Facilities); • Physical movement of vehicles and plant (inter-field and onsite movements); • Construction of new access roads (W1, C1, C2, C3, N1, N2, N3, inter field access roads south and north of the Victoria Nile) and upgrade works of existing roads (A1, A2, A3, A4, B1 and B2) including the installation of drainage; • Civil works for Lake Albert Water Abstraction System; • Deliveries of materials and supplies (including fuel and other hazardous substances) to the Project Site; • Storage of fuel and hazardous substances; • Refuelling of plant and machinery within Project Site; • Waste generation, storage and disposal (hazardous and non-hazardous); • Use of water to suppress dust generation; • Excavation from borrow pits and quarries and the movement of excavated materials; • Restoration of borrow pits; • Construction of Victoria Nile Ferry Crossing Facility, including piling for the jetties; • Discharge of surface runoff from roads, well pads, Industrial area; • Creation of impermeable areas; • Construction activities within floodplains within Project Site; and • Disposal of treated waste water (grey and black).
Construction and Pre-Commissioning	• Mobilisation of plant and construction vehicles to the Project Site; • Physical movement of construction vehicles and plant within the Project Site; • Deliveries of materials and supplies (including fuel and other hazardous substances) to the Project Site; • Refuelling of plant and machinery within Project Site; • Storage of fuel and hazardous materials; • Use of Power generation sets (e.g. Diesel generators); • Construction of Lake Albert Water Abstraction System (either Temporary or Permanent); • Operations at camps, Masindi Vehicle Check Point and Bugungu Airstrip; • Transportation of materials and supplies including hazardous substances (i.e. drill cuttings) within the Project Site; • Clearance of vegetation and soils for Production and Injection Network Right of Way (RoW), Water Abstraction System pipeline RoW and Horizontal Directional Drilling (HDD) Construction Area; • Movement of construction vehicles for Production and Injection Network RoW, Water Abstraction System pipeline RoW and HDD Construction Area; • Construction of Production and Injection Network and Water Abstraction System pipeline RoW including trenching, welding, storage of material, backfilling etc.; • Restoration of Production and Injection Network RoW, Water Abstraction System pipeline RoW and HDD Construction Area; • Operation and discharge from temporary SuDS drainage system (including use of stormwater facility); • Waste generation, storage and disposal (hazardous and non-hazardous); • Drilling of wells at well pads; • Containment and storage of drilling fluids and drill cuttings;

Phase	Activity
	• Pre-commissioning activities including use and disposal of treated water and associated chemicals; • Painting and coating of pipeline at Tangi and Industrial Area Construction Support Base; • Pre-commissioning and abstraction of water from Lake Albert; • HDD activities at the Victoria Nile Crossing Points; • Creation of impermeable area; and • Construction activities within floodplains within Project Site.
Commissioning and Operations	• Waste generation, storage and disposal (hazardous and non-hazardous); • Deliveries of materials and supplies (including fuel and other hazardous substances) to the Project Site; • Refuelling of plant and machinery within Project Site; • Storage of fuel and hazardous substances; • Management of produced water generated at Central Processing Facility (CPF), including re-injection; • Operation of CPF plant and equipment; • Discharge of surface runoff from all permanent facilities via drainage system (SuDS); • Operation of plant and equipment at the well pads; • Production and Injection Network maintenance (e.g. pigging activities); • Abstraction, operation and maintenance of Water Abstraction System; • Operation and maintenance of the Victoria Nile Ferry Crossing; and • Presence of new impermeable areas in various locations across Project Site.
Decommissioning	Dependent upon Decommissioning strategy - but expected to be similar to those for Construction and Pre-Commissioning Phase.

10.11.3 Impact Assessment Criteria

In assessing the significance of the potential impacts on the surface water conditions due to the Project, three key factors were considered – the type and nature of the impact i.e. adverse, beneficial, temporary, direct, indirect etc.; the sensitivity and/or importance of the receptor; and, the potential magnitude of any effect. The significance criteria are based on a combination of impact magnitude and receptor sensitivity. The impact significance matrix in ***Chapter 3: ESIA Methodology*** is used to determine the significance of each impact.

There will be situations using the source-pathway-receptor approach where impacts could occur to identified receptors but where realisation of the impact is considered highly unlikely, for example where the receptor is located a significant distance from the source of the potential impact. The likelihood of an impact being realised also is considered using a qualitative and semi-quantitative assessment on a scale of certain, likely or unlikely to assess whether there is a realistic likelihood of any impact, even where a plausible linkage exists.

10.11.3.1 Receptor Sensitivity

Specific to the surface water impact assessment, the criteria for determining the sensitivity/importance of surface receptors are established based on the baseline conditions and categorisation of the water bodies and watercourses as described in Section 10.6.2, as being either "main" or "ordinary" water bodies. The criteria also take into account the assimilative capacity, sensitivity to change from an ecological perspective, use of the resource (i.e. from a water resources sustainability perspective) for both human (community usage) and livestock purposes, water quality, legislation, statutory designation and professional judgment. Based on these criteria, the sensitivity of the “main” surface water bodies and the Ramsar designated wetlands within the MFNP has been rated as “**high**”. The sensitivity of the small to medium size permanent and continuous flowing ordinary surface water bodies that are tributaries to the main surface water bodies has been rated as “**moderate**”. The sensitivity of the small ordinary surface water bodies, such as small intermittent streams, ephemeral streams, lakes, ditches and ponds collecting surface water runoff is rated as “**low**”. All other surface water features not initially defined in Section 10.6.2, such as heavily modified surface water features (e.g. small irrigation reservoirs, valley tanks, canals or canalised rivers/substantially altered water courses) regularly or not regularly used for irrigation, drinking water supply, and navigation purposes have been rated as "**negligible**". Table 10-24 provides a summary of the receptor sensitivity rating criteria.

Table 10-24: Surface Water Receptor Sensitivity/Importance

Sensitivity /Importance	*Description*
High	• "Main" surface water bodies, watercourses and surface water features, such as rivers, Ramsar designated wetlands and lakes that are of regional (transboundary international water bodies) and national importance in terms of their water resources supply potential and ecological importance. • Receptors are large and permanent and are also hydrologically connected to other main water bodies. • Receptor has good water quality (i.e. within Ugandan standards) and a high water resources supply potential on an international, national or local scale and is suitable for use as a source of potable water supply and for amenity use. • Examples include Lake Albert, Albert Nile River, Victoria Nile River, and MFNP.
Moderate	• "Ordinary" surface water bodies, watercourses and water features, such as permanent and continuous flowing rivers, streams, non-designated wetland that are of national and local significance in terms of their water resources supply potential and ecological importance. • Receptors are small to medium-sized and are permanent. • Less prominent, usually forms tributary to main water bodies but may sometime occur in isolation. • Receptor has good water resources supply potential, good water quality suitable for potable water supply use and amenity use on a national or local scale. • Examples include Tangi, Waisoke, Waiga and Sambiye Rivers and other non-designated permanent wetlands and unnamed rivers used for domestic, agriculture and industrial/process (e.g. mineral washing etc.) water supply purposes.
Low	• "Ordinary" small seasonal unnamed isolated surface watercourses that are used for livestock purposes. • Receptors are small in size and could be permanent, perennial, intermittent or ephemeral. • Includes all ordinary surface water bodies, watercourses and water features, such as rivulets, streams, ponds, watering holes and wetlands that are of local importance in terms of their water resources supply potential and ecological importance. • Examples include ephemeral streams, ditches, lakes and ponds not used as a source of potable water supply, rainfall and surface water runoff.
Negligible	• Heavily modified surface water features with regular or no regular use. • Examples include locally constructed small irrigation reservoirs, valley tanks, water storage systems, etc.

10.11.3.2 Receptor Identification

The baseline surveys and characterisation of the existing surface water environment provide the basis on which surface water environmental receptors/features have been identified within the Study Area. Additionally, the factors used in identifying the relevant receptors consider:

- Surface water drainage pattern, flow direction and landforms;
- Potential flood risk areas;
- The sensitivity/importance of receptors in terms of their ecological importance and water resources supply potential and usage for both human consumption, agriculture, fishing, livestock farming and sustenance of ecological species and ecosystem;
- The proximity (i.e. distance) of each Project component to identified sensitive receptors;
- The geographical location (i.e. whether upstream or downstream) of each water feature/receptor in relation to individual Project component, the nature of activities and associated potential impacts to surface water during each phase of the Project lifespan; and
- Professional judgement.

Table 10-25 provides a list of surface water receptors identified within the Study Area. Some of these receptors are hydraulically or hydrologically connected to one or more of the Project components from a surface water quality, quantity, and flood risk perspective. Groundwater receptors are identified and assessed in ***Chapter 9: Hydrogeology***.

Table 10-25: Description of Principal Receptors

Receptor	***Description***	***Potential Impact / Risk / Assessment Area***	***Receptor Sensitivity / Importance***	***Reasoning***
Victoria Nile River	A **main** river that divides the Study Area from around the central part of the Project Area. The river flows from east to west.	Water Quality and Quantity Flood Risk Morphology	High	Could be affected by potential impacts from the Project, based on the river's proximity to some of the Project components such as proposed pipeline crossing (i.e. Victoria Nile River Crossing) and Ferry Crossing that will be constructed on the river bank and beneath the river bed. Attribute has a high quality and rarity on a regional or national scale. The Victoria Nile is important on an international and regional scale; Uganda is party to the Nile Basin Initiative
Albert Nile River	A **main** river in the northern part (i.e. downstream) of the Project Area flowing in a northerly direction.	Water Quality and Quantity Flood Risk Morphology	High	Could be affected by potential impacts from the Project as a result of its location (downstream) and hydrological connection with other main and ordinary rivers (i.e. Lake Albert and Victoria Nile River, Tangi River etc.). Attribute has a high quality and rarity on a regional or national scale. The Albert Nile is important on an international and regional scale; Uganda is party to the Nile Basin Initiative
Lake Albert	A **main** and prominent surface waterbody / Lake	Water Quality and Quantity	High	Could be affected by potential impacts from the Project given its proximity to the Project components. It will be the

Receptor	Description	Potential Impact / Risk / Assessment Area	Receptor Sensitivity / Importance	Reasoning
	that lies within the western part of the Study Area.	Flood Risk Morphology		primary source of water supply for the Project throughout much of its lifespan. Lake Albert is also located within a potential impact area of Well Pad KW-01 (715 m to the east) and the proposed Water Abstraction System. Attribute has a high quality and rarity on a regional or national scale. Lake Albert is international water and had existing infrastructure along the shores.
Major tributaries to main rivers	Named **ordinary** rivers within the Study Area that form part of the surface water drainage network within the Project Area. They form major tributaries to the **main** rivers. Examples include the Tangi River, Opengor River, Ajai River, Nyamsika River north of the Victoria Nile River and the Waiga River, Sambiye River, Wanseko River south of the Victoria Nile River.	Water Quality and Quantity Flood Risk Morphology	Moderate	Could be affected by potential impacts from the Project as a result of their proximity to the Project components. For example, River Ngazi is within a potential impact area of some Well Pads (KGG-09 and KGG-03). The Sambiye River is within potential impact area of four well pads: (KGG-05, NSO-04, KW-02A and NSO-02). Several watercourses will be crossed by pipeline and new roads. These rivers are also hydrologically connected to the main rivers and are used for irrigation, livestock and industrial water supply within the Study Area. Attribute has a high quality and rarity on a local scale.
Minor tributaries to ordinary and main rivers	Any named or unnamed **ordinary** and permanent rivers/streams that are part of the surface water drainage network within the Study Area. They form minor tributaries to both the **ordinary** and sometimes the **main** rivers.	Water Quality and Quantity Flood Risk Morphology	Moderate	These rivers could be affected by potential impacts from the Project as a result of their proximity to the Project components. Some unnamed surface watercourses have been identified within a 1 km radius of 18 well pads with the closest about 70 m from well pad JBR-03. Several watercourses will be crossed by Pipeline and new roads. These rivers/streams are also connected to the main rivers and are used for water supply within the Study Area. They provide flow to other main or ordinary water bodies and are therefore of local importance from ecological and water resources perspective. Attribute has a high quality and rarity on a local scale.
Wetland / Marsh and swampland	With the exception of the Ramsar recognised wetland (i.e. wetland that lies within the Victoria Nile River), these include other	Water Quality and Quantity Flood Risk	Moderate	These features could be affected by the Project as a result of their proximity and hydrological / hydraulic connection to the Project components and or other surface

Receptor	Description	Potential Impact / Risk / Assessment Area	Receptor Sensitivity / Importance	Reasoning
	permanent and seasonal small to medium size **ordinary** surface water bodies (i.e. wetlands, marshes and swamplands) that are hydrologically connected to other **ordinary** and **main** surface water bodies or groundwater systems within the Study Area.	Morphology	Low	water bodies within the Study Area that are likely to be impacted by the Project. Attribute has a high quality and rarity on a local scale. They may be affected by the Project where Pipeline and new roads cross them.
Ponds and Watering Holes	Small isolated **ordinary** surface water bodies not hydrologically linked to the main surface water network within the Study Area.	Water Quality and Quantity Flood risk	Low	Could be affected by potential impact from the Project components. Wildlife or livestock use them as a drinking water source.
Streams / rivulets, ponds, ditches, surface runoff (seasonal)	**Ordinary** water bodies such as ephemeral streams, ponds and ditches only present during the wet season or after a period of extended rainfall. These water bodies are not used for water supply, but may sometimes be used by wildlife animals.	Water Quality and Quantity Flood Risk	Low	Could be affected by impacts from the Project components.

10.11.3.3 Impact Magnitude

The magnitude of any impact considers the likely scale of the potential changes to the baseline conditions and takes into account the duration, proximity of receptors, extent, reversibility and permanency of any effect, i.e. temporary or permanent. The impacts assessed in this chapter are those that are likely to occur as a result of routine and non-routine events where, in general, the magnitude is not anticipated to be high. ***Chapter 20: Unplanned Events*** considers the potential impact of major events that are unlikely to occur but have the potential of high impact magnitude.

Impact significance is assessed taking into account the sensitivity of the identified water environmental features/receptors, and the magnitude of potential impact on each feature. The resulting significance level is also interpreted based on professional judgement and expertise and adjusted if necessary. The impact significance definitions are outlined in ***Chapter 3: ESIA Methodology***.

For each phase of the Project, a 1 km potential impact area around each component is used as a first pass screening approach to determine the likelihood, magnitude and significance of potential direct and indirect impacts from specific Project components on nearby water features/receptors. All water features that are within the Area of influence (AoI) are automatically considered through the impact assessment and screening process.

Where the magnitude of potential impacts on receptors/features from a Project activity is considered to be low or negligible through the different phases of the Project development, it has been screened out and not considered further through the assessment process. Further mitigation measures are proposed where the potential impact magnitude and effect significance is considered moderate or high.

From a surface water quality, quantity and flood perspectives, the criteria for determining the magnitude of potential impacts varies as this depends on factors as discussed further below.

10.11.3.3.1 Water Quality

From a surface water quality perspective, for a potential impact resulting from surface water contamination to occur, three factors must be present as summarised below:

- There must be a contamination or pollution source point (i.e. ***Source***) of a potential impact, such as an oil spillage or poorly treated wastewater discharge;
- A pathway or connection (i.e. ***Pathway***), which allows the contaminant to impact a receptor; and
- A surface water body/watercourse (i.e. ***Receptor***) which can be adversely affected.

Only when all three factors are present can a potential effect/impact be realised. Impacts to wetlands are captured as part of the water quality assessment for each Project component.

10.11.3.3.2 Water Quantity

From a surface water quantity point of view, the magnitude of impact has been assessed from a water resources availability and sustainability (i.e. demand and supply) perspective and takes into account the volumes of surface water required by the Project and how the proposed Project would use water efficiently. It also assesses the potential impacts of water consumption for the Project may have on any surface water receptor’s ability to assimilate changes.

10.11.3.3.3 Flooding

Regarding flooding, the magnitude of potential impact takes into consideration the duration and level of change (i.e. whether temporary or permanent) to the established baseline surface water drainage pattern and characteristics, caused by the Project development and how these can influence flood risk within the Study Area. The criteria also take into consideration the potential impacts that climate change may have on the Project. There is uncertainty associated with climate change predictions and so it should be noted that such assessments are estimates.

10.11.3.3.4 River Morphology

Regarding morphology, the assessment takes into account any changes (i.e. whether temporary or permanent) to the established baseline surface water morphology likely to be caused by the Project. These include impacts that cause changes in the physical dimensions (such as the morphology of the stream beds, channel width and/or depth).

Guidance for defining the impact magnitude and significance on surface water receptors is provided in Table 10-26.

Table 10-26: Impact Magnitude

Impact Magnitude	*Description*
High	• Major pollution that causes important water quality parameters to significantly exceed the Ugandan standard thereby leading to regulatory failure and imminent danger to public health (i.e. both human and livestock health). Significant deterioration in water quality compared with baseline conditions, where parameters already exceed Ugandan standards. Permanent deterioration in the quality and integrity of the attribute/receptors. • Significant dewatering or depletion of water feature supporting ecological and water supply thereby rendering the supply unusable or unavailable for use. • Major and adverse impact (flood, water quality and/or quantity) on internationally designated area and water receptors. • Impacts resulting in permanent change in the drainage pattern that leads to continuous flooding during normal rainfall events. • Impacts resulting in permanent change and alteration in the baseline morphology of a surface water feature that leads to a significant deterioration or total loss of the feature.

Impact Magnitude	Description
Moderate	• Pollution that causes important water quality parameters to slightly exceed the Ugandan standard thereby leading to regulatory failure but no health risk or imminent danger to public health (i.e. both human and livestock health). Long-term (>365 days) deterioration in the quality and integrity of the attribute/receptors. • Moderate dewatering of water feature supporting ecological and water supply thereby resulting in temporary (short-term) (<30 days) water supply disruption or making the source temporary unavailable for use. • Moderate and potential adverse impact (flood, water quality and/or quantity) on internationally and /or nationally designated area and water receptors. • Impacts resulting in long-term (>365 days) change in the drainage pattern that leads to flooding during periods of severe rainfall events. • Impacts resulting in long-term (>365 days) change to baseline morphology of a surface water feature that leads to a significant deterioration or total loss of the feature.
Low	• Minor localised pollution causing short-term (<30 days) or localised water quality parameter to change but with concentrations remaining below Ugandan standards with no regulatory failure, no health-related risk or public health impact. Impacts resulting in some temporary measurable changes in attribute's quality or vulnerability. • Minor impact on water level due to abstraction for the Project use but not affecting the ability of the source to continue to provide adequate water supply. • Minor impact on water level or quality of wetland/watering hole not designated and not used for water supply. • Minor impacts resulting in temporary (short-term) (<30 days) change in the drainage pattern that leads to minor localised flooding during periods of severe rainfall events. • Minor impacts resulting in (short-term) (<30 days) change in the baseline morphology of a surface water feature that leads to a minor deterioration or total loss of the feature.
Negligible	• Insignificant pollution and/or dewatering or depletion of surface water supporting potable water supply with no measurable increase in contaminant concentrations or decrease in water availability at the source. • Impacts resulting in effect on attribute, but of insufficient magnitude to affect the continued use or integrity. • Impacts with insignificant (<5 days) change in the baseline morphology of a surface water feature

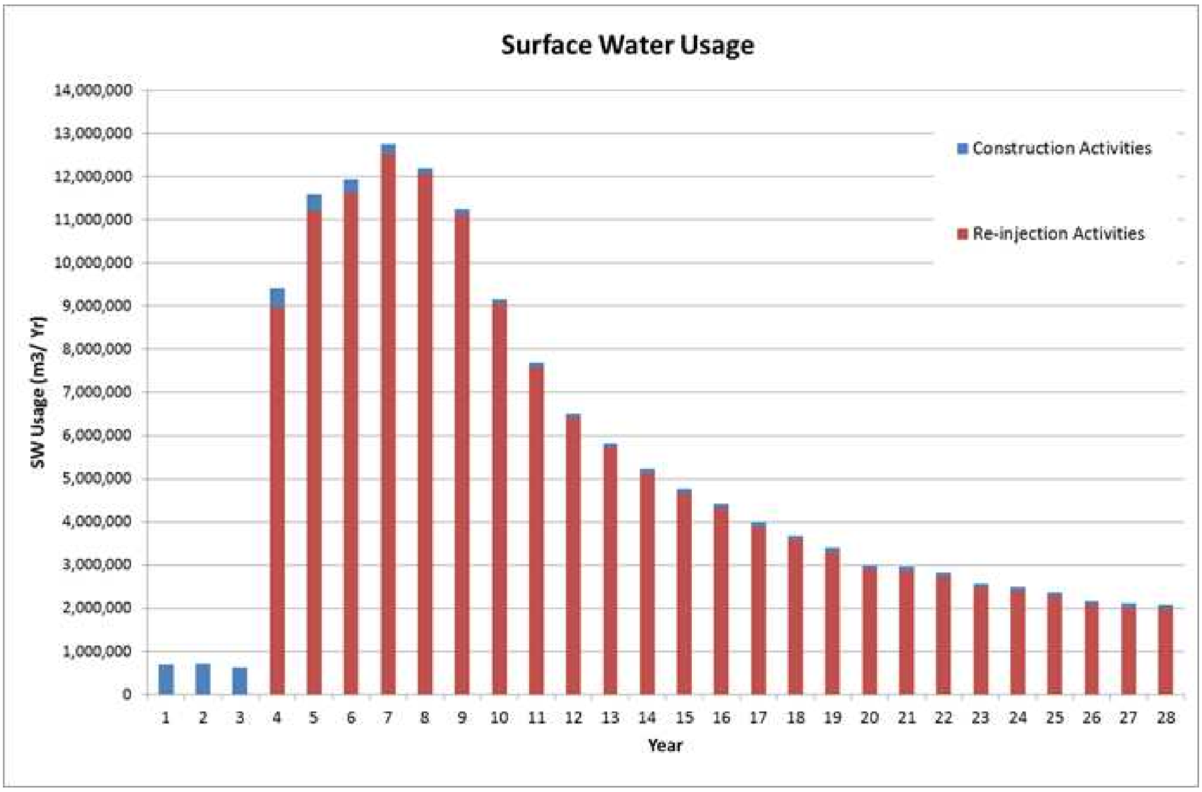
Using a combination of receptor sensitivity and impact magnitude, the significance of any actual or potential impacts can be defined as high, moderate, low or insignificant. These matrices are presented in Tables 3-1 and 3-2 in ***Chapter 3: ESIA Methodology***. The significance of any impact is identified after implementation of embedded mitigation (potential impact) and again after the implementation of additional mitigation measures (residual impact).

10.11.4 Surface Water Resources Availability and Usage for Project

The expected service life of the Project is 25 years. As discussed in ***Chapter 4: Project Description and Alternatives,*** it is proposed that groundwater will form the primary source of water supply for the first years (i.e. ~Year 1 – 5) of the Project. After the early years, surface water abstracted from Lake Albert will constitute the primary source of water for the Project to supply water for construction and mainly for water reinjection. However, should ongoing studies show that groundwater is inadequate to meet the Project water needs for the early years, temporary surface water abstractions will be established from Lake Albert at the same location as the Water Abstraction System and from the Victoria Nile River as required.

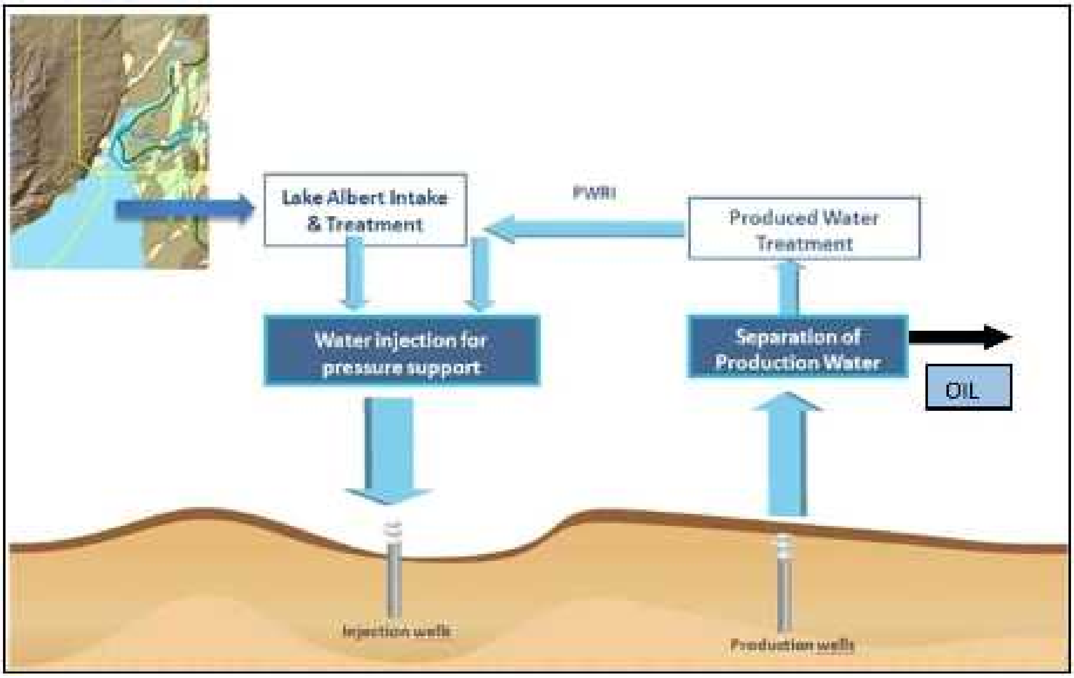
Figure 10-27 shows that a significant proportion of the surface water supply forecast for the Project will be used mainly for reservoir pressure management purposes (water injection) from Year 9 onwards.

The predicted maximum water demand for surface water is in Year 7 when approximately 12,762,000 m^3/annum will be abstracted from Lake Albert. By the end of the Project in Year 28, the surface water demand will have reduced to approximately 2,690,000 m^3/annum. The potential surface water usage distribution for the lifespan of the Project is provided in Figure 10-27 and Table 10-27. As shown in Figure 10-27, the amount of water abstracted from Lake Albert to support reservoir management by water injection decreases as the field life progresses. This is due to the increased volumes of produced water coming from the reservoir (Figure 10-28). The potential combined surface water usage for the Tilenga Project and other related oil and gas projects (i.e. other associated oil and gas projects in the area) is provided in Figure 10-29. The predicted maximum consolidated water demand for the oil and gas projects is estimated at approximately 42,000 m^3/day (i.e. 15,333,000 m^3/annum).



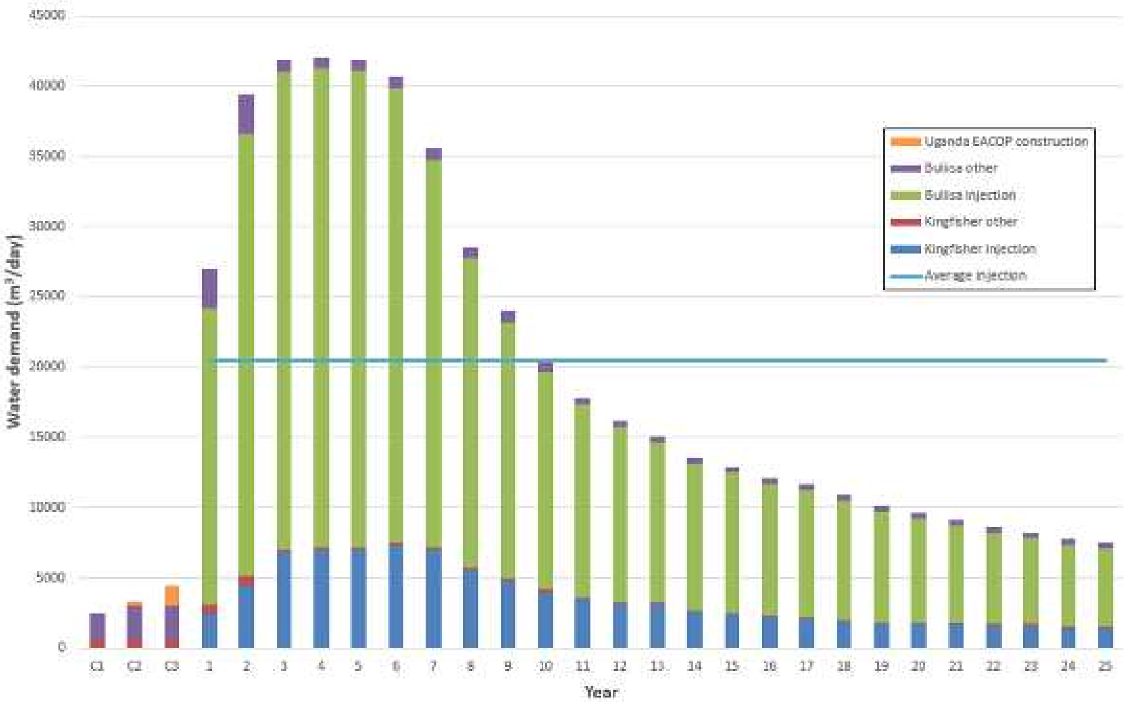
Source: TEPU 2018

Figure 10-27: Water Resources Demand Forecast



Source: TEPU 2018

Figure 10-28: Water Re-use Concept for the Project



Source: TEPU 2018

Figure 10-29: Consolidated Water Resources Demand for the Projects

Table 10-27: Surface Water Requirement during the Project Life

Year	Other (Construction and Pre-Commissioning, Commissioning and Operations)	Re-injection	TOTAL (cubic meters)
1	707,772	0	707,772
2	707,772	0	707,772
3	707,772	0	707,772
4	707,772	8,973,094	9,680,866
5	707,772	11,213,711	11,921,483
6	707,772	11,621,383	12,329,155
7	707,772	12,517,756	13,225,528
8	707,772	12,069,757	12,777,529
9	707,772	11,125,300	11,833,072
10	707,772	9,049,844	9,757,616
11	707,772	7,573,580	8,281,352
12	707,772	6,419,405	7,127,177
13	707,772	5,730,245	6,438,017
14	707,772	5,136,575	5,844,347
15	707,772	4,661,960	5,369,732
16	707,772	4,327,275	5,035,047
17	707,772	3,884,474	4,592,246
18	707,772	3,590,087	4,297,859
19	707,772	3,300,564	4,008,336
20	707,772	2,908,965	3,616,737
21	707,772	2,866,229	3,574,002
22	707,772	2,735,654	3,443,426
23	707,772	2,477,332	3,185,104
24	707,772	2,397,672	3,105,444
25	707,772	2,280,169	2,987,941
26	707,772	2,083,302	2,791,074
27	707,772	2,012,446	2,720,218
28	707,772	1,983,214	2,690,986

10.11.5 Embedded Mitigation

There are several activities associated with the Project that are standard for each of the four phases of the Project and common for other similar oil and gas production projects throughout the world. These include activities such as bulk fuel and chemical storage and usage, plant refuelling, wastes management, including drilling muds and drill cuttings and storage, water injection, and vehicle washout. Whilst several of these activities pose potential risks to surface water quality and quantity and flooding, a number of embedded mitigation measures have been adopted into the Project design to circumvent these risks.

In-built design (embedded) mitigation measures are features of the design of Project components that are intended to preclude adverse impacts to the environment. A list of relevant embedded mitigation measures already built into the design of the Project is outlined within ***Chapter 4: Project Description and Alternatives****.* Table 10-28 lists those embedded mitigation measures relevant to the protection of surface water quality, quantity, flood risk and the morphology of surface water features. These measures have been taken into account when assessing the significance of the potential impacts.

Full detailed descriptions of the embedded design mitigations integrated into each component of the Project are presented in ***Chapter 4: Project Description and Alternatives****.* Implementation of these embedded mitigation measures has been assumed when predicting the significance of the potential impacts of the Project.

Table 10-28: Summary of Embedded Mitigation Measures for Surface Water

Embedded Mitigation Measures for the Protection of Surface Water
All fuels and hazardous materials will be stored within appropriate bunds and drip trays, providing appropriate containment, where practicable
Chemicals and hazardous liquids will be supplied in dedicated tote tanks made of sufficiently robust construction to prevent leaks/spills. Dedicated procedures will be developed for fuel and hazardous material transfers and personnel will be trained to respond. Spill kits will be available at all storage locations
Main refuelling facilities will be located within the Industrial Area, the camps and the Masindi Vehicle Check Point. Facilities will be located within bunded areas with appropriate capacity (110% tank containment). The refuelling pumps will be equipped with automatic shut off and there will be dedicated procedures and spill kits available. Bunds will be designed to minimise ingress of surface water, facilities roofed where practicable and any contaminated water collected will be trucked off site for disposal
With the exception of the CPF which has a bespoke drainage arrangement, drainage arrangements for the permanent facilities will be as follows: • Potentially contaminated areas (i.e. fuel and chemical storage areas) will be provided with local effluent collection (sumps, kerbing and bunding) whereby the potentially contaminated water will be collected and removed by road tanker to a licenced waste disposal facility; and • Uncontaminated areas which will drain naturally to the environment via Sustainable Drainage System (SuDS) comprising filter drains and soakaways. The SuDS design is subject to further detailed design. Sampling points will be established for all potentially contaminated areas to enable samples to be collected for analysis
There will be a 15 m wide buffer from the perimeter security structure, which will be cleared of vegetation. Within the MFNP, the structure will be designed to prevent the ingress of animals entering the well pads and will comprise a bund wall structure
Each well pad will include an emergency pit with capacity for up to 50 cubic metres (m^3) for use should there be an unplanned event i.e. blowout. The pit will be lined and covered to prevent rainwater ingress
The pipelines will comprise carbon steel with adequate corrosion allowance built into material specifications (wall thickness) to prevent leaks
An anticorrosion coating will be applied for external protection and a corrosion inhibitor will be injected for internal protection
The Production and Injection Network outside the Industrial Area will be buried at least 0.8m below the ground surface; markers will be used to denote the location (including the water abstraction pipeline in Lake Albert)
The drainage arrangement of the CPF will be designed to segregate clean and potentially contaminated effluent streams. The drainage for the CPF will be segregated as follows: • Continuously Contaminated Drains will collect hazardous fluids from process and utility equipment. All effluent collected in the closed drainage system will be returned back to the oil treatment trains. There will be no discharge to environment from the closed drains system; • Potentially Contaminated Drains will collect rainfall, wash-water or fire water that falls on paved process and equipment areas that could contain contaminants such as hydrocarbons, metals and solids. Drip pans and kerbs will be provided below every process or utility system that may potentially leak or overflow. Any drips or leaks will be routed to the open drain system via a sump. Roofing will be provided where practicable to prevent surface water ingress. During normal operating conditions, rainwater from potentially contaminated areas will be directed to an the oil water separator prior to discharge to environment in accordance with applicable discharge standards as presented in Chapter 10: Surface Water. When the oil-water separator is full, it will overflows to an associated storm basin via an overflow diverter which will act as a buffer. When the level in the separator falls, the water collected in the storm basin will be sent by storm water pumps back to the overflow diverter and on to the separator. The storm water basin will be sized to withstand a 1 in 100 year event. An oil in water analysers will be installed on the discharge point of the potentially contaminated drains to provide continuous monitoring of the discharge; and • Uncontaminated Drains will manage clean surface water from uncontaminated areas via suitably designed SuDS (network of filter drains and soakaways).

Embedded Mitigation Measures for the Protection of Surface Water
At the Water Abstraction System, a flow meter will be installed and sample point established for ongoing monitoring purposes
Drainage channels will be installed along the edges of the upgraded roads to prevent excessive runoff and cross drainage culverts will be installed, where appropriate. All drainage infrastructure will be designed taking into account the Uganda Ministry of Works and Transport - Road and Bridge Works Design Manual for Drainage (January 2010)
Surface water will be managed via temporary sustainable drainage systems (SuDS) to manage flood and contamination risk. The requirements for construction SuDS will be adapted depending on the nature of the activities utilising the principles as outlined in Chapter 23: Environmental and Social Management Plan
During site clearance, vegetation stripping will be undertaken using a phased approach to minimise sediment pollution from runoff
Buffer zones will be established to protect watercourses and habitats
Contaminated run off will be minimised by ensuring adequate storage facilities are in place for materials stockpiles, waste, fuels/chemicals/hazardous materials, vehicles/washing areas, parking facilities
Clean surface water will be diverted away from exposed soils with use of diversion drains and bunds
All dewatering from excavations or isolated work areas will be provided with appropriate level of treatment prior to discharge
All drill cuttings from borehole drilling activities will be collected and disposed of appropriately. Disposal methods will be pre-agreed with NEMA prior to commencement of activities
The Project Proponents are aware of the need to employ water efficiency measures throughout the lifetime of the Project; they will consider water reduction measures, where feasible
The installation of boreholes across the Project Area is subject to the outcome of the Water Abstraction Feasibility Study currently being undertaken by the Project Proponents
Pre-commissioning water (used for pipeline cleaning and hydrostatic tests) will be reused wherever practicable on multiple pipelines. The base case for management of hydrostatic test water is for the treated water to be left in situ until start up. Final disposal will be determined and selected depending on water quality and available discharge options. The base case for ESIA is that water left in the pipeline from hydrotesting will be disposed via the Produced Water Treatment Train and transferred back via the Production and Injection Network to the well pads for re-injection, subject to further technical assessment
All wells will be drilled using a Blow Out Preventer (BOP) system prior to entering hydrocarbons bearing reservoirs to prevent an uncontrolled release of hydrocarbons in the event that well control issues are experienced during drilling
Synthetic Based Muds will be transferred from the Liquid Mud Plant to the well pads via truck in dedicated sealed containers to reduce the risk of spillage during storage, handling and transportation operations
• Mud Products will comply with Uganda's Health, Safety and Environment Regulations. Only Chemicals ranked E or D in the OCNS (Oil Chemical National Scheme classification) will be allowed to be used; • All products for completion and drilling fluids will be free of chlorides; the upper limit will be 2% by weight; • All Products entering in the mixing of drilling, completion and cementing will be free of aromatic Hydrocarbon, the upper limit is fixed at 300 parts per million (ppm); and • No asphalt, no gilsonite, nor equivalent so called "black" products will be permitted in the drilling fluids and cementing formulations.
Spent muds will be temporary stored in containers prior to removal by a vacuum truck, waste cuttings will collected via augers to the Roll-on Roll-off (Ro-Ro) skips (or equivalent) and transferred off the well pad for treatment and disposal
Disposal of drill cuttings will be in accordance with Ugandan Legislation and IFC Environmental Health and Safety (EHS)
Construction activities for the Production and Injection Network will be contained within the permanent RoW which will have a width of 30 m and is designed to accommodate the pipeline trench(s), stockpile areas, laydown, welding, and the movement of construction equipment alongside the trench(s)

Embedded Mitigation Measures for the Protection of Surface Water
Ditch plugs will be installed on all trenches to prevent the pooling of water in the trenches
Prior to starting HDD activities a risk assessment will be undertaken to identify the necessary design of the HDD tunnels including appropriate tunnelling and slurry management practice to control groundwater ingress and minimise slurry loss from the tunnel into surrounding aquifers/surface waters
Any residues and wastes generated from pre-commissioning activities will be managed in accordance with the site Waste Management Plan
For any chemical usage [with respect to pre-commissioning], a thorough Chemical Risk Assessment will be undertaken and lowest toxicity chemicals will be used wherever possible
Pre-commissioning water (used for pipeline cleaning and hydrostatic tests) will be reused wherever practicable on multiple pipelines
[Decommissioning of Masindi] All wastes will be removed and disposed of at dedicated waste treatment facilities in accordance with the Waste Management Plan. A detailed Decommissioning Plan will be developed for the works during the Site Preparation and Enabling Works Phase of the Project
Commissioning tests will be undertaken using feedstock oil, natural gas, methanol and chemicals. All commissioning fluids will be managed either at CPF or transferred off site for disposal
A dedicated Pipeline Integrity Management System will be implemented during the Commissioning and Operations Phase. This will include regular preventative maintenance including operational pigging, intelligent pigging and inspection campaigns to monitor the status of pipelines
The chemicals used for polymer injection will be subject to detailed environmental risk assessment prior to use taking into account all chemical /biological properties and the specific requirements for early oil recovery use
A review of relevant studies, if necessary, will be undertaken during the Commissioning and Operations Phase to confirm that the planned decommissioning activities utilise good industry practices and are the most appropriate to the prevailing circumstances and future land use
In general, the following principles will be adopted where practicable and will be subject to detailed assessment prior to decommissioning: • Above ground infrastructure will be removed to 0.5 m below ground level and backfilled and vegetated; • Access roads may be left in place depending upon the subsequent use of the land; • Shallow foundations for infrastructure may be excavated, demolished and disposed of; • Where piled foundations exist, these may be excavated to a depth of 1 m below the existing ground level and removed; • Excavations resulting from the removal of foundations will be backfilled; • It is expected that pipelines will be cleaned, capped and let in situ, to prevent disturbing the reinstated habitats; and • Where the environment assessment identifies it is acceptable, in some locations pipeline sections may be cleaned, reclaimed and re-used.
During the Decommissioning Phase the following assumptions are applicable regarding supporting facilities: • Water will be supplied from dedicated abstraction boreholes; • Localised effluent collection facilities will be provided for chemical storage, hazardous materials storage, liquid waste storage, tanks, and fuelling facilities. Such containment will include impermeable areas, kerbing, bunding and drip trays as appropriate; • Drainage systems will remain until sites are free of contamination. SuDS will also manage flood risk during this phase of work; • No discharge of water used for decommissioning activities will be discharged to the environment; • Sewage will be treated by existing wastewater treatment plants (WWTPs) and discharged in accordance with wastewater treatment standards as presented in Chapter 10: Surface Water or collected and transferred to suitably licensed treatment facilities for processing and disposal; and • Waste will be segregated and managed in accordance with a Waste Management Plan.

Embedded Mitigation Measures for the Protection of Surface Water
Depending on the final land use agreed with the Ugandan authorities, all or part of the site may need to be rehabilitated. In such circumstances, the Project Proponents will also develop a monitoring programme for completion criteria to verify that the sites are being returned to the agreed representative state.
A Waste Management Plan will be developed and maintained to cover the duration of the Project; and will address the anticipated waste streams, likely quantities and any special handling requirements. The Project Proponent's will implement a waste tracking system to ensure traceability of all wastes removed off site.
Prior to transfer offsite to a licensed waste treatment facility, waste materials will be segregated and stored in appropriate containers to prevent: • Accidental spillage or leakage; • Contamination of soils and groundwater; • Corrosion or wear of containers; • Loss of integrity from accidental collisions or weathering; • Theft; and • Odour and scavenging by animals.
The existing camps have operating WWTPs. Sewage produced from the camps will be treated at the WWTPs in compliance with regulatory requirements (refer to Chapter 10: Surface Water). Sewage from other Project Areas (e.g. road work sites) will be collected and transferred to WWTPs and/or suitably licensed treatment facilities for processing and disposal. All sewage sludge will be removed periodically from WWTPs and transferred off site for disposal
A flow meter will be integrated at the discharge point of the WWTPs to record to all discharges and a sample point will be established to collect spot samples for analysis
For the Masindi Vehicle Check Point, waste will be collected and transferred to an approved waste treatment facility for recycling, treatment, recovery and/or disposal
Sewage produced from the camps and other Project Areas will be treated at the WWTPs located at the camps in compliance with regulatory requirements (refer to Chapter 10: Surface Water). Wastewater from the well pads will be collected and transferred by tanker to the nearest WWTPs
For the Masindi Vehicle Check Point, sewage will either be treated by a wastewater treatment plant on site and discharged in accordance with the wastewater treatment standards presented in Chapter 10: Surface Water or transferred to the Masindi sewage treatment plant for processing (depending on capacity and approval)
During the Commissioning and Operations Phase waste will be stored and processed at the Integrated Waste Management Area located south of Victoria Nile. There will be no waste management facility located north of the Victoria Nile within the MFNP
For the well pads, Victoria Nile Ferry Crossing Facility and the Lake Water Abstraction System, sewage will be collected and transferred to suitably licensed treatment facilities for processing and disposal

10.11.6 Surface Water Abstraction

10.11.6.1 Lake Albert Water Resources Sustainability

This section provides an assessment of the sustainability and potential impacts likely to arise from the proposed water abstraction from Lake Albert. The maximum annual abstraction from Lake Albert over the lifespan of the Project is approximately 12,762,000 m^3 in Year 7. Lake Albert is a designated main surface water body within the Project Area with a high sensitivity due to its importance to the regional environmental setting; water resources supply potential and ecological importance.

In their response to the Scoping Report for the Project, the National Environmental Management Authority (NEMA) requested that:-

“A comprehensive assessment should be undertaken for the project water needs, the estimated amounts of water to be abstracted from the various sources and the capacity of the available resources to meet these needs without compromising the ecosystem and local and regional demands. This should include a detailed hydrological study for the L. Albert and associated systems to inform the design of the project. Options for recycling of water should be assessed and provided in the EIS.”

The potential impacts and effects on the Lake Albert water resources usage and sustainability are based on available data, demand assumptions and usage under different scenarios while taking into consideration the NEMA’s response above, relevant IFC water conservation program requirement as well as the IFC wastewater and ambient water quality guidelines. It is important that the abstraction of water from Lake Albert does not influence the quantity, quality and morphological characteristics of the waterbody. According to the IFC water conservation requirement, potential adverse impacts on water resources in use by communities should be avoided or minimised.

From a Water and Sanitation compliance perspective, the IFC standard requires that potential adverse effects of surface water abstraction are evaluated. This should be done by modelling changes and consequential impacts on surface water flows. Extraction rates and locations should be modified to prevent unacceptable adverse current and future impacts, taking account of realistic future increases in demand.

The IFC water conservation program also should be implemented commensurate with the magnitude and cost of water use. These programs should promote the continuous reduction in water consumption and achieve savings in the water pumping, treatment and disposal costs. Water conservation measures may include water monitoring/management techniques; process and cooling/heating water recycling, reuse, and other techniques; and sanitary water conservation techniques.

10.11.6.2 Water Availability Impact Assessment – Lake Albert Abstraction

As shown Figure 10-27 and Table 10-27, limited quantities of surface water may be used during the early phases of the Project for construction activities should it be demonstrated that inadequate groundwater resources are available during the first five years. It is estimated that approximately 3,538,860m^3 in total may be required for construction purposes; which is approximately 25% of the total surface water demand for year 6. Surface water abstraction is expected to be sourced from Lake Albert via a temporary abstraction facility to be installed at the same proposed location for the permanent Lake Albert Water Abstraction System. Also, under consideration, is the option to temporarily abstract water from the Victoria Nile River and/or Albert Nile prior to the commissioning of the permanent Lake Albert Water Abstraction facility during the early phases of the Project. Lake Albert, the Victoria Nile and the Albert Nile River are receptors of high sensitivity.

The permanent Lake Albert Water Abstraction System will be installed in Lake Albert to house pumps and initial water treatment (i.e. a pre-treatment chlorination and filtration facility). Two options are under consideration for the proposed Lake Albert Water Abstraction intake system which will comprise either:

- An offshore floating pump platform (i.e. ‘pontoon’) with submersible pumps, connected to a 1.5 km water abstraction pipeline extending from the offshore floating platform to the onshore pre - treatment and water abstraction control facility; or
- A mid-water intake structure fixed at the bottom of the lake and connected to a 1.5 km water abstraction pipeline to an onshore pumping and pre-treatment facility.

In any case, the Lake Albert abstraction facility will include components located both offshore as described above and onshore. The onshore facility will include the pre-treatment and water abstraction control facility which will be located on the Lake Albert shoreline. Water will be transported from the pre-treatment facility to the CPF via a 10 km long 24” diameter buried pipeline connecting the onshore lakeside facility to the CPF.

Water abstraction from the Lake Albert Water Abstraction permanent facility is anticipated to commence in Year 4 after commissioning. Figure 10-27 shows that surface water abstraction for the Project will reach its peak demand estimated at approximately 0.013 billion m^3/annum during the seventh year of the Project life before it starts declining particularly during the operational phase of the Project.

The water balance of Lake Albert is dominated by inflows of the Victoria Nile River and Semliki Rivers. Inflow from the Victoria Nile River accounts for about 73% while that of Semliki River accounts for about 10%. Direct rainfall of about 10% and inflow from the regional catchment accounts for the remaining 7%. The total water balance outflow from the Albert Nile River which receives a significant proportion of its flow from Lake Albert is estimated at between 45 million m^3/d and 107 million m^3/d (Ref. 10–44) with an annual estimated average of 37 billion m^3/year (Ref. 10–37). This flow indicates the total available renewable surface water resources potential of Lake Albert. The proposed peak water abstraction volume (0.013 billion m^3/annum) from Lake Albert for the Project equates to only 0.034% of the annual outflow from Lake Albert. From a water quantity and sustainability point of view and taking into account the high sensitivity rating of the Lake, the magnitude of the potential impact as a result of the proposed maximum abstraction from the lake is considered negligible. Accordingly, the impact significance is therefore assessed to be **Insignificant**. This comparison is illustrated in Figure 10-30.

Several studies have been completed by Project Proponents to assess the option of abstracting water from Lake Albert to meet the planned water supply demand for the Project. The studies consider the impact of the proposed abstraction on the overall surface water resources and sustainability. A summary of the reviews of these studies is contained in the Lake Albert Basin Upstream Development Water Source Evaluation for Development and Production Water Concept Selection Study 2016 (Ref. 10–44). Findings of the studies also concluded that the potential impacts of the required abstraction on the lake water levels and the volume of outflow are negligible/ insignificant.

Similarly, on a regional scale, it is considered that the anticipated rates of abstraction/water supply demand forecasted for the Project will not present any significant impact or risk to the sustainability of the regional water resources supply. Accordingly, it is concluded that the magnitude of the impact as a result of surface water abstraction from Lake Albert for the Project will effectively be negligible, the sensitivity is high and hence the significance of the impact will be **Insignificant**.

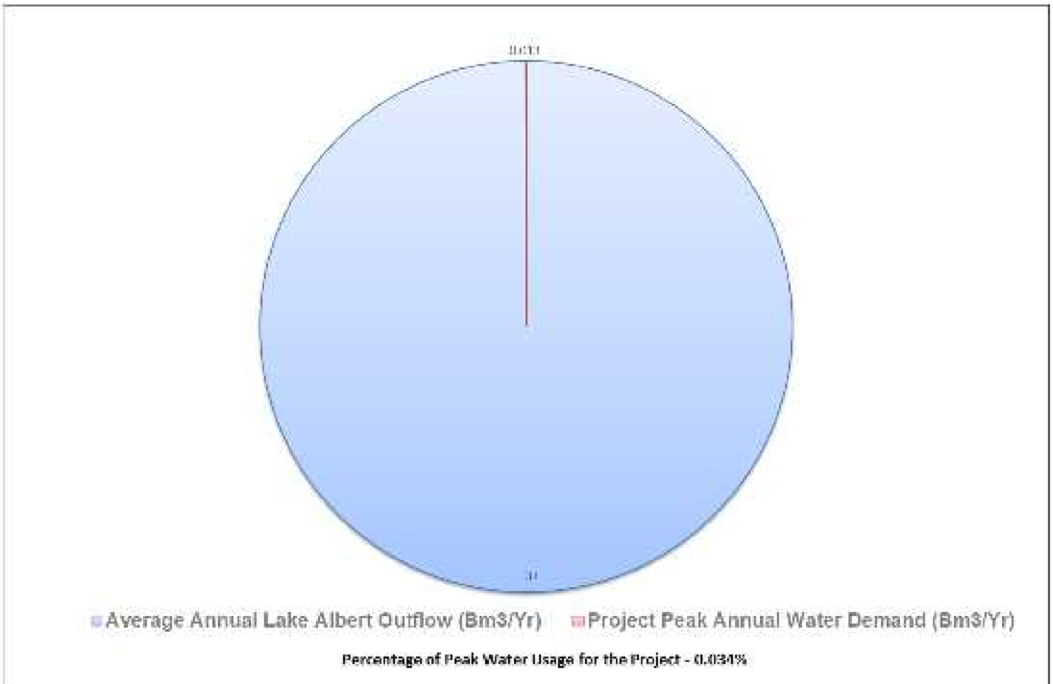


Figure 10-30: Comparison of Lake Albert Outflow with the Project Water Demand Forecast

10.11.6.3 Water Quality Impact Assessment – Lake Albert

Baseline data for Lake Albert shows that the water quality from the lake is generally good compared with Ugandan potable water standards and is suitable for water supply purposes with minimal treatment.

A number of less-frequent water quality impact incidents (MWE, 2016) (Ref 10–36) have been reported for Lake Albert and other surface water bodies within the Study Area. However, there is no quantitative data to estimate the magnitude of the overall impacts and possible deterioration in water quality as a result of these incidents.

It is considered that potential water quality impacts on Lake Albert will arise principally during the activities associated with the Construction and Pre-Commissioning phase of the Project. A summary of the potential impacts are outlined below:

- Localised contamination arising from accidental discharge/leakage of fuel, oil and other lubricating fluids from vehicles and equipment;
- Localised increase in water turbidity near the construction areas;
- Localised contamination from cement concrete works during the installation of the offshore and onshore water abstraction pipeline and ancillaries; and
- Localised contamination arising from the potential risk of foul water from the workforce unintentionally being discharged into the lake.

These potential impacts are more likely to be temporary over the period of the construction and installation of the abstraction facilities in close proximity to the bank of Lake Albert and within the lake itself. Lake Albert is a designated main surface water body with high sensitivity. However, given the substantial dilution capacity of the lake and the quantity of contaminants that could be accidentally or unintentionally discharged into the lake from the construction activities, the magnitude of the potential impact is considered negligible. Hence the significance of the potential impacts will be **Insignificant**.

10.11.6.4 Flood Risk and Morphology – Lake Albert

Embedded mitigation should ensure that the activities being undertaken at the Water Abstraction System onshore facility do not produce a flood risk. In accordance with the IFC requirements, construction of facilities in a floodplain should be avoided, whenever practical, and within a distance of 100 m of the normal high-water mark of a water body (Ref. 10-11). However, it is recognised that certain activities will take place within this limit such as installation of the water abstraction pipeline.

For the purpose of this assessment, it is assumed that the Water Abstraction System facility will be positioned 200 m from the edge of Lake Albert at a location which it is considered outside of the normal flood zone. Any changes in fluvial flood flows, fluvial processes or channel morphology through the removal of morphological features in the lake are unlikely to be significant. However, there is still potential for surface water flows to be obstructed locally. The size of the facility in comparison to Lake Albert means that flood risk impacts are likely only to be felt locally, and therefore the impact significance is **Insignificant**.

Further information is provided in each of the impact assessment sections for each phase below as required.

10.11.7 Assessment of Impacts: Site Preparation and Enabling Works

10.11.7.1 Introduction

Surface water quantity and quality and flood risk and potential morphological impacts are principal indicators that have been used to assess the potential impacts and effects on the surface water environment from the different phases of the Project. Table 10-23 provides a list of the main activities that will be carried out during the Site Preparation and Enabling Works phase of the Project development.

For this phase of the Project, taking into account the similarity of the activities, such as site clearance and earthworks activities requiring dozers and other earth moving equipment, the potential impacts from the activities at the location of each of the Project component sites are likely to be similar. However, the magnitude of the potential impacts and impact significance may vary depending on the receptor designation, proximity to the Project activity, and sensitivity of the surface water feature/receptor. The sensitivity of the surface water receptors is listed in Table 10-24.

The potential direct or indirect impacts on surface water that could arise as a result of these activities during this phase of the Project are as follows:

- Direct contamination of main and/or ordinary surface watercourses/water bodies and indirect contamination from groundwater discharges arising from accidental chemical (oil, fuel and drilling chemical) discharges during transport, offloading, use and storage at the Project worksite areas;
- Interruptions or changes to natural watercourse flow regimes, drainage patterns and levels of surface water and increased flood risk, specifically at Project worksites (such as the Lake Albert Abstraction System site and Victoria Nile Ferry Crossing sites and some well pads) close to main or ordinary watercourses;
- Mobilisation and discharge of sediments/debris from earthworks and excavations within or near floodplains of main and/or ordinary water bodies that can lead to siltation and changes in their morphological features (e.g. river beds) which could consequently impact on aquatic ecology including fish, invertebrates and macrophytes;
- Erosion as a result of changes in surface water run-off rates due to vegetation removal and soil compaction which could potentially cause impacts such as erosion loss of riparian land, increased sediment delivery and potential release of contaminants into the nearby surface water bodies;
- Localised impacts on surface water quality due to direct or indirect accidental discharges of poorly treated wastewater and other waste materials into surface water bodies close to Project worksites;
- Impacts on watercourse structure (river banks and beds) and hydraulic flow; and
- Flood risk at or within the vicinity of, or downstream of Project component as a result of increased surface runoff and changes to flood flow routes arising from the Project.

It is envisaged that groundwater will be used to meet most of the Project water requirements during the Site Preparation and Enabling Works activities. Potential impacts on groundwater are discussed in ***Chapter 9: Hydrogeology***. However, potential indirect impacts on groundwater dependent wetlands are considered where necessary within this Chapter. The Ramsar designated wetlands in the MFNP is the only permanent wetland within the Study Area (Figure 10-9).

Table 10-29, Table 10-30, Table 10-31 and Table 10-32 present the Project components and their approximate distances to the main and ordinary surface water bodies including wetlands within the Project Area and access roads respectively. Based on the surface water assessment methodology and the receptor identification criteria, a number of ordinary and main surface water receptors have been identified within the 1 km potential impact area of at least one or more Project components. The sensitivity of these surface water receptors ranges from moderate to high depending on their characteristics (i.e. whether pond, stream, river, watering hole, open water sources or wetlands).

The likelihood of potential adverse impacts to water resources reduces as the distance from site activities increases. Taking into account the nature of the activities, potential impacts to surface water features at a distance of less than 1 km have been assessed in the following sections.

Table 10-29: Approximate distances of main surface water bodies to the Project components

Project Component	Approximate Distance to Lake Albert, Albert Nile and Victoria Nile River (m)	Closest Designated Main Surface Water Bodies / Receptor	Sensitivity of this Receptor
GNA-01	2,450	Victoria Nile River	High
GNA-02	2,640	Victoria Nile River	High

Project Component	Approximate Distance to Lake Albert, Albert Nile and Victoria Nile River (m)	Closest Designated Main Surface Water Bodies / Receptor	Sensitivity of this Receptor
GNA-03	4,820	Victoria Nile River	High
GNA-04	4,000	Victoria Nile River	High
JBR-01	2,140	Victoria Nile River	High
JBR-02	2,380	Victoria Nile River	High
JBR-03	4,700	Victoria Nile River	High
JBR-04	4,530	Victoria Nile River	High
JBR-05	4,000	Albert Nile River	High
JBR-06	4,400	Albert Nile River	High
JBR-07	3,150	Albert Nile River	High
JBR-08	3,050	Albert Nile River	High
JBR-09	2,350	Albert Nile River	High
JBR-10	1,120	Victoria Nile River	High
KGG-01	10,940	Victoria Nile River	High
KGG-03	12,500	Victoria Nile River	High
KGG-04	10,170	Lake Albert	High
KGG-05	9,830	Victoria Nile River	High
KGG-06	8,560	Lake Albert	High
KGG-09	11,580	Lake Albert	High
KW-01	840	Lake Albert	High
KW-02A	2,770	Lake Albert	High
KW-02B	1,620	Lake Albert	High
NGR-01	923	Victoria Nile River	High
NGR-02	2,380	Victoria Nile River	High
NGR-03A	2,550	Victoria Nile River	High
NGR-05A	3,670	Victoria Nile River	High
NGR-06	4,160	Lake Albert	High
NSO-01	6,940	Victoria Nile River	High
NSO-02	8,930	Victoria Nile River	High
NSO-03	7,370	Lake Albert	High
NSO-04	8,530	Lake Albert	High
NSO-05	9,150	Victoria Nile River	High
NSO-06	6,920	Victoria Nile River	High
Victoria Nile HDD Crossing – Option 1 (N)	160	Victoria Nile River	High
Victoria Nile HDD Crossing – Option 1 (S)	200	Victoria Nile River	High
Victoria Nile HDD Crossing – Option 2 (N)	200	Victoria Nile River	High
Victoria Nile HDD Crossing – Option 2 (S)	350	Victoria Nile River	High
Water Abstraction System	Approximately 200m	Lake Albert	High
CPF (Industrial Area)	3,120	Victoria Nile River	High
Ferry Crossing (N)	50	Victoria Nile River	High
Ferry Crossing (S)	86	Victoria Nile River	High
Bugungu Airstrip	6,460	Victoria Nile River	High

Project Component	Approximate Distance to Lake Albert, Albert Nile and Victoria Nile River (m)	Closest Designated Main Surface Water Bodies / Receptor	Sensitivity of this Receptor

Distances <1km are highlighted in red

In Table 10-29 it is noted that only two well pads are near the main surface water bodies. The main receptors are the Victoria Nile River from the Victoria Nile HDD Crossing and Ferry crossing and Lake Albert from the Water Abstraction System. However, a number of ordinary surface water bodies and wetlands falls within the 1 km potential impact areas as shown in Table 10-30.

Table 10-30: Approximate distances of Ordinary surface water bodies and wetlands to the proposed Project components

Project Component	Approximate Distance to Designated Ordinary Water Courses (Receptor) (m)	Names of Receptor	Distance to wetland (m)
GNA-01	767	Not identified	2,155*
GNA-02	315	Not identified	1,676
GNA-03	108	Not identified	2,648
GNA-04	520	Not identified	1,508
JBR-01	470	Not identified	1,088
JBR-02	540	Not identified	617
JBR-03	245	Not identified	1,500
JBR-04	153	Not identified	148
JBR-05	605	Not identified	1,106
JBR-06	574	Not identified	277
JBR-07	213	Not identified	1,134
JBR-08	152	Not identified	1,818
JBR-09	270	Not identified	651
JBR-10	2,116	Not identified	768*
KGG-01	900	Not identified	897
KGG-03	330	Ngazi River	1,495
KGG-04	750	Not identified	676
KGG-05	185	Sambiye River	145
KGG-06	540	Not identified	587
KGG-09	190	Ngazi River	563
KW-01	560	Sambiye River	Within wetland
KW-02A	300	Sambiye River	221
KW-02B	936	Sambiye River	891
NGR-01	210	Not identified	640*
NGR-02	2,390	Not identified	1,567*
NGR-03A	2,349	Not identified	215
NGR-05A	1,660	Not identified	1,651
NGR-06	800	Not identified	816
NSO-01	1,380	Not identified	1,371
NSO-02	200	Sambiye River	687
NSO-03	590	Not identified	500
NSO-04	160	Sambiye River	100
NSO-05	320	Not identified	340
NSO-06	540	Not identified	2,284

Project Component	Approximate Distance to Designated Ordinary Water Courses (Receptor) (m)	Names of Receptor	Distance to wetland (m)
Victoria Nile Pipeline HDD Crossing North - Option 1	160	Closest to Victoria Nile	256*
Victoria Nile Pipeline HDD Crossing South - Option 1	198	Closest to Victoria Nile	Within wetland*
Victoria Nile Pipeline HDD Crossing North - Option 2	230	Closest to Victoria Nile	199*
Victoria Nile Pipeline HDD Crossing South - Option 2	376	Closest to Victoria Nile	61*
Water Abstraction System	75	Closest to Lake Albert	256
CPF (Industrial Area)	0	Stream within boundary	Within wetland
Ferry Crossing (N)	50	Closest to Victoria Nile	199*
Ferry Crossing (S)	86	Closest to Victoria Nile	61*
Bugungu Airstrip	200	Not identified	418
Masindi Vehicle Check Point	538 665	Biraizi River Waiga River	815
Buliisa Camp	1,267	Sambiye	1,270
Bugungu Camp	185	Not identified	1,446
Tangi Camp	0 (adjacent)	Not identified	Within wetland

Distances <1km are highlighted in red; * indicates the Ramsar wetland

Table 10-31: Approximate distances of Ordinary surface water bodies and wetlands to the proposed Project component (Roads)

Project Component Road Number	Closest watercourse	Number of crossings	Distance to closest watercourse (m)	Distance to wetland (m)
A1	Stream	0	40	120
A2	River	2	0	Intersects
A3	Stream	1	0	340
A4	Stream / River Sambiye	2	0	Intersects
B1	River	1	0	Intersects
B2	River Sambiye	1	0	Intersects
C1	Stream / River Tangi	6	0	Intersects
C2	Stream / River	8	0	Intersects
C3	Stream	0	30	350*
D1	Stream	0	300	580*
D2	Stream	0	2,300	1,700*
D3	Stream	0	2,500	190
D5	Stream	0	1,750	1,745
D6	Stream	0	825	825
D8	Stream	0	670	1,700*
D9	Stream	0	470	1,770
D10	Stream	0	100	2,800
D11	Stream	0	173	1,500
D11 Alt	Stream	0	290	1,410
D12	River	0	650	5
D13	River	0	370	210
D14	Stream	0	530	1,500
D15	Stream	0	330	810
D16	River	1	0	Intersects
D17	River Sambiye	0	270	225
D18	Stream	0	130	125
D19	Stream	0	560	2,170
D19 Alt	Stream	0	245	1,970
D20	River Sambiye	0	845	825
D22	Stream	1	0	1,620
D23	Stream	0	820	730
D24	Stream / River Sambiye	2	0	Intersects
D25	Stream	1	0	Intersects
D26	Stream	2	0	350
D27	River	0	1,390	1,000
N1	Stream	0	1,500	2,200
N2	Stream	0	400	380
N3	Stream	0	30	240
W1	Lake Albert/Stream	0	70	Intersects

Distances <1km are highlighted in red; * indicates the Ramsar wetland

Table 10-32: Approximate distances of Ordinary surface water bodies and wetlands to the proposed Project components (Production and Injection Network)

Project Component (Pipeline Route)	Closest watercourse	Number of crossings	Distance to closest watercourse (m)	Distance to wetland (m)
GNA-01 to CPF	Stream	1	0	1,267*
GNA-02 to GNA-04	Stream	1	0	1,697
GNA-04 to GNA-01	Stream	1	0	1,681
GNA-04 to GNA-03	Stream	1	0	1,608
JBR-01 to HDD Crossing (Option 1)	Stream	0	30	236*
JBR-02 to JBR-01	Stream	0	30	757
JBR-03 to JBR-01	Stream	1	0	956
JBR-04 to JBR-03	Stream	0	220	232
JBR-05 to JBR-03	Stream	1	0	863
JBR-06 to JBR-05	Stream	1	0	488
JBR-07 to JBR-06	Stream	0	750	125
JBR-08 to JBR-07	Stream	0	150	1,148
JBR-09 to JBR-08	Stream	0	240	808
JBR-10 to JBR-01	Stream	1	0	850*
JBR-10 to HDD Crossing (Option 2)	Victoria Nile	0	160	190*
KGG-01 to KGG-04	Stream	1	0	826
KGG-03 to KGG-01	Stream	1	0	933
KGG-04 to NSO-04	Sambiye River	1	0	Intersects
KGG-05 to NSO-02	Stream / Sambiye River	2	0	Intersects
KGG-06 to KGG-04	Stream	1	0	Intersects
KGG-09 to KGG-04	Stream	2	0	302
KW-01 to KW-02A	Stream	1	0	Intersects
KW-02A to KW-02B	Stream	0	420	313
KW-02B to NGR-06	Stream	1	0	397
NGR-02 to NGR-01	Stream	2	0	733*
NGR-03A to NGR-05A	Stream	0	1,600	397
NGR-05A to CPF	Stream	0	1,100	1,182
NGR-06 to NGR-05A	Stream	0	650	675
HDD Crossing (Option 1) to CPF	Stream	4	0	Intersects*
HDD Crossing (Option 1) to CPF - alt	Stream	5	0	Intersects*
HDD Crossing (Option 1) to HDD Crossing (Option 1)	Victoria Nile	1	0	Intersects*
HDD Crossing (Option 2) to CPF via NGR-01	Stream	0	200	60*
HDD Crossing (Option 2) to HDD Crossing (Option 2)	Victoria Nile	1	0	Intersects
NSO-01 to NSO-05	Stream	0	110	142
NSO-02 to NSO-06	Stream	1	0	833
NSO-03 to CPF	Stream	1	0	Intersects
NSO-04 to NSO-03	Stream	2	0	Intersects

Project Component (Pipeline Route)	Closest watercourse	Number of crossings	Distance to closest watercourse (m)	Distance to wetland (m)
NSO-05 to NSO-03	Stream	0	110	Intersects
NSO-06 to NSO-01	Stream	0	280	1,535
Water station to KW-02B	Lake Albert	0	70	Intersects

Distances <1km are highlighted in red; * indicates the Ramsar wetland

10.11.7.2 Potential Impacts - Site Preparation and Enabling Works

10.11.7.2.1 Introduction

During this phase of the Project, construction works pose a risk of impacting on the surface water environment. It is anticipated that water will be sourced from groundwater aquifers; however, until the Lake Albert Water Abstraction System is functioning, surface water may be abstracted at the same location using temporary pumps and tankers. Abstraction of water from the Victoria Nile to facilitate construction of the Victoria Nile Ferry Crossing is proposed for this phase, subject to confirmation that groundwater is adequate to meet the Project water demands. Accordingly, there will be limited abstraction of surface water for this phase of the Project and hence **negligible** impacts on surface water quantity and availability are anticipated. Other than for the Nile Ferry Crossing, impacts on surface water quantity are not addressed further for this phase of the Project. Impacts on water quantity for Lake Albert are discussed in Section 10.11.4.

The principal activities that can directly and/or indirectly impact on surface water receptors and can impact on Flood Risk and Morphological changes during this phase are outlined below for each key Project component.

10.11.7.2.2 Impact Assessment - Industrial Area/CPF

The Industrial Area is a key component of the Project located to the south of the Victoria Nile River, outside of the MFNP. The Industrial Area is expected to cover a total area of approximately 307 ha which will be cleared and prepared for construction of the proposed facilities in this phase of the Project. Site activities include clearing (including demolition), tree/bush felling and uprooting, stripping of topsoil and subsoil; excavation of drainage channels; site pre-levelling; compaction; and final levelling. A detailed description of this facility is provided in ***Chapter 4: Project Description and Alternatives***.

Water Quality- Industrial Area/CPF

The main surface water bodies within the Project Area are Lake Albert, Albert Nile River and the Victoria Nile River and their sensitivity rating is high. However, as shown in Table 10-29, the Victoria Nile River is located more than 3 km downstream from the Industrial Area and is the closest of the main surface water bodies within the Project Area. As the river is significantly outside the 1 km potential impact area and based on the nature of the activities at the Industrial Area during this phase of the Project, it is considered that the potential impacts on surface water quality from direct or indirect water contamination from accidental fuels and chemical spills and uncontrolled discharges are unlikely to affect any of the main surface water bodies.

Table 10-30 shows that the Industrial Area is located within a wetland and there is one ordinary surface water body (i.e. a perennial stream) in the potential impact area (i.e. within the boundary) of the Industrial Area. The sensitivity of the wetland and the stream is moderate. There is a potential risk of direct contamination of the stream and the wetland due to contaminated/untreated and turbid surface water runoff from the Industrial Area to enter the stream and the wetland. Based on professional judgement from a water quality perspective, and given that embedded mitigation measures will include appropriate storage of fuels / chemicals and use of SuDS, the magnitude of any potential impacts on the ordinary surface water bodies (i.e. the stream and the wetland) is considered likely to be low. Accordingly, the significance of the potential impacts on the water quality of the stream is considered to be **Low Adverse.**

Flood Risk and Morphology – Industrial Area/CPF

There is potential for this phase of works to impact flood risk as a result of changes to the land surface. Vegetation clearance, levelling and earth compaction, and removal of topsoil and sub soils will decrease the permeability of the ground surface encouraging greater surface water runoff. This could result in the creation of new overland flood flow routes, soil erosion and increasing flood risk downstream.

Morphological changes resulting from increased surface run-off also has the potential to increase soil erosion, damaging the landscape and causing sediment slumps / blockages in downstream channels, changes in stream bed morphology, including the existing stream on the site. The perennial stream within the Industrial Area boundary is the only surface water receptor likely to be impacted. As the stream falls within the 1 km potential impact area, given the nature of the activities at the Industrial Area during this phase of the Project, it is considered that the magnitude of potential impacts on surface water quality from direct or indirect flow interruptions and from debris/sediment loading are moderate.

As there is a perennial stream of moderate sensitivity within close proximity of the Industrial Area which is at risk of moderate impacts from increased runoff, erosion and sedimentation – the significance of the potential impact is **Moderate Adverse**.

10.11.7.2.3Impact Assessment – Well Pads

A total of 34 well pads spread across the entire Project Area have been proposed for the Project. A detailed description of the well pads is provided in ***Chapter 4: Project Description and Alternatives.*** The main activities (Table 10-23) and the nature of associated potential impacts likely to arise at the well pad locations during this phase of the Project development are similar to those for the Industrial Area as described above. Water supply boreholes will be drilled at the well pads during this phase of the Project but there are no proposals for production well drilling in this phase of the Project. Due to the varying locations of the well pads across the Project Area, the magnitude and significance of the potential impact on surface water will vary. This variation will depend on many factors in particular the presence and proximity of surface water receptors to each individual well pad.

Water Quality Impact Assessment – Well Pads

The activities and nature of associated potential impacts on water quality during this stage of the Project are likely to be similar at each well pad location. The significance of potential impacts on surface water quality will vary as this is subject to a number of factors including the quality, seasonality, flow direction and proximity of each well pad to the main and ordinary surface water receptors. Potential water quality impacts from the construction of the well pads include contamination of surface waters arising from accidental direct discharge of hydrocarbons (i.e. oil, fuel and lubricants), waste and silt contaminated run-off from the well pad worksite area into nearby surface water receptors. This is more likely to be the case for well pads that are in proximity to sensitive surface water receptors.

As shown in Table 10-29 and Table 10-30, well pads NSO-04, KGG-05, NSO-02, and KW-02A are close (i.e. at 160 m, 185 m, 200 m and 300 m respectively) to the Sambiye River. It is noted also that with the exception of well pads JBR-10, NGR-02, NGR-03A, NGR-05A and NSO-01 which are all more than 2 km from any surface water receptors, the remaining well pads are less than 1 km from at least one or more surface water receptor. Table 10-30 also shows that well pad KW-01 is located in a wetland. Only a few of these ordinary watercourses are named. Based on the receptor identification criteria, the sensitivity of the ordinary surface water receptors is moderate. Therefore, taking into account the embedded mitigation measures and the nature of the potential water quality impacts associated with the activities for this phase of the Project, the magnitude of any potential impacts from the well pads on the ordinary surface water receptors is considered to be low. Accordingly, the potential significance of impacts to surface water quality from the construction works at the well pads is assessed to be **Low Adverse.**

For the main surface water bodies, with the exception of well pads KW-01 and NGR-01 which are located approximately 840 m and 920 m from Lake Albert and the Victoria Nile River, respectively, the remaining well pads fall outside the 1 km potential impact area. The potential impacts on water quality from the construction of the two well pads KW-01 and NGR-01 are similar to those already discussed above for the ordinary watercourses. Both Lake Albert and the Victoria Nile River are designated main surface water bodies with high sensitivity. From a water quality perspective, taking into account a number of factors including the embedded mitigation measures, the dilution available in the lake and the river, the quantity of any contaminant likely to be accidentally discharged from the well pads worksite area during this phase of the Project, the magnitude of the potential impacts will be negligible. Accordingly, the significance of potential impacts to water quality is assessed to be **Insignificant.**

Flood Risk and Morphology – Well Pads

The impacts of well pad preparation activities on flood risk and morphology are similar to those for the Industrial Area.

An increase in impermeable area, caused by land compaction and vegetation clearance and the construction of concrete areas can increase surface run-off and in turn increase flood risk and soil erosion. The impacts of this will depend on the location of the well pads and the proximity to a watercourse. The distance of well pads to watercourses can be seen in Table 10-29 and Table 10-30. The distance between a well pad and its nearest watercourse can affect the magnitude of the impact (i.e. well pads >200 m from the nearest watercourse are considered to have a low impact magnitude and well pads <200 m from the nearest watercourse are considered to have a moderate impact magnitude). The location of facilities, drainage channels and fencing as part of well pad construction may cause water to be impounded or redirect flows to other areas, which may be more vulnerable. The impacts will be local to the well pad and so are considered to have a **Low** to **Moderate Adverse** potential impact significance in respect of flood risk, depending on the proximity of the well pad to the nearest watercourse.

Taking into account the embedded mitigation measures, the magnitude of any morphological impacts on nearby surface water receptor to the well pads during this phase of the Project is considered to be negligible to low, depending on the proximity of the well pad to the nearest watercourse. Accordingly, the significance of any potential impact is assessed as **Low** to **Moderate Adverse**.

10.11.7.2.4Impact Assessment – Water Abstraction System

A description of the Lake Albert Water Abstraction System is provided in ***Chapter 4: Project Description and Alternatives.*** There are two potential options for the Water Abstraction System currently under consideration: a floating platform, or onshore facility. Site clearance, land preparation and civil works will take place during this phase of the Project; hence the nature of the impacts will be similar to those as described for the Industrial Area and well pads worksites.

Water Quality Impact Assessment- Water Abstraction System

From a water quality perspective, there is a potential risk of water quality impacts arising from sediment-laden storm water and accidental hydrocarbon (i.e. oil, fuel and lubricant) contaminated runoff being discharged from the Water Abstraction System worksite area into Lake Albert. The lake is a main surface water receptor with a high sensitivity rating. However, any water quality impacts will only be localised given the dilution available in the lake and the anticipated low volume of any contamination. Also, any impacts resulting in localised contamination or an increase in turbidly from uncontrolled runoff would be temporary and would not diminish the availability of the water to users. Taking into account other factors as given in Section 10.11.6, including the lake's assimilative capacity, and with the embedded mitigation measures in place, the magnitude of any potential impacts will be negligible. Accordingly, the significance of potential impacts to the surface water quality of the lake is assessed to be **Insignificant**.

Flood Risk and Morphology – Water Abstraction System

For the purpose of this assessment, it is assumed that the Water Abstraction System onshore facility will be positioned 200 m from the Lake Albert shoreline at a minimum elevation of 624.3 m above sea level, above the 1 in 100-year flood level. This removes the abstraction facility from the floodplain, and so floodplain flows are unlikely to be impacted. There is potential however for overland flows which naturally run to Lake Albert, to be obstructed by the positioning of the facility. While the impacts of the development are likely to have an insignificant impact on Lake Albert due to its small size in comparison to the surrounding landscape, it is a possibility that flood risk could be increased locally.

Whilst Lake Albert is categorised as high sensitivity, the minimum 200 m distance of the onshore abstraction facility from the lake shore, appropriate elevation of the proposed abstraction facility, and embedded mitigation measures mean that the flood risk and morphological impact magnitude associated with this component is assessed to be negligible. The potential impact significance is therefore considered to be **Insignificant**.

10.11.7.2.5Impact Assessment – Masindi Vehicle Check Point and Bugungu Airstrip

A description of the Masindi Vehicle Check Point at the Masindi Airstrip and the Bugungu Airstrip upgrade works are provided in ***Chapter 4: Project Description and Alternatives***. The Bugungu Airstrip is located on the southern side of the Victoria Nile River within the MFNP and will be extended. Site clearance, land preparation and upgrading works will take place at the Masindi Vehicle Check Point during this phase of the Project. The nature of the potential impacts likely to arise as a result of the activities at these locations is similar to those described for the Industrial Area and well pads.

Water Quality Impact Assessment– Masindi Vehicle Check Point

As shown in Table 10-30, the Biraizi River and the Waiga River are the only surface water receptors within 1 km of the Masindi Vehicle Check Point; at a distance of approximately 540 m and 670 m, respectively. The sensitivity of both rivers is moderate. The potential impacts are similar to those described for the development of the well pads and the Industrial Area. Impacts from accidental spillages and leakage of fuel, oils and chemicals stored and machinery on the site may pose a potential risk to the water quality of the River Biraizi and River Waiga, particularly during episodes of heavy rainfall. In addition, discharge of contaminated storm water runoff from the site into the Biraizi and or the Waiga poses a risk to the river water quality. From a water quality perspective, taking into account the embedded mitigation measures and given the approximate distances of both rivers from the Masindi Vehicle Check Point, it is unlikely that any of these potential impacts from the worksite area will impact these rivers. In the unlikely event that contaminants do reach the rivers, given the nature of activities at the site and potential volume (small incidental leaks and spills of about 10 to 50 litres) of contaminants that could be released from the site in comparison to the volume of water flowing in the rivers, it is considered likely, that any effects will only be localised given the size of the rivers and the river assimilative capacity. Based on the above, using professional judgement, the magnitude of any potential impacts is considered negligible. Accordingly, the significance of any potential impacts on the water quality in the two rivers is assessed to be **Insignificant**.

Flood Risk and Morphology – Masindi Vehicle Check Point

The redevelopment of the existing grass strip for this Project component is likely to increase surface run off as a result of an increased impermeable area provided by new hardstanding. The Biraizi and Waiga Rivers are located within 1 km of the Masindi Vehicle Check Point, and there is potential for increased sediment laden surface water flows to reach these watercourses, particularly if the gradient / positioning of the airstrip encourages a flow route. An increase in the amount of fine sediment and turbidity of these watercourses from sediment laden run-off entering the rivers could cause short-term changes in channel morphology and sediment regime.

Whilst both watercourses are classed as having a moderate sensitivity, the distance from the Masindi Vehicle Check Point means that any increase in surface water flows is likely to have only a negligible impact magnitude, as any runoff either will drain into the underlying ground and/or sediment will be captured by the vegetation in the zone between the check point and the rivers. The potential impact significance is therefore assessed to be **Insignificant**.

Water Quality Impact Assessment– Bugungu Airstrip

There is an unnamed perennial stream within 1 km of the Bugungu Airstrip; at a distance of approximately 200 m. The sensitivity of this stream is classified as moderate and the stream is likely to be utilised by wildlife as a drinking water source. Impacts from accidental spillages and leakage of fuel, oils, and chemicals stored and machinery on the site may pose a potential risk to the quality of the watercourses. Given the distance of the stream to the worksite area, there is a potential risk that hydrocarbon contaminated and sediment-laden runoff from the worksite area could discharge into the stream. From a water quality perspective, taking into account the Project's embedded mitigation measures such as the use of SuDS process for storm water discharge and removal of all foul and potentially contaminated water to dedicated treatment facilities, the likelihood for contaminated runoff to be discharged to the stream is unlikely. However, in worst case scenarios, if a small quantity (about 200 litres to 1000 litres) of potentially contaminated water (i.e. whether hydrocarbon contaminated or silt-laden storm water or poorly treated sewage) in the unlikely event of a contaminated discharge from the site to the watercourse, taking into account the stream's assimilative capacity, the impact will likely be localised within the stream mainly around the point where the runoff enters the stream. Consequently, the magnitude of any potential impacts as a result of contamination is considered to be Low. Accordingly, the significance of any potential impacts is assessed to be **Low Adverse**.

Flood Risk – Bugungu Airstrip

Similar to the Masindi Vehicle Check Point, the development of the Bugungu Airstrip will increase the impermeable area and in turn increase surface run-off flows. However, as the Bugungu airstrip is closer to a watercourse (approximately 200 m from a perennial stream), the significance of impact from flood risk and potential morphological impacts from sediment-laden runoff will be higher and the significance of any potential impact is classified as **Moderate Adverse**.

10.11.7.2.6Impact Assessment – Victoria Nile Ferry Crossing (North and South of Victoria Nile River)

A dedicated ferry will be used to transport vehicles/trucks across the Victoria Nile River during the later phases of the Project. The ferry crossing will be located about 135 m east of the existing Paara ferry crossing. The Ferry Crossing facility comprises two landing sites (jetties) on the northern and southern banks of the Victoria Nile River as indicated in ***Chapter 4: Project Description and Alternatives***. The jetties will extend approximately 70 m into the river.

Construction of the Victoria Nile Ferry Crossing Jetties and associated buildings to support the ferry operation is expected to commence during this phase of the Project. The associated jetty and buildings (located on the northern and southern bank of the Victoria Nile River) will be used to provide logistical support (i.e. storage, workshop, office etc.). It is estimated that the total land coverage of the ferry landing structures and facilities will be 4,720 m^2 on the southern Nile bank and 2,330 m^2 on the northern Nile bank. The landing structures will comprise a double Roll-on/roll-off (Ro-Ro) ramp placed approximately 70 m from the shore line on the southern side and 30 m on the northern side at a required minimum water depth of -3.5 m MWL (mean water level) for the barge to berth. The Ro-Ro ramp and connection embankments will consist of a mix of earthworks, steel and pilling works along with concrete casting for the ramp. The jetties will be constructed on piled foundations, similar to those shown ***Chapter 4: Project Description and Alternatives***.

Water Quantity Impact Assessment – Victoria Nile Ferry Crossing

During the Site Preparation and Enabling Works phase of the Project, water will be abstracted from the Victoria Nile River for use in the construction works for the Victoria Nile Ferry Crossing. The total water demand for the construction works during the phase is estimated at approximately 8,000 m^3, while the total daily flow through the Victoria Nile River is estimated at 600 cubic metres per second (m^3/sec). Putting this in context, the water demand for the Nile Crossing construction work will constitute less than 0.000001% of the river daily outflow. Consequently, from a water quantity point of view the magnitude of impact as a result of water usage for the construction works will be negligible and the significance of the potential impact is therefore assessed to be **Insignificant**.

Water Quality Impact Assessment - Victoria Nile Ferry Crossing

There is a potential risk of incidents during construction resulting in contaminated / untreated runoff being discharged to the Victoria Nile River during this phase of the Project which can lead to localised water quality impacts. The activities and nature of the associated potential impacts are linked to the operation of vehicles and construction plant (i.e. piling rig and ancillary equipment, crawler cranes and vibration hammer operation), excavation and general earthworks activities including the use of large volume of cements/concreting materials, fuel and chemical storage near and on the bank of the Victoria Nile River. Potential impacts are also linked with the management of temporary and or permanent surface water drainage, management of accidental spills and waste generated at the worksite area during construction activities. For example, piling and hammering activities can lead to increased suspended solids and turbidity in the river water. Earthworks and construction activities at the site can result in the discharge of surface water run-off containing high suspended solids and cement into the Victoria Nile River. These may have potentially adverse effects such as increased turbidity. Also, contaminated surface run-off and discharge of untreated/poorly treated sewage can temporarily change the water quality for the Victoria Nile River.

The Victoria Nile River is a high sensitivity main surface watercourse with significant flow. The minimum flow is approximately 600 m^3/sec. It is likely that any potential impacts will be localised given the river's assimilative capacity and the concentration and quantity of the potential source. Based on the above, using professional judgement, the magnitude of any potential impacts is considered low. Accordingly, the significance of any potential impacts is assessed to be **Moderate Adverse**.

Flood Risk and Morphology Impact Assessment – Victoria Nile Ferry Crossing

The main potential impact of the Victoria Nile Ferry Crossing on flood risk is caused by the landing sites in the rivers. The deck will be on piled structure that will extend into the Victoria Nile from both the north and south banks. Removal of floodplain and wetlands as a result of constructing the jetty can increase flood risk due to storage loss and obstruction of floodplain flows. The construction of associated landing areas and parking contributes to around 5,050 m^2 increase in impermeable area, which will contribute to an increase in surface run off in the area.

Whilst the piered jetty structure allows water to flow around the piles to reduce siltation, there is still the possibility that fluvial flows could be influenced locally, which could in turn influence downstream hydraulic conditions. The impacts of these changes to hydraulic and floodplain characteristics could range from small scale localised flooding to inundation of large areas after heavy or prolonged rainfall, causing significant damage to the environment, infrastructure and surrounding settlement.

The Victoria Nile Ferry Crossing facility is to be constructed 135 m east of the existing Paara ferry crossing. There is potential for flood risk to increase as a result of additional floodplain storage removal and obstruction of flows.

The Victoria Nile River is categorised as high sensitivity, and there is potential for a high magnitude impact, resulting in a potential impact of **High Adverse** significance.

10.11.7.2.7 Impact Assessment – Construction of New Roads and Upgrades to Existing Roads

Some local roads will need to be upgraded and new roads constructed to provide access during this phase of the Project. This will include excavating drainage channels along the edges of the roads. It is not clear at this stage whether the drainage channels will be lined or unlined. It is understood that cross drainage culverts will be installed, where appropriate. The existing roads to be upgraded are referred to as A1 – A4, B1, B2 and M1. It is understood that the upgrade activities will include widening and surfacing with asphalt or gravel.

The proposed new roads are referred to as C1 - C3 and N1 - N3. Also, inter-field access roads to the well pads south of the Victoria Nile will be provided by upgrade works to existing tracks/roads referred to as D1 to D27. Well pads north of the Victoria Nile will be accessed by new roads C1 (for JBR-09) and C2 (for JBR-02), or using the Production and Injection Network Right of Way (RoW). More details of the new road construction and upgrades are provided in ***Chapter 4: Project Description and Alternatives.***

As shown in Table 10-31, the proposed new and existing roads will traverse/intersect many ordinary watercourses including a number of wetlands. Specifically, Table 10-31 shows that the A2, A4, B1, B2, C1, C2, D16, D24, D25 and W1 roads will intersect at least one wetlands. None of the proposed roads is expected to traverse a main surface water body. The proposed C2 road is expected to be constructed close to the Victoria Nile River linking to the Victoria Nile Ferry Crossing facility.

Water Quality Impact Assessment - Roads

The most important issues common to all the road upgrades and new road construction relate to protecting watercourses in proximity to these roads from runoff contaminated with hydrocarbons and silt thereby potentially causing a deterioration in the chemical and biological quality of the watercourses. Consequently, in the event of a deterioration of any ordinary surface water body chemical and/or biological quality, the impacts may result in adverse quality issues.

With respect to ordinary surface water features, adverse impacts to water quality resulting from contamination may preclude their use as water supplies for potable water and animals. The sensitivity of water bodies potentially impacted would be considered low/moderate depending on the proximity of the water body and the magnitude would be low/moderate depending upon the extent and degree of water quality degradation. The impact would be short-term, especially for each particular road and hence the significance of the potential impact is **Low Adverse**.

From a water quality point of view, this significance of impact is likely to remain the same during the construction phase of the Project or will become Insignificant during the subsequent phases of the Project lifespan.

Flood Risk and Morphology Impact Assessment - Roads

The proposed upgrade of local roads and inter-field tracks, and construction of new roads, has the potential to cause significant change to the flood risk conditions. The increase in impermeable areas will increase surface runoff and the risk of erosion of soils, which could increase flood risk locally and potentially further afield.

Some roads will cross ordinary watercourses. The construction of structures in a channel can have a large influence on the natural hydrology and morphology of the watercourse due to the removal or alteration of the baseline morphological features, for example this may arise from a major increase in amount of fine sediment and turbidity in the watercourses or by constricting flows downstream and increasing water levels upstream. The impacts will depend on the location of the crossing and flood levels in the area. The crossings are proposed to only cross ordinary watercourses with a low/moderate sensitivity, it is envisaged that there will be a **Low** to **Moderate Adverse** potential impact significance, as embedded mitigation measures will take into account floodplain removal, freeboard, provide any necessary flood compensation storage and morphological modification or alterations.

The orientation, level and gradient of roads can produce overland flow routes or potentially obstruct them. The flood risk and morphological severity of this impact will depend on the location where flows are directed to / obstructed or the baseline morphology of a water feature and weather the watercourse was to be temporary or permanently modified. The magnitude of the effects could range from minor localised flooding to significant flooding on a larger scale after heavy or prolonged rainfall. Therefore the significance of potential impacts is classed as **Low** to **Moderate Adverse**.

Roads will be designed to Ugandan standards (Drainage design to Uganda Ministry of Works and Transport – Road and Bridge Works Design Manual for Drainage (January 2010)) and designed to appropriate storm capacity.

10.11.7.2.8Impact Assessment – Expansion of the Tangi Camp

The Tangi Operation Support Base Camp located north of the Victoria Nile will be expanded and used to support the Construction and Pre-Commissioning and Commissioning and Operation phases of the Project. A full description of the camp is provided in ***Chapter 4: Project Description and Alternatives.***

Water Quality Impact Assessment – Expansion and Operations of the Tangi Camp

The surface water issues likely to arise during this phase of the Project at the Tangi Base relate to the potential impacts on the water quality of nearby designated sensitive surface water bodies that are within the possible impact area and downstream to the Tangi Base. The activities and nature of the associated potential impacts on surface water quality are similar to those at the other camps and at the Industrial Area. Surface water run-off containing high suspended solids entering watercourses may have potentially adverse effects such as increased turbidity. Also, hydrocarbons and or chemically contaminated surface run-off can change the baseline water quality of the receiving water body which in turn can result in pollution that causes water quality parameters to exceed the Ugandan standard thereby leading to regulatory failure and imminent danger to public health for both human and livestock health.

As shown in Table 10-30, the Tangi River is the only ordinary surface water body located adjacent to the camp that falls within the potential impact area of the camp. It is considered that the potential impacts on the Tangi River water quality could arise from direct or indirect water contamination from fuels and chemical spills and uncontrolled discharges of sediment-laden runoff from the camp into the river. The sensitivity of the river is moderate. Consequently, from a water quality perspective, taking into account many factors including the Project's embedded mitigation measures such as the use of SuDS, drip trays and bunds of chemical storage area, adequate treatment and appropriate disposal of waste/wastewater to dedicated facilities off-site, the proximity of the river to the camp, it is unlikely that the Tangi River will be significantly affected by any potential water quality impacts associated with the site activities. Based on the above, no significant water quality impact is predicted for the river and as such the magnitude of impact is considered negligible. Accordingly, the significance of any potential impacts is assessed to be **Insignificant**.

Flood Risk and Morphology Impact Assessment – Expansion and Operations of the Tangi Camp

The expansion of the Tangi Support Camp may have an influence on current flood risk conditions as there will be a gradual increase in hard standing, impermeable area as the components of the camp are developed. The decrease in infiltration and increased surface run off has the potential to impact on the morphological features and/or to increase flows on and off site.

The Tangi River is located adjacent to the camp and is of moderate sensitivity. The location of the camp may obstruct or redirect overland flow routes, potentially increasing flood risk elsewhere. There is potential for the flood envelope in this area to be significantly influenced, and so the potential impact significance is **Moderate Adverse**.

10.11.7.2.9Impact Assessment - Operations of the Buliisa and Bugungu Camps

The Bugungu, and Buliisa Camps are located south of the Victoria Nile River and are the existing camps that will be used throughout construction phases. Some upgrades to facilities, including to wastewater treatment plant, may be required in order to ensure the sufficient capacities, however no expansion of the area is provisioned. The Buliisa and Bugungu Camps will be decommissioned following the Construction and Pre-Commissioning Phase, and the land will be restored in line with the Site Restoration Plan. A full description of the camps is provided in ***Chapter 4: Project Description and Alternatives***.

Water Quality Impact Assessment –Operations of the Buliisa and Bugungu Camps

There is an unnamed intermittent stream located approximately 160 m from the Bugungu camp, and Sambiye river located in a distance more than 1 km from Buliisa camp. The unnamed stream falls within the potential impact area of the Bugungu camp. The sensitivity of the stream is moderate. The surface water issues likely to arise during this phase of the Project at the Bugungu Camp relate to the potential impacts on the water quality of the nearby stream that is within the possible impact areas and downstream to the Bugungu Camp. The activities (such as the use of detergents and related chemicals for vehicle and equipment washing, generation of foul and domestic wastes etc.) and the nature of the associated potential impacts on surface water quality are very similar to those at the Tangi Camp and at the Industrial Area. If surface water run-off containing high suspended solids is allowed to enter local watercourses, this may have potentially damaging effects such as increased turbidity. Also, contaminated surface run-off and discharge of untreated/poorly treated sewage can change the baseline water quality of the receiving water body which in turn can result in pollution that may cause water quality parameters to exceed the Ugandan standard thereby leading to regulatory failure and imminent danger to public health for both human and livestock health.

Consequently, from a water quality perspective, taking into account many factors including the Project's embedded design mitigation measures (such as the use of dedicated onsite wastewater treatment plant to treat grey and black water etc.), the upstream location and proximity of the stream to the camp, the nature and potential impacts as highlighted above, it is unlikely that the stream will be affected by any potential water quality impacts associated with the camp’s activities. Accordingly, no water quality impact on the nearby stream or any surface water receptors is predicted.

10.11.7.3 Additional Mitigation and Enhancement

Mitigation measures for the protection of surface water quality and sustainability (i.e. water availability) if adhered to, will help avoid, prevent and reduce the effects of the potential impacts on the water environment from water quality and quantity and flood risk perspectives. ***Chapter 4: Project Description and Alternatives*** outlines the embedded mitigation measures that will be implemented to minimise potential adverse impacts associated with the Project. Those measures to protect surface water are listed in Table 10-28. In order to further reduce impacts on surface water, the additional mitigation measures summarised in Table 10-33 have been identified.

The impact significance, post-mitigation is based on the anticipated spatial extent of the impact. A number of designated ordinary and main surface water receptors have been identified within the vicinity of some of the components of the Project. The sensitivity of the receptors ranges from low to high.

Table 10-33: Additional Mitigation Measures

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
SW.1	Majority of coating and painting activities shall be done at the Construction Support Base in dedicated buildings	X	X		
SW.2	On site painting and coating shall be limited to touch up and roller application	X	X		
SW.3	Implementing a **Grievance Mechanism Procedure**, to allow recording and follow up of any complaints related to Project activities, in a timely manner	X	X	X	X
SW.4	Vehicle/equipment maintenance should only be done in designated areas.	X	X	X	X
SW.5	Allow only trained and accredited (as required) personnel in the use of machines	X	X	X	X
SW.6	Ensure proper handling of fuels and hazardous materials. Handling as per MSDS guidelines	X	X	X	X
SW.7	An **Oil Spill Contingency Plan** to be established. This will define notification procedure, response strategy, means, and post-spill actions such as clean-up, monitoring, etc. in the event of uncontrolled/accidental discharge	X	X	X	X
SW.8	Plan site layouts so storage and refuelling areas are located away from the nearest ground and surface water receptors, as far as is practicable	X	X	X	X
SW.9	Avoid unnecessary changes and minimise disturbance to natural drainage patterns, where possible. Consider topography and natural drainage patterns in drainage design for roads, well pads, Industrial area. Existing artificial drainage to be diverted maintaining gravity flows	X	X		X
SW.10	Design and management of site drainage to reduce risk of soil erosion in exposed subsoil areas or in stockpiles	X	X	X	X
SW.11	The drainage system of any bunded area should be sealed to prevent discharge of potentially contaminated water	X	X	X	X
SW.12	Use sediment control measures such as straw bales or silt curtains, where required. Permeable check dams, made from coarsely graded rock fill, will be used to slow the discharge velocity in the drainage channels. Particular care will be taken at and close to watercourse crossings, and when construction is located close to watercourses	X	X		X
SW.13	Protect all stockpiled material including construction material from being washed away by rain run-off and wind by covering the stockpiles with tarpaulin (or equivalent), bunding the edges, vegetating and not storing in areas susceptible to erosion	X	X		X
SW.14	Avoid stockpiling near watercourses, within floodplains or on unstable slopes	X	X		X

No.	Additional Mitigation Measures	Relevant Phase: Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
SW.15	**Livelihood Restoration Plan** (for PAPs) and the **Community Content, Economic Development and Livelihood Plan** (for PACs) will include improvement of access to water measures subject to feasibility studies as defined in **Chapter 16: Social**	X	X	X	X
SW.16	Implement efficient water use by sensitising workers (as part of training) about the importance of efficient water use, adopting suitable water conservation techniques such as water re-use measures and training all contractors working on the Project to implement working methods that control water consumption and ensure water is used efficiently during the Project life	X	X	X	X
SW.17	An **Environmental Monitoring Programme** to be established that assesses the effectiveness and success of water conservation measures. It shall include a comprehensive surface water quality and water level monitoring measures to ensure that the site condition is monitored throughout each Project phase. The location of surface water monitoring points and criteria for monitoring shall be selected based on receptor sensitivity and impact magnitude	X	X	X	X
SW.18	The **Environment Monitoring Programme** will draw on the results of other ongoing studies and will include: 1. review of the suitability of existing water quality baseline information and whether there is need to update it; 2. assessment of the effectiveness and success of water conservation measures; and 3. establishment of surface water monitoring in the Project Area and implementation of an 'early warning' system when the concentration of certain pollutants rises above a threshold value.	X	X	X	X
SW.19	Ensuring compliance to the abstraction and discharge limits permitted	X	X	X	X
SW.20	Minimise construction impacts on receiving water bodies by implementing **Surface Runoff and Drainage Management Plan** which should include best management practice	X	X		X
SW.21	Any ingress of water into excavations will be removed/ discharged immediately in a condition appropriate to meet the requirements of NEMA or other acceptable standard	X	X		X
SW.22	Abstraction and discharge permits will be obtained as required	X	X	X	X
SW.23	Appropriate tunnelling and slurry management practice for HDD to stabilise soil and minimise slurry loss from the tunnel into surrounding aquifers/surface waters		X		
SW.24	For sections of pipelines that cross seasonal wetlands/rivers, pipeline construction works will take place in the dry season where possible. This is to prevent disruption of surface water / shallow groundwater flow thus affecting habitats as well as disturbing the animals relying on those wetlands		X		
SW.25	Reinstate streams disturbed by Project activities as close to original condition as possible	X	X		X

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
SW.26	All works carried out during the construction and installation of the Water Abstraction System and Victoria Nile Ferry Crossing should be follow best practices in order to avoid /reduce release of contamination such as cement and other associated hazardous chemical (e.g. paint, fuels, oil) into the lake or river	X	X		
SW.27	During the HDD works at the Victoria Nile River crossing, adequate temporary measures should be put in place mainly at the entrance of the tunnel area to ensure surface water runoff does not enter the pipeline trenches and tunnel excavation sites		X		
SW.28	Further geomorphology studies are currently being undertaken in relation to the Water Abstraction point in order to further define the design of the scheme	X	X		
SW.29	The planned water abstraction rate will be agreed with regulators and confirmed as sustainable based on studies performed	X	X	X	X
SW.30	The design of Victoria Nile ferry crossing jetty should take into consideration flood risk and consider flood compensatory storage if required	X			
SW.31	The design of the Victoria Nile ferry crossing jetty should take into account the sensitivity of the Ramsar wetland downstream to ensure impacts on hydrology and morphology are minimised as much as possible	X			
SW.32	Construction techniques will allow unimpeded shallow groundwater and surface water flow where they have to cross seasonal watercourses (for example between JBR-01 & JBR-10/Nile crossing; JBR-03 & JBR-04; around JBR-09; between JBR-08 and JBR-09), through use of culverts and permeable layers, avoiding compaction of soils	X	X		X
SW.33	Further mitigation for the pipeline across the seasonal river between JBR-09 and JBR-08 will be considered. This is a deep gully and bridging may be required		X		
SW.34	In locations where tracks, roads and/or pipelines cross smaller surface water bodies such as the River Tangi, crossing options/methods (e.g. bridges, culverts etc.) will be assessed and the most appropriate implemented	X	X		

10.11.7.4 Residual Impacts - Site Preparation and Enabling Works

Based on an assessment of the potential impacts of this phase of the Project on surface water quantity and quality and flood risk, it is concluded that with the implementation of the embdedded mitigation measures and the additional mitigation provided in Table 10-33, the residual impacts on both the ordinary and main surface water receptors will be reduced to **Insignificant** to **Moderate Adverse**.

10.11.7.4.1 Water Quantity

Other than at the Nile Ferry Crossing, it is anticipated that groundwater will be used to meet the requirements of the Site Preparation and Enabling Works phase of the Project. It is considered that the significance of the residual impact of the surface water abstraction from the Victoria Nile for the construction of the Nile Ferry Crossing is **Insignificant**.

10.11.7.4.2 Water Quality

The risk of spillage of contaminants during construction activities cannot be completely removed. Adoption of good construction, fuel and chemical storage, and handling practices can significantly reduce the risk of a spill occurring. Rapid and effective clean up and remediation in the event of a spill will reduce the risk of long-term environmental issues. Appropriate management of discharges and storm water runoff will reduce the likelihood of potentially contaminated materials and sediment entering surface water features. Following implementation of additional mitigation measures the residual impact will be reduced to **Insignificant** to **Low Adverse**.

10.11.7.4.3 Flood Risk and Morphology

Certain aspects of the Project design such as increased impermeable areas, vegetation clearance, loss of floodplain and obstruction of overland flows are expected, and the embedded mitigation measures must take in account any increase in surface run off / flood flows at each project component.

Specific design components such as road crossings will need to be carefully assessed and designed to ensure there is no increase in flood levels or adverse changes in the hydraulic conditions of watercourses local to structures or downstream areas.

Following implementation of identified mitigation measures, an **Insignificant** to **Low Adverse** residual impact significance is predicted for this phase with the exception of the Victoria Nile Ferry Crossing, which has been assessed to have a **Moderate Adverse** residual impact as there is potential for flood risk to increase as a result of removal of floodplain storage, removal of a wetland area and structures in the river.

A summary of the potential impacts of the activities associated with the Site Preparation and Enabling Works phase of the Project on surface water, pre and post-mitigation is provided in Table 10-34 to Table 10-36.

Table 10-34: Residual Impact Assessment of Surface Water Quantity (Availability) – Site Preparation and Enabling Works

Project Component	Industrial Area			Well Pads			Water Abstraction System			Masindi Vehicle Check Point			Upgrade works to Bugungu airstrip upgrade			Victoria Nile Ferry Crossing			Construction and Upgrade of Roads			Camps		
Water Quantity	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre-mitigation	None			None			None			None			None			N	H	I	None			None		
Residual	None			None			None			None			None			N	H	I	None			None		

Note: N- negligible, H-high, I - insignificant

Table 10-35: Residual Impact Assessment of Surface Water Quality – Site Preparation and Enabling Works

Project Component	Industrial Area			Well Pads			Water Abstraction System			Masindi Vehicle Check Point			Upgrade works to Bugungu airstrip upgrade			Victoria Nile Ferry Crossing			Construction and Upgrade of Roads			Camps		
Water Quality	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre-mitigation	L	M	**L**	N/L	M/H	**L/I**	N	H	**I**	N	M	**I**	L	M	**L**	L	H	**M**	L/M	L/M	**L**	N	M	**I**
Residual	N	M	**I**	N	M/H	**I**	N	H	**I**	N	M	**I**	N	M	**I**	N	H	**L**	L	L/M	**I**	N	M	**I**

Note: N- negligible, L – low, M- moderate, H-high, I - insignificant * No water quality impact at Bugungu and Buliisa camps

Table 10-36: Residual Impact Assessment of Flood Risk and Morphology – Site Preparation and Enabling Works

Project Component	**Industrial Area**			**Well Pads (<200m to watercourse)**			**Well Pads (>200m to watercourse)**			**Water Abstraction System**			**Masindi Vehicle Check Point**			**Upgrade works to Bugungu airstrip upgrade**			**Victoria Nile Ferry Crossing**			**Construction and Upgrade of Roads**			**Camps***		
Flood Risk/ Morphology	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre-mitigation	M	M	**M**	M	M	**M**	L	M	**L**	N	H	**I**	N	M	**I**	M	M	**M**	H	H	**H**	L/M	L/M	**L/M**	M	M	**M**
Residual	L	M	**L**	L	M	**L**	N	M	**I**	N	H	**I**	N	M	**I**	L	M	**L**	L	H	**M**	L	L/M	**L**	L	M	**L**

Note: H - high, L – low, M - moderate, I – insignificant, N – negligible * indicates no flood impact at Bugungu or Buliisa Camp

10.11.8 Assessment of Impacts: Construction and Pre-commissioning

10.11.8.1 Introduction

This section considers the potential impacts and effects that construction works for the Project might have on the identified surface water receptors from a water quantity and quality perspective. The potential impacts and effects on flood risk and drainage during this phase of the Project are also discussed. Detailed descriptions of the main construction phase of work and associated activities at the locations of the different components of the Project are provided in ***Chapter 4 Project Description and Alternatives.*** The main elements of this phase of the Project which potentially could impact on surface water are listed in Table 10-23.

The potential direct or indirect impacts on surface water that could arise as a result of activities during this phase of the Project additional to those in Section 10.11.7 are outlined below:

- Potential interruptions or changes to natural watercourse flow regime, drainage pattern or levels of surface water from the installation of the production and injection flowlines;
- Potential accidental discharges of drilling fluid and other hazardous chemicals into surface water and/or groundwater aquifers providing base flows and/or in hydraulic connect with sensitive surface water receptors;
- Potential accidental discharge of fluids used for hydrotesting; and
- Potential obstruction of floodplain flows or reduction in floodplain storage during construction of the Victoria Nile HDD Pipeline Crossing within the floodplain of the Victoria Nile.

Not all of these effects are applicable at all Project component locations. Also, where the impacts are the same, the significance may vary depending on the designation, proximity and sensitivity of the surface water feature/receptor to the Project component.

10.11.8.2 Potential Impacts – Construction and Pre-Commissioning

It is anticipated that during this phase of the project the water will be sourced from:

- Groundwater aquifers via a series of boreholes;
- Lake Albert following the installation of the Water Abstraction System, when available;
- Lake Albert at the same location until the Water Abstraction System is functional using temporary pumps and tankers; and
- Victoria Nile (north of the Victoria Nile).

Construction water demand will be sourced from surface water. Operational water will continue to be supplied from groundwater from boreholes drilled at the well pads, the Industrial Area, camps and at the Masindi vehicle check point. The boreholes at the well pads also will provide a water source for drilling of the wells.

No surface water will be used at the well pads, camps and Masindi vehicle check point and hence a surface water availability assessment is not relevant for these Project elements.

Indirect impacts on water sources due to influx are assessed in ***Chapter 18: Health and Safety***.

10.11.8.2.1 Impact Assessment - Industrial Area

The main activities in the Industrial Area during this phase of the Project consist of the construction of temporary and permanent facilities. Full descriptions of the facilities are discussed in detail in **Chapter 4**: ***Project Description and Alternatives***. It is understood that a perimeter drainage system for the Industrial Area will be established prior to commencement of this phase providing a means of managing surface water runoff from the site. In addition, during this phase, the permanent drainage system will be designed to segregate clean uncontaminated storm water from drainage water generated from potentially contaminated areas.

The identified surface water receptors within a 1 km potential impact area around the Industrial Area are the same as in the previous phase. However, the assessment within this phase takes into account any new and/or potential changes in the scale of activities and the significance of the associated potential impacts from a surface water quantity, quality and flood risk perspective. It also considers that all site works will take place within the prepared area that is surrounded by the drainage systems.

Water Quantity Impact Assessment – Industrial Area

During this phase of the Project the water sourcing is generally evenly split between groundwater and surface water. Groundwater will continue to be sourced from the wells throughout the life of the Project and lake water will be used only for non-domestic purposes. Water may be abstracted from the Victoria Nile in order to support construction activities on a temporary basis. Lake Albert is a designated main surface water body with high sensitivity. Based on the discussion of water availability in Section 10.11.6, the magnitude of the potential impacts as a result of the predicted maximum rate of surface water abstraction from the lake for usage for the Project is assessed to be negligible. Similarly, water abstraction from the Victoria Nile is also considered to be negligible. Consequently, from a water quantity perspective, the magnitude of the potential impact as a result of the use of surface water is considered to be negligible and the significance of any potential impacts is assessed as **Insignificant**.

Water Quality Impact Assessment- Industrial Area

As noted from the previous phase, there is a perennial stream in the potential impact area of the Industrial Area. There is a potential risk from contamination incidents in the Industrial Area resulting in contaminated/untreated runoff being discharged from the Industrial Area into this watercourse. The sensitivity of this stream is considered to be moderate. However, from a water quality perspective, taking into account the Project's in-built mitigation measures such as the appropriate storage of fuels / chemicals and use of SuDS, and given the nature of potential impacts, it is unlikely that the stream will be significantly affected by any of the potential water quality impacts. Accordingly, the significance of potential impact is assessed as **Insignificant**.

Flood Risk and Morphology Impact Assessment- Industrial Area

The construction of facilities during this phase has the potential to impact existing flood conditions as the continued increase in impermeable area from the build out of the Industrial Area will increase the surface runoff entering the nearby perennial stream and eroding the landscape. The Industrial Area requires a total land uptake of 307 ha, runoff from which could significantly increase surface water flows.

In addition to the actual construction of the Industrial Area, the physical location of buildings, fences, access roads and other facilities could influence natural flood flow routes, potentially blocking and diverting flows to vulnerable areas.

The proximity to watercourses and potential impacts are similar to the Site Preparation and Enabling Works Phase, and therefore the potential impact significance remains **Moderate Adverse**.

10.11.8.2.2Impact Assessment – Well Pads

The main activities at each well pad during this phase of the Project consist of the drilling of production wells and the construction and installation of support facilities on the well pads. During the Site Preparation and Enabling Works phase, a drainage system is to be installed surrounding the well pad. All works will be undertaken within the confines of the well pad footprint, which has a fully-contained drainage system designed to retain all water within the well pad prior to removal off-site. Storm water will be discharged to the groundwater via a Sustainable Drainage System (SuDS). This poses a potential impact on groundwater as considered in ***Chapter 9: Hydrogeology*.** Sewage and grey water produced at each well pads will be taken off-site and treated at a licensed WWT facility. The pit will be covered to prevent rainwater ingress. As detailed in the embedded mitigation measures, at each well pad, all fuels and hazardous materials will be stored within appropriate bunds and drip trays in order to provide containment.

The magnitude and significance of potential impacts on surface water will vary because of the different locations of the well pads across the Project Area. The impact will depend on many factors, in particular the presence and proximity of surface water receptors to each well pad. Water quality impacts are assessed for well pads located less than 1 km from a water feature as there is a very low risk of direct or indirect impacts of contaminant migration impacting on receptors at greater distances.

Water Quantity Impact Assessment – Well Pads

The primary source of water that will be used during the drilling of the oil production wells will be sourced from dedicated groundwater supply boreholes drilled at each well pad. Impacts on groundwater as a result of this proposed abstraction are discussed in ***Chapter 9: Hydrogeology***.

As discussed previously, the magnitude of the potential impact on water quantity as a result of abstraction from the lake for the Project is assessed to be negligible and the significance of the potential impact is considered to be **Insignificant**.

Water Quality Impact Assessment – Well Pads

As shown in Table 10-29 and Table 10-30, the locations of some well pads are near to some named and unnamed ordinary and main surface watercourses. The activities and nature of the associated potential impacts on surface water quality during the Construction and Pre-commissioning Phase of the Project are outlined in Section 10.11.8.1 and these impacts are likely to be similar at each well pad location. The surface water issues likely to arise from the well pads worksite area during this phase of the Project relate to the potential impacts on the water quality of nearby surface water receptors that are within the possible impact areas and downstream of each individual well pad. The magnitude and significance of any potential impacts may vary as this is dependent on the proximity of each well pad to a receptor.

The potential impacts on surface water quality are associated with the drilling of the production, injection and observation wells and accidental discharge/leakage of oil-contaminated drilling fluids and other hazardous drilling chemicals. Contaminated surface run-off can change the water quality of the receiving water body which in turn can result in pollution that causes water quality parameters to temporarily exceed the Ugandan standard thereby leading to regulatory failure and a risk to both human and animal health. Hence, there is a potential risk of contamination during the drilling at the well pads in proximity to surface water receptors.

Well pads NSO-04, KGG-05, NSO-02, KW-02A, and KW01 are in close proximity (i.e. at 160 m, 190 m, 200 m, 300 m and 560 m respectively) to the Sambiye River. However, only well pad KGG-05 is considered to be upstream of the Sambiye River and poses a potential risk. It is noted also that with the exception of well pads JBR-10, NGR-02, NGR-03A, NGR-05A and NSO-01 which are all greater than 2 km from any surface water receptors, the remaining well pads are in proximity to at least one of more surface water receptors (i.e. at least one water receptor is within the 1 km potential impact area). Only a few of these ordinary watercourses are named.

The sensitivity of the Sambiye River and the other ordinary water bodies is moderate. Consequently, from a water quality perspective, taking into account the Project's embedded mitigation measures such as the use of SuDS drainage process and sealed drainage around the areas of potential contamination on the well pads to prevent uncontrolled runoff from the well pad, the proximity of the ordinary and main surface water receptors to the individual well pads, the nature and potential impacts, it is considered unlikely that any of these surface water bodies will be affected. However, the effects will likely only be localised given the water body's assimilative capacity. Based on the above, the magnitude of any potential impacts is considered low. Accordingly, the significance of any potential impacts is assessed to be **Insignificant** to **Low Adverse**. Unplanned events during drilling of the oil production wells could result in contamination of adjacent surface waters. Such incidents are discussed in ***Chapter 20: Unplanned Events***.

Flood Risk and Morphology Impact Assessment – Well Pads

The potential impacts of well pad construction are similar to the Industrial Area. An increase in impermeable area can increase surface runoff and in turn increase flood risk and soil erosion; however, the location of drainage channels and the SuDS system, will be appropriately designed and positioned so as to capture surface water discharges and minimise the potential for uncontrolled discharges from the site. The magnitude of impacts to flood risk will depend on the location of the well pad and the proximity to a watercourse (i.e. impacts at distances of >200 m are low magnitude while those <200 m are moderate magnitude).

The flood risks associated with the construction of and drilling at well pads in close proximity to watercourses (i.e. <200 m) are heightened. Construction activity could have a significant influence on the catchment cover and existing overland flow routes leading to increased flood risk and a potential change to hydraulic conditions of the watercourse. The impacts of this could result in a change to the natural characteristics of watercourses and surrounding areas and so the potential impact significance associated with this activity is considered **Moderate Adverse.** The potential impact significance for well pads >200 m from the nearest watercourse is considered **Low Adverse**.

10.11.8.2.3Impact Assessment – Production and Injection Network

A Production and Injection Network comprising a series of pipelines and flowlines will be installed to connect the CPF to the well pads and the CPF to the Lake Albert Water Abstraction System. All pipelines and flowlines outside of the Industrial Area will be below ground. The pipelines will be installed using open-cut trench methods. The construction corridor RoW will have a general width of 30 m and is designed to accommodate the pipeline trench, stockpile areas, laydown, welding, and the movement of construction equipment alongside the trench. Vegetation will be stripped within the boundary of the construction RoW. The pipeline and production network will follow the same route and will be installed together in the same trench. It is understood that the Pipeline and Flowlines will be installed in trenches between 0.8 m to 2 m deep depending on local site conditions, geotechnical constraints and topography.

As shown in Figure 10-1 and Table 10-32, there are a number of ordinary surface watercourses that will be crossed by the pipeline and flowline construction. During construction of the production and injection flowlines and the water abstraction pipeline from Lake Albert, there is potential for the interruption of the surface water flow regime and sediment regime for watercourses, the channel morphology to be disturbed and a risk of surface water contamination from uncontrolled discharge of hydrocarbons and silt-laden surface water from the worksite area into these watercourses. Pipeline trenching activities could also temporarily impact on the natural fluvial processes (such as channel platform evolution or erosion) of traversed watercourses. Given the nature of the trenching activities and embedded mitigation measures, any impacts will be temporary and of a limited nature during pipeline installation and are hence considered to be of low magnitude.

The most critical point is at the location where the pipelines cross below the Victoria Nile River as detailed in ***Chapter 4: Project Description and Alternatives***. The overall impact assessment concerning the Victoria Nile Crossing is discussed separately in Section 10.11.8.2.4. Potential impacts for all other aspects of the Production and Injection Network are discussed below.

Water Quantity Impact Assessment – Production and Injection Network

During this phase of the Project surface water will not be abstracted from any of the surface water receptors crossed along the pipeline routes. Hydrotesting is carried out to check that there are no leaks or deficiencies in the pipeline. An estimated 24,000m^3 of water is proposed for hydrotesting of the flowlines and pipelines and this water will be sourced from either boreholes or Lake Albert for well pads located south of the Victoria Nile and the Victoria Nile for the well pads located north. On completion of pre-commissioning activities, water used for hydrotesting will be transferred to the CPF for treatment and used for re-injection at the well pads.

Following pre-commissioning, and to prevent internal corrosion from rusting before commissioning, the pipelines will be filled with a fluid for preservation which is likely to be inhibited / deoxygenated water. As with the hydrotest water, water used for preservation will be transferred to the Produced Water Treatment Train and re-injected into the water injection wells. As discussed in Section 10.11.6.2, the magnitude of the potential impact on water quantity as a result of surface water abstraction from the Lake Albert for the Project is assessed to be negligible. Accordingly, the significance of any potential impacts on surface water resources for these operations is assessed to be **Insignificant**.

Water Quality Impact Assessment – Production and Injection Network

The potential surface water quality impacts are likely to arise from the operation of vehicles and general excavation/trenching activities, fuel and chemicals storage, the management, discharge and possible dewatering of flooded trenches and surface water runoff, management of accidental spills and waste generated at the worksite area during construction. In addition, the principal potential water quality impact is likely to arise from the use of large volumes of water and hazardous chemicals during subsequent hydrotesting of the pipelines. There is a potential risk of excavation activities during periods of normal or severe rainfall to give rise to an increased concentration of suspended solids from dewatering activities, material stockpiles and run-off water from the RoW.

With the exception of the Victoria Nile River which is a main surface water body of high sensitivity, the Pipeline and Flowlines will traverse a number of designated ordinary surface watercourses of low to moderate sensitivity. At the point where the pipelines and flowlines directly traverse a watercourse, the effects of the potential impacts on surface water quality arising from the works will pose the greatest risk to that receptor. However, taking into account the Project's embedded mitigation measures, the likelihood for any of the above impacts to occur is considered low. The magnitude of the potential impacts on all ordinary and main (i.e. in the case, only the Victoria Nile River) surface water bodies traversed by the pipelines would be low or moderate. Accordingly, the significance of the potential impacts on the water quality of any ordinary surface watercourses is assessed to be **Low Adverse** to **Moderate Adverse.**

Flood Risk and Morphology Impact Assessment – Production and Injection Network

Construction methods to lay the pipeline and pipelines such as trenching and fencing have potential to obstruct flows. This can impound flood water locally or over extensive areas, and also redirect flows to surrounding areas. Trenching works may produce an additional flood risk, as increased sedimentation of watercourses can block channels and cause out of bank flooding. Where the pipelines cross watercourses, they will be installed below the base of the watercourse by trenching. Accordingly, the pipelines will not present a long term risk to flooding or changes in watercourse morphology. Any effects will be temporary and short-lived for the period that the pipelines are being installed.

There are potential morphological impacts associated with the trenching proposed to install 10 km of pipeline from the lake shoreline to the CPF, including the collection of surface water, redirecting flows and sedimentation of watercourses due to soil erosion. Embedded mitigation will ensure that only 1 km stretches are trenched at one time, and so the flood risk and morphological impacts on surface water traversed will only be short-term and minimal.

Embedded mitigation and good practice methods will reduce the possibility of significant adverse impacts and hence the potential impact significance of activity is assessed as **Insignificant**.

10.11.8.2.4Impact Assessment – Victoria Nile River HDD Crossing

As detailed in ***Chapter 4: Project Description and Alternatives***, the Horizontal Directional Drilling (HDD) will be the technique used for the installation of the production and injection network underneath the Victoria Nile River.

In order to minimise the impact on the Victoria Nile River, the HDD technique has been adopted. An open-trench technique was dismissed as a plausible option due to the potential risks to the river from such an intrusive operation. There are currently two crossing location options under consideration for the location of the Victoria Nile HDD Crossing (as shown in Figure 10-1). Both options for the pipeline include one production pipeline, one water injection pipeline, and fibre optic cables for utilities. Key features of the crossing are summarised below:

- A 15 -20 m minimum burial depth below the river bed;
- HDD for the 1.4 km crossing;
- A work area of approximately 100 m x 100 m north of the Nile and 100 m x 100 m to the south for laydown, machine, oil tanks, drilling mud storage, pipe extension and welding; and
- An additional area of approximately 8 hectares north of the Nile required for pipe stringing.

Water Quantity Impact Assessment – Victoria Nile River HDD Crossing

It is anticipated that a small volume of surface water will be required to support the HDD operation and other installation activities at the Victoria Nile Crossing site. It is not clear at this stage where this water will be sourced from. However, it is likely that this water will be sourced from the Victoria Nile River. This would constitute less than 0.00001% of the average daily outflow from the Victoria Nile River. Accordingly, the impact on surface water availability and flow is insignificant and hence no adverse impacts to water availability are anticipated. Based on this assessment, the magnitude of the potential impact on surface water usage to support the HDD operation at the Victoria Nile Crossing during this phase of the Project is considered to be negligible and the significance of the potential impact is therefore assessed to be **Insignificant**.

Water Quality Impact Assessment – Victoria Nile River HDD Crossing

The surface water issues likely to arise during the HDD activities at the Victoria Nile Crossing area relate to the potential impacts on the water quality of river. The HDD activities and nature of the associated potential impacts are linked to the use of drilling muds and chemicals to facilitate the drilling, pipelines stringing and testing, and installation of the pipelines beneath the river bed and at the river banks (i.e. north and south). Water quality impacts can also arise from the uncontrolled discharge of drilling mud and chemicals into the river, operation of vehicles and general earthworks activities during the drilling operation. For example, there is a potential risk of earthworks activities at the worksite areas during periods of normal or severe rainfall to give rise to an increased concentration of suspended solids in site run-off. Also, accidental spillages and leakage of hydrocarbons (fuel, oils and lubricants) from site vehicles, chemical storage areas and machinery on the worksite area can give rise to the discharge of contaminated surface water run-off into the river. If drilling mud and other drilling chemical or surface water run-off containing high suspended solids accidentally enter the river, this may have potentially damaging effects such as increased turbidity. Also, depending on the volume, hydrocarbons (i.e. leakage from plant and equipment at worksite area) and or chemically contaminated surface run-off can temporarily impact on water quality of the river. However, any impact will only be localised and insignificant given the discharge volume and the flow in the Victoria Nile.

The sensitivity of the Victoria Nile River is high and is a host to the MFNP – a Ramsar designated site. Hence any adverse impacts could significantly affect ecological dependent species. Consequently, from a water quality perspective, taking into account the Project's embedded mitigation measures to prevent uncontrolled discharges of potentially contaminated surface water runoff into the river, the nature and potential impacts including the likely low rate of contaminant discharge compared with the flow in the Victoria Nile, the likelihood for the river to be significantly affected by any of the potential impacts highlighted above is low. Based on the above, the magnitude of any potential impacts is considered Low. Accordingly, the significance of any impacts is assessed to be **Moderate Adverse**. Additional mitigation measures are therefore required to manage potential impacts.

An assessment of the impact of the HDD crossing on groundwater is discussed in ***Chapter 9: Hydrogeology.***

Flood Risk and Morphology Impact Assessment – Victoria Nile River HDD Crossing

As it is likely that some of the land-take associated with the drilling equipment for the Victoria Nile River HDD Crossing is within the floodplain of the Victoria Nile, there is potential for floodplain storage to be reduced, floodplain flows to be obstructed, and therefore flood risk could be increased locally and downstream of the Victoria Nile Crossing for the period of the construction of the Pipeline crossing. Whilst the land take will be minimised to a 100 m x 100 m area, the removal of wetland habitat could still have impacts on flood risk, as wetlands contribute significantly to flood water storage.

The Victoria Nile has a classification of high sensitivity, and whilst the impacts are likely to only be felt locally and short-term, there is potential for a moderate to high magnitude of change to flood risk conditions. The potential impact significance is therefore **High Adverse**.

10.11.8.2.5Impact Assessment – Water Abstraction System

A Water Abstraction System will be constructed at Lake Albert and will comprise a water intake pipeline, housing for pumps and water treatment facilities, and an onshore pipeline from the shoreline to the CPF (assessed in Section 10.11.8.2.3 as part of the Production and Injection Network). There are currently two options under consideration by the FEED engineer for the location of the facility to house pumps and water treatment equipment: 1) a floating platform or 2) an onshore facility at least 200 m from the lake shore. For the purposes of the impact assessment, a worst case scenario approach has been adopted for the installation methodology for the intake pipeline. It is therefore assumed that the intake pipeline will be laid on the lake bed and will extend 1.5 km from the shoreline into Lake Albert, with a water intake structure fixed at the bottom of the lake. Further details on the Water Abstraction System are provided in ***Chapter 4: Project Description and Alternatives.***

During this phase of the Project, the water abstraction system from Lake Albert will be commissioned and used.

Water Quantity Impact Assessment – Water Abstraction System

Surface water will be sourced from Lake Albert to support the system construction activities and intake pipeline installation. The quantity of water (i.e. approximately 0.54 m^3) required for these activities will be insignificant in comparison with the volume of water available in the lake. Consequently, from a water quantity perspective, the magnitude of the potential impact on surface water availability is considered to be negligible. Accordingly, the significance of the potential impact is assessed to be **Insignificant**.

Water Quality Impact Assessment – Water Abstraction System

Lake Albert is a surface water receptor of high sensitivity. The potential surface water quality issues likely to arise during the construction and use of the Water Abstraction System are from the operation of vehicles and general construction activities, fuel and chemicals storage, the management and discharge of surface water runoff, physical disturbance of the lake bed and waste generated at the worksite. The principal potential water quality impact is likely to result from the laying of the intake pipeline on the lake bed which could lead to increased suspended solids and turbidity in Lake Albert; however, the effects of this are likely to be short term and limited in scale. If contaminated surface water run-off from the site enters Lake Albert, depending on the quantity, the impact will only be localised given the assimilative capacity of the lake and hence of negligible magnitude. The significance of the potential impact to water quality is assessed to be **Insignificant**.

Flood Risk and Morphology Impact Assessment – Water Abstraction System

The flood risk impact of the construction of the Water Abstraction System is considered similar to that assessed for the site clearance activities and civils works as presented in Section 10.11.7.2.4. It is therefore assumed that the significance of the flood risk impact is **Insignificant** during this phase.

The laying of the intake pipeline on the lake bed during this phase may result in minor morphological changes to the lake bed; however, any impacts would likely recover rapidly through natural processes; therefore, the significance of potential morphological impacts is considered **Insignificant**.

10.11.8.2.6 Impact Assessment – Operations of Camps

The operations at the camps during this phase of the Project will be very similar to those for the Site Preparation and Enabling Works phase. There are no impacts on surface water quantity. Potential impacts on surface water quality are considered to be **Insignificant** and the significance of potential flood risk and morphology impacts remain **Moderate Adverse**.

10.11.8.2.7 Impact Assessment – Victoria Nile Ferry Crossing Facility

During this phase of the Project, the ferry will be used to transport materials and equipment across the Victoria Nile River. Activities at the crossing include onshore parking, and containers for offices, workshops, storage of hazardous and non-hazardous materials and sanitary facilities. There will be a bunded fuel tank (18 m^3 capacity) onshore for refuelling the ferry. At the time this ESIA was prepared, the drainage design for the Victoria Nile Ferry Crossing Facility was still in development; however, the final design will be based on a SuDS approach.

Water Quality Impact Assessment – Victoria Nile Ferry Crossing Facility

The potential surface water quality impacts likely to arise from the Victoria Nile Ferry Crossing Facility during this phase of the Project are linked to accidental leakages/spills of fuel and fluids and from uncontrolled potentially contaminated storm water runoff from the ferry and associated onshore facilities on the northern and southern banks of the river. The Victoria Nile is a receptor of high sensitivity. Given the embedded design mitigation measures such as the use of bunded fuel tank the likelihood of discharging contaminated run-off into the river water is very low. However, in worst case scenarios, if hydrocarbons contaminated or untreated wastewater is discharged from the ferry or the onshore support facilities into the river, the impacts would be localised due to the size of the river and the river's assimilative capacity, which would facilitate mixing and dilution of any contamination. Based on this, the magnitude of any potential impacts on the river water quality will be negligible. Accordingly the significance of any potential water quality impacts would be **Insignificant.**

Flood Risk and Morphology Impact Assessment – Victoria Nile Ferry Crossing Facility

The positioning of the piers on either side of the Victoria Nile River pose a potential obstruction to floodplain overland flows. This in turn could cause localised flooding. The high sensitivity of the Victoria Nile River combined with the magnitude of the impact maintains a potential impact significance of **High Adverse**.

10.11.8.3 Additional Mitigation and Enhancement

Chapter 4: Project Description and Alternatives outlines the embedded mitigation measures which will be implemented to minimise potential adverse impacts on surface water flow and quality. Additional mitigation measures required to manage potential impacts on surface water during the Construction and Pre-Commissioning phase are presented in Table 10-33.

10.11.8.4 Residual Impacts - Construction and Pre-commissioning

Based on an assessment of the potential impacts of this phase of the Project on surface water quantity, quality and flood risk, it is concluded that with the implementation of the embedded mitigation measures and the additional mitigation provided in Table 10-33, the significance of residual impacts on surface water quantity and quality and flood risk will generally be reduced to **Low Adverse** or **Insignificant**.

10.11.8.4.1 Water Quantity

Surface water will constitute the primary source of water supply that will be used to facilitate most of the construction activities during this phase of the Project. Lake Albert will be the primary source of the surface water supply. It is anticipated that a small abstraction may be required from the Victoria Nile River to provide water for the Victoria Nile HDD Pipeline Crossing drilling and associated activities. The potential water quantity impacts as a result of the proposed abstractions from either Lake Albert or the Victoria Nile River will be negligible as the abstractions will constitute less than 0.034% and 0.0001% of the availability water resources of both the Lake Albert and Victoria Nile River respectively. The significance of residual impacts ranges from **None** to **Insignificant**.

10.11.8.4.2 Water Quality

The risk of spillages during construction activities cannot be completed removed. Adoption of the embedded mitigation measures and the additional mitigation measures outlined earlier in this chapter will significantly reduce the risks. Rapid and effective clean up and remediation in the event of a spill will reduce the risk of long-term environmental impact. Adoption of the mitigation measures will reduce the significance of residual impacts to **Insignificant** to **Low Adverse**.

10.11.8.4.3 Flood Risk and Morphology

The potential flood risk impacts associated with the Construction and Pre-Commissioning phase are generally due to increases in impermeable areas and construction works within or near the flood plain of watercourses, such as the Victoria Nile River HDD Crossing. In addition, excavation of pipeline trenches across watercourses can increase water turbidity due to disturbance of the river banks and bed. For construction works in proximity to floodplains, there is potential for floodplain storage to be reduced, flows to be obstructed, and for flood risks to increase.

Based on adoption of the embedded mitigation measures including SuDS to control discharges, and following implementation of the additional mitigation measures identified above, the impact significance will be reduced to **Insignificant** to **Low Adverse** for all components, except for the Victoria Nile Ferry Crossing and the HDD Crossing, which have been assessed to have a **Moderate Adverse** residual impact as there is potential for localised flood risk to increase.

A summary of the potential impacts associated with the Construction and Pre-Commissioning phase of the Project on surface water is provided in Table 10-37 to Table 10-39.

Table 10-37: Residual Impact Assessment of Surface Water Quantity (Availability) – Construction and Pre-commissioning

Project Component	Industrial Area			Well Pads			Production and Injection Network			Victoria Nile River HDD Crossing			Water Abstraction System			Camps		
Water Quantity	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre-mitigation	N	H	**I**	N	H	**I**	None			N	H	**I**	N	H	**I**	None		
Residual	N	H	**I**	N	H	**I**	None			N	H	**I**	N	H	**I**	None		

Note: N- negligible, L – low, M- moderate, H-high, I insignificant

Table 10-38: Residual Impact Assessment of Surface Water Quality – Construction and Pre-commissioning

Project Component	Industrial Area			Well Pads			Production and Injection Network			Victoria Nile River HDD Crossing			Victoria Nile Ferry Crossing			Water Abstraction System			Camps		
Water Quality	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre-mitigation	N	M	**I**	N/L	H/M	**I/L**	L/M	L/M	**L/M**	L	H	**M**	N	H	**I**	N	H	**I**	N	M	**I**
Residual	N	M	**I**	N	H/M	**I**	L	L/M	**L**	N	H	**I**	N	H	**I**	N	H	**I**	N	M	**I**

Note: N- negligible, L – low, M- moderate, H-high, I insignificant

Table 10-39: Residual Impact Assessment of Flood Risk – Construction and Pre-commissioning.

Project Component	Industrial Area			Well Pads (<200m to watercourse)			Well Pads (>200m to watercourse)			Production and Injection Network			Victoria Nile River HDD Crossing and VNFC			Water Abstraction System			Camps		
Flood Risk/ Morphology	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre-mitigation	M	M	**M**	M	M	**M**	L	M	**L**	N	M	**I**	M/ H	H	**H**	N	H	**I**	L	M	**M**
Residual	L	M	**L**	L	M	**L**	N	M	**I**	N	M	**I**	L	H	**M**	N	H	**I**	N	M	**I**

10.11.9 Assessment of Impacts: Commissioning and Operations

10.11.9.1 Introduction

The Commissioning and Operations Phase is expected to commence approximately 36 months after effective data of the main construction contract award. The lifetime of the Project is 25 years. During the Commissioning and Operations phase of the Project, the main activities with the potential to directly and/or indirectly impact on surface water features are presented in Table 10-23.

During this phase of the Project, water will be sourced from groundwater for domestic use and from surface water for the remaining Project use. It is anticipated that surface water abstraction will be only from Lake Albert. This section considers the potential impacts and effects that the Project might have on the identified surface water receptors from a water quantity and quality perspective during this phase of the Project. The potential impacts and effects on flood risk and drainage are also discussed.

During this phase of the Project, surface water abstracted from Lake Albert will be used mainly for reservoir management i.e. water re-injection. Figure 10-27 shows that the volume of surface water required falls significantly and by Year 12 is less than half of the maximum predicted requirement for the previous phase of the Project. The uses of produced water for re-injection will reduce the demand for surface water as well. A detailed assessment of the potential impacts on the regional and local water resources availability and sustainability as a result of the proposed abstraction from Lake Albert is presented in Section 10.11.6. The assessment shows that the peak water abstraction from Lake Albert for the Project will have no significant impact on water availability from the lake. As the volume of surface water required for this phase of the Project is significantly lower, the impact significance remains **Insignificant**.

There will be no construction activities during this phase of the Project. Accordingly, there will be no additional activities which could impact on flood risk and morphology. The significance of the impacts will remain the same or lower than those for the previous phases.

The main surface water issues likely to arise during this phase of the Project are therefore related to impacts on surface water quality and flood risk are associated with the operational activities of the Project. The potential surface water quality impacts to main and/or ordinary surface features are summarised below and may be common across all of the Project component sites:

- Accidental spillage / leaks of hydrocarbons (e.g. oil, fuel, lubricants) or chemicals (e.g. polymer and other hazardous chemicals);
- Uncontrolled discharge of potentially contaminated or untreated wastewater or storm water from Project components; and
- Discharge of poorly treated wastewater or storm water from Project components.

10.11.9.2 Potential Impacts – Commissioning and Operations

10.11.9.2.1 Impact Assessment – Industrial Area

The surface water issues likely to arise during operation of the Industrial Area and its associated facilities relate to potential impacts on the water quality of nearby sensitive surface water receptors that are within the possible impact area and downstream to the Industrial Area.

No impact on water quantity is anticipated and is therefore not discussed below.

Water Quality Impact Assessment – Industrial Area

The operational activities at the Industrial Area and the nature of the associated potential impacts are linked to the processing and storage of large quantities of raw and refined crude products, operation of base camps, storage and use of hydrocarbons (i.e. fuel, lubricants, oil) and chemicals, the operation and management of surface water drainage systems (i.e. both contaminated and potentially contaminated drains), management of accidental spills, leaks and waste generated during the operational activities. Uncontrolled discharges of potentially contaminated and contaminated water from the Industrial Area can pose a significant water quality risk to nearby surface water receptors. Also, the discharge of untreated/poorly treated sewage can change the baseline water quality of the receiving water body which in turn can result in pollution that causes surface water quality parameters to exceed the Ugandan standard thereby leading to regulatory failure and a risk to health for both humans and livestock.

As noted for the previous phases, there is only one ordinary surface water receptor (i.e. a perennial stream) within a 1 km potential impact area of the Industrial Area. The sensitivity of this water body is moderate. From a water quality perspective, using professional judgement and taking into account the Project's embedded mitigation measures such as the appropriate storage of fuels and chemicals, use of SuDS and the segregation of clean and contaminated runoff, the magnitude of impacts on surface water receptors from the Industrial Area are considered negligible and the significance of the potential impact remains **Insignificant**.

Flood Risk and Morphology Impact Assessment – Industrial Area

Whilst the activities associated with commissioning and operations of the Industrial Area are not likely to increase flood risk, it should be noted that flooding is still possible during this phase. This is due to the physical aspects of the infrastructure in the landscape. Increased hardstanding and impermeable areas will increase surface run off, which will collect in areas with low topography, and potentially the perennial stream in the vicinity of the site. Buildings and fencing may obstruct and redirect flood flows which could exacerbate water impoundment or increased flows to other areas on or off-site.

The impacts on flood risk are similar to those for the previous phase of the Project. Given the moderate sensitivity of the watercourse and the low likelihood of these impacts, the significance of the potential impact remains **Moderate Adverse**.

10.11.9.2.2Impact Assessment – Well Pads

During this phase of the Project, activities at the well pads would have reduced significantly. The well pads will be normally unmanned during routine operations. During this time, the facilities will be operational and monitored via Closed-Circuit Television (CCTV) and Integrated Control Safety System (ICSS) from the Central Control Room at the CPF.

It is envisaged that operators will be required to visit each pad periodically to carry out routine checks and maintenance. In addition, pigging activities and work over will be undertaken periodically. All of the above activities have the potential to impact on the water quality of nearby surface receptors.

Water Quality Impact Assessment – Well Pads

The operational activities at the well pads and the nature of the associated potential impacts are similar to those assessed for the previous phase of the Project in Section 10.11.8.2.2.

As noted from the previous phases and as shown in Table 10-29 and Table 10-30, a number of unnamed and named ordinary surface water bodies including the Sambiye River, falls within the potential impact area of some of the well pads. The sensitivity of these water bodies is moderate. As the potential sources of impact are similar to those for the previous phase, the significance of potential impacts on surface water receptors from the well pads remains **Insignificant** to **Low Adverse,** subject to the proximity of the surface water receptors.

Flood Risk and Morphology Impact Assessment – Well Pads

Similarly to the Industrial Area, the activities associated with commissioning and operations of the well pads are not likely to increase flood risk. However, the positioning of well pads may still result in flooding during this phase.

The increase in hardstanding and impermeable areas has the potential to increase surface runoff from the individual well pads to nearby communities and watercourses. The magnitude of this impact depends on the locality of the individual well pad (i.e. distances of >200 m are low magnitude while those <200 m are moderate magnitude). Embedded mitigation in the form of SuDS will help to control run off from surface water flood flows, however the well pads themselves still have the potential to obstruct and redirect flood flows. This may cause water impoundment or increased flood flows to other areas locally or further afield. The potential impact significance is considered to be **Low Adverse** to **Moderate Adverse** depending on the location of the well and proximity to a watercourse.

10.11.9.2.3Impact Assessment – Production and Injection Network

During this phase of the Project, the production and injection pipeline network will be operational and undergoing regular maintenance. The operation of the production line and produced water lines in particular are the main activities in this phase of the Project which have the potential to impact on surface water quality.

Water Quality Impact Assessment – Production and Injection Network

Potential pipeline failure is considered an Unplanned Event and assessed in ***Chapter 20: Unplanned Events***. There is a risk of impact to surface water quality from localised spillages of fuel during maintenance activities on the RoW if the spillages occur in close proximity to any surface water bodies, which are of moderate sensitivity. However, given the low likelihood and localised nature of any spillages, the potential impact significance is considered **Insignificant**.

10.11.9.2.4Flood Risk and Morphology Impact Assessment – Production and Injection Network

As the pipelines and flowlines will be below ground and the ground restored to the original profile following construction, there will be no impacts associated with the pipelines and flowlines in respect of flood flows. The magnitude of potential impact is considered to be negligible and the significance of impact from this phase of the Project on flood risk is **Insignificant**.

10.11.9.2.5Impact Assessment – Water Abstraction System

During the Commissioning and Operation phase there will be limited activities at the Water Abstraction System. Small quantities of non-hazardous and hazardous materials will be present at the onshore/off-shore pre-treatment facility.

Water Quality Impact Assessment – Water Abstraction System

The potential water quality issues likely to arise during this phase of the Project are linked to the maintenance activities that will be conducted. Given the embedded mitigation measures in place, No surface water quality impact is predicted. The significance of the potential impact on surface water quality remains **Insignificant**.

Flood Risk and Morphology – Water Abstraction System

The impact of the construction of the Water Abstraction System has been assessed for the Site Preparation and Enabling Works phase of the Project in Section 10.11.7.2.4 as being Insignificant. As there will be no additional construction works on land for this phase, the significance of the potential impact remains **Insignificant**.

10.11.9.2.6Impact Assessment – Tangi Support Base Camp (Permanent Camp)

Water Quality Impact Assessment – Tangi Support Base Camp (Permanent Camp)

The potential surface water issues likely to arise during this phase of the Project at the Tangi camp are similar to those as already discussed in the previous phase. Potential impacts upon surface water quality are predicted to be **Insignificant**.

Flood Risk and Morphology - Tangi Support Base Camp (Permanent Camp)

Potential flood risk remains **Moderate Adverse** as in the previous phases.

10.11.9.2.7Impact Assessment – Victoria Nile Ferry Crossing Facility

During the Commissioning and Operations phase of the Project, the ferry will be used to transport materials and equipment across the Victoria Nile River. Activities at the crossing include onshore parking, use of onshore facilities, storage of hazardous and non-hazardous materials and refuelling of the ferry.

Water Quality Impact Assessment – Victoria Nile Ferry Crossing Facility

The potential surface water quality impacts likely to arise from the Victoria Nile Ferry Crossing Facility during the operational phase of the Project are similar to those as already discussed in the previous phase. Potential impacts upon surface water quality are predicted to be **Insignificant**.

Flood Risk and Morphology Impact Assessment – Victoria Nile Ferry Crossing Facility

Potential flood risk remains **High Adverse** as in the previous phase due to the presence of the piers on either side of the Victoria Nile River which may pose a potential obstruction to floodplain overland flows and in turn could cause localised flooding.

10.11.9.3 Additional Mitigation and Enhancement

Chapter 4: Project Description and Alternatives outlines the embedded mitigation measures which will be implemented to minimise potential adverse impacts on surface water flow and quality. The additional mitigation measures required to manage potential impacts on surface water during the Commissioning and Operations phase are presented in Table 10-33.

10.11.9.4 Residual Impacts – Commissioning and Operations

Based on an assessment of the potential impacts of this phase of the Project on surface water quantity, quality and flood risk, it is concluded that with the implementation of the embedded mitigation measures and the additional mitigation measures listed in Table 10-33, the significance of residual impacts on both surface water quantity, quality and flood risk will be reduced to **Low Adverse** or **Insignificant**.

10.11.9.4.1Water Quantity (Residual impact – Insignificant)

There is a substantial reduction in the volume of surface water required for this phase. Surface water abstracted from Lake Albert will only be used for reinjection purposes at the well pads during this phase of the Project. The volume of surface water required poses no residual risk to regional surface water resources. Based on this, the significance of any residual impacts is **Insignificant**.

10.11.9.4.2Water Quality

The risk of leaks, spillage and discharge of potentially contaminated runoff from one or more of the Project components into surface water features during Commissioning and Operations activities cannot be completely removed. However, with the implementation of the embedded and additional mitigation measures and the surface water quality monitoring above, the residual significance of impacts to water quantity is **Insignificant**.

10.11.9.4.3Flood Risk and Morphology

The potential flood risk impacts associated with the Commissioning and Operations phase are generally similar to those for previous phases of the Project. Based on the embedded mitigation measures and following implementation of the additional mitigation measures identified, the impact significance will be reduced to **Insignificant** to **Low Adverse** for all components with the exception of the Victoria Nile Ferry Crossing for which residual impact significance is **Moderate Adverse**. The positioning of the Victoria Nile Ferry Crossing piers on both sides of the Victoria Nile River may pose a potential obstruction to flood flows which in turn could cause localised flooding.

A summary of the potential impacts of the activities associated with the Commissioning and Operations phase of the Project on surface water and flood risk, pre and post-mitigation is provided in Table 10-40 to Table 10-42.

Table 10-40: Residual Impact Assessment of Surface Water Quantity (Availability) – Commissioning and Operations

Project Component	Industrial Area			Well Pads			Production and Injection Network			Water Abstraction System			Camps		
Water Quantity	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre-mitigation	None			None			none			N	H	**I**	none		
Residual	None			None			none			N	H	**I**	none		

Note: N- negligible, L – low, M- moderate, H-high, I insignificant

Table 10-41: Residual Impact Assessment of Surface Water Quality – Commissioning and Operations

Project Component	Industrial Area			Well Pads			Production and Injection Network			Water Abstraction System			Victoria Nile Ferry Crossing			Tangi Camp		
Water Quality	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre-mitigation	N	M	**I**	N/L	H/M	**I/L**	N	M	**I**	N	H	**I**	N	H	**I**	N	M	**I**
Residual	N	M	**I**	N	H/M	**I**	N	M	**I**	N	H	**I**	N	H	**I**	N	M	**I**

Table 10-42: Residual Impact Assessment of Flood Risk – Commissioning and Operations

Project Component	Industrial Area			Well Pads (<200 m to watercourse)			Well Pads (>200 m to watercourse)			Production and Injection Network			Water Abstraction System			Victoria Nile Ferry Crossing			Tangi Camp		
Flood Risk/ Morphology	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**	**Magnitude**	**Sensitivity**	**Significance**
Pre-mitigation	M	M	**M**	M	M	**M**	L	M	**L**	N	M	**I**	N	H	**I**	H	H	**H**	M	M	**M**
Residual	L	M	**L**	L	M	**L**	N	M	**I**	N	M	**I**	N	H	**I**	L	H	**M**	L	M	**L**

Note: N- negligible, L – low, M- moderate, H-high, I insignificant

10.11.10 Assessment of Impacts: Decommissioning

10.11.10.1 Introduction

There is currently no detailed decommissioning plan for the Project as the technological options and preferred methods for decommissioning of such systems may be different at the end of the Project lifetime (i.e. 25 years' time). It is understood that a decommissioning plan will be developed during the Commissioning and Operations Phase of the Project. However, for this assessment, the currently envisaged decommissioning plan as set out in ***Chapter 4: Project Description and Alternatives*** is considered.

Prior to undertaking decommissioning activities, the Project Proponents will undertake a review of historical monitoring data and incidents on site that might have caused ground and/or groundwater contamination. The Project Proponents will also develop a monitoring programme for completion criteria to verify that the sites are being returned to the agreed representative condition. Aspects of the Decommissioning Management Plan to safeguard surface water will include:

- Chemical and hazardous substance management;
- Waste management;
- Soils management; and
- Spill contingency.

In general, the following principles will apply:

- Above ground infrastructure shall be removed to 0.5 m below ground level and backfilled and vegetated;
- Access roads may be left in place depending on the subsequent use of the land;
- Shallow foundations for infrastructure may be excavated, demolished and disposed of;
- Where piled foundations exist, these may be excavated to a depth of 1 m below the existing ground level and removed;
- Excavations resulting from the removal of foundations will be backfilled;
- Where the environment assessment identifies it is acceptable, pipeline sections may be cleaned, reclaimed and re-used; and
- Generally it is expected that pipelines will be cleaned, capped and left in situ to prevent disturbing the reinstated habitats.

It is likely that there will be limited surface water requirement during this final phase of the Project other than for use in cleaning pipelines and at the Industrial Area for general cleaning at the CPF. It is likely that the volume of surface water required during this phase will be substantially less than the requirement for previous phases of the Project, for which the impact significance was assessed to be **Insignificant**. Consequently, from a water quantity perspective, no impact on surface water quantity is envisaged during the Decommissioning phase of the Project.

The surface water issues likely to arise during the Decommissioning phase of the Project are therefore related to potential impacts on surface water quality of nearby designated sensitive surface water bodies and flood risk. The potential impacts are associated with the activities set out in Table 10-23.

Surface disturbance, heavy equipment traffic, and changes to surface runoff patterns could cause soil erosion leading to sedimentation of surface water features. It is noted that on completion of decommissioning, disturbed areas would be contoured and revegetated.

10.11.10.2 Potential Impacts – Decommissioning

It is likely that impacts to surface water receptors would be similar in duration and magnitude as those identified during the Site Preparation and Enabling Works and Construction and Pre-Commissioning phases of the Project.

10.11.10.3 Additional Mitigation and Enhancement

The additional mitigation measures required to manage potential impacts on surface water during the Decommissioning phase are presented in Table 10-33.

10.11.10.4 Residual Impacts – Decommissioning

Following implementation of the embedded mitigation measures and the additional mitigation detailed above, residual impacts to surface water receptors during the Decommissioning phase would be expected to be similar to those identified for the Site Preparation and Enabling Works and Construction and Pre-Commissioning phases of the Project. The residual impacts to water quantity are therefore anticipated to be **Insignificant**, and the residual impacts to surface water quality and flood risk are anticipated to be **Low Adverse** or **Insignificant**.

10.12 In-Combination Effects

As described in ***Chapter 4: Project Description and Alternatives***, the Project has a number of supporting and associated facilities that are being developed separately (i.e. they are subject to separate permitting processes and separate ESIAs or EIAs). These facilities include:

- Tilenga Feeder Pipeline;
- East Africa Crude Oil Export Pipeline (EACOP);
- Waste management storage and treatment facilities for the Project;
- 132 Kilovolt (kV) Transmission Line from Tilenga CPF to Kabaale Industrial Park; and
- Critical oil roads.

As these facilities are directly linked to the Project and would not be constructed or expanded if the Project did not exist, there is a need to consider the in-combination impacts of the Project and the supporting and associated facilities. This is distinct from the Cumulative Impact Assessment (CIA) which considers all defined major developments identified within the Project's Area of Influence (and not just the associated facilities) following a specific methodology which is focussed on priority Valued Environmental and Social Components (VECs) (see ***Chapter 21: Cumulative Impact Assessment***).

The in-combination impact assessment considers the joint impacts of both the Project and the supporting and associated facilities. The approach to the assessment of in-combination impacts is presented in ***Chapter 3: ESIA Methodology***.

For the purpose of this ESIA, in-combination impacts are determined when considering the potential joint impacts of both the Project and the Supporting Infrastructure and associated facilities. No detailed information is available for the water demand for these projects (with the exception of construction volumes for the pipelines), however the demand is expected to be temporary. The construction of the transmission line should have very limited water requirements and temporary in duration. Any accidental spills or small leakages would be localized.

There is a possibility that the critical oil roads and the Tilenga Feeder pipeline will constructed concurrently with Phase 1 Site Preparation and Enabling Works for the Project. The water demands for waste management and treatment facilities is unknown but would likely be sourced from groundwater. Each project will put in a place a whole suite of embedded and additional mitigation measures to help prevent any significant adverse impacts.No significant in-combination effects on surface water or flood risk have been identified based of the temporal and spatial extent of the Project components and activities in relation to the location of supporting infrastructure and associated facilities.

10.13 Unplanned Events

There are significant sources of potential impact to surface water that could occur in the event of an unplanned event. This is particularly true in the event of accidental leakage/discharge of significant volumes of hydrocarbon from major failure of fuel storage tanks at the CPF, well blow-outs, or the major failure of a pipeline. An assessment of the impact of unplanned events on surface water is detailed in ***Chapter 20: Unplanned Events***.

10.14 Cumulative Impact Assessment

The potential cumulative impacts associated with the Project relating to surface water are assessed in Chapter ***21: Cumulative Impact Assessment.*** The CIA focussed on VECs that were selected on the basis of set criteria including the significance of the effects of the Project, the relationship between the Project and other developments, stakeholder opinions and the status of the VEC (with priority given to those which are of regional concern because they are poor or declining condition). On the basis of the selection process, Access to Safe Drinking Water Resources was considered to be a priority VEC and is therefore considered further in the CIA.

10.15 Conclusions

Impact assessment criteria were developed and utilised for assessing the potential impacts to surface water, flood risk and river morphology from the Site Preparation and Enabling works, Construction and Pre-Commissioning, Commissioning and Operations; and Decommissioning phases of the Project, and include impact magnitude and receptor sensitivity. The assessment of impacts has been undertaken by identifying and evaluating a range of activities and scenarios that are likely to occur throughout the four phases of the Project. Direct impacts address water availability, water quality, flood risk and impact to morphology. Direct impacts have the potential to result in indirect impacts to water quality resources such that they become unsuitable for use for potable water or drinking sources for animals and wildlife. This indirect impact is captured under water availability. The indirect impacts have been identified where appropriate and relevant.

Taking into consideration impact magnitude, likelihood and receptor sensitivity, the significance of impacts was established for the pre-mitigation and post mitigation scenarios. The residual impacts for each phase of the Project after the implementation of mitigation measures are summarised in Table 10-43.

Table 10-43: Residual impact to surface water– Post-mitigation

Topic	Residual Impact Significance			
	Site Preparation and Enabling works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
Surface Water Quantity (Availability)	**Insignificant**	**Insignificant**	**Insignificant**	**Insignificant**
Surface Water Quality	**Insignificant to Low Adverse**	**Insignificant to Low Adverse**	**Insignificant**	**Insignificant to Low Adverse**
Flood Risk/ Morphology	**Insignificant to Moderate Adverse**	**Insignificant to Moderate Adverse**	**Insignificant to Moderate Adverse**	**Insignificant to Low Adverse**

From a surface water quantity and water resources sustainability perspective, the residual impact as a result of the proposed abstraction of surface water from Lake Albert for the Project is considered to be **Insignificant**, with a maximum water demand requiring only 0.034% of the water available.

Following the implementation of embedded and additional mitigation measures, potential risks to surface water quality are considered to be **Insignificant** to **Low Adverse**.

Residual impacts to flood risk / morphology are primarily considered to be **Insignificant** to **Low Adverse** with the exception of the flood risk impacts which are considered **Moderate Adverse** for the Victoria Nile Ferry Crossing (during the Site Preparation and Enabling Works, Construction and Pre-Commissioning and Commissioning and Operations phases) and HDD crossing of the Victoria Nile (during the Construction and Pre-Commissioning phase). There is a potential for localised flood risk to increase due to potential reduction of floodplain storage and obstruction to flood flows.

No significant in-combination effects have been identified based of the temporal and spatial extent of the Project components and activities in relation to the location of supporting infrastructure and associated facilities hence in combination effects are considered to be **Insignificant**.

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Ref. 10-38 Uganda Categorised Flood Hazard Map https://oasishub.co/dataset/uganda-categorised-flood-hazard-ssbn/resource/ (Accessed 25 September 2017).

Ref. 10-39 USAID 2014. An Overview of Climate Change and Biodiversity in Uganda, August 2014.https://www.climatelinks.org/sites/default/files/asset/document/Uganda%2520CC%2520and% (Accessed 25th September 2017).

Ref. 10-40 Lake Albert as part of the Lake Albert Offshore Exploration Drilling ESIA, (2007).

Ref. 10-41 NEMA (2017). State of Environment Report for Uganda 2015. National Environment Management Authority (NEMA), Kampala.

Ref. 10-42 http://www.ramsar.org/murchison-falls-albert-delta-wetland-system

Ref. 10-43 Guidelines for Environmental Impact assessment in Uganda (NEMA 1997) (national Environmental Management Authority).

Ref. 10-44 Tullow (9th March 2017) Lake Albert Basin Upstream Development Water Source Evaluation for Development and Production.

Ref. 10-45 TOTAL. Buliisa Development FEED. Environmental Optimum Requirements. December 2016.

11 – Landscape and Visual

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11 Landscape and Visual

11.1 Introduction

This Landscape and Visual Impact assessment (LVIA) identifies the potential landscape and visual effects of the Project Area.

In terms of landscape effects, the Project could physically affect the land cover, features and character within the Study Area as well as the aesthetic and perceptual aspects of the wider landscape and its distinctive character. These effects are determined through an assessment of the existing character of the landscape, and how this is likely to be altered by the Project.

In relation to visual effects, visual amenity is defined as the overall pleasantness of the views people enjoy of their surroundings. The visual assessment determines the degree of anticipated change to visual amenity that would occur as a result of the Project, considering buildings, areas of public open space, roads and paths. The visual assessment considers static effects through analysis of individual viewpoints, considered representative of the range of views within the Study Area.

Landscape and visual effects are interrelated but assessed separately. It is possible for greater weight to be placed on only one element of the assessment e.g. the Project may result in no adverse landscape character effects but could result in adverse visual effects, conversely, the Project may result in no adverse visual effects but could result in adverse landscape character effects.

11.2 Scoping

A review of the scoping report was undertaken which was based on an initial desk based study established from available data, aerial photographs and mapping in July 2015. This exercise identified the broad landscape type of the Albertine Graben of the Western Rift valley as the host landscape type in which the Project sits. Other elements of the landscape and visual resource identified during the scoping stage included the following:

- The Murchison Falls National Park (MFNP);
- Lake Albert and the complex network of wetlands throughout the Nile Delta;
- The series of distinctive landscape features of the rift escarpment rising abruptly to the flat plateau all of which contribute to the distinct elements of landscape character; and
- Range of potential visual receptors including a number of tourist destinations, lodges and strategic transport network.

The Scoping Report identify 3 key areas to be investigated further which included: the potential landscape impacts; the potential visual amenity impacts and potential light impacts at night.

11.3 Legislative Framework

This section summarises key Ugandan legislation and regulations, together with international policies, standards and guidelines that are relevant to the LVIA.

11.3.1 National Standards

There is no national standard specific to LVIA, however the following national standards provide relevant background baseline information:

- The National Environment Management Policy (NEMP) (1994) (Ref 11-1);
- The Environmental Impact Assessment Regulations (1998) (Ref 11-2);
- The Uganda Wildlife Policy (2014) (Ref 11-3);
- The Uganda National Land Policy (2013) (Ref 11-4);
- The National Forestry and Tree Planning Act, 2003 (Ref 11-5);

- Uganda National Policy for the Conservation and Management of Wetland Resources (1995) (Ref 11-6);
- The Physical Planning Act (2010) (Ref 11-7);
- National Development Plan, 2010 (2015 version awaiting adoption) (Ref 11-8);
- Nwoya District Development Plan 2015/16-2019/2020 (Ref 11-9) , Buliisa District Development Plan 2015/16-2019/2020 (Ref 11-10) and The Masindi District 2015/2016 – 2019/2020 Development Plan (Ref 11-11);
- Strategic Plan, National Environment Management Authority 2009 / 2010-2013 / 2014 (Ref 11-12).
- Uganda Wildlife Authority, Strategic Plan (2013-2018) (Ref 11-13); and
- Uganda Wildlife Authority, Murchison Falls National Park, Karuma Wildlife Reserve, Bugungu Wildlife Reserve (Murchison Falls Protected Area) General Management Plan (2012-2022) (MFNP GMP) (Ref 11-14).

11.3.2 International Standards

11.3.2.1 International Finance Corporation (IFC) Performance Standards (PS)

The Relevant Performance Standard within the IFC standard relates to Performance Standard 3: Resource Efficiency and Pollution Prevention (2012) (Ref 11-15) which considers that the term ‘pollution’ includes potential visual impacts, including light.

11.3.2.2 EHS Guidelines

IFC (2007) Environmental, Health and Safety (EHS) Guidelines for Onshore Oil & Gas Development (Ref 11-16). The EHS Guideline states that *“the visual impact of permanent facilities should be considered in design so that impacts on the existing landscape are minimized. The design should take advantage of the existing topography and vegetation, and should use low profile facilities and storage tanks if technically feasible and if the overall facility footprint is not significantly increased. In addition, consider suitable paint colour for large structures that can blend with the background.”*

IFC (2007) EHS Guidelines for Construction Materials Extraction (Ref 11-17). The EHS Guideline provides an overview of techniques to minimise land conversion impacts.

11.3.2.3 European Landscape Convention

In the absence of dedicated national or regional standards to support the LVIA, those outlined within the European Landscape Convention have informed the understanding and approach to the assessment as these have been considered a best practice guide. The key principal of The European Landscape Convention considers that every landscape forms the setting for the lives of the population concerned and the quality of those landscapes affects everyone’s lives.

European Landscape Convention (ELC) (Ref 11-18) defines landscape as *‘…an area, as perceived by people, whose character is the result of the action and interaction of natural and / or human factors”.* The resulting fundamental principal of landscape assessment is that landscape is everywhere and all landscape has character. The implications of this outlines the importance of sympathetic planning, design and management they offer an opportunity to provide a more harmonious link between the built environment and the natural world, for the benefit of both.

The ELC also recognises the need for sensitive, informed, and integrated approaches to conserve, enhance, restore and regenerate landscapes that are attractive, diverse and publicly valued, interrelated links between the environmental, social and economic benefits. These broad principals are non-specific and can be adopted for any site or locations.

11.3.2.4 Guidelines for Landscape and Visual impact assessment

Guidelines for Landscape and Visual Impact Assessment. Landscape Institute and Institute of Environmental Management and Assessment (2013), Guidelines on Landscape and Visual Impact

Assessment (GLVIA) Third Edition. This guidance is considered best practice in a number of countries. In the absence of specific Uganda guidelines, the principals of this Guidance have been followed while the assessment criteria have been refined to suit the Project. The GLVIA places an emphasis on the identification of likely significant impacts and provides the principles and process of the LVIA.

11.4 Spatial and Temporal Boundaries

The Project Area is defined by the boundaries of the Exploration Area 1A (EA-1A), Contract Area 1 (CA-1) and License Area 2 (LA-2) North, whilst the extent of the Project Area of Influence (AoI) is explained in ***Chapter 1: Introduction***. The description of the Project has been broken down into the four following phases: Site Preparation and Enabling Works, Construction and Pre-Commissioning, Commissioning and Operations, and Decommissioning.

A Study Area of 5 kilometres (km) from the site boundary of each of the permanent Project components as described in the Project Description has been identified for the LVIA. The 5 km distance allows for a comprehensive overview of the local landscape and visual context to be achieved and covers all receptors considered to have the potential to be significantly affected by the Project components.

The extent of the Study Area, shown on Figure 11-1 has been derived from a review of maps and aerial photographs and was further verified with on-site appraisal and analysis. Firstly, a broad area of search has been defined using Geographic Information System (GIS) based techniques to assess landform and topography in relation to the Project, which indicates the likely visual influence of the site.

The second stage has involved detailed field analysis to refine the visual envelope and Study Area. The visual envelope is the area of land from which the Project is theoretically visible, on the assumption that there are no intervening landform, vegetation or other elements.

The proposed timescales for the different phases of the Project are set out in ***Chapter 4: Project Description and Alternatives***. A brief summary of the timescales are provided below:

- Site Preparation and Enabling Works Phase expected to take approximately 5 years;
- Construction and Pre-Commissioning is expected to take up to 7 years;
- Commissioning and Operation is expected to commence approximately 36 months after effective date of the main construction contract award. The lifetime of the Project is 25 years; and
- Decommissioning is planned for the end of the 25 year operation.

The phases overlap and in total the duration through all phases will be approximately 28 years. The duration of individual activities which may lead to potential visual and landscape impacts differ between short and long term episodes, all of which are described within the assessment.

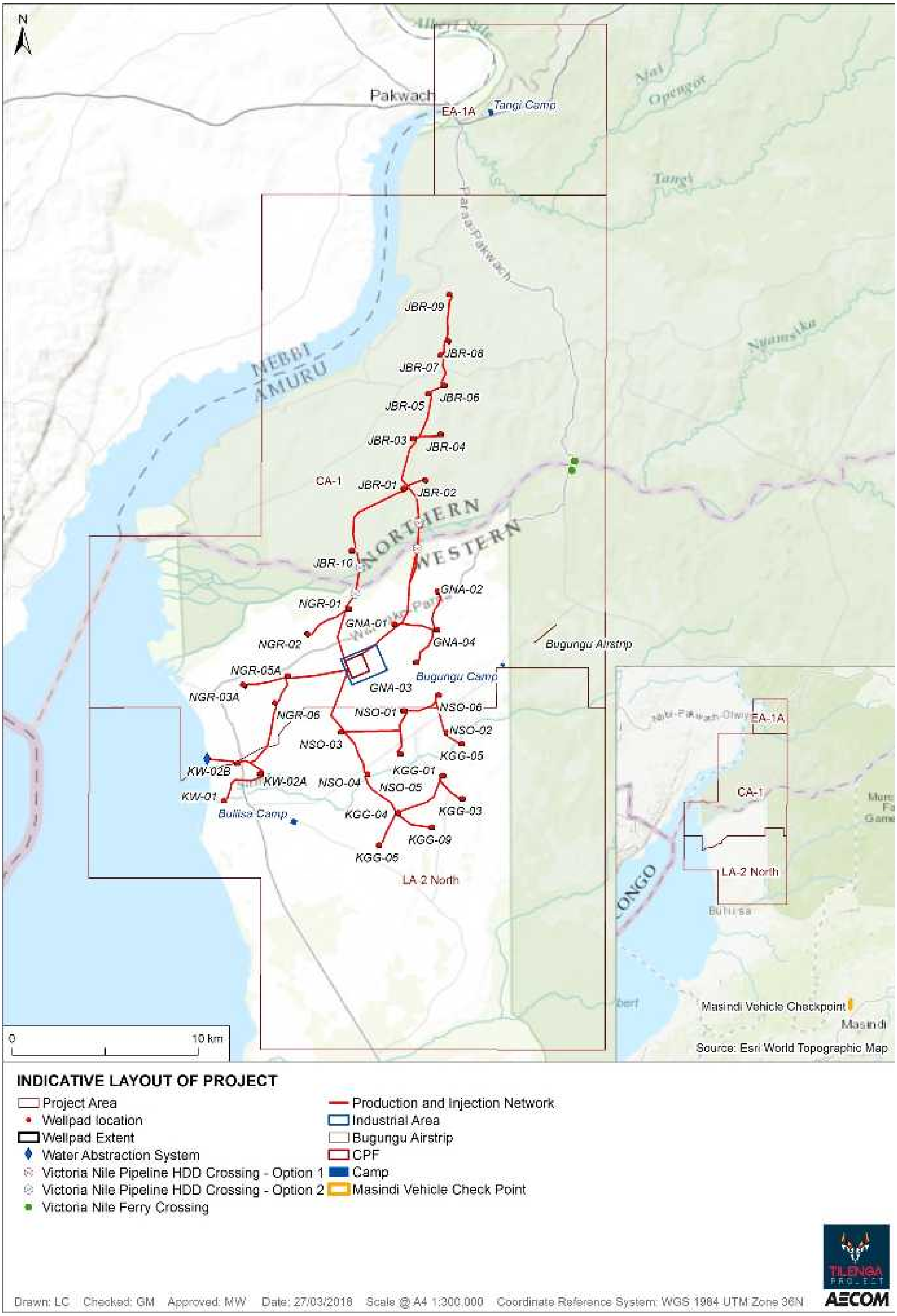

Figure 11-1: Indicative Layout of Project

11.5 Baseline Data

11.5.1 Introduction

In order to undertake an assessment of potential effects it is first essential to establish the existing baseline conditions. The establishment of baseline conditions of the landscape and visual resource has thus far involved a desk study subsequently verified through field work, GIS/computer analysis and informed by local knowledge.

This section provides a description and analysis of the existing landscape designations, landscape character areas/types and existing visual resource. The Study Area is extensive and contains a number of landscape and visual receptors, including settlements, tourist locations and routes.

Key terminology:

- ***Landscape Character Areas (LCAs)***: Areas which are unique, discrete geographical areas of the landscape which demonstrate a series of recognisable features and characteristics;
- ***Visual amenity***: "The overall pleasantness of the views people enjoy of their surroundings, which provides an attractive visual setting or backdrop for the enjoyment of activities of the people living, working, recreating, visiting or travelling through the area" (Ref 11-19); and
- ***Representative viewpoints***: views selected to represent the experience of different types of visual receptor, where larger numbers of viewpoints cannot be included individually and where significant effects are unlikely to differ.

11.5.2 Baseline Data Collection

11.5.2.1 Methodology and data

This section provides details of landscape and visual surveys undertaken within the Study Area as well as providing data sourced from secondary sources as described by 11.5.3. All of this information is then used to help identify the baseline conditions using the following key stages.

11.5.2.1.1 Stage 1 Desk Study

The initial desk study reviewed the existing GIS mapping and relevant documents that cover the Study Area. This review focused on the physical and human influences that have shaped the landscape resource. Physical influences included the landform land cover patterns of development and human occupation. The study also took account of high level cultural and social factors and influences of current pressures for change acting on the landscape of the Study Area.

11.5.2.1.2 Stage 2 Landscape Characterisation

Overlays of desktop information are produced from GIS mapping for ecology, landform, land use and environmental designations. Analysis of this data which covers the natural and perceptual attributes of the landscape informed the development of draft landscape character areas prior to refining in the field.

11.5.2.1.3 Stage 3 Field Survey

A standardised digital field survey sheet was developed on ArcPad to allow the systematic collection of information to add to the desk study. The primary purpose of this was to capture the aesthetic and experiential qualities of the landscape to better inform the boundaries of the draft LCAs and the key characteristics. A summary of the field survey is outlined in section 11.5.4.1.

11.5.2.1.4 Stage 4 Classification and Description

Landscape Character

A final review of the LCA boundaries was undertaken combining the desk based research, field maps and field survey sheets from which summary descriptions and key characteristics were compiled. Boundaries to LCAs are defined but field observation identified a gradual transition in landscape character which rarely changes abruptly apart from at the boundary to MFNP. Although the boundary of the MFNP is not always clearly signposted it is well defined by the transition in vegetation and land use, subtly demarcated, often with white painted stones.

Visual Amenity

Viewpoints captured during field survey were reviewed and 18 viewpoints selected. The viewpoints provide a range of views and viewer types, including settlements, transport routes, recreational routes, main visitor locations and a variety of distances, aspects, and elevations. Subsequently a baseline panorama image for each of the selected viewpoints was produced and has informed the baseline description of each.

11.5.3 Secondary Baseline

Information from the scoping report regarding the landscape and visual context has been summarised above and has informed the scope of the baseline studies. In addition a research exercise into existing documents provided by Total Exploration & Production (E&P) Uganda B.V (TEP Uganda) and Tullow Uganda Operations Pty Ltd (TUOP) has supplemented the landscape and visual baseline.

However it must be noted that specific information regarding landscape character and visual amenity is limited. Broad topics and documents that have contributed to understanding of landscape character baseline include; Geology; Landform; Hydrology; Soils; Land Use; Settlement; Enclosure; Perceptual and Aesthetic factors. The primary information sources most relevant are listed below:

- TUOP, Phase 2 Biodiversity Study: Landcover Mapping for the Albertine Rift Oil Project Basin, Exploration Areas EA1-3, (2015) (Ref 11-20).
- AECOM, on behalf of TUOP, Report on the Environmental Baseline in Exploration Area 2 Volume 1-3, (2012) (Ref 11-21).
- Atacama, prepared for TUOP, Archaeological, Historical and Cultural Baseline Study in exploration Area 2 (Lake Albert Basin) (Phase 1), (2013) (Ref 11-22).
- Artelia EAU & Environment, Social and Health Baseline Survey: Workstream ‘Tourism’ (2015) (Ref 11-23).

The Project baseline has been developed to provide a record against which future changes can be assessed. The data collection exercise focused solely on the Project Study Area and the potential receptors that may be potentially impacted.

11.5.4 Primary Data and Baseline Surveys

11.5.4.1 Summary of Field Survey

Field surveys were undertaken from the 27th November to 7th December 2016 and the 14th to 15th February 2018 to verify the draft landscape character areas in order to identify precise LCA boundaries. Furthermore, the field survey identified the selection of representative viewpoints.

The field survey followed an outline survey route, planned digitally and through analysis of potential survey points accessible by car, foot or watercraft. Field work was further informed by on-site judgement and also involved discussions with tourist lodge managers at Kabalega Wilderness Lodge, Baker’s Lodge, Murchison River Lodge and Nile River Lodge respectively (Refer to Table 11-1).

Local working knowledge of the landscape gained during field work was invaluable in contributing to the understanding of baseline conditions.

The survey was systematic, using written observations, digital map annotations, survey sheets and representative photographs. Standard survey forms were used to ensure landscape features and characteristics were recorded in a consistent manner. The landscape field survey also captured the aesthetic, perceptual and experiential quality of the landscape.

The survey of visual amenity considered a series of viewpoints from which the Project is likely to be seen from. This helped to inform the visual envelope and is analysed in conjunction with a generated Zone of Theoretical Visibility (ZTV) diagrams. Field work involved travelling to publicly accessible viewpoints across areas of land, routes and tourist lodges. The viewpoints selected were used as a tool to aid the assessment of visual effects. The visual study considers the potential influence of the mass and scale of the proposed infrastructure.

11.5.4.2 Data Assumptions and Limitations

There are no published Landscape Character Assessments for Uganda therefore, for the purpose of this Project, and in the absence of existing specific datasets, Geographical GIS and mapping has been used to collate and illustrate the graphical data provided as digital and paper mapping within the Study Area. These included data sets established in the desk based study such as draft landscape character area, local settlements, and proposed Project infrastructure. The visual assessment is based on 18 representative viewpoints which have been selected to represent the experience of the different types of visual receptor where significant visual impacts are most likely.

11.5.4.3 Primary Data - 2017 Early Works Baseline Study

As part of the Early Works Project Brief (Ref 11-24), AWE conducted a study in 2017 to provide an understanding of the landscape in the area that might be affected, including its character and condition.

An assessment was also undertaken for visual amenity to establish the areas in which the proposed development may be visible, the viewpoints from which it can be seen, the people who experience views at those points, and the nature of the views. Key viewpoints were selected on access routes including roads, walkways, and footpaths and at activity nodes e.g. residential areas, important public open spaces and landmarks, etc.

The study comprised a combination of desk study and field work to identify and record the character of the landscape and the elements, features and aesthetic and perceptual factors which contribute to it, as well as the value attached to the landscape in the Study Area.

The landscape assessment generally covered the following aspects:

- Physical aspects such as drainage, landform patterns that give rise to landscape character, and local and regional distinctiveness;
- Human aspects such as cultural features, landscape history, buildings and settlements, people affected and their perception of the landscape character; and
- Aesthetic aspects such as the views available, visual amenity and visual character.

Further details and results of the landscape and visual study undertaken by AWE have informed the baseline. A summary of the AWE Early Works Project Brief is provided in Appendix C.

11.5.5 Landscape Baseline Characteristics

This section presents an overview of the landscape context of the Study Area providing information about landscape character and its respective elements, the current condition of the landscape and national or local landscape designations. This section also sets out the landscape receptors to be assessed.

11.5.5.1 Study Area Context

The Study Area extends to 5 km in all directions from the key components of the Project and identified as being appropriate for a development of this nature. The Project's physical footprint inclusive of the boundaries of CA-1 and LA-2 North lie within the Buliisa and Nwoya Districts. The Project also includes the temporary conversion of the Masindi Airstrip to a vehicle transit checkpoint located approximately 10 km from Masindi, 70 km from Hoima and 80 km from Buliisa. The entire Project falls within the Albertine Graben, Western Uganda. The Albertine Rift region as a whole is recognised internationally for its biodiversity and ecological value which in turn influences the natural and cultural associations of the landscape.

The topography across the Project Area ranges from flat at LA-2 North to gently rolling lowlands within CA-1 and elevations range from approximately 600 metres (m) Above Sea Level (ASL), near Lake Albert, to 850-1,000 m ASL close to the eastern and western CA-1 boundary. More specifically, the greater elevations (1,000 m ASL) are located near the southwestern border of the west Nile area within CA-1, and are characterised by steep slopes typical of the pronounced rift escarpment. From this undulating zone the elevations gently decrease gradually eastward to the west bank of the Albert Nile River and Lake Albert in LA-2 at the lowest heights (600 – 650 m ASL) (see Figure 11-2).

Starting from the southeast of the Study Area, the landscape character is a narrow corridor of coastal fringe, running north to south along Lake Albert, south of the Victoria Nile. Reaching inland from the coastline, the arid landscape comprises a patchwork of dry grassland and bare ground with intermittent areas of thicket and scrub vegetation. The area's eastern boundary extends just beyond the Buliisa - Wanseko road which stretches south to north, joining these two larger settlements. The road runs parallel to the coastline up to 3 km inland before turning westwards and terminating at Wanseko. A concentration of settlements including, Ndandamire, Kigwera, Kisansya and Buliisa flank the road, making up the most densely populated corridor in the area. Each settlement is dispersed in nature, with key village centre focal points concentrated nearest the road. The MFNP occupies almost the entire northern compartment of the Study Area and falls mostly within CA-1.

Lake Albert is one of the most important natural resources within the Study Area and has shaped both the regional and local landscape, as well as supporting the natural and built environment throughout history. The divergence of the Victoria Nile into Lake Albert is an important wetland habitat and a key part of the landscape.

The Bugungu Wildlife Reserve contributes to the wider landscape context of the region and is an example of rich wooded landscape and is part of the wider conservation interests of the Murchison Falls Protection Area (MFPA). The unique landscape characteristics of the Study Area including the Nile Delta and MFNP contribute to its importance for tourism.

Project components within the Study Area to the north of the Victoria Nile are largely located within the MFNP. Whereas components south of the Victoria Nile are located in pockets of more densely populated areas typically consisting of dispersed dwellings, grazing land and domestic crops including cassava and banana.

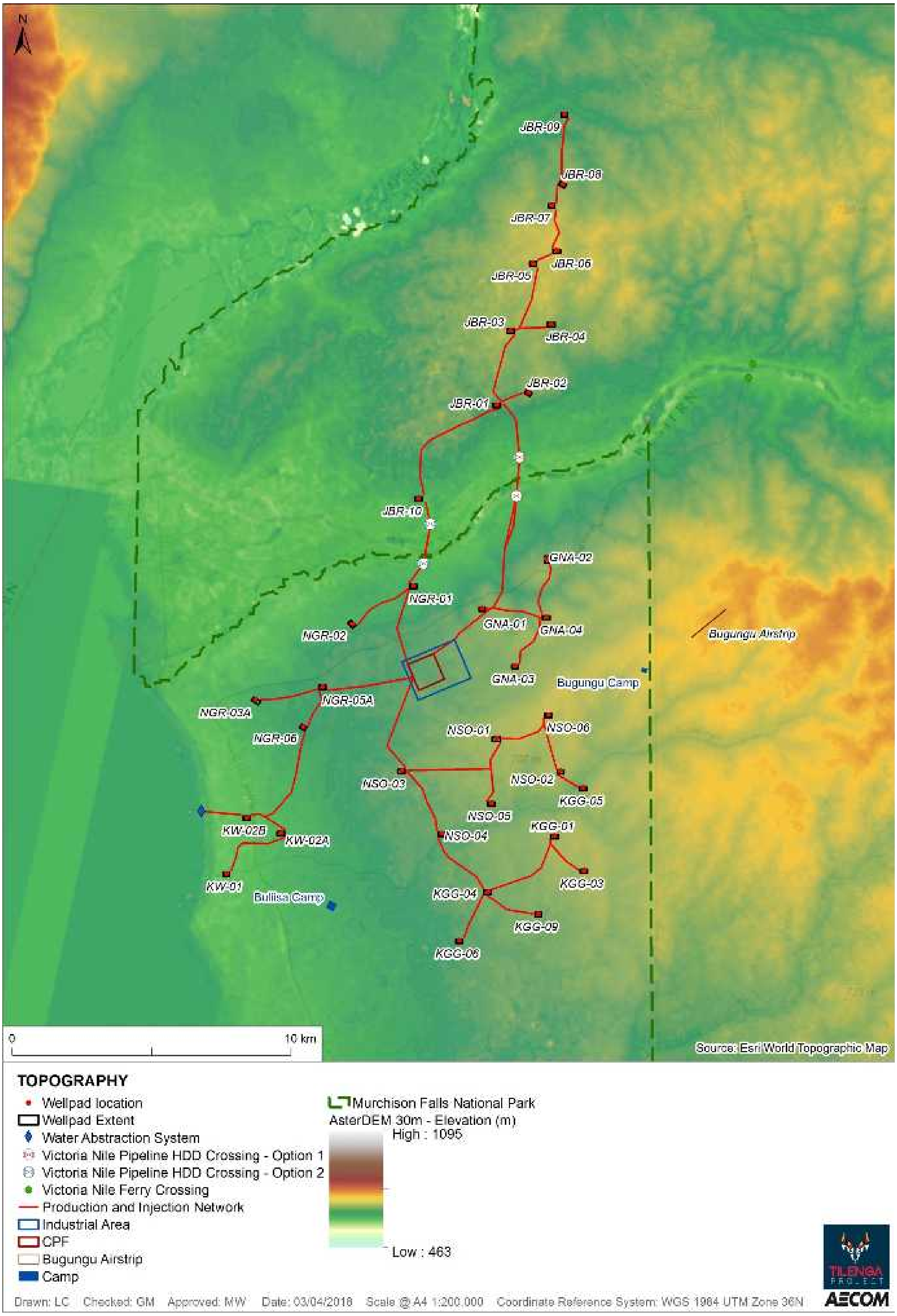

Figure 11-2: Topography

11.5.5.2 Landscape Character

The character of the landscape within the Study Area arises from natural process and human activities that have occurred over long periods to shape the land into its present condition. Many aspects which contribute to landscape character (e.g. cultural heritage, land use and ecology), are subject of separate sections of this report, however their contribution to, and influence on, character has been addressed within the assessment.

The landscape character of the Study Area is defined in this chapter at national level and developed in greater detail at local level.

The MFNP General Management Plan (GMP) is a useful source document, which characterises broad landscape types within MFNP. However these broad categories are more suited to inform strategic approaches for tourism and wilderness zones. The remainder of the Study Area is not described under any current landscape characterisation document. Therefore, Tilenga ESIA team has carried out a local landscape character assessment of the Study Area.

11.5.5.2.1 Landscape Designations

The Murchison Falls Protection Area (MFPA)

The MFPA is one of the oldest and the largest protected areas in Uganda. It comprises Murchison Falls National Park, Bugungu Wildlife Reserve and the adjacent Karuma Wildlife Reserve and acts as a wildlife buffer zone for the Murchison Falls National Park. The MFPA is not assessed as a whole; however, the relevant units that comprise the MFPA are assessed individually and outlined below.

Murchison Falls National Park (MFNP)

National Parks are wildlife protected areas of importance for conservation and management. MFNP has both international and national importance because of its biological diversity, landscape or national heritage in which biodiversity conservation, recreation, scenic viewing, scientific research and other economic activity may be permitted. The Murchison Falls National Park occupies the majority of west and northern compartments of the Study Area.

Although Murchison Falls was officially designated as a national park in 1952 under the ‘National Parks Act of Uganda’, some of the area has been recognised and protected since 1910 under the Bunyoro Game Reserve. The National Park covers 3,893 square kilometres (km²) and is managed by the Uganda Wildlife Authority (UWA), a semi-autonomous government agency that is responsible for conservation and management of Uganda’s wildlife. The UWA works within the remit of the Uganda Wildlife Act 1996 (Cap. 2000). This Act forms the basic legislation that governs National Parks and other protected areas and species. The park is identified as an area of national and international importance due to factors previously mentioned but specifically: landscape, recreation and scenic viewing.

Within the park also lies the Murchison Falls – Albert Delta Wetland System Ramsar Site, an internationally recognised ecological designation. This Ramsar site stretches from the top of Murchison Falls, where the River Nile flows through a rock cleft up to 6 m wide, to the delta at its confluence with Lake Albert. The convergence between Lake Albert and the delta forms a shallow area that is important for water birds. The rest of the site is dominated by rolling savannas and tall grass with increasingly thick bush, woodlands and forest patches in the higher and wetter areas to the south and east.

The MFNP GMP identifies a number of important zones within the park including the dual management and critical ecosystem zones; those most relevant to the landscape and visual resource include the following:

<u>MFNP Tourism Zone</u>

The Tourism Zone considers areas in Murchison ‘of spectacular scenery and wild game for visitor enjoyment. ‘…*Tourism use of Murchison Falls Protected Area currently comprises the launch trip to the Falls, the drive to the Falls, game-viewing in the Buligi area, and occasional visits by boat to the Delta for bird-watching’* (Ref. 11-14).

MFNP Wilderness Zone

The identified Wilderness Zone '*is an area comprising dense bush land and thicket with low wildlife numbers. This zone will be subjected to minimal disturbance where infrastructure will be limited to access tracks for patrols*' (Ref. 11-14). Access is limited to foot patrols. Boundaries of the Wilderness Zone are soft-edge, reflecting suitability-of-use, rather than strict regulation of activities. This designation is important for tourism activities.

MFNP falls across multiple Landscape Character Areas and influences the sensitivity and key characteristics of each individually. Therefore, to avoid duplication, the assessment of landscape effects is limited to each of the LCAs and not MFNP as a whole.

11.5.5.2.2 Local Landscape Character Areas

Landscape character areas are identified at a local level and comprise distinct areas which have particular combinations of landform, land cover and a consistent pattern of elements. Factors to be considered on site when identifying landscape character areas include:

- Land Cover and Vegetation Types;
- Geology;
- Landform;
- Hydrology;
- Soils;
- Land Use;
- Settlement;
- Enclosure;
- Cultural associations;
- Perceptual and Aesthetic factors; and
- Existing infrastructure.

The identified LCAs are shown on Figure 11-3. The key characteristics are described in the following paragraphs and illustrated by representative photographs.

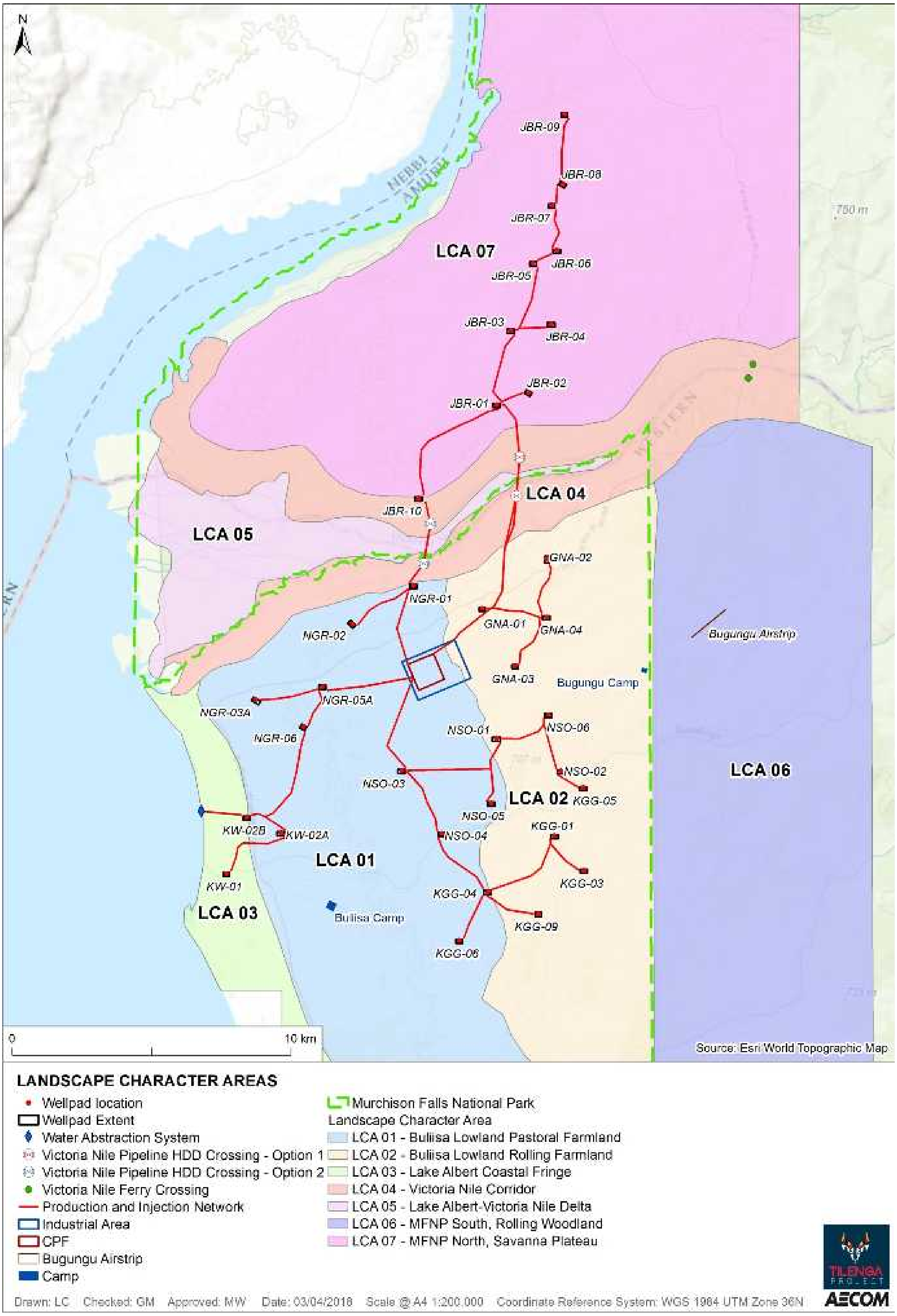

Figure 11-3: Landscape Character Areas

LCA 01 - Buliisa Lowland Pastoral Farmland

This LCA occupies a substantial part of the Study Area south of the Nile and west of the south MFNP; it flanks the Albert Coastal Fringe LCA to the west and the rolling farmlands to the east. This LCA consists of a broad open pastoral landscape. This open pasture features grazing cattle, short grasses and irregular patterns of semi mature to mature trees with elements of thicket. There are few sporadic settlements with a complex minor road network extending from the major routes between the larger settlements of Buliisa and to a lesser extent Ngwedo Town Centre.

Key Characteristics:

Topography

- Large scale pastoral lowland created by the vast escarpment across the Buliisa District.

Vegetation cover

- Vegetation is predominantly grassland for rough cattle grazing with sparse copse woodland. Grassland is extensive and up to 1.6 m tall in the wet season and almost bare in the dry season. The change in seasons alters and contributes to the dynamic texture and tone of this vast landscape.

Land use and field patterns

- Land use is almost entirely comprised of open rough grazing, commonly grazed by cattle and goats;
- In general there are no obvious field boundaries and livestock roam the open grasslands. However, some small areas, typically associated with homesteads, are enclosed by simple timber fencing, or prickly barrier planting;
- There are a number of former oil exploration pads that remain fenced and managed by the operators. These are flat open expanses devoid of activity. The physical influence of these flat expanses is limited to their immediate setting;
- There is a simple and repeating mosaic of habitats particularly where shelterbelts of acacia have been planted alongside occasional fruit trees, particularly mango; and
- Small pockets of woodland often associated with villages.

Settlement and pattern of tracks and roads

- Settlements are scattered and predominantly comprised of residential dwellings of simple construction, typically mud brick with thatch or metal sheet roof;
- Roads are typically of compacted earth track and larger townships feature some elements of infrastructure;
- The majority of residential dwellings are hidden within the thicket and are accessed by local tracks which transverse across this landscape in meandering contours; and
- The existence of few primary routes and infrequency of vehicles contribute to a tranquil setting across large expanses of pasture. The majority of movement is by people on foot or bicycle.

Views and perceptual qualities

- The monthly market at Kibambura is a key event and attracts trade with neighbouring townships and is a vibrant hub activity;
- Views short distance with occasional long framed views along linear roads and tracks;
- Occasional open views extend across this lowland landscape featuring the roofline of thatched and tin roofed residential dwellings; and

- Telecommunication masts and occasional overhead power lines from focal points in predominantly horizontal views containing few vertical elements.

Typical settlement set within grazed pasture.

Views along pedestrian track within Buliisa.

Kibambura Market day, December 2016.

Figure 11-4: Typical Characteristics within LCA 01

LCA 02 - Buliisa Lowland Rolling Farmland

This LCA occupies a single compartment within the Study Area, located south of the Nile extending to the southern extremity of the Study Area. The South MFNP and the lowland pastoral farmland character areas bound this LCA to the east and west respectively. This LCA is characterised by subsistence farming across a patchwork of agricultural gardens. The MFNP provides a distinct boundary to this LCA to the east and highlights the difference in condition and intactness of the landscape with the farmlands significantly degraded in comparison.

Key Characteristics:

Topography

- Expanse of rolling farmland gently rising west to east. This LCA extends across the sloped area from Ngwedo, with low rolling hills, between 610 m to 670 m ASL and smaller valleys which flood during the rainy seasons.

Vegetation cover

- Vegetation is predominately comprised of cultivated crops with occasional pockets of woodland and shelter belt planting. Larger mature trees tend to be associated near clusters of residential dwellings.

Land use and field patterns

- Land use is dominated by a dense network of small scale crop cultivation, in particular cassava of maize along with cotton and banana. These small scale field patterns are described locally as agricultural gardens;
- Field patterns and boundaries vary. Tall trees and cactus species demarcate ownership boundaries with some fields bound by informal tracks;
- There are a number of former oil exploration pads that remain fenced and managed by the operators. These are flat open expanses devoid of activity. The physical influence of these flat expanses is limited to their immediate setting;

- Clusters of trees typically mango, neem, and banana, alongside pockets of woodland and shelter belts provide habitats to the largely repeating crop gardens; and
- In the east, the transition between the agricultural fields and the MFNP is distinct and abrupt. Although not fenced, local communities respect the boundary of the park and land use encroachment is uncommon.

Settlement and pattern of tracks and roads

- Settlements are scattered across this landscape but less sporadic than the neighbouring pastoral farmlands. Clusters of dwellings tend to be centred on access to agricultural gardens. As a result there are less obvious tracks across the landscape and routes beyond the few primary roads follow field boundaries;
- Ngwedo Farm is a key agricultural hub for cash crops; and
- Movement and transport is at a human scale typically on foot or bicycle with very limited vehicular movement.

Views and perceptual qualities

- The majority of views are enclosed in the wet season by crops and channelled along tracks; however more open and long distance views are obtainable in the dry season;
- From the more open and elevated areas there are occasional long views north to the park and west to the mountain range in the Democratic Republic of Congo (DRC); and
- There is a close relationship with the neighbouring pastoral lowlands as many families work and live between the two character areas, with men largely working in the pastoral areas whilst women and children typically live in the agricultural farmlands and travel between the two at weekends.

Elevated area of cotton farmland.

Typical pattern of agricultural gardens including cassava.

Community centre and residential dwellings within agricultural farmland.

Figure 11-5: Typical Characteristics within LCA 02

LCA 03 - Lake Albert Coastal Fringe

This LCA is characterised by settled costal lowlands that line the eastern banks of Lake Albert and extends south from Wanseko Pier south to Bugongo. Much of this LCA is comprised of fishing communities set within fragmented landscape components.

An irregular pattern of gardens occupy areas at the periphery of settlements but are subject to pressures from animal grazing.

Key Characteristics:

Topography

- Much of this LCA lies on black sands clay and has been established as a lowland coastal landscape, fairly flat with some gentle undulation extending east to the pastoral farmlands.

Vegetation cover

- Vegetation cover is mixed, ranging from open grassland in the east to more wetland; and

- Wetlands are comprised of flat marshy grassland with sporadic groups of cacti and native scrub.

Land use and field patterns

- The wetland is used for free range animal grazing and as a drinking area; goats and sheep belonging to the settlements also graze in this area. However, there are no distinctive field boundaries;
- Small scale shell collection is evident;
- Landing sites for fishing boats tend to be located at the edge of fishing communities;
- There are a number of former oil exploration pads that remain fenced and managed by the operators. These are flat open expanses devoid of activity. The physical influence of these flat expanses is limited to their immediate setting; and
- The wetland and grazing landscape are largely focused on smaller areas off scrubland, partially submerged marshes and occasional belts of mature trees.

Settlement and pattern of tracks and roads

- Settlements are located along and adjacent to the primary road network that links the larger towns of Buliisa and Wanseko;
- Wanseko is the main town within this LCA. Wanseko Pier is a vibrant hub for fishermen and ferries cross between Panyimur (DRC) and Wanseko;
- The main arterial road that connects many of the smaller villages forms the eastern periphery of this LCA; and
- The shores of Lake Albert are primarily used for fishing activities and features some settlements and structures located directly on the lake shore such as the Kalolo landing site.

Views and perceptual qualities

- The shoreline is a distinctive and rare landscape feature that has perceptual connections for local fishing communities;
- These fishing communities are relatively busy in contrast to the more tranquil areas along the coast line which acts as informal recreational asset to local communities; and
- This coastal landscape is comparatively low lying but open and as such views west are wide angled and long, across Lake Albert to the hillside and mountains of DRC. The contrasting landform across the lake has a strong influence on the setting of this LCA.

Views west across the Lake Albert coastline towards Mountain range in DRC.

Views west, from small coastal fishing community.

Views along coastline of Lake Albert from Kisimo.

Figure 11-6: Typical Characteristics within LCA 03

LCA 04 - Victoria Nile Corridor

This LCA comprises of the north and south banks of the Victoria Nile and the adjoining scrub and woodland. This LCA extends from the eastern extent of Lake Albert, east across the Study Area along the Nile. The riverine forests that line the banks of the Nile are an important wildlife resource and the majority of this LCA falls within the national designated MFNP. The banks of the river also fall within the Murchison Falls-Albert Delta Wetland System (Ramsar site).

Key Characteristics:

Topography

- The boundaries of this LCA are influenced by topography. Landform rises steeply from the banks of the Nile into the riverine forests to the south and savanna plateau to the north.

Vegetation cover

- The river banks comprise riparian wetlands, dense closed forestry, typically featuring native woodland species;
- Linear blocks of wetland species and scrub line the banks of the river and form a physically impenetrable boundary to the wetland marshes; and
- As the landform rises vegetation is dominated by largely native bushland and thicket.

Land use and field patterns

- Land use comprises of a mix of subsistence and community farming (largely papyrus harvesting) towards the west and a dense network of bush and thicket extending east into the south MFNP;
- Land use in north MFNP is entirely comprised of designated parkland within which there is dense woodland scrub and wetland vegetation;
- This LCA is a relatively intact example of natural and semi natural landscape along the banks of the Nile.

Habitats

- Wetland and wet woodland habitats found along the banks of the Nile are valued wildlife habitats much of which lie within the designated MFNP.

Settlement and road pattern

- With the exception of UWA rangers settlements associated with park boundaries, there are no permanent residential settlements (as is the case throughout the MFNP). However, tourism activities can be experienced at the periphery of this area;
- In particular there is a cluster of tourist lodges along the south bank of the Nile, most of which are orientated north along the river corridor, which provides an indication of the importance of tourism in this area; and
- There are very few roads, limited to occasional tracks.

Views and perceptual qualities

- The density of the closed forest creates a sense of enclosure in many parts, limiting views and experiences beyond the immediate context;
- This is a very tranquil landscape with very little activity limited to the harmonious balance between localised tourism activities including safari tours and lodges, and subsistence farming;
- The savanna plateau to the north of this LCA heavily influences the setting of this landscape, which is also of historical and cultural importance; and

- Views throughout this LCA are generally limited by intervening topography and vegetation; however tourist lodges are generally constructed to offer framed views of the river corridor and the north MFNP.

Recreational assets

- Recreational opportunities include bird walks and wildlife viewing areas leading from the various tourist lodges set upon the banks of the river; and
- The Paraa ferry crossing is a key node and transport route for tourists accessing the park and people travelling between the surrounding communities.

Typical papyrus wetland along the south bank near Paraa ferry crossing.

Paraa ferry crossing, south bank.

Fire pit at Baker's Lodge.

Figure 11-7: Typical Characteristics within LCA 04

LCA 05 - Lake Albert-Victoria Nile Delta

This LCA stretches along the Nile corridor from Paraa to the Victoria Nile Delta at its confluence with Lake Albert. This area includes a series of islands and mix of temporary and permanent wetland. This LCA sits entirely within the Murchison Falls – Albert Delta Wetland System Ramsar Site and is an internationally designated ecological resource.

Key Characteristics:

Topography

- This LCA is entirely flat and at times partially submerged depending on water levels.

Vegetation cover

- The dynamic nature of the wetlands in this area are distinctive and feature wetland vegetation types set on peat and peaty sands which extend across an irregular network of associated islands; and
- The flat island plains are transverse by numerous tributaries flowing through the papyrus marsh.

Land use and field patterns

- This landscape is uninhabited by humans and comprises entirely of wetland species dominated by Papyrus swamps. The water itself is also used a source of water supply for livestock; and
- The network of islands that comprise this LCA provide a protected habitat for birds including a wide range of species.

Settlement and road pattern

- There are no settlements within this LCA. Overall existing infrastructure in this area is very limited which contributes to a sense of tranquillity.

Views and perceptual qualities

- Views within the LCA are experienced from watercrafts and channelled along the river corridor and towards the delta and to the savanna plateau of the north MFNP;

- This LCA is host to a number of tourists lodges and provides a naturalistic and unique setting at the water's edge and at the gateway to MFNP; and
- Views west towards the mountains of the DRC exert an influence on this LCA.

Recreational assets

- This LCA is a tourist destination even though land is not physically accessible; private boat trips tour the delta offering a tranquil experience. The majority leave from the Paraa crossing and tourist lodge docks and head upstream to the Murchison Falls.

***Views of papyrus wetland islands from watercraft*.**

Views northwest across the delta towards Mountain range in DRC.

Views of Delta islands from coastal plain of north MFNP.

Figure 11-8: Typical Characteristics within LCA 05

LCA 06 - MFNP South, Rolling Woodland

This is a particularly distinctive LCA located within both the Tourism and Wilderness Zones of the MFNP, south of the Nile. This landscape is predominantly comprised of dense rolling woods that occupy much the southern area of MFNP. Most of this landscape can be described as open wooded grassland.

Key Characteristics:

Topography

- Landform is varied and generally rolling with some small incised valley and erosion gullies. The westward drainage pattern informs the pattern of the landscape sweeping into the occasionally wet valley floors.

Vegetation cover

- Vegetation is dominated by mature and semi-mature woodland with a dense understorey of scrub opening up into more open rough grassland further south; and
- To the east of this LCA lies the unspoiled network of irregular incised valley characterised by dense woodland slopes to more open wooded areas with some bare ground at higher elevations.

Land use and field patterns

- Land use is entirely designated parkland, managed by the UWA;
- The Bugungu Airstrip is the only substantial area not designated for wildlife conservation;
- Burning occurs to control grassland and regenerate habitats;
- The park boundaries are controlled by UWA resulting in a clear distinction between the more lush vegetation within the park than the neighbouring agricultural gardens; and
- The closed canopy woodland and understorey found throughout this area are all of important nature conservation interest and value.

Settlement and road pattern

- There are no permanent residential settlements within this area as is the case throughout the park, however there are a number of tourist lodges and the UWA rangers station at Mubako at the western periphery of this LCA;
- There are few tracks and vehicle movement is generally limited to UWA rangers and tourist game drives, and the tracks tend to be of much greater quality and condition than those beyond its boundary; and
- Primary access through this part of the park is via the Bugungu gate, which leads to the Bugungu airstrip and the Paraa Ferry crossing.

Views and perceptual qualities

- There is very little human infrastructure and areas beyond the main tracks have almost no human access resulting in a distinctive tranquil and unspoilt landscape;
- The sense of wildness within this landscape is an intrinsic component; and
- Views are predominantly limited to the immediate extents due to the dense nature of the vegetation; however isolated more elevated areas offer long distance views north to the savanna plateau and east across the Buliisa lowlands.

Recreational assets

- Recreational opportunities include game drives, but typically pass through this part of the park heading north across the river or further east to Murchison Falls.

Typical Incised Gully within south MFNP.

Elevated views of woodland Canopy off the Paraa-Masindi-Pakwach Road.

Bugungu Gate to MFNP.

Figure 11-9: Typical Characteristics within LCA 06

LCA 07 - MFNP North, Savanna Plateau

This LCA falls entirely within the MFNP and occupies a large swathe within CA-1, north of the Victoria Nile Corridor LCA. This is a vast upland landscape characterised by open savanna grassland dotted with large swathes of palm trees. This LCA is entirely designated and provides substantial habitat for internationally important wildlife.

Key Characteristics:

Topography

- This LCA is a large scale upland plateau rising up from the river valley at 620m ASL to around 720m ASL from the valley slopes of the Nile corridor; and
- The plateau itself is vast and gently undulating.

Vegetation cover

- Vegetation is predominantly comprised of open savanna grassland with sporadic vast swathes of Palm trees sweeping across the landscape; and
- In addition, there are a number of other tree species dotted across this upland plateau, with more frequent clusters in isolated incised valleys which are seasonally wet.

Land use and field patterns

- The entire LCA is designated parkland, managed by UWA. The sparse woodland pattern follows the contours;
- Some belts of trees appear random but are heavily influenced by wildlife behaviour, in particular the spread of palm trees by elephants;
- Sensitively managed habitats, controlled by UWA Rangers who undertake conservation and landscape management for the benefit of habitat restoration and establishment; and
- Small watercourses/ tributaries fluctuate between the wet and dry season and are micro habitats.

Settlement and road pattern

- There are no permanent residential settlements within this area; however there are a number of tourist lodges and UWA ranger's station in the Paraa area. Lodges include; Paraa Safari Lodge, near the Nile and Pakubu Lodge, further north along the Lake Albert shoreline;
- There are a few winding tracks predominantly used for tourism, in particular game drives. Key tracks include the Albert Track, Delta Track and Buligi Track;
- A basic, small scale airstrip, comprising a runway and associated reception buildings and low key infrastructure at Pakuba is located in the northwest of this LCA; and
- Although past oil exploration developments have been undertaken, they have been completely restored with no obvious physical or visual signs of disruption to the landscape.

Views and perceptual qualities

- Panoramic open views can be experienced from a variety of locations across the landscape, particularly more elevated locations;
- Sense of wildness and natural landscape heightened by lack of infrastructure or human settlement;
- This LCA is an important tourism resource primarily for people seeking to experience the iconic wildlife from game tracks; and
- The UWA rangers working within this part of MFNP have strong associations and connections with this landscape and the landscape is highly revered.

Recreational assets

- The Buligi Circuit is a key recreational opportunity within this LCA and is popular with tourists. Taking this into account wildlife habitat forms a crucial role in this more open landscape, in which scenic quality is important. Open views across this LCA can be experienced throughout and offers a distinct scenic quality noted in the MFNP GMP and guide books; and
- This LCA offers distinct and highly valued scenic quality across a dramatic and iconic landform.

Elevated vista across open grassland from game track.

Scattered palm trees across savanna grassland.

Elevated vista from game track.

Figure 11-10: Typical Characteristics within LCA 07

11.5.6 Visual Amenity Baseline Characteristics

11.5.6.1 Analysis of Visual Envelope

The Project components are considered in detail within the Project Description (***Chapter 4: Project Description and Alternatives***). The Project Area to the north of the Nile (e.g. north of CA-1) generally offers a more widespread visibility compared further south (e.g. LA-2) due to topography and the grassland vegetation. CA-1 is highly valued and recognised as a scenic tourist area through which popular safari routes pass. LA-2's rolling lowland topography results in a range of scenic qualities form very short vistas to occasional medium and distant views from isolated highpoints.

Much of the settlements throughout the Study Area are inward orientated and focused on agricultural activities. The irregular patchwork pattern of pastoral grazing, agricultural gardens, settlements and minor routes through them often limit vistas. The larger primary routes such as the Buliisa- Paraa Road offer longer framed views. Views from the more rolling agricultural farmlands occasionally offer elevated and long distance views north across to the north MFNP and west towards Lake Albert. The contrasting landform of the mountain range within DRC, west of Lake Albert draws the focus of views towards the elevated west.

11.5.6.2 Protected Views

No recognised protected views, such as designated specific viewpoints marked on maps, have been identified within the Study Area. However throughout the MFNP, it is likely that people, in particular tourists will generally attribute a high value to many views within this National Park and the visual quality of much of this area has few existing detractors.

11.5.6.3 Key Visual Receptors

The visual assessment considers the changes that people would likely see in views from various locations. Viewers can include but are not limited to residents, and all forms of tourists using recreational routes, safaris, and road users.

Potential visual receptors include:

- People visiting the MFNP for recreational purposes, using the local road network, game tracks and waterways;
- People who work within the MFNP and nearby settlements;
- People passing through the area, particularly on the major transport routes; and
- People living in the major and minor settlements within close proximity to Project components where little screening is provided by vegetation or topography.

11.5.6.3.1 Residential settlements

There is a dispersed spread of settlements and small villages across the Study Area, in particular within LA-2, south of the Nile. There are a number of identified larger settlements from which smaller villages disseminate from, typically adjacent to primary transport routes. The larger settlements of Wanseko, Buliisa and Ngwedo Town Centre along with adjacent villages feature the highest concentrations for visual receptors. Viewpoints 1, 2, 3, 4 5, 16 and 17 have been selected to represent views from residential receptors.

11.5.6.3.2 Tourist Destinations

Lodges

Tourist lodges and camp sites are important visual receptors and are concentrated within the MFNP near along the Nile in close proximity to the Paraa Ferry Crossing. Tourist destinations within the nationally recognised MFNP and associated views are considered to be an intrinsic characteristic of the tourist experience. Figure 11-11 outlines the locations of current tourist lodges in the area.

Viewpoints 7, 8, 9, 10 and 11 are representative of the tourist lodges across the Study Area.

Paraa Area

Though not a settlement in its own right, Paraa is an important tourist hub for the MFNP, through which major roads converge. The Ferry terminal and route is an important visual receptor. The convergence of various routes and important ancillary facilities and frequent footfall in comparison to other areas within the Study Area warrants the inclusion of Paraa as an important visual receptor. Potential views of the Victoria Nile Ferry Crossing are likely from Viewpoint 12, Paraa Crossing however, views of much of the Project are unlikely from this area due to topography and vegetation screening views from the most sensitive locations.

11.5.6.3.3 Recreational Routes

Buligi Circuit

The Buligi Circuit is the most popular safari route within the MFNP. This 170 km route is a network of spaces through MFNP centred from Paraa and is the primary area for game viewing located within the peninsula between the Victoria and the Albert Niles. The route passes through the open savanna landscape and riverine corridors along the Nile (Ref. 11-25). Although the scenic quality of the circuit plays an important role in context of wildlife viewing, the primary focus of the view is generally on the wildlife itself.

Viewpoints 13 and 18 have been selected to represent open views from this tourist route.

Paraa Ferry Crossing

The Paraa Ferry crossing is a primary transport route primarily for tourists to access the areas of the MFNP either side of the Nile. Views at each terminal and along this route offer more open views which extend along the Nile corridor and feature many of the characteristic elements of the landscape. The width and depth of views along the Victoria Nile varies along this sequential route.

Viewpoint 12 has been selected to represent the likely visual effects from the Paraa area and crossing.

Other MFNP Game Tracks

A complex network of informal game tracks weave throughout the MFNP. The nature of views ranges within these areas but most are typically enclosed with limited glimpses beyond the immediate context. This is often due to the sheer density of the forest and thicket vegetation or may result from the height of adjacent grassland vegetation. The primary focus of recreational users along these tracks is to experience views of wildlife rather than the scenic qualities that provide the wider context in which these habitats exist. There are however elevated locations along these tracks offering long distance and panoramic views across the savanna plateau.

Viewpoint 14 is representative of views from game tracks offering open and panoramic views.

11.5.6.3.4 Transport Routes

The Buliisa – Wanseko Road, Buliisa-Paraa Road, Wanseko-Paraa Road and tracks to associated towns and villages, are primary transport routes through the Study Area and inform the visual resource baseline. There is an extensive network of pedestrian tracks used by the local population which offers typically short to middle distant views often limited by the gently undulating topography and vegetation. Transport routes offer sequential views, some of which are from elevated areas which offer more long distance views west towards Lake Albert and north towards the savanna plateau.

Viewpoint 6 has been selected to be representative of the local road network within the Study Area.

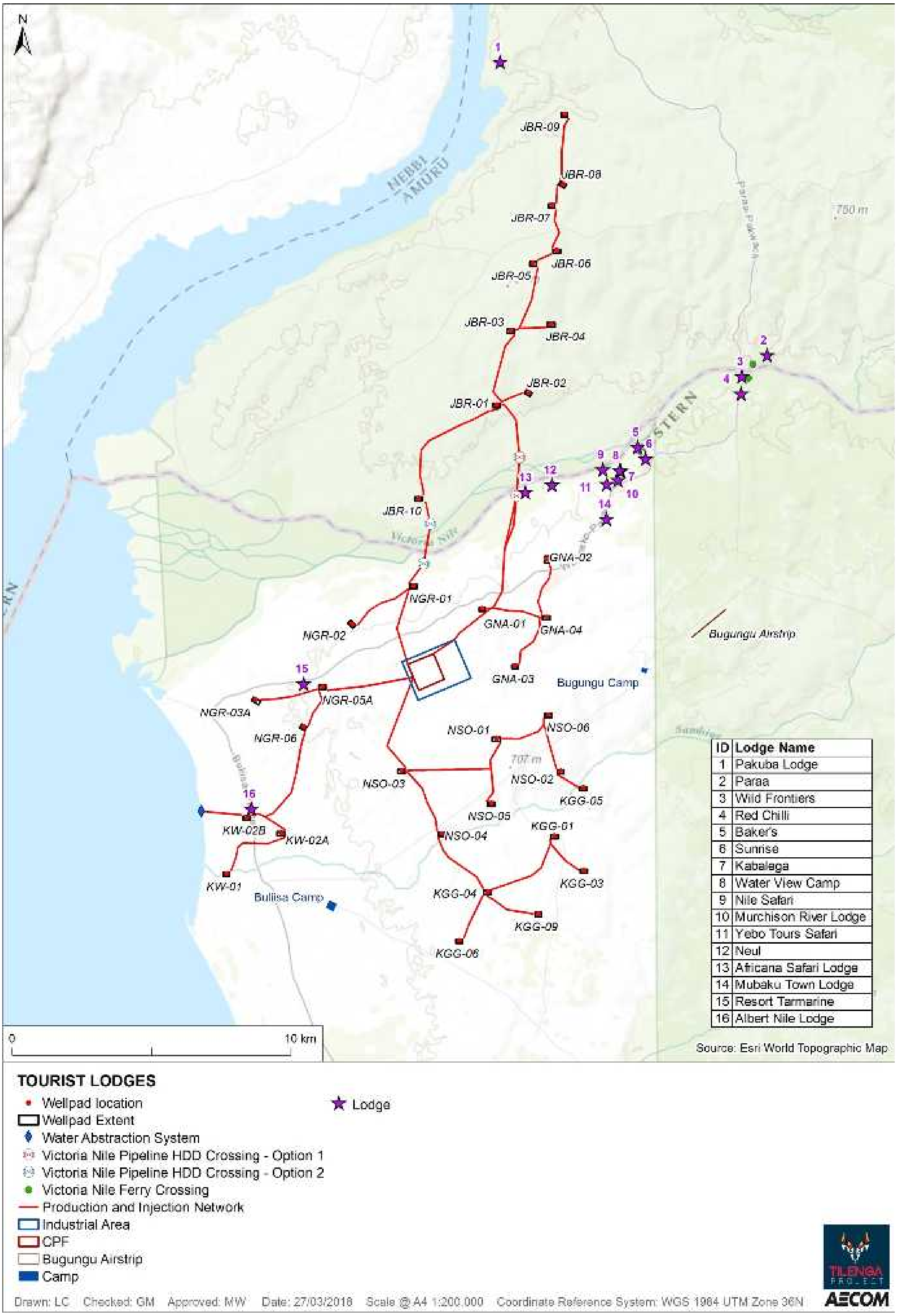

Figure 11-11: Tourist Lodges

11.5.6.4 Viewpoints

Eighteen representative viewpoints have been selected to cover a range of views and viewer types, including settlements, transport routes, recreational routes, main visitor locations and a variety of distances, aspects, and elevations. These viewpoints are intended to represent the typical views that people who live, visit and pass through the Study Area are likely to experience. Viewpoint locations were selected following a familiarisation site visit and informed by analysis of the visual envelope and local knowledge. A baseline description for each viewpoint, considers the following:

- Receptor type (residents / road / footpath / open space etc.);
- Relative numbers of people represented by the viewpoint; and
- Nature of the existing view (composition, quality, key characteristics - nature and extent of skyline, aspects of visual scale and proportion and key foci).

Viewpoints used to assess the visual effects are listed in Table 11-1 below, illustrated on Figure 11-12 and shown on Figure 11-13 to Figure 11-30.

Table 11-1: Representative Viewpoints

ID	Viewpoint Name	Receptor Type	Grid reference		Distance to potentially visible Project components
			Easting	Northing	
1	Kimoli	Residential	328958	242632	146 m - Industrial Area
2	Kibambura	Residential	329701	236482	506 m - NSO-04
3	Buliisa (West)	Residential	322440	234416	539 m - KW-01
4	Kisimo	Residential	321246	235327	1 km - KW-01
5	Kirama	Residential	324156	241274	1.3 km - NGR-03A
6	Ngwedo Farm	Road User	333228	238973	4.7 km - NSO-04 2.6 km - NSO-05 3.6 km - Industrial Area
7	Baker's Lodge	Tourist Lodge	336700	249876	5.3 km - JBR-01 4.4 km - JBR-02
8	Kabalega Wilderness Lodge	Tourist Lodge	335936	249278	4.8 km - JBR-01 4.1 km - JBR-02
9	Murchison River Lodge	Tourist Lodge	335706	249186	4.7 km - JBR-01 3.9 km - JBR-02
10	Nile River Lodge	Tourist Lodge	335397	249053	3.8 km - JBR-02 4.5 km - JBR-01
11	Pakuba Safari Lodge	Tourist Lodge	332201	263784	2.8 km - JBR-09
12	Paraa Ferry Crossing	Tourist Route	340705	252814	111 m - Paraa ferry crossing (North)
13	Buligi Track, Delta Track Junction	Tourist Route	335127	257535	2.4 km - JBR-05 1.5 km - JBR-06 1.9 km - JBR-07
14	Albert Track	Tourist Route	329628	257317	3.4 km - JBR-05 4.2 km - JBR-06 4.1 km - JBR-07
15	Wanseko beach	Recreational	319358	240681	4.2 km - Water Abstraction System 3.6 km - NGR-03A
16	Kasinyi (West)	Residential	328809	245077	642 m - HDD pipeline crossing 252 m - NGR-01

ID	Viewpoint Name	Receptor Type	Grid reference		Distance to potentially visible Project components
			Easting	Northing	
17	Kasinyi (East)	Residential	330667	242950	518m - Industrial Area
18	Buligi Track (Pakubu Airfield)	Tourist Route	331419	256834	1.5km - JBR-05 2.4km - JBR-06 2.8km – JBR-07

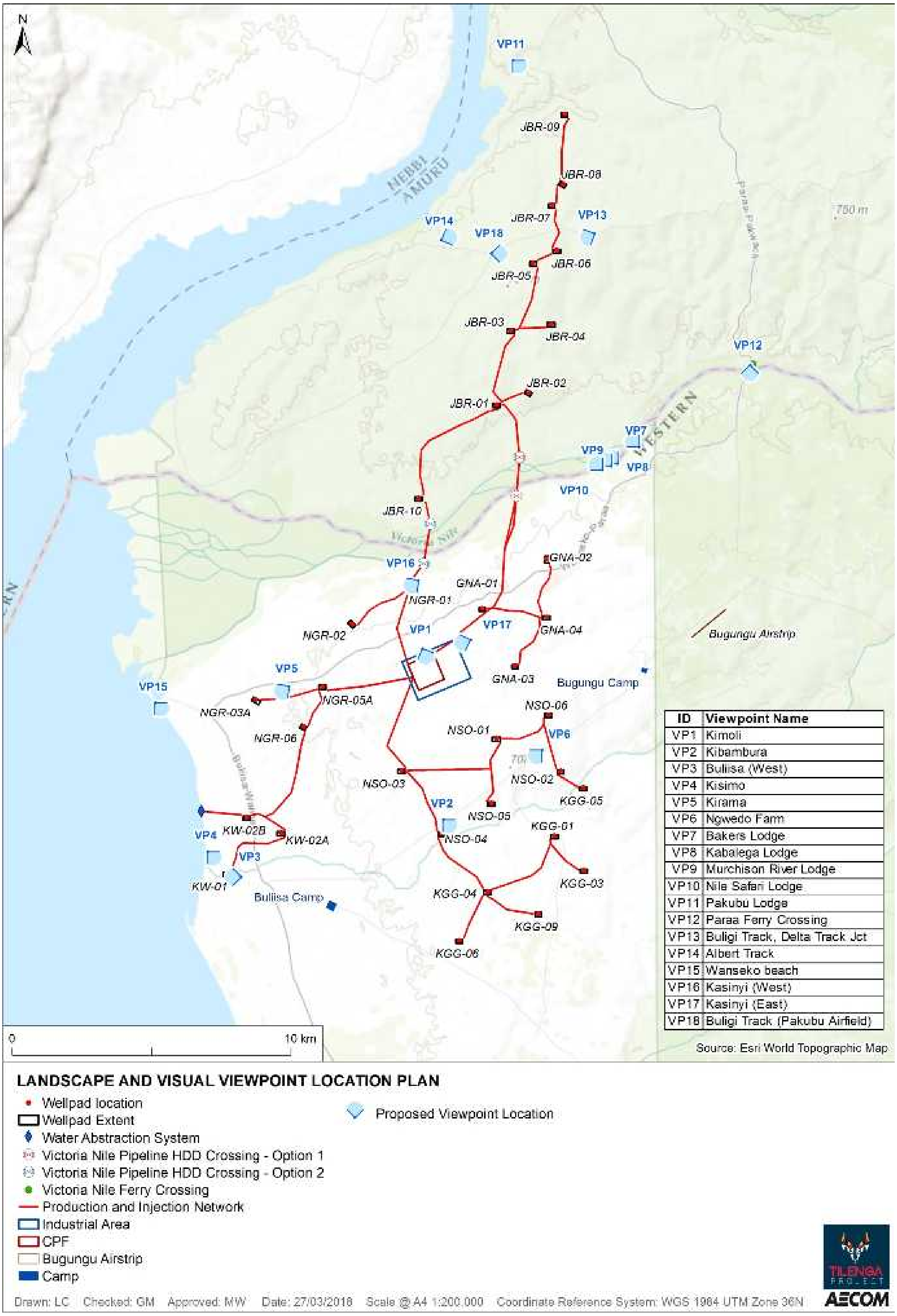

Figure 11-12: Viewpoint Location Plan

11.5.6.4.1 Viewpoint Descriptions

The section below provides a description of the existing views experienced by the receptor. These are supported by baseline panoramic photographs that are mostly orientated towards the proposed Project comments that have the potential to alter the existing view. The photographs (Figure 11-13 to Figure 11-30) are illustrative at about 90 degrees rather than a full 360 degree panorama.

Viewpoint 1 - Kimoli

Shown on Figure 11-13, this viewpoint, which is representative of residents in the Kimoli area, illustrates views to the south towards the proposed Central Processing Facility (CPF)/Industrial area site. The foreground to middle ground is characterised by the rough grassland with the emerging thatch roof dwellings. The low scale and height of development and grassland expanse enable middle distant and wide angled views. However, the background of the view is contained by the linear belt of woodland trees with one particularly tall mature tree, which is an identifiable and clearly distinguishable feature on the skyline. This is a typical residential view from within the pastoral farmland LCA in which the sporadic thatch roofs are an intrinsic visual characteristic.

Viewpoint 2 - Kibambura

Shown on Figure 11-14, this medium distance view, looking southeast from the boundary of Kibambura Primary School grounds, adjacent to residential dwellings, is representative of residents of Kibambura. The foreground is comprised of the main road which is the primary route through this settlement connecting to minor tracks. The middle ground consists of rough grass land fragmented by clusters of trees and shrubs. The fragmented tree line extends into the background with the occasional thatch roof appearing on the skyline. This is a common view within this area in which the scale of vegetation is the largest feature. The road corridor and associated activity is the primary focus of views and is seen in succession with Kibambura Primary School, the most noticeable structure within the surrounding context. The fragmented spread of mature trees across the middle and background heavily filters views beyond.

Viewpoint 3 - Buliisa (West)

Shown on Figure 11-15, this view, looking west along the minor track, is representative of residents from the clusters of dwellings east of Buliisa town centre who may have an appreciation of the view. This is a medium distance view in which the foreground is comprised of a small track alongside a cluster of residential dwellings set within grazed pasture. The left of the view is characterised by bush thicket which extends into the middle ground, characterised by a line of taller shrubs and trees, bisected by the track, which filter views beyond. The background is delineated by the mountain range of the DRC beyond Lake Albert. The mud and thatch dwellings are the only noticeable built features within the view but are comparable in scale to the surrounding vegetation. However, the small scale nature of foreground features is in contrast with the vast scale of the mountain range sitting on the distant horizon and provides the focus to the view.

Viewpoint 4 - Kisimo

Shown on Figure 11-16, this long distance view looks southeast from the edge of the settlement of Kisimo and is representative of residents in this local community. The foreground is comprised of the scattered layout of thatch and metal sheet roof dwellings set within grazed pasture, bisected by pedestrian tracks. The pasture grassland extends into middle ground, in which the grass is rougher and there are sporadic clumps of thicket and small trees alongside small thatched roof dwellings. The background predominantly comprises of thicket and trees forming a consistent and relatively unbroken skyline. However, two communications masts in Buliisa can be seen on the distant horizon and assist in wayfinding. The comparable scale of development and vegetation tends to focus views to the immediate foreground context.

Viewpoint 5 - Kirama

Shown on Figure 11-17, this viewpoint is located within the settlement of Kirama located off the main Wanseko-Paraa Road and is representative of residents. Views south are comprised of open grassland with occasional trees and the rooflines of residential properties that break the skyline. Views north are similar across the foreground and middle ground, however the savanna plateau of the north MFNP sits on the horizon and although distant, feature within the view and is a more notable focus than the more typical views south of grazing land.

Viewpoint 6 - Ngwedo Farm

Shown on Figure 11-18, this channelled view looks southwest from the Buliisa-Paraa Road and is representative of road users including pedestrians, cyclists and people using vehicles. The foreground of the view is comprised of the main dirt track road and the vegetated banks and ditches. Garden boundary trees occupy an elevated position on either side of the road. Swathes of tall grass line the road embankment which channels views along the downward sloping road corridor through the middle ground in which cassava crops emerge above the embankments either side of the road. The road itself continues along a straight line slightly rising and extending toward the far distance, bisecting the block of trees extending across the horizon line. The communications mast on the skyline, just north of the road is the tallest and most prominent feature visible and is a reference point in the landscape indicating the presence of Ngwedo Town Centre. The vertical extent of the communications mast is in stark contrast to the surrounding elements in the view and is the principal focus of the view.

Viewpoint 7 - Baker’s Lodge

Shown on Figure 11-19, this viewpoint is located at Baker’s Lodge, along the south bank of the Nile, and is representative of tourists visiting this lodge. This view looks northwest and is located in front of the thatched roof central lounge area, where evening fires are lit for enjoyment and creation. The immediate foreground is characterised by the landing steps and grassed river bank, punctuated by the sole tree, which acts as a location reference for docking watercrafts. The middle ground is comprised entirely of the calm waters of the Victoria Nile in which hippos, buffalo and other wildlife emerge above the surface of the water alongside the occasional watercraft. The background view consists of the wooded north bank of the river contributing to a consistent skyline. This iconic setting at the river’s edge is synonymous with tourists and the key focus of this largely horizontal view.

Viewpoint 8 - Kabalega Wilderness Lodge

Shown on Figure 11-20, this view looking northwest is located at the sunset viewing platform of the Kabalega Wilderness Lodge and is representative of tourists visiting this lodge. The foreground of the view is comprised of the viewing platform and mature trees that frame the view. The middle ground steeply slopes down to the bank of the river. The calm river waters gently extend to the bright green wetland marshes of the north bank. The background is characterised by the north bank of the river rising up through the forested slopes and beyond to the savanna plateau of the north MFNP. The contrasting tones of the river, lush papyrus wetlands and golden savanna are integral to the iconic image of the park. This is an elevated view designed to capture a small section of the Victoria Nile framed to capture the sunset.

Viewpoint 9 - Murchison River Lodge

Shown on Figure 11-21, this view looking west-northwest is located at the sunset viewing platform at the Murchison River Lodge and is representative of tourists visiting this lodge. This is a framed view of the Victoria Nile elevated and orientated towards the sunset. The foreground slopes from the viewing platform down through the thicket and wetlands along the south bank of the Victoria Nile. The middle ground extends across the calm river water to the papyrus wetland islands along the north bank. From this location these wetland islands seem joined as one stretching across the bank and rising up through the closed canopy woodland up to the savanna plateau on the distant horizon. The consistent scale of vegetation and gently rising landform on the horizon form a consistent skyline within MFNP. This is an attractive and iconic view of the river and the north bank of MFNP in which no human development or infrastructure is visible.

Viewpoint 10 - Nile River Lodge

Shown on Figure 11-22, this view looking west-northwest is located at the sunset viewing platform of the Nile River Lodge and is representative of tourists visiting this lodge. The foreground frames the view beyond and is comprised of the large tree and viewing platform orientated to capture sunsets. The foreground slopes steeply into the wetland south bank of the Nile and extends to the middle ground of the river. The view then extends across to the papyrus islands along the north bank which rises up into the closed canopy forested slopes within north MFNP. The background is comprised of the open woodlands of north MFNP rising up to the savanna grasslands on the distant horizon. The consistent scale of vegetation and gently rising landform on the horizon form a consistent skyline across MFNP. This view is framed and termed the 'Shoebill View' and is designed to capture views of wildlife within this attractive landscape setting. Human intervention is notably absent from this location.

Viewpoint 11 - Pakuba Safari Lodge

Shown on Figure 11-23, this slightly elevated view looks southeast from the entrance track to the Pakuba Safari Lodge, located near the eastern bank of the Albert Nile, and is representative of tourists visiting this safari lodge. Panoramic views from this location are an important part of the experience within the MFNP. The foreground is characterised by the rough grass, low shrubs and thicket bisected by the sandy dirt track, gently sloping away. The middle ground consists of scattered drifts of trees, typical of the upland savanna which seemingly stretches to the distant background beyond extending across this wide angled view. The ground is undulating, rising slightly to the west. The small scale height of the vegetation set alongside this vast landform results in an uninterrupted skyline. This is an expansive view and one that is distinctive of MFNP.

Viewpoint 12 - Paraa Ferry Crossing

Shown on Figure 11-24, this viewpoint is representative of people using the ferry crossing from the north terminal. The view looks south across the Victoria Nile River towards the south terminal. This route is frequently used by both tourists and locals alike; however the visual amenity for tourists is an integral part of the experience. This is a low level view characterised by the grassland vegetated north bank across the foreground interrupted by a boat trailer. The foreground and middle ground is characterised by the gently flowing watercourse extending to the north bank of the river. The background is comprised of the southern bank of the river where the ferry crossing and associated structures are clearly distinguishable in front of the densely vegetated backdrop. This is an attractive view of the river corridor which is the primary focus of the view.

Viewpoint 13 - Buligi Track, Delta Track Junction

Shown on Figure 11-25, this long distance view looking west from the junction between the Delta Track and the Buligi Track is representative of views experienced by tourists on game drives within MFNP. Expanses of open grassland define the foreground view and extend into the middle ground, punctuated but sporadic clumps of palm trees. The grassland expanse extends to the background in which more mature trees line the background, particularly in line with the Pakuba Airstrip. The hillside beyond the Albert Nile is visible on the distant horizon. The panoramic nature of this uninterrupted view is characteristic of the MFNP and provides a dramatic visual setting in which the focus of views is multi directional.

Viewpoint 14 - Albert Track

Shown on Figure 11-26, this medium level view, looking east from an elevated location on the Albert Track, is representative of views experienced by tourists on game drives within MFNP. The expansive grasslands and sporadic trees characterise the foreground-to-middle ground of the view. From this location the ground gently undulates north into the background where more trees populate the upland landscape. This is a panoramic, long distance view in which the vast scale of the landscape is the multidirectional focus of the view and distinctive of the upland expanse within this part of MFNP.

Viewpoint 15 - Wanseko Beach

Shown on Figure 11-27, this low level view looking southeast from the Lake Albert Coastline is representative of views experienced by local communities. This beach, although not designated is used for informal recreational use in which people have an appreciation of the visual amenity. The foreground is characterised by the sandy beach extending east into the marshy grasslands towards the main settlement of Wanseko. The middle ground is comprised of an expanse of marshy grassland, grazed by cattle. The background consists of consistent low level roofline comprised of thatch and metal sheet set against a backdrop or trees. A transitional band of vegetation cover marks the change between coastal edge and settlement. Transitional Communication masts within Wanseko and Buliisa break the skyline and are reference points within the view. This location is part of a well-used local resource because of its proximity to Lake Albert and recreational pursuits. The visual amenity is an important element and intrinsically linked to the appeal of the area. Users of the beach have an appreciation of the setting and an appreciation of the open vistas. This is a multi-directional view in which the mountain range to the west across the lake is viewed in succession with the beach and lowland escarpment to the east.

Viewpoint 16 - Kasinyi (West)

Shown on Figure 11-28, this viewpoint is representative of residential receptors with views southwest across open grazing land. This is an open and long distance view predominantly comprised of grassland with occasional individual trees extending from the foreground to the background. The middle ground of the view also features a cluster of thatch roof dwellings. No other structures break the skyline which is punctuated only by vegetation. This is a typical view with no particular focus.

Viewpoint 17 - Kasinyi (East)

Shown on Figure 11-29, this viewpoint is representative of residential receptors to the west of the village of Kasinyi. This is a relatively open, medium distance view, partly channelled along the road corridor. The foreground mango trees are typical of the vegetation located within the curtilage of local properties in Kasinyi. This view is orientated west and is typical of the local area in which sporadic trees appear above grassland within an open grazing landscape. There are no other distinguishable features on the skyline and there is no particular focus beyond the road corridor itself.

Viewpoint 18 - Buligi Track (Pakuba Airfield)

Shown on Figure 11-30, this long distance view looking east from the Buligi Track is representative of views experienced by tourists on game drives and travelling through the north MFNP. The view is characterised by open grasslands extending from the foreground to the distant horizon. Mature trees appear sporadically across the background whilst the fence at the Pakuba Airfield is noticeable in the middle distance. The uninterrupted nature of the panoramic view results in a multidirectional focus.

Existing view

This image provides landscape and visual context only

PROJECT: EA-1, EA-1A & EA2 North Project ESIA

CLIENT: Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd

OS reference: E 328958 N 242632
Distance to Proposal: 345m to CPF
Camera: Canon EOS 5D Mk2

Lens: 50mm (Canon EF 50mm f/1.8)
Date: 28/11/2016
Paper size: A3

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PROJECT NUMBER: 60429486
Baseline Panoramas
VIEWPOINT: 1. Kilomi
SHEET NUMBER 1 OF 15

Do not scale this document

Figure 11-13: Viewpoint 1 - Baseline Panorama Photograph

Existing view

This image provides landscape and visual context only

PROJECT:	EA-1, EA-1A & EA2 North Project ESIA	OS reference:	E 329701 N 236482	Lens:	50mm (Canon EF 50mm f/1.8)
		Distance to Proposal:	1004m to NSO-04	Date:	28/11/2016
CLIENT:	Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd	Camera:	Canon EOS 5D Mk2	Paper size:	A3

AECOM

PROJECT NUMBER: 60429486
Baseline Panoramas
VIEWPOINT: 2. Kibambura
SHEET NUMBER 2 OF 15

Figure 11-14: Viewpoint 2 - Baseline Panorama Photograph

Existing view

This image provides landscape and visual context only

PROJECT:	EA-1, EA-1A & EA2 North Project ESIA	OS reference:	E 322440 N 234416	Lens:	50mm (Canon EF 50mm f/1.8)	PROJECT NUMBER: 60429486
		Distance to Proposal:	537m to KW-01	Date:	29/11/2016	Baseline Panoramas
CLIENT:	Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd	Camera:	Canon EOS 5D Mk2	Paper size:	A3	VIEWPOINT: 3. Buliisa (West)
						SHEET NUMBER 3 OF 15

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Figure 11-15: Viewpoint 3 - Baseline Panorama Photograph

Existing view

This image provides landscape and visual context only

PROJECT:	EA-1, EA-1A & EA2 North Project ESIA	OS reference:	E 321246 N 235327	Lens:	50mm (Canon EF 50mm f/1.8)	AECOM	PROJECT NUMBER: 60429486
		Distance to Proposal:	1031m to KW-01	Date:	29/11/2016		Baseline Panoramas
CLIENT:	Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd	Camera:	Canon EOS 5D Mk2	Paper size:	A3		VIEWPOINT: 4. Kisimo
							SHEET NUMBER 4 OF 15

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Figure 11-16: Viewpoint 4 - Baseline Panorama Photograph

Existing view

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PROJECT:	EA-1, EA-1A & EA2 North Project ESIA	OS reference:	E 324156 N 241274	Lens:	50mm (Canon EF 50mm f/1.8)	AECOM	PROJECT NUMBER: 60429486
		Distance to Proposal:	654m to NGR-03	Date:	30/11/2016		Baseline Panoramas
CLIENT:	Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd	Camera:	Canon EOS 5D Mk2	Paper size:	A3		VIEWPOINT: 5. Kirama
							SHEET NUMBER 5 OF 15

Figure 11-17: Viewpoint 5 - Baseline Panorama Photograph

Existing view

This image provides landscape and visual context only

PROJECT:	EA-1, EA-1A & EA2 North Project ESIA	OS reference:	E 333228 N238973	Lens:	50mm (Canon EF 50mm f/1.8)	AECOM	PROJECT NUMBER: 60429486
		Distance to Proposal:	2070m to NSO-05	Date:	30/11/2016		Baseline Panoramas
CLIENT:	Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd	Camera:	Canon EOS 5D Mk2	Paper size:	A3		VIEWPOINT: 6. Ngwedo Farm
							SHEET NUMBER 6 OF 15

Figure 11-18: Viewpoint 6 - Baseline Panorama Photograph

Existing view

This image provides landscape and visual context only

PROJECT:	EA-1, EA-1A & EA2 North Project ESIA	OS reference:	E 336700 N 249876	Lens:	50mm (Canon EF 50mm f/1.8)
		Distance to Proposal:	4190m to JBR-02	Date:	03/12/2016
CLIENT:	Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd	Camera:	Canon EOS 5D Mk2	Paper size:	A3

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PROJECT NUMBER: 60429486
Baseline Panoramas
VIEWPOINT: 7. Baker's Lodge
SHEET NUMBER 7 OF 15

Figure 11-19: Viewpoint 7 - Baseline Panorama Photograph

Existing view

This image provides landscape and visual context only

PROJECT: EA-1, EA-1A & EA2 North Project ESIA

CLIENT: Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd

OS reference: E 335936 N 249278
Distance to Proposal: 3944m to JBR-02
Camera: Canon EOS 5D Mk2

Lens: 50mm (Canon EF 50mm f/1.8)
Date: 03/12/2016
Paper size: A3

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PROJECT NUMBER: 60429486
Baseline Panoramas
VIEWPOINT: 8. Kabalega Wilderness Lodge
SHEET NUMBER 8 OF 15

Figure 11-20: Viewpoint 8 - Baseline Panorama Photograph

Existing view

This image provides landscape and visual context only

PROJECT: EA-1, EA-1A & EA2 North Project ESIA

CLIENT: Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd

OS reference: E 335706 N 249186
Distance to Proposal: 3727m to JBR-02
Camera: Canon EOS 5D Mk2

Lens: 50mm (Canon EF 50mm f/1.8)
Date: 03/12/2016
Paper size: A3

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PROJECT NUMBER: 60429486
Baseline Panoramas
VIEWPOINT: 9. Murchison River Lodge
SHEET NUMBER 9 OF 15

Figure 11-21: Viewpoint 9 - Baseline Panorama Photograph

Existing view

This image provides landscape and visual context only

PROJECT:	EA-1, EA-1A & EA2 North Project ESIA	OS reference:	E 335397 N 249053	Lens:	50mm (Canon EF 50mm f/1.8)
		Distance to Proposal:	3597m to JBR-02	Date:	07/12/2016
CLIENT:	Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd	Camera:	Canon EOS 5D Mk2	Paper size:	A3

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PROJECT NUMBER: 60429486

Baseline Panoramas

VIEWPOINT: 10. Nile Safari Lodge

SHEET NUMBER 10 OF 15

Figure 11-22: Viewpoint 10 - Baseline Panorama Photograph

Existing view

This image provides landscape and visual context only

PROJECT: EA-1, EA-1A & EA2 North Project ESIA

CLIENT: Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd

OS reference: E 332201 N 263784
Distance to Proposal: 2675m to JBR-09
Camera: Canon EOS 5D Mk2

Lens: 50mm (Canon EF 50mm f/1.8)
Date: 06/12/2016
Paper size: A3

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PROJECT NUMBER: 60429486
Baseline Panoramas
VIEWPOINT: 11. Pakuba Safari Lodge
SHEET NUMBER 11 OF 15

Figure 11-23: Viewpoint 11 - Baseline Panorama Photograph

Existing view

This image provides landscape and visual context only

PROJECT:	EA-1, EA-1A & EA2 North Project ESIA	OS reference:	E 340705 N252814	Lens:	50mm (Canon EF 50mm f/1.8)
				Date:	15/02/2018
CLIENT:	Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd	Camera:	Canon EOS 5D Mk2	Paper size:	A3

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PROJECT NUMBER: 60429486

Baseline Panoramas

VIEWPOINT: 12. Paraa Ferry Crossing

SHEET NUMBER 12 OF 18

Figure 11-24: Viewpoint 12 - Baseline Panorama Photograph

Existing view

This image provides landscape and visual context only

PROJECT:	EA-1, EA-1A & EA2 North Project ESIA	OS reference:	E 335127 N 257535	Lens:	50mm (Canon EF 50mm f/1.8)
		Distance to Proposal:	1477m to JBR-06	Date:	04/12/2016
CLIENT:	Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd	Camera:	Canon EOS 5D Mk2	Paper size:	A3

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PROJECT NUMBER: 60429486
Baseline Panoramas
VIEWPOINT: 13. Buligi Track, Delta Track Jct
SHEET NUMBER 13 OF 15

Figure 11-25: Viewpoint 13 - Baseline Panorama Photograph

Existing view

This image provides landscape and visual context only

PROJECT:	EA-1, EA-1A & EA2 North Project ESIA	OS reference:	E 329628 N 257317	Lens:	50mm (Canon EF 50mm f/1.8)
		Distance to Proposal:	3390m to JBR-05	Date:	04/12/2016
CLIENT:	Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd	Camera:	Canon EOS 5D Mk2	Paper size:	A3

AECOM

PROJECT NUMBER: 60429486
Baseline Panoramas
VIEWPOINT: 14. Albert Track
SHEET NUMBER 14 OF 15

Figure 11-26: Viewpoint 14 - Baseline Panorama Photograph

Existing view

This image provides landscape and visual context only

PROJECT: EA-1, EA-1A & EA2 North Project ESIA

CLIENT: Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd

OS reference: E 319358 N 240681
Distance to Proposal: 2887m to NGR-04
Camera: Canon EOS 5D Mk2

Lens: 50mm (Canon EF 50mm f/1.8)
Date: 07/12/2016
Paper size: A3

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PROJECT NUMBER: 60429486
Baseline Panoramas
VIEWPOINT: 15. Wanseko Beach
SHEET NUMBER 15 OF 15

Figure 11-27: Viewpoint 15 - Baseline Panorama Photograph

Existing view

This image provides landscape and visual context only

PROJECT:	EA-1, EA-1A & EA2 North Project ESIA	OS reference:	E 328809 N 245077	Lens:	50mm (Canon EF 50mm f/1.8)	PROJECT NUMBER: 60429486
				Date:	14/02/2018	Baseline Panoramas
CLIENT:	Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd	Camera:	Canon EOS 5D Mk2	Paper size:	A3	VIEWPOINT: 16. Kasinyi (West)
						SHEET NUMBER 16 OF 18

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Figure 11-28: Viewpoint 16 - Baseline Panorama Photograph

Existing view

This image provides landscape and visual context only

PROJECT:	EA-1, EA-1A & EA2 North Project ESIA	OS reference:	E 330667 N 242950	Lens:	50mm (Canon EF 50mm f/1.8)
				Date:	14/02/2018
CLIENT:	Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd	Camera:	Canon EOS 5D Mk2	Paper size:	A3

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PROJECT NUMBER: 60428486
Baseline Panoramas
VIEWPOINT: 17. Kasinyi (East)
SHEET NUMBER 17 OF 18

Figure 11-29: Viewpoint 17 - Baseline Panorama Photograph

Existing view

This image provides landscape and visual context only

PROJECT:	EA-1, EA-1A & EA2 North Project ESIA	OS reference:	E 331419 N 256834	Lens:	50mm (Canon EF 50mm f/1.8)
				Date:	
CLIENT:	Total E&P Uganda B.V. and Tullow Uganda Operations Pty Ltd	Camera:	Canon EOS 5D Mk2	Paper size:	A3

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PROJECT NUMBER: 60429186

Baseline Panoramas

VIEWPOINT: 18. Buligi Track (Pakuba Airfield)

SHEET NUMBER 18 OF 18

Figure 11-30: Viewpoint 18 - Baseline Panorama Photograph

11.6 Impact Assessment and Mitigation

11.6.1 Landscape and Visual Impact Assessment Methodology

Chapter 3: ESIA Methodology sets out the standard impact assessment methodology. The standard methodology includes the following elements, each of which has been adapted for the assessment of Landscape and Visual:

- A brief description of the main Project activities that will affect landscape and visual amenity;
- Assessment criteria to determine the significance of impacts;
- The description of the main receptors and their sensitivity; and
- The criteria to be used to define the magnitude of impacts.

The landscape and visual assessments have been undertaken in accordance with the principles set out in the Guidelines for Landscape and Visual Impact Assessment (GLVIA), Landscape Institute and Institute of Environmental Management and Assessment (2013) (Ref 11-19). This guidance is considered best practice in a number of countries. In the absence of specific Ugandan guidelines, the principles of this Guidance have been followed while the assessment criteria have been refined to suit the Project.

The assessments are based on an evaluation of the sensitivity to change and the magnitude of change for each landscape or visual receptor. For clarity and in accordance with best practice, the assessment of potential effects on landscape character and visual amenity, although closely related, are undertaken separately.

In terms of 'landscape impacts', the proposed development could directly affect the land cover, features and character within the Study Area as well as the aesthetic and perceptual aspects of the landscape and its distinctive character. These effects are determined through an assessment of the existing character of the landscape, and how this is likely to be altered by the development.

In relation to 'visual impacts', visual amenity is defined as 'the overall pleasantness of the views people enjoy of their surroundings. The visual assessment determines the degree of anticipated change to visual amenity that would occur as a result of the development, considering buildings, areas of public open space, roads and footpaths.

A computer generated ZTV map has been prepared for the Project components (well pads) in the north MFNP. The ZTV map indicates areas from where it may be possible to view part or the entire well pad infrastructure. The ZTV maps are shown (and qualified by a series of limitations) in Appendix M. The ZTV has been used as an iterative tool for the assessment, but has a number of limitations which prevent over reliance on its output.

11.6.2 Project Activities

This section outlines the key Project activities that have the potential to change the existing landscape and visual amenity. Table 11-2 below provides a list of relevant activities during each of the four Project phases.

Table 11-2: Project Activities which have Potential to Change the Landscape and Visual Resource

Assessment Activities for each Phase
Site Preparation and Enabling Works Phase
Land acquisition and resettlement: • Land acquisition for all Project components Site clearance and land preparation: • Transportation of construction personnel to and from the Project Site • Increased vehicle movements on the local and national road network • Deliveries of materials and supplies to the Project Site • Physical presence of construction personnel • Waste generation, storage and disposal (hazardous and non-hazardous) • Physical movement of vehicles and plant (Industrial Area, well pads, Water Abstraction System, Bugungu Airstrip and Victoria Nile Ferry Crossing Facilities) • Clearance of vegetation and soils (Industrial Area, well pads, Water Abstraction System, Bugungu Airstrip and Victoria Nile Ferry Crossing Facilities) • Demolition of existing structures at the Industrial Area, well pads, Water Abstraction System, if present • Installation of structure around well pads in the north of the Victoria Nile • Civil works activities at well pads and Water Abstraction System sites Construction of temporary facilities: • Mobilisation of plant and construction vehicles to the Project Site • Lighting emissions • Construction of Camp (temporary facility) within Industrial Area • Installation of temporary facilities at the Masindi Vehicle Check Point. Extraction of materials: • Excavation from borrow pits and quarries and the movement of excavated materials • Resource use (i.e. construction materials) • Restoration of borrow pits and quarries Upgrade works to roads and construction of new roads: • Increased vehicle movements on the local and national road network • Discharge of surface runoff from roads • Construction of new access roads (W1, C1, C2, C3, N1, N2 ,N3, inter field access roads south of the Victoria Nile) and upgrade works of existing roads (A1, A2, A3, A4, B1 and B2) including the installation of drainage • Restoration of Rights of Way (RoWs) Construction of the Victoria Nile Ferry Crossing jetty: • Construction of Victoria Nile Crossing Facility, including piling for the jetties • Installation of facilities at Victoria Nile Ferry Crossing (i.e. containers)

Assessment Activities for each Phase
Construction and Pre-Commissioning Phase
Construction, installation and pre-commissioning of the plant and equipment within the Industrial Area and at the Water Abstraction System: • Increased vehicle movements on the local and national road network • Physical movement of construction vehicles and plant within the Project Site • Mobilisation of plant and construction vehicles to the Project Site • Transportation of construction personnel to and from the Project Site • Construction activities at the Industrial Area and Water Abstraction System • Storage of fuel and hazardous materials • Installation of structures around all key Project components • Transportation of materials and supplies including hazardous substances (i.e. drill cuttings) within the Project Site Operations of Masindi Vehicle Check Point: • Increased vehicle movements on the national road network • Transportation of materials and supplies to the Project Site Installation and pre-commissioning of plant and equipment at each well pad: • Increased vehicle movements on the local and national road network • Mobilisation of plant and construction vehicles to the Project Site • Transportation of construction personnel to and from the Project Site • Installation of structures around all key Project components Drilling of 412 wells across the 34 well pad locations: • Mobilisation of plant and construction vehicles to the Project Site • Transportation of construction personnel to and from the Project Site • Drilling of wells (on a 24 hour / 7 days a week basis) • Containment and storage of drilling fluids and drill cuttings • Transportation of drill cuttings Upgrade work to existing construction camps: • Clearance of vegetation and soils for the expansion of the existing Tangi Camp • Construction activities at Tangi Camp to expand facilities Construction, installation and pre-commissioning of the Production and Injection Network: • Clearance of vegetation and soils for Production and Injection Network RoW and horizontal directional drilling (HDD) Construction Area • Movement of construction vehicles for Production and Injection Network RoW, Water Abstraction System pipeline RoW and HDD Construction Area • Construction of Production and Injection Network (i.e. Pipelines and Flowlines) and Water Abstraction System pipeline RoW including trenching, welding, pressure testing, storage of material, backfilling etc. • HDD activities at the Victoria Nile Crossing Points (on a 24 hour / 7 days a week basis) • Pre-commissioning activities including use and disposal of treated water and associated chemicals • Restoration of Projection and Injection Network RoW, Water Abstraction System pipeline RoW and HDD Construction Area Extraction of materials: • Excavation of construction material from quarries and movement and of excavated materials • Resource use (i.e. construction materials) • Restoration of borrow pits and quarries

Assessment Activities for each Phase
Commissioning and Operations Phase
Commissioning activities involving checking the equipment and plant prior to first oil: • Physical movement of vehicles and plant within the Project Site • Storage of fuel and hazardous materials • Refuelling of plant and machinery within Project Site • Lighting emissions from Industrial Area, Tangi, well pads (during work over activities only) • Operation of CPF plant and equipment Well pad maintenance activity: • Transportation of operational personnel to and from the Project Site • Delivery of materials and supplies (including fuel and other hazardous substances) to the Project Site • Physical movement of vehicles and plant within the Project Site • Operation of plant and equipment at the well pads • Well pad maintenance activities (including the use of work-over rig) • Projection and Injection Network maintenance (e.g. pigging activities) Flaring (considering both the enclosed ground flare and the elevated flare options): • Flaring (Enclosed Ground Flare or Elevated Flare) with associated release of emissions in case of emergency and during start-up Victoria Nile Ferry Crossing Facility: • Operation and maintenance of the Victoria Nile Ferry Water Abstraction System maintenance activity: • Operation and maintenance of Water Abstraction System
Decommissioning Phase: Dependent upon Decommissioning strategy - but expected to be the same as those for the Construction and Pre-Commissioning phase.

Not all of the Project activities may be relevant to individual landscape and visual receptors. At the assessment stage activities have been summarised into key activities which relate directly to the specific landscape and visual receptor. The sequence and details of the activities are considered within ***Chapter 4: Project Description and Alternatives.***

Due to the existing use of the Masindi Airstrip it was deemed unnecessary to undertake a detailed assessment for this Project Component as the conversion into a vehicle checkpoint would not lead to any significant differences to its existing use in terms of landscape and visual assessment.

11.6.3 Assessment Criteria

The following provides details of the process and classification criteria employed in undertaking the landscape and visual assessments. The criteria detailed in Table 11-3 to Table 11-8 are not intended to be prescriptive. Rather these examples are used to illustrate potential combinations of judgements which relate to the scales for, sensitivity to change, magnitude of change and impact significance as described subsequently.

11.6.3.1 Receptors and Sensitivity

The landscape resources within the Study Area that could be affected by the development include:

- Physical resources such as buildings, open space, landform, trees, woodland, watercourses alongside other landscape features;
- Landscape Character Areas; and
- Designated, valued or recognised landscapes that contribute to landscape character. GLVIA3 (Ref 11-19) refers to Designated Landscapes as - *'Areas identified a being of importance at international, national or local levels, either defined by statute of identified in development plans or other documents.'*

Landscape receptors are defined as those landscape resources within the Study Area which have the potential to be affected by the Project.

The quality or condition of a landscape character receptor is a reflection of its attributes, such as the condition of the buildings and spaces or forest components and the attractiveness and landscape quality of the area as well as its sense of place. A landscape with consistent, intact and well-defined, distinctive attributes is generally considered to be of higher quality and, in turn, higher sensitivity, than a landscape where the presence of inappropriate or discordant elements has detracted from its inherent attributes. The higher the quality of a receptor the greater is its sensitivity to the proposed Project.

Visual Receptors can be identified as Individuals and /or groups of people who have the potential to be affected by the Project.

11.6.3.1.1 Landscape Sensitivity to Change

The evaluation of landscape sensitivity to change involves consideration of the nature of the landscape and its ability to accommodate change without compromising its key elements or characteristics. Sensitivity to change is defined through appraisal of landscape value, undertaken as part of the baseline study, and the susceptibility of the landscape to change.

Landscape value is frequently addressed by reference to designations determined by statutory bodies. The absence of such a designation does not necessarily imply a lack of quality or value. Factors such as accessibility and local scarcity can render areas of nationally unremarkable quality, highly valuable as a local resource. The quality and condition is also considered in the determination of the value of a landscape.

The susceptibility to change is a measure of the ability of the landscape receptor to accommodate the proposed development without undue consequences for the maintenance of the baseline situation.

The landscape sensitivity to change may be rated as **High, Moderate** or **Low**, based on professional judgement and the criteria set out in Table 11-3 below.

Table 11-3: Landscape Sensitivity

Class	Criteria
High	• Protected by a statutory designation, an iconic landscape contributing strongly to a sense of place, or an unspoilt landscape containing unique or scarce elements/features with few, if any, detracting elements/features. • Attributes that contribute to a landscape which is considered to be intolerant of even minor change without fundamentally altering key characteristics.
Moderate	• Undesignated landscape with locally important, but more commonplace, features and containing some detracting elements/features. • Attributes that contribute to a landscape which offers some opportunities to accommodate change without fundamentally altering the key characteristics.
Low	• Undesignated landscape with few, if any, notable elements/features, or containing several detracting elements/features. • Attributes that contribute to a landscape which is considered to be tolerant of a large degree of change without fundamentally altering the key characteristics.

11.6.3.1.2 Visual Sensitivity to Change

Sensitivity of a visual receptor considers the nature of the receptor, for example a person occupying a residential dwelling is generally more sensitive to change than someone travelling for the purposes of work. The importance of the view experienced by the receptor also contributes to an understanding of the susceptibility of the visual receptor to change as well as the value attached to the view.

The susceptibility of visual receptors to changes in views and visual amenity is a function of:

- The occupation or activity of people experiencing the view at a particular location; and

- The extent to which their attention or interest may therefore be focused on the views and visual amenity they experience at particular locations.

Value of the view is an appraisal of the value attached to views and is often informed by the appearance on tourist maps and in guidebooks, literature or art. Value can also be indicated by the provision of parking or services and signage and interpretation. The nature and composition of the view is also an indicator. A further definition is provided within Table 11-4 below.

Table 11-4: Visual Sensitivity

Class	Criteria
High	• Users of outdoor recreational facilities, routes frequently used and recognised by tourists or in nationally designated landscapes. • Tourists in tourist lodges and residents in dwellings with views orientated towards a Project component. • High quality views of the landscape with very few, if any, detracting elements. • Locations where the view is of primary importance and receptors are likely to notice even minor change.
Moderate	• Generally pleasing and well composed view, with few detracting elements. • Typically users of primary transport road network, orientated towards a Project component, likely to be travelling for other purposes than just the view. • Residents in dwellings with oblique views towards a Project component • Locations where the view is important but not necessarily the primary focus and receptors are tolerant of the type of change proposed.
Low	• Typical or poorly composed view, often with numerous detracting elements. • Locations where the view is incidental or unimportant to receptors and tolerant of a high degree of change.

11.6.3.2 Landscape Impact Magnitude

Landscape impact magnitude refers to the extent to which the Project would alter the existing characteristics of the landscape.

Consideration is given to whether the likely significant landscape and visual effects result directly from the development itself or from consequential change resulting from the development, such as alterations to a drainage regime which might change the vegetation downstream with consequences for the landscape, or requirements for associated development.

Landscape magnitude of change is an expression of the size or scale of change to the landscape, the geographical extent of the area influenced and its duration and reversibility. The variables involved are described below:

- The extent of existing landscape elements that will be lost, the proportion of the total extent that this represents and the contribution of that element to the character of the landscape;
- The extent to which aesthetic or perceptual aspects of the landscape are altered either by removal of, or change to existing components of the landscape or by addition of new ones;
- Whether the change alters the key characteristics of the landscape, which are integral to its distinctive character;
- The geographic area over which the change will be felt (within the Study Area itself, the immediate setting of the site, at the scale of the landscape type or character area, on a larger scale influencing several landscape types or character areas); and
- The duration of the change (short term 0 – 5 years, medium term 5 – 10 years or long term 10+ years) and its reversibility (whether it is permanent, temporary or partially reversible).

The magnitude of landscape impact has been evaluated and rated as: **High, Moderate, Low** or **Negligible**. These ratings are based on professional judgment and consideration of Table 11-5.

Table 11-5: Landscape Impact Magnitude

Level of Magnitude	Size or Scale of Change	Geographical Extent	Duration	Reversibility
Higher	Highly noticeable change, affecting many key characteristics and dominating the experience of the landscape; and Introduction of highly incongruous development	Very extensive, affecting several landscape character areas.	Long-term (10 years +)	Irreversible
	Noticeable change, affecting some key characteristics and the experience of the landscape; and Introduction of some uncharacteristic elements.	Affecting a substantial proportion of the landscape character area.	Medium-term (5-10 years)	Partially reversible
	Minor change, affecting some characteristics and the experience of the landscape to an extent; and Introduction of elements that are not uncharacteristic.	Affecting the immediate setting of the Project component site.	Short-term (0-5 years)	Reversible
Lower	Little perceptible change	Limited to within the Project Study Area.	Short-term (0-5 years)	Reversible

11.6.3.3 Visual Impact Magnitude

Visual impact magnitude relates to the extent to which the proposed development would alter the existing view and is an expression of the size or scale of change in the view, the geographical extent of the area influenced, and its duration and reversibility. The variables involved are described below:

- The scale of the change in the view with respect to the loss, change or addition of features in the view and changes in its composition, including the proportion of the view occupied by the Project;
- The degree of contrast or integration of any new features or changes in the form, scale, composition and focal points of the view;
- The nature of the view of the Project in relation to the amount of time over which it will be experienced and whether views will be full, partial or glimpsed;
- The angle of view in relation to the main activity of the receptor, distance of the viewpoint from the Project and the extent of the area over which the changes would be visible; and
- The duration of the change (short term, medium term or long term) and its reversibility (whether it is permanent, temporary or partially reversible).

The magnitude of visual impact has been evaluated and rated as: **High, Moderate, Low** or **Negligible**. These ratings are based on professional judgment and consideration of Table 11-6 below.

Table 11-6: Visual Impact Magnitude

Level of Magnitude	Size or Scale of Change	Geographical Extent	Duration	Reversibility
Higher	Extensive change to the existing view including the loss of existing characteristic features, and/or introduction of new discordant features. A change to an extensive proportion of the view. Views where the proposed development would become the dominant landscape feature or contrast heavily with the current view.	The development is located in the main focus of the view; and or at close range over a large area.	Long-term (10 years +)	Irreversible
	The proposed development will result in a change to the view but not fundamentally change its characteristics. Changes that would be immediately visible but not the key feature of the view.	Changes where the proposed development is located obliquely to the main focus of the view; and/or at medium range; and/or over a narrow area.	Medium-term (5-10 years)	Partially irreversible
Lower	The proposed development would result in a small change to the composition of the view. Changes that would only affect a small portion of the view or introduce new features that are partially screened.	Changes where the proposed development is located on the periphery to the main focus of the view; and/or long range; and/or over a small area.	Short-term (0-5 years)	Partially reversible
	Little perceptible change in the existing view.	Changes where the proposed development is peripheral to the overall view.	Short-term (0-5 years)	Reversible

11.6.3.4 Landscape Impact Significance

Determination of the level and significance of landscape effects has been undertaken by employing professional judgement to combine and analyse the magnitude of change, against the identified sensitivity to change. The assessment takes account of the change on existing landscape elements, features and key characteristics and evaluates the extent to which these would be lost or modified, in the context of their importance in determining the existing baseline character. Further information is provided in Table 11-7.

Table 11-7: Significance of Landscape Impacts

Significance	Classification
High Significance	Substantial loss or alteration to elements/features of the baseline (pre-development) conditions. Notably affect an area of recognised national landscape quality. Substantial alteration to the character, scale or pattern of the landscape.
Moderate Significance	Alteration to elements/features of the baseline conditions. Affects an area of recognised landscape quality. Alteration to the character, scale or pattern of the local landscape.
Low Significance	A minor shift away from baseline conditions. The Project partially changes the character of the site without compromising the overall existing landscape character area.
Insignificant	No or very little change from baseline conditions. Barely distinguishable change or indistinguishable.

11.6.3.5 Visual Impact Significance

Determination of the level and significance of visual effects has been undertaken by employing professional judgement to combine and analyse the magnitude of change against the sensitivity to change. The assessment takes into account likely changes to the visual composition, including the extent to which new features would distract or screen existing elements in the view or disrupt the scale, structure or focus of the existing view.

The levels of visual effects are described with reference to the four point scale outlined in Table 11-8 below.

Table 11-8: Significance of Visual Impacts

Significance	Classification
High Significance	Substantial alteration to elements / features of the baseline (pre-development) conditions. Where the proposed development would cause a very noticeable alteration in the existing view. This would typically occur where the Project closes an existing view of a landscape of regional or national importance and the proposed development would dominate the future view.
Moderate Significance	Alteration to one or more elements / features of the baseline view such that post development character / attributes of the baseline will be noticeably changed. This would typically occur where the Project closes an existing view of a local landscape and the proposed development would be prominent in the future view.
Low Significance	A minor shift away from baseline conditions. This would typically occur where change arising from the alteration would be discernible but the underlying character / composition / attributes of the baseline view will be similar to the pre-development. It would also occur where the Project newly appears in the view but not as a point of principal focus or where the proposed development is closely located to the viewpoint but seen at an acute angle and at the extremity of the overall view.
Insignificant	There would be no discernible improvement or deterioration in the existing view.

11.6.4 Embedded Design Mitigation

A list of relevant embedded design mitigation measures already built into the design of the Project is outlined within ***Chapter 4: Project Description and Alternatives***. These measures seek to reduce physical effects (such as vegetation clearance) and mitigate effects on the landscape character and visual amenity (for example by reducing light pollution) and have been taken into account when predicting the significance of the potential impact. The relevant embedded design mitigation measures are presented in Table 11-9:

Table 11-9: Embedded Mitigation Measures

Embedded Mitigation Measures
Lighting will be reduced to the minimum without impacting safety and security. Where feasible, the light will be directed inwards the facilities and will be of a warm / neutral colour so as to limit nuisance to the surrounding communities and to avoid attracting animals.
The Production and Injection Network outside the Industrial Area will be buried at least 0.8m below the ground surface; markers will be used to denote the location (including the water abstraction pipeline in Lake Albert)
International Civil Aviation Organization (ICAO) lighting and marking are required for structures over 45 m and as such both the radio mast and the elevated flare will have appropriate warning lighting
There will be no routine flaring during normal operations
All site clearance activities will be undertaken in line with the Site Clearance Plan which will be developed by the Contractor(s) prior to commencing the Site Preparation and Enabling Works Phase to limit extent of vegetation clearance, wherever possible
All temporary land required associated with the construction of the roads will be restored following construction in line with the Site Restoration Plan as developed by the Contractor specifically for the roads
As per base case, there will be no routine nightshift activities associated with the Site Preparation and Enabling Works Phase
With the exception of drilling and HDD construction activities there will be no permanent night time working in the MFNP
Laydown areas at each of the well pad sites will be located within the footprint of the well pad; there will be no additional site clearance required outside the well pad footprint during the Construction and Pre-Commissioning Phase
Construction activities for the Production and Injection Network will be contained within the permanent RoW which will have a width of 30 m and is designed to accommodate the pipeline trench(s), stockpile areas, laydown, welding, and the movement of construction equipment alongside the trench(s)
The Production and Injection Network RoW will be restored in line with the Site Restoration Plan as developed by the Contractor specifically for the RoW
The temporary land required for the HDD Construction Areas roads will be restored following construction in line with the Site Restoration Plan as developed by the Contractor
All construction vehicles/equipment will be kept on site when not in use
The base case for Tilenga is that there will be no night driving. However, night driving may be permitted in exceptional circumstances and with internal derogation where it is deemed safe and practicable to do so
Decommissioning work at the Buliisa Camp, Bugungu Camp and 17 ha of the Tangi Camp will be undertaken at the end of the Construction and Pre-Commissioning Phase. The land will be restored in line with the Site Restoration Plan as developed by the Contractor
At the end of the Construction and Pre-Commissioning Phase the C1 road will be restored in accordance with a Site Restoration Plan by the Contractor
The ferry will operate for 8 hours a day and will be dedicated to Project use only. There will be no ferry movements during night time hours except in exceptional circumstances and with internal derogation
The permanent RoW will be kept clear of trees, deep rooting vegetation, poles, structures and graves. Regular monitoring will be undertaken, which will include removal of vegetation overgrowth and uprooting tree seedlings
There will be no permanent access restrictions to the pipeline RoW

Embedded Mitigation Measures
In general, the following principles will be adopted where practicable and will be subject to detailed assessment prior to decommissioning: • Above ground infrastructure will be removed to 0.5 m below ground level and backfilled and vegetated; • Access roads may be left in place depending upon the subsequent use of the land; • Excavations resulting from the removal of foundations will be backfilled; and • It is expected that pipelines will be cleaned, capped and left in situ, to prevent disturbing the reinstated habitats.
During the Decommissioning Phase the following assumptions are applicable regarding supporting facilities: • Lighting will be reduced to the minimum without impacting safety and security. Where feasible, the light will be directed inwards the facilities and will be of a warm / neutral colour so as to limit nuisance to the surrounding communities and to avoid attracting animals. As per base case there will be no routine nightshift activities associated with this Phase; • A Construction Support Base will be constructed within the Industrial Area for use during the Decommissioning Phase; and • Waste will be segregated and managed in accordance with a Waste Management Plan
Depending on the final land use agreed with the Ugandan authorities, all or part of the site may need to be rehabilitated. In such circumstances, the Project Proponents will also develop a monitoring programme for completion criteria to verify that the sites are being returned to the agreed representative state.
A Stakeholder Engagement Plan is already in place; this will ensure the community are informed both prior to the commencement of work on site, during the works on a regular basis and after. As stated above a Grievance Mechanism will be established for the local community to raise compliant and concerns relating to Project activities (i.e. dust, noise etc.).
The top soils will be removed to a required depth; material will be temporarily stored within designated areas.
All borrow pits and quarries used by Project Proponents will be re-habilitated following completions of extraction in line with the Site Restoration Plan as developed by the Contractor.
The pipe laying and backfill activity is to be conducted as soon as practicable after the trench excavation utilising standard pipe laying cranes and earthmoving equipment.
All wastes will be removed and disposed of at dedicated waste treatment facilities in accordance with the Waste Management Plan. A detailed Decommissioning Plan will be developed for the works during the Site Preparation and Enabling Works Phase of the Project.

11.7 Sensitivity of Landscape and Visual Receptors

This section details the sensitivity of each of the landscape and visual receptors. Reference should be made to the Landscape and Visual Assessment Methodology, Section 11.6.1.

Table 11-10: Sensitivity of Landscape Receptors

Landscape Character Area	Assessment of sensitivity	Sensitivity
LCA 01 - Buliisa Lowland Pastoral Farmland	There are no landscape designations within this LCA and the pastoral farmlands are common place across a vast lowland area. This landscape is largely shaped by self-sufficient pastoral farmland. There is little existing infrastructure and few distinctive elements of any notable quality. This LCA has experienced oil exploration in the recent past and would be tolerant of some change; however the tranquil setting and typical small scale tracks and transport patterns across this landscape would be more vulnerable to change.	Low
LCA 02 - Buliisa Lowland Rolling Farmland	There are no landscape designations within this LCA and the agricultural farmlands are common place across a vast lowland area. This landscape is largely shaped by self-sufficient agricultural farmland. There is little existing infrastructure and few distinctive elements of notable quality. This LCA has experienced oil exploration in the recent past and would be tolerant of some change; however, the tranquil setting and typical small scale tracks and	Low

Landscape Character Area	Assessment of sensitivity	Sensitivity
	transport patterns across this landscape would be vulnerable to change as a result of the proposed infrastructure.	
LCA 03 - Lake Albert Coastal Fringe	There are no landscape designations within this LCA, however the coastal influence of Lake Albert is a unique landscape feature within the Study Area and is host to numerous landing sites and residential settlements. The shoreline beaches south of Wanseko are of local recreational interest. Existing infrastructure is limited and there is some capacity to absorb change.	Moderate
LCA-04 - River Nile Corridor	The majority of this river bank transitional landscape falls within the nationally designated Murchison Falls National Park (MFNP). This LCA is a combination of comparatively more intricate wetland landscape features, recreational and tourism assets and the ecological resource. Taking this into account this LCA is vulnerable as even a small change could change its character and experience.	High
LCA 05 - Lake Albert-Victoria Nile Delta	This LCA falls entirely within MFNP and the Albert Delta Wetland System Ramsar Site. This uninhabited wetland between the banks of the Nile is particularly susceptible to any change.	High
LCA 06 - MFNP South, Rolling Woodland	This LCA falls entirely within MFNP. This largely undisrupted, designated and protected parkland is largely devoid of development beyond the maintained access routes and is therefore particularly susceptible to change of the nature proposed.	High
LCA 07 - MFNP North, Savanna Plateau	This LCA falls entirely within MFNP. This largely undisrupted, designated parkland is almost completely devoid of development beyond the maintained safari routes alongside tourist lodges and is therefore particularly susceptible to change of the nature proposed.	High

Table 11-11: Sensitivity of Viewpoints

Viewpoint	Assessment of sensitivity	Sensitivity
Viewpoint 1 - Kimoli	This viewpoint is representative of residents and road users who experience a sequence of views largely comprised of sporadic vegetation. The elements within the view experienced from this general location are not designated and features within the view are typical of the wider Kimoli area. Although views are not of a particular high quality, there are few detracting elements. Views from residential receptors are of importance and therefore more susceptible to change.	Moderate
Viewpoint 2 - Kibambura	This viewpoint is representative of residents and road users in Kibambura, who experience a consistent sequence of views framed by the roadside vegetation and roadside pastoral grazing areas. The views experienced are not designated and are heavily influenced by the main road through Kibambura. Taking into account the importance of views for residential areas and the existing influence of the road, views in this area are tolerant of change.	Low
Viewpoint 3 - Buliisa (West)	This viewpoint is representative of residential receptors to the west of Buliisa, near a local track heading west to the Lake Albert coastline. No elements within the view are designated; however, views west are composed of distant views of the mountain range in DRC draw the eye into the background and therefore receptors are more likely to notice a change.	Moderate

Viewpoint	Assessment of sensitivity	Sensitivity
Viewpoint 4 - Kisimo	This viewpoint is representative of residents in Kisimo, looking southeast. This is a typical residential view featuring no designations and is not particularly well composed. Views from these residential areas tend to be of limited importance and in this instance the appreciation of the landscape is not the primary focus.	Low
Viewpoint 5 - Kirama	This viewpoint is representative of residential receptors within Kirama. This is an open view typical of this elevated area in the northern part of the pastoral lowlands. The view comprises few detracting elements. This is a typically composed view with few notably detracting features and is of limited value. Given the open nature of views and the primary focus is generally north, this viewpoint is tolerant of some change.	Moderate
Viewpoint 6 - Ngwedo Farm	This viewpoint is representative of road users, from which no designations are visible. From this location views are incidental to the receptor and therefore tolerant of a high degree of change.	Low
Viewpoint 7 - Baker's Lodge	This view is representative of tourists at Baker's Lodge, where the view is of primary importance. Views north of the Nile and its banks are within MFNP.	High
Viewpoint 8 - Kabalega Wilderness Lodge	This view is representative of tourists at Kabalega Wilderness Lodge, where the view is of primary importance. This viewpoint features iconic views across the Nile to the north MFNP where the savanna is visible above forested slopes.	High
Viewpoint 9 - Murchison River Lodge	This view is a specific sunset view experienced by tourists at Murchison River Lodge, where the view is of primary importance. This viewpoint features iconic views of the sunset across the Nile to the north MFNP.	High
Viewpoint 10 - Nile Safari Lodge	This view is a specific 'shoebill' view experienced by tourists at Nile Safari Lodge, where the view is of primary importance. This viewpoint features iconic views of the sunset across the Nile to the north MFNP where the savanna grasslands form the distant horizon.	High
Viewpoint 11 - Pakuba Safari lodge	This is a well composed, high quality view located within the north MFNP, near Pakuba Safari Loge. This view is representative of tourists for whom views are or primary importance and therefore particularly susceptible to change.	High
Viewpoint 12 - Paraa Ferry Crossing	This viewpoint is representative of views experienced by people using the Paraa ferry crossing. This primary route within MFNP is frequently used and recognised by tourists for whom views are an important part of the experience.	High
Viewpoint 13 - Buligi Track, Delta Track Junction	This panoramic viewpoint is representative of tourists using the main network of safari tracks within MFNP, for whom views are integral to the experience.	High
Viewpoint 14 - Albert Track	This viewpoint is representative of tourists using the Albert Track, one of the main safari tracks within the northwest of MFNP, for whom views are integral to the experience.	High
Viewpoint 15 - Wanseko Beach	This viewpoint is representative of the local communities near Wanseko, who access the beach for various purposes including recreation. No components within the views are designated. Views to the west are of Lake Albert. Views east towards the development are not the primary focus and tolerant of change.	Moderate

Viewpoint	Assessment of sensitivity	Sensitivity
Viewpoint 16 - Kasinyi (West)	This viewpoint is representative of residential receptors to the west of Kasinyi for whom the views south are not central to the experience. This is a long distance open view across the pastoral landscape and is therefore tolerant of some degree of change.	Moderate
Viewpoint 17 - Kasinyi (East)	This viewpoint is representative of residential receptors to the east of Kasinyi for whom the view is an important but not central to the experience. This view is comprised of typical features within the pastoral landscape in which there is no clear focus. Views west are partially filtered by mature trees and undulations in topography and therefore tolerant of some change.	Moderate
Viewpoint 18 - Buligi Track (Pakuba Airfield)	This viewpoint is representative of tourists using the Buligi Track, which is one of the primary safari tracks within the northwest of MFNP, for whom views are integral to the experience.	High

11.8 Assessment of Impacts: Site Preparation and Enabling Works

The impact significance for each of the landscape and visual receptors is determined based on the receptors sensitivity to change and the impact magnitude using the methodology described in Section 11.6.1 above. The key Project activities that have the potential to impact on the receptor being assessed are summarised from Table 11-2 above. Not all of the Project activities may be relevant to individual landscape and visual receptors. The sequence and details of the activities are considered within ***Chapter 4: Project Description and Alternatives***.

The Site Preparation and Enabling Works phase is expected to take up to 5 years.

11.8.1 Potential Landscape Character Impacts

11.8.1.1 LCA 01 - Buliisa Lowland Pastoral Farmland

Sensitivity to change: Low

Relevant Key Activities:

- Land acquisition and resettlement;
- Site clearance and land preparation of the Industrial Area;
- Construction of temporary facilities within Industrial Area;
- Clearance and civil works for well pads south of the Victoria Nile;
- Extraction from of materials from borrow pits;
- Upgrade works to roads A1, A2, B1 and B2;
- Construction of new roads: N1, N2, and inter field access roads; and
- Upgrade works to existing tracks to well pads.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase, construction activity would have a potential direct impact on the character of the existing landscape. Activities including the extraction of material from borrow pits and vegetation clearance in large swathes at well pads, the Industrial Area and within the RoW of new and upgraded roads, would be extensive. These activities and operations would disrupt the layout and local patterns of movement across the landscape. Demolition activities involved in land acquisition and resettlement would alter the existing layout and location of residential communities, particularly at the Industrial Area.

The increase in vehicle movement and machinery associated with new roads and the upgrade of existing roads would result in an intensive change at the site of the Industrial Area and across the local road network.

The extent of works would be limited to the Industrial Area, well pad locations and the RoW of new roads and road upgrades within the LCA. As such the geographical extent of change would result in a limited change to the overall extent of this LCA. Furthermore, the construction activities during the Site Preparation and Enabling Works Phase would be short term and partially reversible.

Taking this into account the potential impact magnitude is considered to be Moderate.

Impact Significance:

Potential impact Significance: **Low Adverse** Significance

11.8.1.2 LCA 02 - Buliisa Lowland Rolling Farmland

Sensitivity to change: Low

Relevant key activities:

- Land acquisition and resettlement;
- Site clearance and land preparation of the Industrial Area;
- Construction of temporary facilities within Industrial Area;
- Clearance and civil works for well pads south of the Victoria Nile;
- Extraction from murram borrow pits;
- Upgrade works to roads A1, A3, A4, and B1;
- Construction of new roads: N3 and inter field access roads; and
- Upgrade works to existing tracks to well pads south of Victoria Nile.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase, construction activity would result in potential direct impacts on the existing landscape. Localised areas of change would include the eastern extents of the Industrial Area, well pad sites and the upgrade works to Road A1 (between Kimoli and Kasinyi, north of the Industrial Area) and Road A4, heading south towards Ngwedo. At these locations, vegetation clearances would be apparent. There would be disruption to local patterns of movement and reduced access to some grazing and agricultural farmlands as well as residential properties. The size and intensity of the machinery and vehicle movements particularly at the Industrial Area would be a noticeable and disruptive change affecting the character and experience of this area and its immediate setting, particularly at the boundary with the pastoral farmlands to the west.

The increase in movement and equipment alongside the construction of new roads and upgrade of existing roads would result in an intensive change at the sites of the Industrial Area and well pad locations. Construction activities would be disruptive and noticeable at multiple locations across the geographical extent of this LCA. Furthermore these works would be short term and partially reversible.

Taking this into account the potential impact magnitude is considered to be Moderate.

Impact Significance:

Potential impact Significance: **Low Adverse** Significance

11.8.1.3 LCA 03 - Lake Albert Coastal Fringe

Sensitivity to change: Moderate

Relevant key activities:

- Site clearance and land preparation of the Water Abstraction System onshore facility;

- Civil works for well pads KW-01 and KW-02B and Water Abstraction System; and
- Upgrade works to existing tracks to well pads south KW-01 and KW-02B of Victoria Nile.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase, construction activity would result in potential direct but localised impacts on the landscape. Construction activities would vary depending on the final design solution for the Water Abstraction System. Impacts would result from the introduction of vehicles and machinery, storage of materials and vegetation clearances at the Water Abstraction System onshore solution and the well pad sites. If the Water Abstraction System is an offshore solution, activities will also take place onshore but impacts will be similar in nature.

The scale of activity would reduce the relative levels of tranquillity and recreational quality over a very limited extent. The pattern and layout of the landscape would remain intact. Impacts at this phase would be short-term and reversible.

The potential impact magnitude is considered to be Negligible.

Impact Significance:

Potential impact Significance: **Low Adverse** Significance

11.8.1.4 LCA-04 River Nile Corridor

Sensitivity to change: High

Relevant key activities:

- Clearance and civil works for well pad JBR-10 north of the Victoria Nile;
- Construction of new roads: C2 and C3; and
- Construction of the Victoria Nile Ferry Crossing jetty and associated building to support ferry operation.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase, construction activity would result in limited change to the quality and character of this LCA. The introduction of construction activity would be limited to the site of the Victoria Nile Ferry Crossing and within the RoW of small sections of new roads. The scale and intensity of plant, vehicle movements, storage of materials and vegetation clearance would have the potential to slightly affect the landscape character and relative tranquillity of the LCA but over a very limited geographical extent at the north and south bank of the Nile. Potential construction impacts would also be short-term and reversible.

The potential impact magnitude is considered to be Very Low.

Impact Significance:

Potential Impact Significance: **Low Adverse** Significance

11.8.1.5 LCA 05- Lake Albert-Victoria Nile Delta

Sensitivity to Change: High

Relevant key activities:

None

Impact Magnitude:

Not Applicable

Impact Significance:

Not Applicable

11.8.1.6 LCA 06- MFNP South, Rolling Woodland

Sensitivity to change: High

Relevant key activities:

- Extraction from murram borrow pits;
- Bugungu Airstrip upgrade; and
- Construction of new roads: N3.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase, construction activity would be limited to the movements of construction plant, and activities and personal that would be required to upgrade the Bugungu Airstrip and extraction of material from borrow pits. There would be increased associated traffic along the main road between Buliisa, Bugungu Camp and MFNP via the Bugungu Gate.

Although activities would be limited in geographical extent, access routes into this part of the Park would be required. This resulting increase in activity over a few months would result in a potential very minor shift from the existing scale of movement and would not alter the recreational qualities of this part of MFNP. Overall the vast majority of this LCA and its key characteristics would be unaffected and would be short-term and reversible.

The potential impact magnitude on this LCA would therefore be Negligible.

Impact Significance:

Potential impact Significance: **Low Adverse** Significance

11.8.1.7 LCA 07 – MFNP North, Savanna Plateau

Sensitivity to Change: High

Relevant key activities:

- Extraction from murram borrow pits;
- Construction of new roads: C1 and C2, and inter field access roads; and
- Clearance and civil works for well pads north of Victoria Nile.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase, construction activity would be apparent at each of the well pad sites, at borrow pit locations and within the RoW of the new roads. The scale of change resulting from the introduction of plant, earthworks, vegetation clearance vehicles and construction personnel would noticeably affect the local pattern, layout and levels of tranquillity experienced within the RoW and its immediate context. Although these activities would occupy a noticeable portion of the landscape they would be relatively clustered along a central line north to south between the RoW of new road C1 to well pad site JBR-01 and then east along the RoW of road C2. Overall construction activities would affect some of the key characteristics; however, impacts would be short-term and reversible.

The potential impact magnitude on this LCA would therefore be Moderate.

Impact Significance:

Potential impact Significance: **High Adverse** Significance

11.8.2 Potential Visual Impacts

Refer to Table 11-1 for distances to the relevant Project components that have the potential to be visible from the viewpoints.

11.8.2.1 Viewpoint 1 - Kimoli

Sensitivity to change: Moderate

Relevant key activities:

- Site clearance and land preparation of the Industrial Area, Construction of temporary facilities within Industrial Area; and
- Construction of new roads: N1.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase, construction activities 150 m south of this viewpoint associated with the clearance of the Industrial Area and upgrade of road A1 would dominate foreground views.

Extensive change would result from the physical presence, intensity of movement and activity within close proximity. These works include vegetation clearances, earthwork operations, movement of plant and construction personnel which would be the prominent focus of views, and fundamentally alter visual amenity experienced from this area.

Construction activities associated with works at the Industrial Area would partially be screened by construction activities within the foreground RoW. However, the scale and height of plant and equipment would be apparent across the background. Potential impacts would be short term and reversible. Overall the potential impact magnitude is considered to be High.

Impact Significance:

Potential impact Significance: **High Adverse** Significance

11.8.2.2 Viewpoint 2 - Kibambura

Sensitivity to change: Low

Relevant key activities:

- Upgrade works to roads: B1;
- Upgrade works to existing tracks to well pad NSO-04 south of Victoria Nile; and
- Clearance and civil works for well pad NSO-04 south of Victoria Nile.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase visual change would be limited to the works associated with the upgrade of road B1 1.3 km northwest of this viewpoint and earthworks for the well pad NSO-04 and access tracks 506 m south. The related activities would appear northwest and therefore oblique to the main focus of views. Existing vegetation would partially screen the majority of plant and machinery associated with road upgrades. From this location vegetation clearances would result in a subtle change across a very limited extent of the background, and unlikely to alter the primary focus of view. As such the potential impact magnitude is considered to be Negligible.

Impact significance

Potential impact Significance**: Insignificant**

11.8.2.3 Viewpoint 3 - Buliisa (West)

Sensitivity to change: Moderate

Relevant key activities:

- Upgrade works to existing tracks to well pad KW-01 south of Victoria Nile; and
- Clearance and civil works for well pad KW-01 south of Victoria Nile.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase construction activities 539 m west of the viewpoint would be partially filtered by intervening topography and vegetation. The extent of change visible would include the introduction of plant and vehicles, vegetation clearance and civil works required for the preparation at well pad site KW-01. These activities would only affect a small proportion of the background and unlikely to alter the main of focus of views. Potential impacts would be temporary and reversible.

Overall the potential impact magnitude is considered to be Low.

Impact Significance:

Potential impact Significance: **Low Adverse** Significance

11.8.2.4 Viewpoint 4 - Kisimo

Sensitivity to change**:** Low.

Relevant key activities:

- Upgrade works to existing tracks to well pad KW-01 south of Victoria Nile; and
- Clearance and civil works for well pad KW-01 south of Victoria Nile.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase construction activities 1 km east of this viewpoint would be heavily filtered by intervening topography and vegetation. The extent of change visible would be due to vehicle movements required for the preparation at well pad site KW-01. Some vegetation clearance works have the potential to be visible in the background. However, the anticipated activities would not shift the balance of features visible and potential impacts would be temporary and reversible.

Overall the potential impact magnitude is considered to be Negligible.

Impact Significance:

Potential impact Significance: **Insignificant**

11.8.2.5 Viewpoint 5 - Kirama

Sensitivity to change: Low

Relevant key activities:

- Upgrade works to roads: A1;
- Upgrade works to existing tracks to well pad NGR-03A south of Victoria Nile; and
- Clearance and civil works for well pads NGR-03A south of Victoria Nile.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase construction activities would be limited to the works associated with the upgrade of road A1 and enabling works for NGR-03A 1.2 km southwest. The construction plant, vehicles and personal would dominate the visual experience of views given the proximity of the RoW. Given the immediate proximity and intensity of activity, enabling works would be the prominent focus of views. Impacts would be short-term and reversible. Overall the potential impact magnitude would be Moderate.

Impact significance

Potential impact Significance: **Low Adverse** Significance

11.8.2.6 Viewpoint 6 - Ngwedo Farm

Sensitivity to change: Low

Relevant key activities:

- Site clearance and land preparation of the Industrial Area;
- Construction of temporary facilities within Industrial Area;
- Upgrade works to roads: A2 and A4;
- Upgrade works to existing tracks to well pads NSO-04 and NSO-05 south of Victoria Nile; and
- Clearance and civil works for well pads NSO-04 and NSO-05 south of the Victoria Nile.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase construction activities would be located at well pad sites and within the RoW of the proposed upgrades to roads A4 and A2. Construction activities at well pad sites NSO-04 (4.7 km), NSO-05 (2.6 km) and RoWs would largely be screened by intervening landform and vegetation. Clearance works at the Industrial Area may also be perceptible in the background, 3.6 km northwest. The extent of change visible would be limited to the noticeable increased vehicle movements along this primary route and vegetation clearance across limited parts of the background. Potential impacts would be short-term, reversible, and unlikely to disrupt the primary focus of views. Therefore, the potential impact magnitude is considered to be Low.

Impact Significance:

Potential impact Significance: **Low Adverse** Significance

11.8.2.7 Viewpoint 7 - Baker's Lodge

Sensitivity to change: High

Relevant key activities:

- Clearance and civil works for well pads JBR-01 and JBR-02 north of the Victoria Nile and inter field access roads; and
- Construction of new roads: C2.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase construction activities at road C2 will be entirely screened and activities at well pads JBR-01, 4.7 km north and JBR-02, 4.3 km north would be barely discernible. The lower level elevation of view from this lodge combined with the intervening vegetation would screen views of machinery and vehicle movements beyond. Therefore, the potential impact magnitude is considered to be Negligible.

Impact Significance:

Potential impact Significance: **Insignificant**

11.8.2.8 Viewpoint 8 - Kabalega Wilderness Lodge

Sensitivity to change: High

Relevant key activities:

- Clearance and civil works for well pads JBR-01 and JBR-02 north of the Victoria Nile and inter field access roads.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase construction activities at well pad sites JBR-01, 4.8 km north and JBR-02, 4 km north would be largely screened by intervening vegetation.

Site preparation works at well pads are unlikely to be clearly distinguishable in the distant background. There would be little perceptible change in the focus of views. Therefore the potential impact magnitude is considered to be Negligible.

Impact Significance:

Potential impact Significance: **Insignificant**

11.8.2.9 Viewpoint 9 - Murchison River Lodge

Sensitivity to change: High

Relevant key activities:

- Clearance and civil works for well pads JBR-01 and JBR-02 north of the Victoria Nile and inter field access roads.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase construction activities at well pad sites JBR-01, 4.6 km north and JBR-02, 3.9 km north to the north would be largely screened by intervening vegetation. There would be little perceptible change in the view. Therefore, the potential impact magnitude is considered to be Negligible.

Impact Significance:

Potential impact Significance: **Insignificant**

11.8.2.10 Viewpoint 10 - Nile Safari Lodge

Sensitivity to change: High.

Relevant key activities:

- Clearance and civil works for well pads JBR-01 and JBR-02 north of the Victoria Nile and inter field access roads.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase construction activities at well pads JBR-01, 4.5 km north and JBR-02, 3.8 km north would be screened by intervening vegetation. Construction activity including vegetation clearances would be barely perceptible and the balance of features and focus of views would remain unchanged. Therefore, the potential impact magnitude is considered to be Negligible.

Impact Significance:

Potential impact Significance: **Insignificant**

11.8.2.11 Viewpoint 11 - Pakuba Safari lodge

Sensitivity to change: High

Relevant key activities:

- Construction of new roads: C1, and inter field access roads; and
- Clearance and civil works for well pad JBR-09 north of the Victoria Nile.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase construction activities 2.6 km south would appear distant beyond intervening vegetation. Site preparation works at well pad JBR-09 and road C1 would occupy a small extent of the view. Construction machinery, earthworks, vegetation clearance, storage of materials and vehicles movements at the well pad site and RoW would be visible in the background view, but oblique to the main focus. Impacts would also be short-term and reversible. Therefore, the potential impact magnitude is considered to be Low.

Impact Significance:

Potential impact Significance: **Moderate Adverse** Significance

11.8.2.12 Viewpoint 12 - Paraa Ferry Crossing

Sensitivity to change: High.

Relevant key activities:

- Construction of new roads: C2, C3; and
- Construction of the Victoria Nile Ferry Crossing jetty and associated building to support ferry operation.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase, impacts would result from construction activities at the ferry crossing jetty and compounds at the North and South Banks of the Nile. The location of activities would be 135 m east of the existing Paraa ferry crossing. The introduction of machinery, vehicle movements, earthworks and vegetation clearance would be clearly visible in relatively close proximity. Piling works would extend up to 70 m into the river (excluding 30 m across an area of wetland) and 40 m from the north bank. The increasing in massing of machinery would distract from the existing focus of visual amenity albeit experienced alongside existing ferry facilities at the north and south banks of the Nile. Potential impacts will be short term and reversible. Therefore, the potential impact magnitude is considered to be Moderate.

Impact Significance:

Potential impact Significance: **High Adverse** Significance

11.8.2.13 Viewpoint 13 - Buligi Track, Delta Track Junction

Sensitivity to change: High

Relevant key activities:

- Clearance and civil works for well pads JBR-05, JBR-06 and JBR-07 north of the Victoria Nile and inter field access roads.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase construction activities would be largely visible at three well pad sites JBR-05 (2.4 km), JBR-06 (1.5 km), and JBR-07 (1.9. km) across the horizontal extent of the view. Activities including vegetation clearance, storage of materials earthworks, machinery and vehicle movements would increase the massing of structures and movements that are incongruous with the existing view and likely to distract from the primary focus. Potential impacts will be short term and reversible. Therefore, the potential impact magnitude is considered to be Moderate.

Impact Significance:

Potential impact Significance: **High Adverse** Significance

11.8.2.14 Viewpoint 14 - Albert Track

Sensitivity to change: High

Relevant key activities:

- Clearance and civil works for well pads JBR-05, JBR-06 and JBR-07 north of the Victoria Nile and inter field access roads.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase construction activities associated with the clearance and site preparation of well pad sites JBR-05 (3.4 km) JBR-06 (4.2 km) and JBR-07 (4.1 km) would be located obliquely to the main focus of views. The scale and intensity of vehicle movements, vegetation clearances and earthworks would appear distant across a small proportion of the background. The addition of construction activity would slightly alter the composition and balance of the view; however, potential impacts would be short-term and reversible. Therefore, the potential impact magnitude is considered to be Low.

Impact Significance:

Potential impact Significance: **Moderate Adverse** Significance

11.8.2.15 Viewpoint 15 - Wanseko Beach

Sensitivity to change: Moderate.

Relevant key activities:

- Site clearance and land preparation for the Water Abstraction System onshore facility.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase construction activities 4.3 km south at the Water Abstraction System (for either onshore of offshore options) would be visible in the distant background. Construction activity related to the onshore solution would be located obliquely to the main focus of views whereas views of construction activity off shore would be slightly more distracting across a similar horizontal extent of the view. Potential impacts for both options are unlikely to change the overall balance of the view and would be short-term and reversible. Therefore, the potential impact magnitude is considered to be Low.

Impact Significance:

Potential impact Significance: **Low Adverse** Significance

11.8.2.16 Viewpoint 16 - Kasinyi (West)

Sensitivity to change: Moderate

Relevant key activities:

- Clearance and civil works for well pad NGR-01 south of Victoria Nile.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase activities at 252 m distance would be visible across views to the southwest of the residential dwellings. Construction activities including the introduction of moving plant and vehicles, vegetation clearances, and earthworks required for the preparation of well pad site NGR-01 would be noticeable above the intervening grassland across a small proportion of the overall view. The scale and intensity would be in contrast to the existing composition views and oblique to the primary focus of views north. However, potential impacts would be short-term and reversible. Therefore, the potential impact magnitude is considered to be Low.

Impact Significance:

Potential impact Significance: **Low Adverse** Significance

11.8.2.17 Viewpoint 17 - Kasinyi (East)

Sensitivity to Change: Moderate

Relevant key activities:

- Site clearance and land preparation of the Industrial Area, construction of temporary facilities within Industrial Area; and
- Upgrade of existing roads: A1.

Impact magnitude:

During the Site Preparation and Enabling Works Phase, activities would be located both in the immediate context of the road corridor and at the site of the Industrial Area 518 m west of this location. Construction activities and the RoW would dominate foreground views and would substantially change the existing view. Activities associated with clearance and preparation of the Industrial Area would include largescale vegetation clearance and earthworks. Movement of plant, vehicles and personal would occur across a noticeable extent of the background, southeast of the road corridor.

Overall the scale of change and intensity of activity would be prominent across a wide proportion of the view occupying the foreground and extending to the background. Although potential impacts would be short term and reversible, overall the potential impact magnitude is considered to be High.

Impact Significance:

Potential impact Significance: **High Adverse** Significance

11.8.2.18 Viewpoint 18 - Buligi Track (Pakuba Airfield)

Sensitivity to Change: High

Relevant key activities:

- Clearance and civil works for well pads JBR-05, JBR-06, JBR-07 north of the Victoria Nile and inter field access roads.

Impact Magnitude:

During the Site Preparation and Enabling Works Phase construction activities would be largely visible at three well pad sites JBR-05 (1.5 km east) JBR-06 (2.4 km east) and JBR07 (2.8 km north), across a small but noticeable proportion of the background to the south of the airstrip. Activities would include vegetation clearance, storage of materials and earthworks. Machinery and vehicle movements would result in an increased massing of structures and activity within this open view and would temporarily become a prominent feature. The nature of activity would be in contrast with the largely natural setting. Potential impacts would be short term and reversible. Therefore, the potential impact magnitude is considered to be Moderate.

Impact Significance:

Potential impact Significance: **High Adverse** Significance

11.8.3 Additional Mitigation

The measures identified in Table 11-12 below have the potential to reduce some landscape and visual effects:[1]

Table 11-12: Additional Mitigation Measures

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
LV.1	All site clearance activities will be undertaken in line with the Site Clearance Plan which will be developed by the Contractor(s) prior to commencing the Site Preparation and Enabling Works Phase to limit extent of vegetation clearance wherever possible	X	X		

[1] Additional mitigation is helpful in reducing the impact magnitude however in some cases the extent to which the impact magnitude is reduced is unlikely to be sufficient to reduce the overall rating or the impact significance.

No.	Additional Mitigation Measures	Relevant Phase			
		Site Preparation and Enabling Works	Construction and Pre-Commissioning	Commissioning and Operations	Decommissioning
LV.2	Avoid introduction of roads at right angles to existing roads, where practicable	X			
LV.3	Materials required for roads shall meet the material specifications and mechanical properties required for the class of road. However, where possible, material selection shall also take into account aesthetic aspects to blend in with existing landscape subject to technical constraints and availability	X			
LV.4	Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable	X	X	X	
LV.5	Use of lights, for example on well pads, will be minimised, and light spill controlled (e.g. restricted lighting height, shading light sources and/or direct them onto site areas)		X	X	
LV.6	Implementing a Grievance Management Procedure, to allow recording and follow up of any complaints related to Project activities, in a timely manner	X	X	X	X
LV.7	An Environmental Monitoring Programme to be established which will include landscape and visual monitoring, focussed on reinstatement works	X	X	X	X
LV.8	Any areas of land which are disturbed during construction should be restored to help prevent any erosion	X	X		X
LV.9	Design the Project to use colours that match the surroundings for the infrastructure and fencing. This includes a blend of subtle light browns, pastel greens, rust, and greys			X	
LV.10	Design the Project to use materials on the infrastructure that will minimise glare, as much as practicable			X	
LV.11	Material finishes to buildings to be non-reflective and muted colour palette			X	
LV.12	Consideration shall be given to planting naturalistic woodland/bush to blend subject to site specific conditions			X	
LV.13	Soften boundary edges of Industrial Area/CPF with native planting which could also benefit the community (formation of allotments/gardens and /or tree or plant nurseries)			X	
LV.14	Roads will be well maintained to keep the roads usable. Responsibilities for roads maintenance will be defined with relevant authorities. A dedicated handover plan for roads will be implemented with the relevant Authorities when the Construction and Pre-commissioning Phase is complete. The handover plan will be subject to consultation and agreement with the authorities and shall specify the long term arrangements and responsibilities to be adopted	X	X	X	X
LV. 15	Landscaping, including earth bunds around well pads within the park will be established, and will be covered with topsoil and plants associated with the immediate vicinity and monitored and maintained to ensure success and stability of these bunds. Consideration will be given to the need to avoid attracting animals (e.g. the oasis effect in dry seasons)	X	X	X	

For the avoidance of repetition, additional mitigation measures LV.1, LV.6, LV.7, LV.14 and LV.15 apply to each Landscape Character Area and Viewpoints and have not been included in full in Table 11-13.

11.8.4 Residual Impacts

A summary of the residual landscape and visual impacts taking into account additional mitigation is provided in Table 11-13 below.

Table 11-13: Assessment of Residual Impacts: Site Preparation and Enabling Works

Receptor	Sensitivity	Magnitude	Potential impact significance	Additional mitigation	Residual impact significance
Landscape Character Areas					
1 - LCA 01 - Buliisa Lowland Pastoral Farmland	Low	Moderate	**Low Adverse**	LV.1, LV.6, LV.7, LV.14 and LV.15 LV.2 Avoid introduction of roads at right angles to existing roads, where practicable. LV.3 Material selection for roads to take into account aesthetic aspects to blend in with existing landscape, where possible. LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Low Adverse**
2 - LCA 02 - Buliisa Lowland Rolling Farmland	Low	Moderate	**Low Adverse**	LV.1, LV.6, LV.7, LV.14 and LV.15 LV.2 Avoid introduction of roads at right angles to existing roads, where practicable. LV.3 Material selection for roads to take into account aesthetic aspects to blend in with existing landscape, where possible. LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Low Adverse**
3 - LCA 03 - Lake Albert Coastal Fringe	Moderate	Negligible	**Low Adverse**	Not applicable	**Low Adverse**
4 - LCA 04 - Victoria Nile Corridor	High	Very Low	**Low Adverse**	Not applicable	**Low Adverse**
5 - LCA 05 - Lake Albert-Victoria Nile Delta	High	Negligible	**N/A**	Not applicable	**N/A**
6 - LCA 06 - MFNP South, Rolling Woodland	High	Negligible	**Low Adverse**	LV.1, LV.6, LV.7, LV.14 and LV.15 LV.2 Avoid introduction of roads at right angles to existing roads, where practicable. LV.3 Material selection for roads to take into account aesthetic aspects to blend in with existing landscape, where possible. LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Low Adverse**

Receptor	Sensitivity	Magnitude	Potential impact significance	Additional mitigation	Residual impact significance
7 - LCA 07 - MFNP North, Savanna Plateau	High	Moderate	**High Adverse**	LV.1, LV.6, LV.7, LV.14 and LV.15 LV.2 Avoid introduction of roads at right angles to existing roads, where practicable. LV.3 Material selection for roads to take into account aesthetic aspects to blend in with existing landscape, where possible. LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Moderate Adverse**
Viewpoints					
1 - Kimoli	Moderate	High	**High Adverse**	LV.1, LV.6, LV.7, LV.14 and LV.15 LV.2 Avoid introduction of roads at right angles to existing roads, where practicable. LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**High Adverse**
2 - Kibambura	Low	Negligible	**Insignificant**	Not applicable	**Insignificant**
3 - Buliisa (West)	Moderate	Low	**Low Adverse**	Not applicable	**Low Adverse**
4 - Kisimo	Low	Negligible	**Insignificant**	Not applicable	**Insignificant**
5 - Kirama	Moderate	Moderate	**Moderate Adverse**	LV.1, LV.6, LV.7, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Low Adverse**
6 - Ngwedo Farm	Low	Low	**Low Adverse**	LV.1, LV.6, LV.7, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Low Adverse**
7 - Baker's Lodge	High	Negligible	**Insignificant**	Not applicable	**Insignificant**
8 - Kabalega Wilderness Lodge	High	Negligible	**Insignificant**	Not applicable	**Insignificant**
9 - Murchison River Lodge	High	Negligible	**Insignificant**	Not applicable	**Insignificant**
10 – Nile Safari Lodge	High	Negligible	**Insignificant**	Not applicable	**Insignificant**
11 - Pakuba Safari Lodge	High	Low	**Moderate Adverse**	LV.1, LV.6, LV.7, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Moderate Adverse**

Receptor	Sensitivity	Magnitude	Potential impact significance	Additional mitigation	Residual impact significance
12 - Paraa Ferry Crossing	High	Moderate	**High Adverse**	LV.1, LV.6, LV.7, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Moderate Adverse**
13 - Buligi Track, Delta Track Junction	High	Moderate	**High Adverse**	LV.1, LV.6, LV.7, LV.14 and LV.15	**Moderate Adverse**
14 - Albert Track	High	Low	**Moderate Adverse**	LV.1, LV.6, LV.7, LV.14 and LV.15	**Moderate Adverse**
15 - Wanseko beach	Moderate	Low	**Low Adverse**	Not applicable	**Low Adverse**
16 - Kasinyi (West)	Moderate	Low	**Low Adverse**	Not applicable	**Low Adverse**
17- Kasinyi (East)	Moderate	High	**High Adverse**	LV.1, LV.6, LV.7, LV.14 and LV.15 LV.8 Any areas of land which are disturbed during construction should be restored to help prevent any erosion.	**Moderate Adverse**
18 - Buligi Track (Pakuba Airfield)	High	Moderate	**High Adverse**	LV.1, LV.6, LV.7, LV.14 and LV.15 LV.8 Any areas of land which are disturbed during construction should be restored to help prevent any erosion.	**Moderate Adverse**

11.9 Assessment of Impacts: Construction and Pre-commissioning

Details of the activities are provided in 11.6.2 and ***Chapter 4: Project Description and Alternatives***. The Project components relevant to each receptor are detailed in Site Preparation and Enabling Works and therefore not repeated in the following sections. The Construction and Pre-commissioning phase is expected to last approximately 7 years, between Years 2 and 8.

11.9.1 Potential Landscape Character Impacts

11.9.1.1 LCA 01 - Buliisa Lowland Pastoral Farmland

Sensitivity to Change: Low

Relevant key activities:

- Construction, installation and pre-commissioning of the plant and equipment within the Industrial Area;
- Installation and pre-commissioning of plant and equipment at each well pad: NGR-01, NGR-02, NGR-03A, NGR-05A, NGR-06, NSO-03, NSO-04, NSO-05, KGG-04, KGG-06 and KW-02A;
- Drilling of wells at pad locations; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network (30m RoW).

Impact Magnitude:

During the Construction and Pre-commissioning Phase potential direct impacts on the character of this LCA would result from the introduction of construction plant, operation of construction camps and associated vehicle movements. Direct impacts on the character of this area would include the introduction of large-scale industrial development within a predominantly pastoral landscape.

Construction and pre-commissioning activities would be scattered across the northern half of this LCA, extending further south at the western boundary. Therefore, the central and southwestern extents of this landscape would not be affected by direct construction activity; however vehicular traffic would use the primary roads heading north introducing a greater volume of vehicular movement affecting the relative tranquillity and movement patterns across this LCA. Construction activities would be most intensive within the Industrial Area at the CPF. The intensity of activity at the Industrial Area would vary over the construction period.

Open trench construction activity within the RoW of the pipeline network would also affect the relative levels of tranquillity and landscape patterns. Construction earthworks associated with the pipelines would occur in 1 km sections before being reinstated. In addition there will be 11 well pad sites in which drilling would temporarily introduce further large-scale plant and machinery. However, no more than two drilling rigs would operate within this LCA at any one time.

The scale and intensity of construction activities including the use of vehicles and plant on temporary access tracks and the use of numerous borrow pits would noticeably change the appearance and quality of the rural landscape across a substantial portions of this LCA. In addition, the frequency and movement of personal to and from the Industrial Area Camp and the Buliisa and Bugungu Camps would noticeably increase activity during peak construction. Overall impacts would be medium-term and reversible. On balance, the potential impact magnitude is considered to be High.

Impact Significance:

Potential impact Significance: **Moderate Adverse** Significance

11.9.1.2 LCA 02 - Buliisa Lowland Rolling Farmland

Sensitivity to Change: Low

Relevant key activities:

- Construction, installation and pre-commissioning of the plant and equipment within the Industrial Area;
- Installation and pre-commissioning of plant and equipment at each well pad: GNA-01, GNA-02, GNA-03, GNA-04, NSO-01, NSO-02, NSO-06, KGG-05, KGG-01, KGG-03, and KGG-09;
- Drilling of wells at pad locations; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network (30m RoW).

Impact Magnitude:

During the Construction and Pre-commissioning Phase, potential direct impacts on the character of this LCA would result from the key activities listed above. Construction activities at the Industrial Area will increase in scale from those experienced at the Site Preparation and Enabling Works phase for up to 7 years. The addition of large-scale plant and increased numbers of personal and machinery would increase the scale and intensity of change.

Construction activity related to the installation of infrastructure at the 11 well pads would temporarily introduce further large-scale plant and machinery into the previously cleared well pad sites. During drilling no more than two drilling rigs would operate within this LCA at any one time.

Open trench construction activity within the RoW of the pipeline network would also affect the relative levels of tranquillity and landscape patterns. Construction earthworks associated with the pipelines would occur in 1 km sections before being backfilled and reinstated. The frequency and movement of personnel to and from the Industrial Area Camp and the Bugungu Camp would result in a noticeable increase in activity during peak construction. Overall, the geographical extent of activity would be extensive throughout this LCA.

Construction activities would be medium-term extending up to 7 years overall for the Project and reversible. On balance, the potential impact magnitude is considered to be High.

Impact Significance:

Potential impact Significance: **Moderate Adverse** Significance

11.9.1.3 LCA 03 - Lake Albert Coastal Fringe

Sensitivity to Change**:** Moderate

Relevant key activities:

- Installation and pre-commissioning of the plant and equipment at the Water Abstraction System, including associated pipelines (onshore and offshore);
- Installation and pre-commissioning of plant and equipment at well pads KW-01 and KW-02B
- Drilling of wells at pad locations; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network.

Impact Magnitude:

During the Construction and Pre-commissioning Phase, potential impacts would be located at the site of the Water Abstraction System. Installation activities would vary depending on the final solution of implementation but likely to be of a similar scale and would temporarily reduce relative pockets of tranquillity along the shoreline. Associated construction activities may extend into Lake Albert if an offshore solution is selected.

Construction activity related to the installation of infrastructure at the two well pads would temporarily introduce further large-scale plant and machinery into the previously cleared well pad sites. During drilling only one drilling rig is likely to operate within this LCA at any one time.

Construction and installation activities related to pipelines would include the 1.5 km intake pipeline into Lake Albert, the pipeline from the Water Abstraction System to the CPF and the production and injection network connecting the well pads. Construction earthworks associated with the pipelines would occur in 1 km sections before being backfilled and reinstated. Potential impacts would be localised to the site of the Water Abstraction System, RoW of the pipelines and the one well pad site and unlikely to affect the majority of the key characteristics.

Overall, given the minor change to the existing character, short-term, (which would be partially reversible for temporary construction sites) the potential impact magnitude is considered to be Low.

Impact Significance:

Potential impact Significance: **Moderate Adverse** Significance

11.9.1.4 LCA 04 - River Nile Corridor

Sensitivity to Change: High

Relevant key activities:

- Installation and pre-commissioning of plant and equipment at each well pad;
- Drilling of wells at well pad location JBR-10;
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network (including the Victoria Nile crossing using HDD); and
- Ferry movements (and vehicles stationary waiting for the ferry) associated the Victoria Nile Ferry Crossing Facility.

Impact Magnitude:

During the Construction and Pre-commissioning Phase potential impacts would be localised to the operation of the Victoria Nile Ferry Crossing Facility, the Victoria Nile crossing (using HDD) and well pad location JBR-10.

Construction activities at the Nile Crossing would include the introduction of large scale machinery, drilling rig, winch, vehicles and construction personnel required for HDD at both the South and North banks of the Nile, and would disrupt the relative pockets of tranquillity experienced along its the banks. The operation of the ferry crossing would not be entirely uncharacteristic; however, the scale and extent of activity would increase. The scale and intensity of movement of plant and construction activity alongside drilling activities at JBR-10 would increase the scale and spread of uncharacteristic operations within the landscape.

Although activities at these sites have the potential to affect the relative tranquillity, the geographical extent of change is limited given the wider scale of the LCA as a whole. Furthermore, potential impacts would be short-term and reversible. Taking all of this into account the potential impact magnitude is considered to be Low.

Impact Significance:

Potential impact Significance: **Moderate Adverse** Significance

11.9.1.5 LCA 05 - Lake Albert-Victoria Nile Delta

Sensitivity to Change: High

Relevant key activities:

- Construction, installation and pre-commissioning of the plant and equipment required for the Victoria Nile crossing using HDD.

Impact Magnitude:

During the Construction and Pre-commissioning Phase, potential impacts associated with HDD operations would occur largely beneath this LCA and therefore no physical change to the landscape is predicted.

Construction activities and operations associated with HDD would be located to the north and south in the neighbouring LCA -04 (Victoria Nile Corridor) and would be an uncharacteristic influence on the setting and tranquillity of this LCA. Construction activities influencing the setting of this LCA would be isolated to the eastern extents of the LCA, short term and temporary. The majority of the key characteristics would not be altered and therefore the potential impact magnitude is considered to be Low.

Although the construction activities in the neighbouring LCA- 04 would temporarily affect this LCA, the result effect would not be significant.

Impact Significance:

Potential impact Significance: **Low Adverse** Significance

11.9.1.6 LCA 06- MFNP South, Rolling Woodland

Sensitivity to Change: High

Relevant key activities:

- Increased operation of Bugungu Airstrip.

Impact Magnitude:

During the construction and pre-commissioning phase, Project related air travel to the Bugungu Airstrip would increase, primarily for the transportation of Project staff. This would result in a slight increase in vehicular traffic between the Airstrip and the Bugungu Gate.

However, the increase in traffic and activity on an existing route over a 1.9 km stretch of road would be a barely perceptible change to the overall character and experience of this LCA and MFNP. The majority of the key characteristics of this LCA would remain intact and the potential impact magnitude is considered to be Negligible.

Impact significance

Potential impact Significance: **Insignificant**

11.9.1.7 LCA 07 MFNP North, Savanna Plateau

Sensitivity to Change: High

Relevant key activities:

- Installation and pre-commissioning of plant and equipment at each well pad;
- Drilling of wells at the well pad locations; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network (30m RoW).

Impact Magnitude:

During the Construction and Pre-commissioning Phase, potential impacts resulting from construction activities would be located at each of the nine well pad sites and RoW of pipelines. Construction activities including earthworks, transportation of materials and vegetation clearance associated with the construction of pipelines using open trench techniques and RoW would extensively alter the existing landform and landscape pattern within this LCA. These activities also have the potential to disrupt the recreational opportunities and scenic quality (the scenic quality is covered in more detail within the visual assessment).

Activities associated with installation and pre-commissioning at each of the nine well pad sites would further increase the scale and intensity of activity to that experienced during Site Preparation and Enabling Works. Drilling would be sequential and one drilling rig would operate at one well pad at a time. However drilling would extensively reduce the levels of tranquillity within the Park. Much of this activity would extend across the 7 year construction and pre-commissioning period with staged drilling and construction at each well pad site and production and injection network.

Overall construction and pre-commissioning activities would affect many of the key characteristics of this LCA and dominate the perceptual and physical qualities of this part of MFNP. Taking all of this into account the potential impact magnitude is considered to be High.

Impact Significance:

Potential impact Significance: **High Adverse** Significance

11.9.2 Potential Visual Impacts

Refer to Table 11-1 for distances to the relevant Project components that have the potential to be visible from the viewpoints.

11.9.2.1 Viewpoint 1- Kimoli

Sensitivity to change: Moderate

Relevant key activities:

- Construction, installation and pre-commissioning of the plant and equipment within the Industrial Area; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network.

Impact Magnitude:

During the Construction and Pre-commissioning Phase, construction activities would be apparent and in relatively close proximity across an extensive horizontal and vertical proportion of the view. The scale and height of plant, movement of vehicles, machinery and personnel would dominate the focus of views. The potential cranes used to erect the tallest structures would be apparent on the skyline. Construction of pipeline would further increase the scale of activity extending from the Industrial Area beyond the extent of views.

Construction activity would extensively change the composition of the existing view albeit short-term and reversible. The resulting potential impact magnitude is considered to be High.

Impact Significance:

Potential impact Significance: **High Adverse** Significance

11.9.2.2 Viewpoint 2 - Kibambura

Sensitivity to change: Low

Relevant key activities:

- Installation and pre-commissioning of plant and equipment at well pad NSO-04;
- Drilling of wells at well pad location NSO-04; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network.

Impact Magnitude:

During the Construction and Pre-commissioning Phase, construction activities would be partially filtered by intervening topography and vegetation. The extent of visual change would result from the clearance of vegetation, movement of people and transportation of plant, and be contained within the RoW of the proposed pipelines and drilling at well pads.

Construction activities associated with the pipeline including vegetation clearance and earthworks would open up views towards well pad site (NSO-04) and be visible across a noticeable extent of background views. However, during drilling (of each of the 11 wells) the 43 m high drilling rig would be a prominent and incongruous on the skyline and would temporarily form an additional focus of views. Overall, potential impacts would be short-term and reversible. The resulting potential impact magnitude is considered to be Moderate.

Impact Significance:

Potential impact Significance: **Low Adverse** Significance

11.9.2.3 Viewpoint 3 - Buliisa (West)

Sensitivity to change: Moderate

Relevant key activities:

- Installation and pre-commissioning of plant and equipment at well pad KW-01;
- Drilling of wells at well pad location KW-01; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network.

Impact Magnitude:

During the Construction and Pre-commissioning Phase, activities would be partially filtered by intervening topography and vegetation. The extent of change visible would increase from that experienced during site preparation and enabling works. The RoW of the pipeline would be located obliquely to the main focus of views; however, vegetation clearance and earthworks would open up views towards well pad site KW-01. Views of installation and activities would be noticeable across a small extent of the background. However, during drilling (of each of the 5 wells) the 43 m high drilling rig would be a prominent and incongruous on the skyline and would temporarily form an additional focus of views.

Potential visual impacts at construction and pre-commissioning would be short term and reversible. Therefore, the potential impact magnitude is considered to be Moderate.

Impact significance:

Potential impact Significance: **Moderate Adverse** Significance

11.9.2.4 Viewpoint 4 - Kisimo

Sensitivity to Change: Low

Relevant key activities:

- Installation and pre-commissioning of plant and equipment at well pad KW-01;
- Drilling of wells at well pad location KW-01; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network.

Impact Magnitude:

During the Construction and Pre-commissioning Phase, construction activities located at the well pad site KW-01 and the pipeline network would appear distant and oblique to the main focus of views east.

Construction activities would include vegetation clearance, earthworks, and storage of materials associated with open trench construction of pipelines approximately 1 km to the southeast. The movement of plant and construction personal would be noticeable in the mid-to-background, and for a short duration would become a distracting focus.

At well pad site KW-01 ground level operations would be filtered by intervening landform and vegetation. Large-scale machinery would occupy a relatively small proportion of the overall view. However, during drilling (at each of the 5 wells) the 43 m high drilling rig would be a prominent and incongruous on the skyline and would temporarily form an additional focus of views.

Overall construction activities would be short-term and reversible. The potential impact magnitude is considered to be Moderate.

Impact significance

Potential impact Significance: **Moderate Adverse** Significance

11.9.2.5 Viewpoint 5 - Kirama

Sensitivity to Change: Low

Relevant key activities:

- Construction, installation and pre-commissioning of the plant and equipment within the Industrial Area;
- Installation and pre-commissioning of plant and equipment at well pad NGR-03A;
- Drilling of wells at well pad location NGR-03A; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network.

11.9.2.5.1 Impact Magnitude:

Construction and Pre-Commissioning activities would be located at the well pad NGR-03A and the RoW required for pipelines running west to east.

Construction activities including plant mobilisation and machinery required for open trench construction would be largely screened by the sloping topography and vegetation. However, the tallest plant and access to the site would be visible across a small proportion of the overall view.

Construction activities at well pad site NGR-03A would be largely screened. The scale and intensity of movement would be most prominent during drilling (at each of the 11 wells) and the 43 m high drilling rig would be a prominent addition to the relatively undisturbed skyline. Construction activities would disrupt the primary focus of the view albeit short-term and reversible. On balance, the potential impact magnitude is considered to be Low.

Impact significance

Potential impact Significance: **Low Adverse** Significance

11.9.2.6 Viewpoint 6 - Ngwedo Farm

Sensitivity to Change: Low

Relevant key activities:

- Construction, installation and pre-commissioning of the plant and equipment within the Industrial Area;
- Installation and pre-commissioning of plant and equipment at well pads NSO-04 and NSO-05;
- Drilling of wells at well pad locations NSO-04 and NSO-05; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network.

Impact Magnitude:

During the Construction and Pre-Commissioning Phase, construction activities would be located obliquely to the primary focus of views along the main road and partially screened by existing landform and vegetation.

Vegetation clearance works associated with the RoW of the pipelines would be barely perceptible in distant background views and noticeable changes limited to the use of access tracks by vehicles and personnel.

Views of construction activities associated with the well pads NSO-04 and NSO-05 would be limited to the presence of cranes and drilling equipment (at each of the 22 wells); in particular the 43 m high drilling rig. Although temporary, the presence of the drilling rig would be a prominent addition on the skyline. In addition, plant and machinery such as cranes required to construct the tallest structures at the Industrial Area (in particular the CPF site) would be visible in the background further fragmenting the skyline. However, construction and pre-commissioning activities are unlikely to become the primary focus of views along the road. Potential impacts would be short to medium term and reversible.

On balance, the potential impact magnitude is considered to be Low.

Impact significance

Potential impact Significance: **Low Adverse** Significance

11.9.2.7 Viewpoint 7 - Baker's Lodge

Sensitivity to Change: High

Relevant key activities:

- Installation and pre-commissioning of plant and equipment at well pads JBR-01 and JBR-02;
- Drilling of wells at well pad locations JBR-01 and JBR-02; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network.

Impact Magnitude:

Intervening vegetation would almost entirely screen views of construction activity from this low-lying viewpoint. The only noticeable change in views from Baker's Lodge would be during drilling which would be temporary in nature (at each of the 21 wells). The upper portions of the 43 m high drilling rig and night time lighting at each of the two well pad sites JBR-01 and JBR-02 would be visible across a very small proportion oblique to the focus of the view. Any change in view would be barely perceptible from this low-level viewpoint. Given that, the potential impacts would be short–term and reversible the overall potential impact magnitude is considered to be Negligible.

Impact significance

Potential impact Significance: **Low Adverse** Significance

11.9.2.8 Viewpoint 8 - Kabalega Wilderness Lodge

Sensitivity to Change: High

Relevant key activities:

- Installation and pre-commissioning of plant and equipment at each well pad JBR-01 and JBR-02;
- Drilling of wells at well pad locations JBR-01 and JBR-02; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network.

Impact Magnitude:

During the Construction and Pre-Commissioning Phase, the visible extent of change from this lodge would be limited to a small proportion of the background on the north bank of the Nile.

Construction activities at the two well pad sites (JBR-01 and JBR-02) would be barely perceptible and largely screened by the intervening topography. However, during drilling (at each of the 21 wells) the height and scale of the 43 m high drilling rig and night time lighting would be a noticeable but distant addition on the skyline.

The introduction of such activities would temporarily alter the balance and composition of the view. Potential impacts would be short-term and reversible. Therefore, the potential impact magnitude is considered to be Low.

Impact significance

Potential impact Significance: **Moderate Adverse** Significance

11.9.2.9 Viewpoint 9 - Murchison River Lodge

Sensitivity to Change: High

Relevant key activities:

- Installation and pre-commissioning of plant and equipment at each well pad JBR-01 and JBR-02;
- Drilling of wells at well pad locations JBR-01 and JBR-02; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network.

Impact Magnitude:

During the Construction and Pre-Commissioning Phase, activities would be largely screened by intervening topography and vegetation. The extent of visible change would result from plant mobilisation between the Nile crossing and the well pad site JBR-01. This activity would occupy a very small proportion of the background, across the north bank of the Nile.

Construction activities at both well pad sites (JBR-01 and JBR-02) would be largely screened, however during drilling (at each of the 21 wells) the height and scale of the 43 m high drilling rig, presence of cranes and night time lighting would be visible on the distant skyline.

Albeit short-term and reversible, construction activities in the background of the view would temporarily contrast with the composition and setting of the view. On balance, the potential impact magnitude is considered to be Low.

Impact significance

Potential impact Significance: **Moderate Adverse** Significance

11.9.2.10 Viewpoint 10- Nile River Lodge

Sensitivity to Change: High

Relevant key activities:

- Installation and pre-commissioning of plant and equipment at well pads JBR-01 and JBR-02;

- Drilling of wells at well pad locations; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network.

Impact Magnitude:

During Construction and Pre-Commissioning Phase, activities would be largely screened by intervening topography and vegetation.

The extent of visible change would result from distant views of plant mobilisation and the movement of cranes at well pad sites JBR-01 and JBR-02. This activity would occupy a very small proportion across the north bank of the Nile in the distant background. During drilling (at each of the 21 wells) the height and scale of the 43 m high rig presence of cranes and lighting of night time activities would appear on the skyline. Drilling would be temporary but would alter composition of the view. Taking all of this into account, the potential impact magnitude is considered to be Low.

Impact significance

Potential impact Significance: **Moderate Adverse** Significance

11.9.2.11 Viewpoint 11 - Pakuba Safari lodge

Sensitivity to Change: High

- Installation and pre-commissioning of plant and equipment at well pad JBR-09;
- Drilling of wells at well pad location JBR-09 and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network.

Impact Magnitude:

During Construction and Pre-Commissioning Phase, activities would be partially screened by intervening vegetation and topography.

The introduction of construction activities including the presence of cranes at well pad site JBR-09 would appear distant; however, vehicular access moving plant and the transport of personal along road C1 would be a noticeably contrasting addition to the existing view. Given the panoramic nature of views, construction activities would occupy a small but noticeable proportion of the view.

During drilling (at each of the 14 wells), the height and scale of the 43 m high drilling rig would become a noticeable feature on the skyline. Drilling would be temporary but would alter the composition of the view and is likely to become the primary focus. Transportation of drilling and construction materials will add to the disturbance of the view.

Taking all of this into account, the potential impact magnitude is considered to be Low.

Impact significance

Potential impact Significance: **Moderate Adverse** Significance

11.9.2.12 Viewpoint 12 - Paraa Ferry Crossing

Sensitivity to Change: High

Relevant key activities:

- Ferry movements (and vehicles stationary waiting for the ferry) associated with the Victoria Nile Ferry Crossing facility.

Impact Magnitude:

During the Construction and Pre-Commissioning Phase, activities associated with the Victoria Nile Ferry Crossing facility at the north and south bank would occupy views experienced by tourists and communities using the existing Paraa ferry crossing. The southern jetty extends 70 m into the Victoria Nile from the south bank whilst the northern jetty extends 40 m from the north bank. The presence of the onshore facilities would introduce further development across a small proportion of the background. The scale and mass of plant and equipment being transported would be noticeable from both the southern and northern banks. The introduction of the new ferry crossing and the intensity of movement and activity at the shoreline and within the Victoria Nile would alter the balance and composition of the existing view such that operations would become the main focus of the views both north and south. However disruption to the view would be medium-term and reversible. Taking all of this into account the potential impact magnitude is considered to be Moderate.

Impact significance

Potential impact Significance: **High Adverse** Significance

11.9.2.13 Viewpoint 13 - Buligi Track, Delta Track Junction

Sensitivity to Change: High

Relevant key activities:

- Installation and pre-commissioning of plant and equipment at well pads JBR-05, JBR-06 and JBR-07;
- Drilling of wells at well pad locations JBR-05, JBR-06 and JBR-07; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network.

Impact Magnitude:

During the Construction and Pre-Commissioning Phase, activities would be largely in similar locations to that experienced at Site Preparation and Enabling Works. The further increase in height and mass of plant and machinery including cranes at each of the well pad sites would further alter the balance and composition of the view. This activity would fragment the background composition and would be seen in combination across the main focus of westerly views of MFNP. Construction activities within the RoW of the proposed pipeline including the clearance of vegetation, earthworks and storage of materials would be particularly noticeable.

During drilling (at each of the 37 wells) the 43 m high drilling rig would become the prominent feature and lighting of night time activities on the skyline at each of the well pad locations throughout the drilling period. Transportation of drilling and construction materials to the three well pads will add to the disturbance of the view. Only one drilling rig will be visible at any one time.

Albeit for a short duration and reversible, the introduction of these activities in the background of the view would be of a contrasting scale to the existing features in view and likely to become the primary focus.

Taking all of this into account, the potential impact magnitude is considered to be High.

Impact significance

Potential impact Significance: **High Adverse** Significance

11.9.2.14 Viewpoint 14 - Albert Track

Sensitivity to Change: High

Relevant key activities:

- Installation and pre-commissioning of plant and equipment at well pads JBR-05, JBR-06 and JBR-07;

- Drilling of wells at well pad locations JBR-05, JBR-06 and JBR-07; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network.

Impact Magnitude:

During the Construction and Pre-Commissioning Phase, activities associated with the construction of flowlines and well pads would appear in long-distance views to the east and northeast. The activities would be in similar locations to that experienced at Site Preparation and Enabling Works.

The closest distance to the works would be 3.4 km at well pad site JBR-05. The scale and intensity of plant and movement of machinery including the presence of cranes would introduce additional features on the skyline at three key locations (JBR-05, JBR-06 and JBR-07) linked by further activity along the RoW of the pipelines. Construction activities within the RoW including the clearance of vegetation, earthworks and storage of materials would be particularly noticeable.

During drilling (at each of the 51 wells) the 43 m high drilling rig and lighting of night time activities would particularly prominent and uncharacteristic structures on the skyline. Transportation of drilling and construction materials to the three well pads will add to the disturbance of panoramic view.

Overall construction and pre-commissioning activities would occupy a small part of this panoramic view, and although drilling would be prominent it would not dominate the multi-directional focus of views from the Albert Track. The size and scale of activities would be short-term and reversible. As such the potential impact magnitude is considered to be Moderate.

Impact significance

Potential impact Significance: **High Adverse** Significance

11.9.2.15 Viewpoint 15 - Wanseko Beach

Sensitivity to Change: Moderate

Relevant key activities:

- Installation and pre-commissioning of the plant and equipment at the Water Abstraction System, including associated pipelines (onshore and offshore); and
- Drilling of wells across well pad locations NGR-03A and NGR-06.

Impact Magnitude:

During the Construction and Pre-Commissioning Phase, activities associated with the construction of well pads would be largely screened by intervening built form and vegetation. The tallest elements associated with drilling and other tall elements of the plant including cranes would be noticeable in long-distance views to the east and northeast.

The upper portion of the 43 m high drilling operations would be visible for the majority of the drilling period. However during a two year period, there is the potential for two rigs at sites NGR-03A and NGR-06 to be visible. The addition of these structures on the skyline would add to the existing telecoms towers and therefore not be uncharacteristic. This scenario would be short-term and reversible and is unlikely to alter the primary focus of views across Lake Albert.

Overall the potential impact magnitude is considered to be Low.

Impact significance

Potential impact Significance: **Low Adverse** Significance

11.9.2.16 Viewpoint 16 - Kasinyi (West)

Sensitivity to change: Moderate

Relevant key activities:

- Installation and pre-commissioning of plant and equipment at well pad NGR-01;
- Drilling of wells at well pad NGR-01; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network (including the Victoria Nile pipeline crossing using HDD).

Impact Magnitude:

During the Construction and Pre-Commissioning Phase, construction activities will be undertaken at the well pad site NGR-01 (252 m southwest) and the RoW for the section of pipeline heading north from the well pad to the Victoria Nile HDD Crossing (642 m northwest). Construction activities including the presence of cranes at the well pad site would be slightly greater in scale to that experienced during Site Preparation and Enabling Works. The scale and intensity of movement from plant and vehicles would be noticeable across a small proportion of the view southwest.

Construction activities within the pipeline RoW including the movement of plant, vegetation clearances and earthworks would extend the influence of activity further west and to the northwest which would temporarily distract from the focus of views towards the savanna plateau.

In addition, during drilling activities (at each of the 13 wells) the 43 m high would appear prominent and night time lighting would also temporarily disrupt the focus of views southwest. Potential impact would be short-term and reversible. Overall construction activities would increase the scale of visual intrusion and the potential impact magnitude is considered to be Moderate.

Impact Significance:

Potential impact Significance: **Moderate Adverse** Significance

11.9.2.17 Viewpoint 17 - Kasinyi (East)

Sensitivity to Change: Moderate

Relevant key activities:

- Construction, installation and pre-commissioning of the plant and equipment within the Industrial Area; and
- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network.

Impact Magnitude:

During the Construction and Pre-Commissioning Phase, construction activities would be apparent and in relatively close proximity beyond the intervening vegetation. The scale and mass of plant and activity would be visible across an extensive horizontal and vertical proportion of the view. The movement of plant and tallest structures including cranes would dominate the background of views and would become a distracting focus. The size and scale of activities would be short-term and reversible. Overall the potential impact magnitude is considered to be High.

Impact significance

Potential impact Significance: **High Adverse** Significance

11.9.2.18 Viewpoint 18 - Buligi Track (Pakuba Airfield)

Sensitivity to Change: High

Relevant key activities:

- Installation and pre-commissioning of plant and equipment at well pads JBR-05 JBR-06 and JBR-07;
- Drilling of wells at well pad locations; and

- Construction, installation and pre-commissioning of the plant and equipment required for the Production and Injection Network.

Impact Magnitude:

During the Construction and Pre-Commissioning Phase, activities would be largely in similar locations to that experienced at Site Preparation and Enabling Works. The further increase in height and mass of plant and machinery including cranes at each of the well pad sites would further alter the balance and composition of the view. This activity would fragment the background composition and would be seen in combination across views east across the savanna. Construction activities within the RoW of the proposed pipeline including the clearance of vegetation, earthworks and storage of materials would also be noticeable on the distant horizon.

During drilling (at each of the 31 wells across the two well pads) the 43 m high drilling rig would become the tallest and most prominent feature on the skyline throughout the drilling period. Transportation of drilling and construction materials to the two well pads will further disrupt the composition and balance of the view. However, only one drilling rig will be visible at any one time.

Albeit for a short duration and reversible, the introduction of these activities in the background of the view would be of a contrasting scale and appearance to the existing features in view and likely to become the primary focus.

Taking all of this into account, the potential impact magnitude is considered to be High.

Impact significance:

Potential impact Significance: **High Adverse** Significance

11.9.3 Additional Mitigation (Construction and Pre-Commissioning)

Additional mitigation measures which have the potential to reduce some landscape and visual effects during the Construction and Pre-Commissioning Phase are identified in Table 11-12.

For the avoidance of repetition, mitigation measures LV.6, LV.7, LV.8, LV.14 and LV.15 apply to each Landscape Character Area and Viewpoints and have not been included in full in Table 11-14.

11.9.4 Residual Impacts

A summary of the residual landscape and visual impacts taking into account additional mitigation is provided in Table 11-14 below.

Table 11-14: Summary of Residual Impacts: Construction and Pre-commissioning

Receptor	Sensitivity	Magnitude	Potential impact significance	Additional mitigation	Residual impact significance
Landscape Character Areas					
1 - LCA 01 - Buliisa Lowland Pastoral Farmland	Low	High	**Moderate Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Moderate Adverse**
2 - LCA 02 - Buliisa Lowland Rolling Farmland	Low	High	**Moderate Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Moderate Adverse**
3 - LCA 03 - Lake Albert Coastal Fringe	Moderate	Low	**Moderate Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15	**Moderate Adverse**
4 - LCA 04 - Victoria Nile Corridor	High	Low	**Moderate Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15	**Moderate Adverse**
5 - LCA 05 - Lake Albert-Victoria Nile Delta	High	Low	**Low Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15	**Low Adverse**
6 - LCA 06 - MFNP South, Rolling Woodland	High	Negligible	**Insignificant**	LV.6, LV.7, LV.8, LV.14 and LV.15	**Insignificant**
7 - LCA 07 - MFNP North, Savanna Plateau	High	High	**High Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**High Adverse**
Viewpoints					
1 - Kimoli	Moderate	High	**High Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**High Adverse**
2 - Kibambura	Low	Moderate	**Low Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Low Adverse**
3 - Buliisa (West)	Moderate	Moderate	**Moderate Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Moderate Adverse**

Receptor	Sensitivity	Magnitude	Potential impact significance	Additional mitigation	Residual impact significance
4 – Kisimo	Low	Moderate	**Moderate Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15 LV.1 Limit extent of vegetation clearance wherever possible. LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Moderate Adverse**
5 - Kirama	Moderate	Low	**Low Adverse**	Not applicable	**Low Adverse**
6 - Ngwedo Farm	Low	Low	**Low Adverse**	Not applicable	**Low Adverse**
7 - Baker's Lodge	High	Low	**Low Adverse**	Not applicable	**Low Adverse**
8 - Kabalega Wilderness Lodge	High	Low	**Moderate Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15 LV.1 Limit extent of vegetation clearance wherever possible.	**Moderate Adverse**
9 - Murchison River Lodge	High	Low	**Moderate Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15 LV.1 Limit extent of vegetation clearance wherever possible.	**Moderate Adverse**
10 - Nile Safari Lodge	High	Low	**Moderate Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Moderate Adverse**
11 - Pakuba Safari Lodge	High	Low	**Moderate Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Moderate Adverse**
12 - Paraa Ferry Crossing	High	Moderate	**High Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Moderate Adverse**
13 - Buligi Track, Delta Track Junction	High	High	**High Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15	**High Adverse**
14 - Albert Track	High	Moderate	**High Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15	**High Adverse**
15 - Wanseko beach	Moderate	Low	**Low Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15	**Low Adverse**
16 - Kasinyi (West)	Moderate	Moderate	**Moderate Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15	**Moderate Adverse**
17 - Kasinyi (East)	Moderate	High	**High Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Moderate Adverse**

Receptor	Sensitivity	Magnitude	Potential impact significance	Additional mitigation	Residual impact significance
18 - Buligi Track (Pakuba Airfield)	High	High	**High Adverse**	LV.6, LV.7, LV.8, LV.14 and LV.15	**High Adverse**

11.10 Assessment of Impacts: Commissioning and Operations

Commissioning and Operations are expected to commence approximately 36 months after effective date of the main construction contract award. The lifetime of the Project is 25 years.

11.10.1 Potential Landscape Impacts

11.10.1.1 LCA 01 - Buliisa Lowland Pastoral Farmland

Sensitivity to Change: Low

Relevant completed Project components:

- Industrial Area;
- Well pads: NGR-01, NGR-02, NGR-03A, NGR-05A, NGR-06, NSO-03, NSO-04, NSO-05, and KGG-06;
- Production and Injection Network RoW; and
- Upgraded and new roads: A1, A2, B1, B2, N1, N2 and inter field access roads.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues;
- Well pad maintenance activity including venting and workover activities using workover rig; and
- Flaring (considering both the enclosed ground flare and the elevated flare options).

Impact Magnitude:

During the Commissioning and Operations Phase, the introduction of the completed and operational Project infrastructure would noticeably change the characteristics and perceptive qualities of this LCA.

The most noticeable scale of change within this LCA would be located at the Industrial Area, extending 2.5 km by 1.5 km and covering 307 hectares (ha), most notably within the CPF. The built form would comprise a series of oil processing facilities extending up to 60 m in height. The Industrial Area itself would be the hub of activity and operation and would transform the character and land use within this part the landscape and the surrounding areas.

The introduction and operation of the CPF and associated facilities would be highly contrasting with the largely rural landscape setting. The scale and mass of industrial development including the radio mast at 60 m, turbines at up to 45 m and the heater at 30 m would result in an extensive change over a limited geographical area within the wider scale of this LCA.

Flaring considers two options. The introduction of the enclosed ground flare would add to the height (26 m) and mass (13 m diameter) of development within the CPF. Whereas a 50 m elevated flare would be much higher than the surrounding built form and would become a landmark structure, however with a much lower mass (1.3 m diameter). Although rare, emergency flaring from the elevated flare would be particularly noticeable and affect the relative tranquillity and vast skyline experienced within this LCA beyond the immediate setting of the Industrial Area.

During servicing, the influx in vehicle movement and lighting at night would also alter the balance of tranquillity and pastoral land use within the northern part of this LCA.

In isolation each well pad is relatively small in comparison to the vast scale of the landscape; however together, the 11 well pads and associated infrastructure up to 5 m in height, would noticeably expand the footprint of oil infrastructure across this landscape. Although maintenance operations would be infrequent the scale of activity, in particular use of the 30 m high workover rig, would be more noticeable given the numerous (11) well pad locations within this LCA.

Overall the Project components will alter a number of key characteristics and largely influence the experience in localised areas throughout this LCA. Landscape potential impacts would be long-term and partially reversible.

Taking into account the scale, extent and duration of change the overall the potential impact magnitude is considered to be High.

Impact significance

Potential impact Significance: **Moderate Adverse** Significance

11.10.1.2 LCA 02 - Buliisa Lowland Rolling Farmland

Sensitivity to Change: Low

Relevant completed Project components:

- Industrial Area;
- Well pads: GNA-01, GNA-02, GNA-03, GNA-04, NSO-01, NSO-02, NSO-06, KGG-05, KGG-01, KGG-03 and KGG-09;
- Production and Injection Network RoW; and
- Upgraded and new roads: A1, A3, A4, N3, and inter field access roads.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues;
- Well pad maintenance activity including venting and workover activities using workover rig; and
- Flaring (considering both the enclosed ground flare and the elevated flare options).

Impact Magnitude:

During the Commissioning and Operations Phase potential impacts on this LCA would be largely similar to that experienced in neighbouring LCA 01 - Buliisa Lowland Pastoral Farmland.

The difference in potential impacts in this LCA would result from the greater shift in landscape pattern and perceptive qualities including tranquillity. The disruption in pattern would result from the introduction of the Project components which would more noticeably disrupt the mosaic pattern of agricultural fields characteristic of this LCA. Similarly, the network of pipelines would have been reinstated; however, the pipeline routes would be discernible as straight edge lines in the landscape, void of mature trees across the 30m RoW. Maintenance operations would also disturb relative pockets of tranquillity throughout this LCA. Therefore, the shift in land use would be slightly greater than in the neighbouring LCA 01.

Overall the operational development would result in a noticeable change affecting some characteristics over the long-term but partially reversible. As such the potential impact magnitude is considered to be High.

Impact significance

Potential impact Significance: **Moderate Adverse** Significance

11.10.1.3 LCA 03 - Lake Albert Coastal Fringe

Sensitivity to Change: Moderate

Relevant completed Project components:

- Well pads: KW-02B and KW-01;
- Production and Injection Network RoW; and
- Lake Water Abstraction System.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues;
- Well pad maintenance activity including venting and workover activities using workover rig.
- Operation and maintenance of Water Abstraction System.

Impact Magnitude:

Potential direct impacts on the characteristics of this landscape would result from operation and commissioning activities associated with the Water Abstraction System and well pads KW-02B and KW-01.

Potential impacts relating from the introduction of the Water Abstraction System considers two options.

The offshore solution would include the presence and operation of a floating pump platform, which would be an uncharacteristic addition to the setting and shoreline of this LCA. However, the size and scale of this structure would be very limited and potential impacts would be relatively localised. Maintenance operations would also be un-characteristic but limited in scale and intensity.

Potential impacts resulting from the onshore solution which would be located 200 m from the lakeshore would be a noticeable addition of uncharacteristic built form along the shore. Maintenance and service operations would further increase the influence of Project infrastructure in this location. The site and location could alter the location of typical landing sites and fishing activities as well as existing patterns of movement along the coastline.

The operational well pads KW-02B and KW-01 would be unmanned, with a workover rig mobilising periodically every 1 to 5 years for each well, and this one well pad in isolation would affect the immediate context of the well pad. Potential impacts would be limited to the immediate setting, of the well pad site and access road.

During operation, the area above pipelines would have been reinstated. The pipeline routes would be discernible as straight edge lines in the landscape, void of mature trees across the 30m RoW and would slightly reduce the naturalistic landscape patterns within this LCA.

There will be an introduction of some Project elements which are uncharacteristic to the area, and give rise to some minor, long-term changes to the character and experience of the LCA. However, the overall extent of operational activities would be comparatively limited in geographical extent. Therefore, the potential impact magnitude is considered to be Low.

Impact significance

Potential impact Significance: **Low Adverse** Significance

11.10.1.4 LCA 04 - River Nile Corridor

Sensitivity to Change: High

Relevant completed Project components:

- Production and Injection Network RoW, including the Nile HDD pipeline crossing;
- Well pads: JBR-10;
- New roads: C1, C2 and C3; and
- Victoria Nile Ferry Crossing Facility.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues;

- Well pad maintenance activity including venting and workover activities using workover rig; and
- Ferry movements (and vehicles stationary waiting for the ferry) associated with the Victoria Nile Ferry Crossing Facility.

Impact Magnitude:

The completed and operational buried Nile HDD pipeline crossing would result in a barely perceptible change to the key characteristics of this LCA.

The introduction of well pad JBR-10 would be a noticeable and obvious change to the character of this part of MFNP. The influence of this well pad within the landscape would be greater when the 30 m high workover rig is in operation, albeit limited in area. The introduction of oil and gas industry would affect both the physical and perceptual quality and experience of the landscape.

The presence and operation of the Industrial Area to the south would also give rise to potential impacts on the setting across the southern portion of this LCA, where the tallest structures (potentially including an elevated flare (50 m)) would appear on the skyline.

The operational Project components would not compromise the overall character and experience and over time the establishment of vegetation would reduce the scale of change further.

Although potential impacts would be long-term, the geographical extent of change experienced in LCA 04 would be limited and partially reversible. On balance the magnitude of potential impact would be Low.

Impact significance

Potential impact Significance: **Low Adverse** Significance

11.10.1.5 LCA 05 - Lake Albert-Victoria Nile Delta

Sensitivity to Change: High

Relevant completed Project components:

None

Relevant key activities:

None

Impact Magnitude:

The completed and operational buried Nile HDD pipeline crossing would result in a barely perceptible change to any of key characteristics of this LCA. The majority of the key characteristics would remain intact, as such, the potential impact magnitude is considered to be Negligible.

Impact significance

Potential impact Significance: **Insignificant**

11.10.1.6 LCA 06 - MFNP South, Rolling Woodland

Sensitivity to Change: High

Relevant completed project components:

- Upgraded road N3; and
- Bugungu airstrip.

Relevant key activities:

- Operation of Bugungu airstrip.

Impact Magnitude:

At operation, use of the Bugungu for the transportation of Project staff would result in a slight increase in vehicular traffic between the Airstrip and the Bugungu Gate. However, the increase in traffic and activity on an existing route over a 1.9 km stretch of road would be a barely perceptible to the overall character and experience of this LCA and MFNP. The majority of the key characteristics of this LCA would remain intact and the potential impact magnitude is considered to be Negligible.

Potential impact Significance: **Insignificant**

11.10.1.7 LCA 07 - MFNP North, Savanna Plateau

Sensitivity to Change**:** High

Relevant completed Project components:

- Well pads JBR-01, JBR-02, JBR-03, JBR-04, JBR-05, JBR-06, JBR-07, JBR-08 and JBR-09;
- Production and Injection Network RoW; and
- New road C2.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues; and
- Well pad maintenance activity including venting and workover activities using workover rig.

Impact Magnitude:

During the Commissioning and Operations Phase a total of 9 well pads would extend throughout this LCA connected by a network of buried pipelines leading to the Nile HDD pipeline crossing in the neighbouring LCA 04.

The presence of the Project components, in particular the 9 well pads, would be an uncharacteristic addition and alteration to the land use and pattern within this LCA. Furthermore, the cluster of well pads would reduce the high levels of tranquillity experienced within this part of MFNP. It is anticipated that well pads within this part of MFNP would be contained by a structure such as a bund wall (to be determined). Given the flat nature of the landscape, it is likely the containment structures would be visually incongruous within the largely flat landscape.

The completed and operating well pads would be largely unmanned; however, a workover rig will periodically mobilise to perform well maintenance activities, with occasional vehicular and personal access along existing and proposed routes C1 and C2. Together these activities would reduce pockets of tranquillity within this landscape.

At Commissioning and Operations, the network of pipelines would have been reinstated. However the pipeline routes would be discernible as straight edge lines in the landscape, void of mature trees across the 30 m RoW and would in turn disrupt the naturalistic patterns of the savannas extending across this LCA.

Effects on the setting of this LCA would arise from the presence and operation of the Industrial Area to the south, where the tallest components and flare stacks would be visible on the skyline. Any episodes of flaring would be particularly disruptive given the elevated topography of this LCA. The presence of the Project components would alter both tourist and UWA perceptions of the North MFNP and its iconic associations.

Although clustered along a linear stretch at the centre of this LCA, the Project components would affect a noticeable geographical extent of this LCA. Potential impacts are considered to be long term and partially reversible.

Overall, the introduction of largescale oil production infrastructure within a largely unspoiled and naturalistic landscape of recognised quality would be a substantial shift from the existing physical character and perceptual qualities of this LCA.

Taking all of this into account the potential impact magnitude is considered to be High.

Impact significance

Potential impact Significance: **High Adverse** Significance

11.10.2 Potential Visual Impacts

11.10.2.1 Viewpoint 1 - Kimoli

Sensitivity to Change: Moderate

Relevant completed Project components:

- Industrial Area;
- Production and Injection Network RoW; and
- New roads: N1.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues; and
- Flaring (considering both the enclosed ground flare and the elevated flare options).

Impact magnitude:

During the Commissioning and Operations Phase the Project infrastructure would be located 146 m south of the viewpoint. The scale and intensity of activity within views would have reduced from the construction and pre-commissioning phase. Foreground views could be partially disrupted by the transport of operational personnel to and from the site.

The introduction of built form and tall infrastructure components, in particular: diesel generators, water injection units, storage tanks, heaters, de-aeration tower and flare stack would transform the background skyline. The tallest components of the Industrial Area including the radio mast at 60 m above ground level; elevated flare 50 m (if considered), turbines at up to 45 m and the heater at 30 m would be the most prominent additions on the skyline. Together the scale and mass of development would dominate the focus of views. If the elevated flare option is considered, emergency flaring, albeit rare and temporary, would further increase the prominence of the Project components.

Background views would be further disrupted by night time lighting spill. Lighting at night would become a distracting focus of views and would heavily contrast with the dark skies presently experienced.

Overall, the introduction of Project components would become the main focus within views from this location and would be highly discordant in views to the south. Therefore the magnitude of potential impact is considered to be High.

Impact significance

Potential impact Significance: **High Adverse** Significance

11.10.2.2 Viewpoint 2 - Kibambura

Sensitivity to Change**:** Low

Relevant completed Project components:

- Well pads: NSO-04; and
- Production and Injection Network RoW.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues; and
- Well pad maintenance activities and workover activities using work-over rig.

Impact magnitude:

During the Commissioning and Operations Phase, the Project components and associated activities 506 m south would result in a less noticeable change than those experienced during construction once vegetation has been reinstated. Structures visible would be limited to the presence and operation of the 30 m workover rig. However, the workover rig will be mobilised only when well maintenance is required therefore potential impacts would be temporary. Although visible, the overall horizontal extent of change in views would be very limited, and the change in background views would not noticeably alter the balance and composition. Potential visual impacts would also be reversible.

Taking all of this into account, the potential impact magnitude is considered to be Low.

Impact significance

Potential impact Significance: **Low Adverse** Significance

11.10.2.3 Viewpoint 3 - Buliisa (West)

Sensitivity to Change**:** Moderate

Relevant completed Project components:

- Well pads: KW-01; and
- Production and Injection Network RoW.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues; and
- Well pad maintenance activities and workover activities using workover rig.

Impact magnitude:

During the Commissioning and Operations Phase the Project components in view would be limited to structures within well pad KW-01, 539 m west. The upper portions of the built form structures would be visible across a small proportion of the overall view. Maintenance activities particularly occasional use of the 30 m high workover rig would be more noticeable but temporary in nature. Views would also be interrupted by the movement of service personal and machinery, which although infrequent would be disruptive. The extent of change in views would be long term (excluding workover rig) and partially reversible.

The introduction of Project infrastructure in relatively close proximity to these residential areas would fundamentally alter the composition of views albeit across a small horizontal extent. Taking all of this into account the potential impact magnitude is considered to be Low.

Impact significance

Potential impact Significance: **Low Adverse** Significance

11.10.2.4 Viewpoint 4 - Kisimo

Sensitivity to Change**:** Low

Relevant completed Project components:

- Well pads: KW-01; and
- Production and Injection Network RoW.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues; and
- Well pad maintenance activities and workover activities using work-over rig.

Impact magnitude:

During the Commissioning and Operations Phase the extent of change visible would be partially filtered by intervening landform and vegetation. Pipelines would be buried and reinstated, however straight voids in mature vegetation such as trees have the potential to be perceptible across mid-to-background views.

The 15 m clearance buffer surrounding the KW-01 well pad located 593 m east would open up some views towards well pad infrastructure. The completed built form and structures would occupy a small but noticeable proportion of the wider background of view. Maintenance activities particularly occasional use of the 30 m high workover rig would be more noticeable but temporary in nature. However given that a number of telecommunication towers are visible in the existing view, the temporary addition of the workover rig would not be entirely uncharacteristic.

Overall the completed and operational Project components would be partially visible across a small proportion of mid-to-distant views but not at the primary focus. The duration of change in views would be long-term and partially reversible. Taking all of this into account the potential impact magnitude is considered to be Low.

Impact significance

Potential impact Significance: **Low Adverse** Significance

11.10.2.5 Viewpoint 5 - Kirama

Sensitivity to Change: Low

Relevant completed Project components:

- Well pads:NGR-03A; and
- Production and Injection Network RoW.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues; and
- Well pad maintenance activities and workover activities using work-over rig.

Impact magnitude:

During the Commissioning and Operations Phase, potential impacts would be limited to the site of well pad NGR-03A located 1.3 km southwest of this location. Noticeable change in views would be limited to the occasional use of the 30 m high workover rig. The height of the rig would be a noticeable contrast on the skyline above vegetation and would be a temporary additional focus within views.

Occasional vehicular access associated with maintenance at the well pad would temporarily disrupt views for residents. Potential visual impacts from this location would be long-term (with the exception of workover rigs) and reversible. On balance the potential impact magnitude is considered to be Low.

Impact significance

Potential impact Significance: **Low Adverse** Significance

11.10.2.6 Viewpoint 6 - Ngwedo Farm

Sensitivity to Change: Low

Relevant completed Project components:

- Industrial Area;
- Well pads: NSO-04 and NSO-05; and
- Production and Injection Network RoW.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues; and
- Well pad maintenance activities and workover activities using work-over rig.

Impact Magnitude:

During the Commissioning and Operations Phase most of the completed built form and structures within the well pad sites would be screened by intervening landform and vegetation. The extent of visible change at well pads would be limited to maintenance activities particularly occasional use of the 30 m high workover rig would be more noticeable but temporary and in nature.

Distant views of the tallest components within the Industrial Area 3.6 km to the northwest would be visible on the skyline across a small but noticeable proportion of the view. The height of the structures including radio mast at 60 m and elevated flare at 50 m (if considered), would be the most noticeable elements. Given the small extent of change across the background and the temporary nature of the workover rig, the balance and composition of the view would not be fundamentally compromised. Any perceptible changes would be long term but reversible. Overall the potential impact magnitude is considered to be Low.

Impact significance

Potential impact Significance: **Low Adverse** Significance

11.10.2.7 Viewpoint 7 - Baker's Lodge

Sensitivity to Change: High

Relevant completed Project components:

- Well pads: JBR-01 and JBR-02; and
- Production and Injection Network RoW.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil to and addressing any issues; and
- Well pad maintenance activities and workover activities using work-over rig.

Impact magnitude:

Intervening topography would almost entirely screen views of the operational Project components some 4 km north. However, the upper portions of workover activities may appear on the distant skyline. The temporary mobilisation of the 30 m high workover rig would break the sinuous skyline and temporarily distract form the focus of views. The extent of change in views from this lodge would be barely discernible most of the time and on balance the potential impact magnitude is considered to be Negligible.

Impact significance

Potential impact Significance: **Insignificant**

11.10.2.8 Viewpoint 8 - Kabalega Wilderness Lodge

Sensitivity to Change: High

Relevant completed Project components:

- Well pads JBR-01 and JBR-02; and
- Production and Injection Network RoW.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues; and
- Well pad maintenance activities and workover activities using work-over rig.

Impact Magnitude:

During the Commissioning and Operations Phase the introduction and operation of the Project components at the two well pad sites (JBR-01, 4.8 km north and JBR-02, 4 km north) would be barely perceptible in views experienced by receptors at Kabalega Wilderness Lodge. Intervening vegetation would almost entirely screen views of Project infrastructure from this location.

However the upper portion of the workover rig would occasionally appear on the distant skyline against the savanna plateau. Given the distance and very temporary nature of the workover rig, it is unlikely the extent of change in views would alter the composition and primary focus of the view in the long-term. Taking this into account the potential impact magnitude is considered to be Negligible.

Impact significance

Potential impact Significance: **Low Adverse** Significance

11.10.2.9 Viewpoint 9 - Murchison River Lodge

Sensitivity to Change: High

Relevant completed Project components:

- Well pads JBR-01 and JBR-02; and
- Production and Injection Network RoW.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues; and
- Well pad maintenance activities and workover activities using workover rig.

Impact magnitude:

During the Commissioning and Operations Phase, the tallest structures at the two well pads (JBR-01 and JBR-02) including the containment structure such as a bund wall (to be determined) is unlikely to exceed 5 m in height. Given the 3.9 km distance, the extent of change would be limited to a very small proportion of the background on the distant savanna plateau and would be a barely discernible element in the view.

The upper portion of the 30 m high workover rig would occasionally appear on the distant skyline against the savanna plateau. Given the distance and very temporary nature of the workover rig, it is unlikely the extent of change in views would alter the composition and primary focus of the view in the long-term. Taking this into account the potential impact magnitude is considered to be Negligible.

Potential impact Significance: **Low Adverse** Significance

11.10.2.10 Viewpoint 10 - Nile Safari Lodge

Sensitivity to Change: High

Relevant completed Project components:

- Well pads JBR-01 and JBR-02; and
- Production and Injection Network RoW.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues; and
- Well pad maintenance activities and workover activities using work-over rig.

Impact Magnitude:

During the Commissioning and Operations Phase the extent of change visible would be very limited. The tallest structures at the two well pads (JBR-01 and JBR-02) including the containment structure (to be determined) is unlikely to exceed 5 m in height. Given the 3.8 km distance to the closest well pad (JBR-01), the extent of change would be a barely discernible element in the distant background.

The upper portion of the 30 m high workover rig would occasionally appear on the distant skyline against the savanna plateau. Given the distance and very temporary nature of the workover rig, it is unlikely the extent of change in views would alter the composition and primary focus of the view in the long-term. Taking this into account the potential impact magnitude is considered to be Negligible.

Impact significance

Potential impact Significance: **Low Adverse** Significance

11.10.2.11 Viewpoint 11 - Pakuba Safari Lodge

Sensitivity to Change: High

Relevant completed Project components:

- Well pads: JBR-09; and
- Production and Injection Network RoW.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues; and
- Well pad maintenance activities and workover activities using work-over rig.

Impact Magnitude:

During the Commissioning and Operations Phase the extent of change visible would be dependent on the final height and mass of the containment structure surrounding well pad JBR-09 at a distance of 2.8 km. The tallest structures at the well pad (JBR-09) including the containment structure (to be determined) are unlikely to exceed 5 m in height. The addition of structures within the view would only occupy a very small proportion of the background oblique to the main focus of views.

During maintenance the 30 m high workover rig would occasionally appear on the distant skyline but is unlikely alter the composition and primary focus of the view in the long-term. Taking all of this into account the potential impact magnitude is considered to be Low.

Impact significance

Potential impact Significance: **Moderate Adverse** Significance

11.10.2.12 Viewpoint 12 - Paraa Ferry Crossing

Sensitivity to Change: High

Relevant completed Project components:

- Production and Injection Network RoW; and
- Victoria Nile Ferry Crossing Facility.

Relevant key activities:

- Ferry movements (and vehicles stationary waiting for the ferry) associated with the Victoria Nile Ferry Crossing Facility.

Impact Magnitude:

During the Commissioning and Operations Phase, the only component visible would be the presence and operation of the Victoria Nile Ferry Crossing 100 m south of this location whilst the south jetty would be 475 m south. Potential impacts will largely be as described during the Construction and Pre-Commissioning phase. However the frequency of activity would be less than that experienced during construction. The introduction of ferry movements would be a noticeable addition within close proximity views. Disruption to the view would be long-term and reversible. Taking all of this into account the potential impact magnitude is considered to be Low.

Impact significance:

Potential impact Significance: **Moderate Adverse** Significance

11.10.2.13 Viewpoint 13 - Buligi Track, Delta Track Junction

Sensitivity to Change**:** High

Relevant completed Project components:

- Well pads: JBR-05, JBR-06 and JBR-07; and
- Production and Injection Network RoW.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues; and
- Well pad maintenance activities and workover activities using work-over rig.

Impact magnitude:

During the Commissioning and Operations Phase, well pads JBR-05 (2.4 km west), JBR-06 (1.5 km west) and JBR-07 (1.9 km west) would be seen in combination across the central portion of views west. The tallest structures at the well pads including the containment structure (to be determined) are unlikely to exceed 5 m in height. The addition of these components within the view would alter the balance and composition of elements within the view. The presence of built form in general would be in contrast to the naturalistic setting which is primary importance of tourists.

During maintenance the 30 m high workover rig would occasionally appear on the skyline and is likely to be the most prominent feature in the view, albeit occasional and temporary. On balance the potential impact magnitude is considered to be Moderate.

Impact significance

Potential impact Significance: **High Adverse** Significance

11.10.2.14 Viewpoint 14 - Albert Track

Sensitivity to Change**:** High

Relevant completed Project components:

- Well pads: JBR-05, JBR-06 and JBR-07; and
- Production and Injection Network RoW.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues; and
- Well pad maintenance activities and workover activities using work-over rig.

Impact magnitude:

During the Commissioning and Operations Phase, the addition of the completed well pads would be located in the distant background of views experienced from the Albert Track. The tallest elements including the containment structure (to be determined) are unlikely to exceed 5 m in height. The addition of these components within the view (i.e. well pads; JBR-05 (3.4 km east), JBR-06 (4.2 km east), and JBR-07 (4.1 km east)), may be perceptible and in slight contrast to the surrounding trees along the skyline oblique to the main focus of views. The most noticeable change would occur during maintenance when the 30m high workover rig would occasionally appear on the skyline but is unlikely to be prominent.

For the vast majority of the operational period, changes in the existing view would be barely perceptible, particularly because of the panoramic nature and multidirectional focus of views experienced at this location. Taking all of this into account, the potential impact magnitude is considered to be Negligible.

Impact significance

Potential impact Significance: **Low Adverse** Significance

11.10.2.15 Viewpoint 15 - Wanseko Beach

Sensitivity to Change: Moderate

Relevant completed Project components:

- Industrial Area;
- Water Abstraction System;
- Well pads: KW-01 and NGR-03A; and
- Production and Injection Network RoW.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues;
- Well pad maintenance activities and workover activities using work-over rig; and
- Operation and maintenance at water abstraction facilities.

Impact Magnitude:

During the Commissioning and Operations Phase, the completed well pads would be located in the distant background and almost entirely screened by intervening built form within Wanseko and vegetation beyond. However the tallest structures within the Industrial Area would be visible some 8.9 km east. The cluster of taller development including the 60 m radio mast (and potentially a 50 m elevated flare) would add to fragmentation of the skyline in which tall masts feature in the existing view.

During maintenance, the 30 m high workover rig would also occasionally appear on the skyline but would not compromise the balance of features within the view. Furthermore the presence of either Water Abstraction System option, albeit visible, is unlikely to distract from the primary focus of views across views Lake Albert. Overall the potential impact magnitude is considered to be Low.

Impact significance

Potential impact Significance: **Low Adverse** Significance

11.10.2.16 Viewpoint 16 - Kasinyi (West)

Sensitivity to change: Moderate

Relevant completed Project components:

- Well pads: NGR-01; and
- Production and Injection Network RoW.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues; and
- Well pad maintenance activities and workover activities using work-over rig.

Impact magnitude:

During the Commissioning and Operations Phase, potential visual impacts would be largely limited to the site of well pad NGR-01 located 252 m southwest. There would be a noticeable change at the well pad site resulting from the presence of the well pad infrastructure which would visible above the intervening grassland. Occasional use of the 30 m high workover rig would further disrupt the view. The height of the rig would be a noticeable contrast on the skyline above vegetation and would be a temporary additional focus within views. Occasional vehicular access associated with maintenance at the well pad would temporarily disrupt views for residents.

The RoW of the pipeline that heads north to the Nile HDD pipeline crossing would be reinstated and grassland vegetation re-established. However, the buried pipeline would leave small but noticeable gaps in tall vegetation which may frame some views towards the Nile HDD pipeline crossing area. Over time, vegetation will establish and the extent of noticeable change would reduce. Potential visual impacts from this location would be long-term (with the exception of workover rigs) and reversible. On balance the potential impact magnitude is considered to be Low.

Impact Significance:

Potential impact Significance: **Low Adverse** Significance

11.10.2.17 Viewpoint 17 - Kasinyi (East)

Sensitivity to Change: Moderate

Relevant completed Project components:

- Industrial Area; and
- Upgraded roads: A4.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues;
- Well pad maintenance activity including venting and workover activities using workover rig; and
- Flaring (considering both the enclosed ground flare and the elevated flare options).

Impact Magnitude:

During the Commissioning and Operations Phase the Project infrastructure would be located 518 m southwest of the viewpoint.

Foreground views would disrupted by the transport of operational personnel to and from the site along the upgraded 10 m wide gravel road A4. The introduction of built form and tall infrastructure components, in particular: diesel generators, water injection units, storage tanks, heaters, de-aeration tower and flare stack would be apparent across the background. The height and mass of development would create an industrial façade across the backdrop of views southwest and west. The tallest components of the Industrial Area including the radio mast at 60 m above ground level; elevated flare at 50m (if considered), turbines at up to 45 m and the heater at 30 m would be the most prominent additions on the skyline. Together the scale and mass of development would dominate the focus of views. If the elevated flare option is considered, emergency flaring, albeit rare and temporary, would further increase the prominence of the Project components.

Background views would be further disrupted by night time lighting spill. Lighting at night would become a distracting focus of views and would heavily contrast with the dark skies presently experienced.

Overall, the introduction of large and dominant Project components in the background and the widened road corridor in the foreground would largely alter the composition of the view. Therefore the magnitude of potential impact is considered to be High.

Impact significance:

Potential impact Significance: **High Adverse** Significance

11.10.2.18 Viewpoint 18 - Buligi Track (Pakuba Airfield)

Sensitivity to Change: High

Relevant completed Project components:

- Well pads: JBR-05, JBR-06 and JBR-07; and
- Production and Injection Network RoW.

Relevant key activities:

- Commissioning activities involving checking the equipment and plant prior to first oil and addressing any issues; and
- Well pad maintenance activities and workover activities using work-over rig.

Impact magnitude:

During the Commissioning and Operations Phase, well pads JBR-05 (1.5 km east) and JBR-06 (2.4 km east) would be seen in combination across the central portion of views west. The tallest structures at the well pads including the containment structure (to be determined) are unlikely to exceed 5 m in height. The addition of these components within the view would be a noticeable and uncharacteristic addition to the background. The presence of the well pads would be in contrast to the naturalistic setting which is of primary importance for tourists within MFNP. During maintenance the 30 m high workover rig would occasionally appear on the skyline and is likely to be the most prominent feature in the view, albeit occasional and temporary. On balance the overall potential impact magnitude is considered to be Moderate.

Impact significance:

Potential impact Significance: **High Adverse** Significance

11.10.3 Additional Mitigation (Commissioning and Operations)

Additional mitigation measures which have the potential to reduce some landscape and visual effects during the Commissioning and Operations Phase are identified in Table 11-12.

For the avoidance of repetition, mitigation measures LV.5, LV.6, LV.7, LV.14 and LV.15 apply to each Landscape Character Area and Viewpoints and have not been included in full in Table 11-15 below.

11.10.4 Residual Impacts

A summary of the residual landscape and visual impacts taking into account additional mitigation is provided in Table 11-15 below.

Table 11-15: Summary of Residual Impacts: Commissioning and Operations

Receptor	Sensitivity	Magnitude	Potential impact significance	Additional mitigation	Residual impact significance
Landscape Character Areas					
1 - LCA 01 - Buliisa Lowland Pastoral Farmland	Low	High	**Moderate Adverse**	LV.5, LV.6, LV.7, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable. LV.10 Design the Project to use materials on the infrastructure that will minimise glare, as much as practicable. LV.11 Material finishes to buildings to be non-reflective and muted colour palette. LV.12 Consideration shall be given to planting naturalistic woodland/bush to blend subject to site specific conditions. LV.13 Soften boundary edges of Industrial Area/CPF with native planting which could also benefit the community (formation of allotments/gardens and /or tree or plant nurseries).	**Moderate Adverse**
2 - LCA 02 - Buliisa Lowland Rolling Farmland	Low	Moderate	**Moderate Adverse**	LV.5, LV.6, LV.7, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable. LV.10 Design the Project to use materials on the infrastructure that will minimise glare, as much as practicable. LV.11 Material finishes to buildings to be non-reflective and muted colour palette. LV.12 Consideration shall be given to planting naturalistic woodland/bush to blend subject to site specific conditions. LV.13 Soften boundary edges of Industrial Area/CPF with native planting which could also benefit the community (formation of allotments/gardens and /or tree or plant nurseries).	**Moderate Adverse**
3 - LCA 03 - Lake Albert Coastal Fringe	Moderate	Low	**Low Adverse**	LV.5, LV.6, LV.7, LV.14 and LV.15 LV.12 Consideration shall be given to planting naturalistic woodland/bush to blend subject to site specific conditions.	**Low Adverse**
4 - LCA 04 - Victoria Nile Corridor	High	Low	**Low Adverse**	LV.5, LV.6, LV.7, LV.14 and LV.15 LV.12 Consideration shall be given to planting naturalistic woodland/bush to blend subject to site specific conditions.	**Low Adverse**
5 - LCA 05 - Lake Albert-Victoria Nile Delta	High	Negligible	**Insignificant**	Not applicable	**Insignificant**

Receptor	Sensitivity	Magnitude	Potential impact significance	Additional mitigation	Residual impact significance
6 - LCA 06 - MFNP South, Rolling Woodland	High	Negligible	**Insignificant**	Not applicable	**Insignificant**
7 - LCA 07 - MFNP North, Savanna Plateau	High	High	**High Adverse**	LV.5, LV.6, LV. , LV.14 and LV.15 LV.12 Consideration shall be given to planting naturalistic woodland/bush to blend subject to site specific conditions.	**Moderate Adverse**
Viewpoints					
1 - Kimoli	Moderate	High	**High Adverse**	LV.5, LV.6, LV.7, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable. LV.9 Design the Project to use colours that match the surroundings for the infrastructure and fencing. LV.10 Design the Project to use materials on the infrastructure that will minimise glare, as much as practicable. LV.11 Material finishes to buildings to be non-reflective and muted colour palette.	**Moderate Adverse**
2 - Kibambura	Low	Low	**Low Adverse**	LV.5, LV.6, LV.7, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Low Adverse**
3 - Buliisa (West)	Moderate	Low	**Low Adverse**	LV.5, LV.6, LV.7, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Low Adverse**
4 - Kisimo	Low	Low	**Low Adverse**	LV.5, LV.6, LV.7, LV.14 and LV.15 LV.10 Design the Project to use materials on the infrastructure that will minimise glare, as much as practicable.	**Low Adverse**
5 - Kirama	Moderate	Low	**Low Adverse**	LV.5, LV.6, LV.7, LV.14 and LV.15 LV.10 Design the Project to use materials on the infrastructure that will minimise glare, as much as practicable.	**Low Adverse**
6 - Ngwedo Farm	Low	Low	**Low Adverse**	LV.5, LV.6, LV.7, LV.14 and LV.15 LV.10 Design the Project to use materials on the infrastructure that will minimise glare, as much as practicable.	**Low Adverse**
7 - Baker's Lodge	High	Low	**Insignificant**	Not applicable	**Insignificant**

Receptor	Sensitivity	Magnitude	Potential impact significance	Additional mitigation	Residual impact significance
8 - Kabalega Wilderness Lodge	High	Negligible	**Low Adverse**	LV.5, LV.6, LV. , LV.14 and LV.15 LV.10 Design the Project to use materials on the infrastructure that will minimise glare, as much as practicable.	**Low Adverse**
9 - Murchison River Lodge	High	Negligible	**Low Adverse**	LV.5, LV.6, LV.7, LV.14 and LV.15 LV.10 Design the Project to use materials on the infrastructure that will minimise glare, as much as practicable.	**Low Adverse**
10 - Nile Safari Lodge	High	Negligible	**Low Adverse**	LV.5, LV.6, LV. , LV.14 and LV.15 LV.10 Design the Project to use materials on the infrastructure that will minimise glare, as much as practicable.	**Low Adverse**
11 - Pakuba Safari Lodge	High	Low	**Moderate Adverse**	LV.5, LV.6, LV.7, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable.	**Low Adverse**
12 - Paraa Ferry Crossing	High	Low	**Moderate Adverse**	LV.5, LV.6, LV. , LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable. LV.10 Design the Project to use materials on the infrastructure that will minimise glare, as much as practicable. LV.11 Material finishes to buildings to be non-reflective and muted colour palette.	**Moderate Adverse**
13 - Buligi Track, Delta Track Junction	High	Moderate	**High Adverse**	LV.5, LV.6, LV.7, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable. LV.10 Design the Project to use materials on the infrastructure that will minimise glare, as much as practicable.	**Moderate Adverse**
14 - Albert Track	High	Negligible	**Low Adverse**	LV.5, LV.6, LV.7, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable. LV.10 Design the Project to use materials on the infrastructure that will minimise glare, as much as practicable.	**Low Adverse**
15 - Wanseko Beach	Moderate	Low	**Low Adverse**	Not applicable	**Low Adverse**

Receptor	Sensitivity	Magnitude	Potential impact significance	Additional mitigation	Residual impact significance
16 - Kasinyi (West)	Moderate	Low	**Low Adverse**	LV.5, LV.6, LV.7, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable. LV.10 Design the Project to use materials on the infrastructure that will minimise glare, as much as practicable.	**Low Adverse**
17 - Kasinyi (East)	Moderate	High	**High Adverse**	LV.5, LV.6, LV.7, LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable. LV.9 Design the Project to use colours that match the surroundings for the infrastructure and fencing. LV.10 Design the Project to use materials on the infrastructure that will minimise glare, as much as practicable. LV.11 Material finishes to buildings to be non-reflective and muted colour palette.	**Moderate Adverse**
18 - Buligi Track (Pakuba Airfield)	High	Moderate	**High Adverse**	LV.5, LV.6, LV. , LV.14 and LV.15 LV.4 Vegetating stockpiles of material remaining on site for a significant amount of time to merge with the surroundings as much as practicable. LV.10 Design the Project to use materials on the infrastructure that will minimise glare, as much as practicable.	**Moderate Adverse**

11.11 Assessment of Impacts: Decommissioning

Activities at decommissioning are expected to be similar to those at construction but will last less time and will be less extensive. This will be dependent upon final decommissioning strategy. Details of impacts at decommissioning are contained within Appendix M of this ESIA.

11.11.1 Summary of Potential Impacts at Decommissioning

At decommissioning, the majority of the Project infrastructure would be removed and ground reinstated.

Much of the activity and decommissioning operations would be similar to those experienced at construction; and as such the scale and extent of change would be similar. However, the duration of activities would be reduced. Once decommissioning activities have been completed and planting regenerates and matures, lasting impacts would be barely discernible. Therefore, the impact magnitude for the majority of the landscape and visual receptors would be Negligible and the resulting impact significance would be Insignificant. Those landscape and visual with impacts above insignificant include the following:

- The impact significance for LCA 01 Buliisa Lowland Pastoral Farmland and LCA 02 Buliisa Lowland Rolling Farmland would be assessed as Low Adverse. This is largely due to the flat expanses at former well pads sites and the Industrial Area which may lead to other further forms of development, given their access to infrastructure;
- The impact significance for LCA 07 MFNP North, Savanna Plateau would also remain Low Adverse as some project components such as pipeline would be left in situ as such no mature trees would establish in those locations; and
- The impact significance at Viewpoint 1-Kimoli and 17 Kasinyi (East) are also anticipated to be Low Adverse for similar reasons, with a particular focus on a flat expanse across the site of the Industrial Area.

11.12 In Combination Effects

As described in ***Chapter 4: Project Description and Alternatives***, the Project has a number of supporting and associated facilities that are being developed separately (i.e. they are subject to separate permitting processes and separate ESIAs or EIAs). These facilities include:

- Tilenga Feeder Pipeline;
- East Africa Crude Oil Export Pipeline (EACOP);
- Waste management storage and treatment facilities for the Project;
- Kabaale- Tilenga 132 Kilovolt (kV) transmission line; and
- Critical oil roads.

As these facilities are directly linked to the Project and would not be constructed or expanded if the Project did not exist, there is a need to consider the in-combination impacts of the Project and the supporting and associated facilities.

This is distinct from the Cumulative Impact Assessment (CIA) which consider all defined major developments identified within the Project's AoI (and not just the associated facilities) following a specific methodology which is focussed on priority Valued Environmental and Social Components (VECs) (see ***Chapter 21: Cumulative Impact Assessment***).

The in-combination impact assessment considers the joint impacts of both the Project and the supporting and associated facilities. The approach to the assessment of in-combination impacts is presented in ***Chapter 3: ESIA Methodology***, Section 3.3.5.

The identified residual impacts of the Project are predicted to have the potential to be exacerbated due to in-combination effects with supporting and associated facilities. A comment is provided on the potential in-combination impacts and the need for additional collaborative mitigation between project proponents to address these impacts. The identification of in-combination impacts only considers the landscape and visual receptors where in-combination impacts are anticipated. Each individual project will incorporate a suite of embedded and additional mitigation measures to help prevent any significant adverse impacts, which will help further reduce any in-combination effects.

Table 11-16: In Combination Impacts

Description of Potential Impact of Project	Comment on potential in-combination effects with associated facilities	Comment on the need for additional collaborative mitigation
LCA 01- Buliisa Lowland Pastoral Farmland Impacts on the physical landscape resulting from the scale and intensity of activity, removal of vegetation, loss of landscape pattern and introduction of uncharacteristic infrastructure.	In-combination impacts within this LCA would result from the addition of the Tilenga Feeder Pipeline, critical oil roads and the Kabaale-Tilenga transmission line. The Tilenga Feeder Pipeline would temporarily and slightly increase the overall scale of simultaneous construction activity within this LCA. However, once ground is reinstated the extent of in-combination change relating to this pipeline would be barely discernible. The addition of the critical oil roads would temporarily increase the scale of activity and movement associated with construction. Given that the critical oil roads within this LCA are upgrades to existing roads noticeable long-term change would be limited. The Project in-combination with the Kabaale-Tilenga transmission line would further increase the overall presence of activity and infrastructure within the landscape which would exacerbate the geographical extent of impacts.	The limited nature of in-combination effects predicted does not warrant additional collaborative mitigation measures.
LCA 02 - Buliisa Lowland Rolling Farmland Impacts on the physical and perceptual landscape qualities resulting from the scale and intensity of construction activity, removal of vegetation, loss of landscape pattern and introduction of uncharacteristic elements.	The associated facilities within this LCA are limited to the critical oil roads and the Kabaale-Tilenga transmission line. Activities associated with the critical oil roads involve upgrade to existing roads; therefore, the in-combination impacts would be limited to the temporary increase in construction activity and vehicle movements. However the addition of the Kabaale-Tilenga transmission line would further increase the overall presence of large-scale infrastructure within the landscape. As a result there would be a slight increase in the scale and extent of in-combination long-term impacts to the character to this LCA.	The limited nature of in-combination effects predicted does not warrant additional collaborative mitigation measures.
LCA 06 - MFNP South, Rolling Woodland Landscape impacts limited to the perceptual qualities including tranquillity.	The associated facilities within this LCA are limited to the critical oil roads. Given these would be an upgrade to an existing road, the in combination impacts would be limited to the temporary increase in construction activity and in vehicle movements. The nature of in-combination impacts would be localised to the existing road corridor and unlikely to alter the overall quality and character of this LCA.	The limited nature of in-combination effects predicted does not warrant additional collaborative mitigation measures.

Description of Potential Impact of Project	Comment on potential in-combination effects with associated facilities	Comment on the need for additional collaborative mitigation
Viewpoint 2 - Kibambura Visual impacts limited to the presence of vehicular traffic associated with maintenance.	The in-combination impacts resulting from the addition of the critical oil roads would temporarily increase the overall scale and intensity of construction activity experienced from this viewpoint and is likely to dominate the visual amenity. However, long-term in-combination impacts are unlikely to further alter the balance and composition of views.	The limited nature of in-combination effects predicted does not warrant additional collaborative mitigation measures.
Viewpoint 5 - Kirama Visual impacts limited to the presence of vehicular traffic associated with maintenance.	The in-combination impacts resulting from the addition of the critical oil roads would temporarily increase the overall scale and intensity of construction activity experienced from this viewpoint which would be prominent for a short duration. Long-term, in-combination impacts would result from the addition of the Kabaale-Tilenga transmission line which would increase the extent to which largescale infrastructure is visible.	The limited nature of in-combination effects predicted does not warrant additional collaborative mitigation measures.
Viewpoint 6 - Ngwedo Farm Visual impacts limited to the presence of vehicular traffic associated with maintenance and elements within the CPF visible in the background.	The in-combination impacts resulting from the addition of the critical oil roads would temporarily increase the overall scale and intensity of construction activity experienced from this viewpoint. Long-term, in-combination impacts would increase the extent to which related infrastructure is visible as a result of the addition of the Kabaale-Tilenga transmission line.	Given the very limited extent of in-combination change, additional collaborative mitigation is not required

11.13 Unplanned Events

In the event of unplanned events the additional scale and intensity of activity and movement is unlikely to further exacerbate the impact magnitude and therefore impact significance for any of the landscape and visual receptors beyond that which is recorded at each of the Phases. Unplanned Flaring would be particularly prominent throughout the Study Area and would result in a substantial visual impact from visual receptors, but very limited in duration and therefore unlikely to increase the overall visual impacts. Other less likely unplanned and emergency events have the potential to substantially alter the quality and character of the landscape and further exacerbate the impact magnitude. Further general information relating to unplanned events is included within ***Chapter 20: Unplanned Events***.

11.14 Cumulative Impact Assessment

Chapter 21: Cumulative Impact Assessment provides an assessment of the cumulative effects of the Project together with other defined developments in the Project AoI. The CIA focussed on VECs that were selected on the basis of set criteria including the significance of the effects of the Project, the relationship between the Project and other developments, stakeholder opinions and the status of the VEC (with priority given to those which are of regional concern because they are poor or declining condition). On the basis of the selection process, Landscape Character was not considered to be a priority VEC and is not considered further in the CIA as no significant impacts are anticipated.

11.15 Conclusion

11.15.1 Site Preparation and Enabling Works Phase

Site Preparation and Enabling Works would include site clearance, vegetation removal and mobilisation of construction activities. Significant residual landscape impacts are predicted only for LCA 07 - MFNP North, Savanna Plateau, which is predicted to have Moderate Adverse impacts. Impacts will be temporary and overall reversible.

With additional mitigation there would be a slight reduction in effects in both Viewpoint 12 and Viewpoint 13, however, effects on visual amenity would remain Moderate Adverse. Residual visual impacts of Moderate or High impact significance are predicted for Viewpoints 1 - Kimoli; 11 - Pakuba Safari Lodge; 12 - Paraa Ferry Crossing; 13 - Buligi Track, Delta Track Junction; 14 - Albert Track; 17 - Kasinyi (East) and 18 - Buligi Track (Pakuba Airfield).

11.15.2 Construction and Pre-Commissioning

During the Construction and Pre-Commissioning phase, direct impacts would arise from the scale and intensity of activity, removal of vegetation, loss of landscape pattern and introduction of uncharacteristic infrastructure. There would be adverse impacts on the perceptive qualities and pockets of tranquillity experienced throughout the landscape. Impacts will be temporary and overall reversible.

Residual landscape impacts of Moderate or High impact significance could occur at LCA 01 - Buliisa Lowland Pastoral Farmland; LCA 02 - Buliisa Lowland Rolling Farmland; LCA 03 - Lake Albert Coastal Fringe, LCA 04 - Victoria Nile Corridor and LCA 07 - MFNP North, Savanna Plateau. Due to the scale and spread of activities during this phase, impacts with mitigation could remain Significant.

Visual intrusion would result from a combination of construction activities including, but not restricted to, the Industrial Area, drilling at wells, and vegetation clearance. Additional mitigation would provide some localised benefits to some receptors, but the significance of effects in visual amenity would remain largely unchanged during this phase.

Residual visual impacts of Moderate or High impact significance are predicted for Viewpoints 1 - Kimoli; 3 - Buliisa (West); 4 - Kisimo; 8 - Kabalega Wilderness Lodge; 9 - Murchison River Lodge; 10 - Nile Safari Lodge; 11 - Pakuba Safari Lodge; 12 - Paraa Ferry Crossing; 13 - Buligi Track, Delta Track Junction; 14 - Albert Track; 16 - Kasinyi (West); 17 - Kasinyi (East) and 18 - Buligi Track (Pakuba Airfield).

11.15.3 Commissioning and Operations Impacts

During Commissioning and Operations there would be a reduction of activity in comparison to that experienced during Construction and Pre-Commissioning. Impacts will be overall reversible.

Significant landscape impacts could occur for LCA 01 - Buliisa Lowland Pastoral Farmland LCA 02 – Buliisa Lowland Rolling Farmland and LCA 07 - MFNP North, Savanna Plateau arising from the introduction of uncharacteristic infrastructure with adverse effects on the perceptual qualities of the landscape character including remoteness and tranquillity.

With additional mitigation there would be a slight reduction in localised effects. Measures including use of colours in the design of the Project to match the surroundings for the infrastructure and fencing and softening hard angular lines of infrastructure by planting naturalistic copses of native trees to provide screening, will lessen adverse effects. However, given the scale and spread of infrastructure within the landscape, effects would not be reduced to Insignificant.

Residual visual impacts of Moderate or High impact significance could occur at Viewpoints 1 - Kimoli, 12 - Paraa Ferry Crossing, 13 - Buligi Track, Delta Track Junction, 17 - Kasinyi and 18 - Buligi Track (Pakuba Airfield).

11.15.4 Decommissioning

Once decommissioning activities have been completed and planting regenerates and matures, lasting impacts would be barely discernible; therefore, the impact magnitude for the majority of the landscape and visual receptors would be Negligible and the resulting impact significance would be Insignificant.

11.16 References

Ref. 11-1 Ministry of Natural Resources (1994), The National Environment Management Policy.

Ref. 11-2 The National Environment Management Authority (1998), The Environmental Impact Assessment Regulations.

Ref. 11-3 Republic of Uganda, Ministry Of Tourism, Wildlife and Antiquities, (2014) The Uganda Wildlife Policy.

Ref. 11-4 Republic of Uganda, Ministry or Lands, Housing and Urban Development, (2013). The Uganda National Land Policy.

Ref. 11-5 Republic of Uganda (2003), The National Forestry and Tree Planning Act.

Ref. 11-6 Republic of Uganda, Ministry of Natural Resources (1995), Uganda National Policy for the Conservation and Management of Wetland Resources.

Ref. 11-7 Republic of Uganda (2010), The Physical Planning Act.

Ref. 11-8 National Planning Authority (2010), National Development Plan (2015 version awaiting adoption).

Ref. 11-9 Nwoya District Local Government (2015), District Development Plan 2015/16-2019/2020.

Ref. 11-10 Buliisa District Local Government (DLG) (2015), Five Year District Development Plan 2015/2016-2019-2020.

Ref. 11-11 Masindi District Local Government (DLG) (2015), Five Year District Development Plan 2015/2016-2019/2020.

Ref. 11-12 The National Environment Management Authority (2009), Strategic Plan, National Environment Management Authority 2009 / 2010-2013 / 2014.

Ref. 11-13 Uganda Wildlife Authority (2013), Strategic Plan 2013-2018.

Ref. 11-14 Uganda Wildlife Authority (2013), Murchison Falls National Park, Karuma Wildlife Reserve, Bugungu Wildlife Reserve (Murchison Falls Protected Area) General Management Plan (2012-2022) (MFNP GMP).

Ref. 11-15 International Finance Corporation (2012), IFC Performance Standard 3: Resource Efficiency and Pollution Prevention.

Ref. 11-16 International Finance Corporation (2007), Environmental, Health, and Safety Guidelines for Onshore Oil and Gas Development.

Ref. 11-17 International Finance Corporation (2007), Environmental, Health, and Safety Guidelines for Construction Materials Extraction.

Ref. 11-18 Council of Europe (2000), European Landscape Convention, Council of Europe, Florence, October 2000.

Ref. 11-19 Landscape Institute and Institute of Environmental Management and Assessment (2013), Guidelines on Landscape and Visual Impact Assessment (GLVIA) Third Edition.

Ref. 11-20 Tullow Uganda Operations PTY (2015), Phase 2 Biodiversity Study: Landcover Mapping for the Albertine Rift Oil Project Basin, Exploration Areas EA1-3.

Ref. 11-21 AECOM on behalf of Tullow Uganda Operations PTY (2012). Environmental Baseline in Exploration Area 2 Volume 1-3.

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Ref. 11-23 Artelia EAU & Environment (2015). Social and Health Baseline Survey: Workstream 'Tourism'.

Ref. 11-24 Air Water Earth (AWE) Engineers on behalf of Total (2017), Tilenga Early Works Project Brief.

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12 – Waste

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12 Waste Management

12.1 Introduction

The waste management chapter considers the potential impacts of all Project solid and liquid wastes, which are likely to arise as a result of Project activities. The assessment covers waste generated during the four phases of the Project: Site Preparation and Enabling Works, Construction and Pre-Commissioning, Commissioning and Operations and Decommissioning.

The indicative construction schedule for the Site Preparation and Enabling Works and the Construction and Pre-Commissioning phases is detailed in Figure 4-16 of the Project Description. It is clear from the schedule that the majority of the work for these two phases shall be undertaken concurrently. The only exception to this is clearance and construction of temporary facilities of the Industrial Area, and upgrade work to Bugungu and Tangi Camps. Because of the concurrent nature of the activities and the similarities between the waste streams, the impacts associated with these two phases of the work have been considered together in this report.

Decommissioning refers to removal of temporary infrastructure and remediation work required post Site Preparation and Enabling Works, and Construction and Pre-Commissioning phases; and dismantling, decontamination and removal of process equipment, removal of facility structures and remediation work required post Commissioning and Operations phase.

This chapter relates to the management of hazardous and non-hazardous solid and liquid wastes other than those that will be managed by the dedicated drainage and sewage treatment systems at the Project facilities. Site drainage, run-off water and wastewater[1] are discussed in ***Chapter 9: Hydrogeology*** and ***Chapter 10: Surface Water***. This chapter has been produced based on the information provided in relation to the design of the Project (***Chapter 4: Project Description and Alternatives***) as well as from two independent waste studies which were commissioned by the Project Proponents and their Joint Venture Partners (JVPs), namely the "*Non-Hazardous Waste Management Infrastructure Concept Study for the Integrated Development of the Lake Albert Oil Fields*" (Ref. 12.1) and "*Consultancy Services to Develop Ugandan Capacity to Manage Hazardous Waste from Oil Fields"* (Ref. 12.2), and a report on waste facilities titled *"Waste Management Compliance Audit and Site Assessment"* (Ref. 12.3).

12.2 Scoping

The Scoping process identified potential waste management impacts that could occur as a result of the Project; which are summarised in Table 12.1. It is worth noting that the Project phasing and identified list of potential impacts have evolved during the completion of this Environmental and Social Impact Assessment (ESIA) and consequently build and expand on those originally identified in Table 12.1 during the Scoping phase.

Table 12.1: Potential Waste Impacts as identified during Scoping

Potential Impact	Potential Cause	Potential Sensitivity	Phase
Potential impacts upon existing waste management facilities in the region as a result of the anticipated waste streams.	Waste generation particularly during the variety of construction activities, but also during the operation of the facilities.	Existing waste management facilities in the region and local users.	Construction Operations Decommissioning

[1] "Wastewater" means "process wastewater, sanitary (domestic) sewage, or stormwater" as set out in Section 1.3 of the IFC General EHS Guidelines.

Potential Impact	Potential Cause	Potential Sensitivity	Phase
Potential impacts on local communities and environmental media (soil, air, water etc.) in relation to transport and storage and disposal of waste.	All site preparation, construction, drilling operations, oil and gas production and decommissioning activities, such as site clearance and preparation, vegetation clearance, disposal of potentially contaminating material and waste derived from the construction camps. Storage of waste during operation, including operation of the waste treatment facilities.	Local communities, water resources, geology and soils within the Project Area.	Construction Operations Decommissioning

12.3 Legislative Framework

This section summarises key Ugandan legislation and regulations, together with international policies, standards and guidelines regarding waste management.

12.3.1 National Policy

12.3.1.1 The National Environment Management Policy (2014)

The National Environment Management Policy (NEMP) (Ref. 12-13) acknowledges that Uganda, like most other developing countries, does not yet have in place adequate waste disposal facilities. The NEMP therefore sets out an objective to "*control pollution of the environment, and promote environmentally sound management of domestic and industrial wastes".* The intention is to achieve this objective through, amongst other measures, applying the 'Polluter Pays' principle and seeking to minimise and prevent the discharge of harmful substances. The NEMP also sets out the aspiration for a strategy to develop and adopt appropriate technologies for waste management.

With regard to hazardous waste, the NEMP states that: "*The waste profile in Uganda is increasingly becoming complex with new additions of electronic waste, radioactive waste, plastics and polythene materials, industrial wastes and medical wastes and traditional organic wastes (NDP, 2010). The poor disposal of e-waste and hazardous / toxic waste from industries; urban areas and hospitals among others have put the health and livelihoods of thousands of inhabitants at risk*."

The NEMP therefore sets out an objective to promote the environmentally sound management of electronic waste (e-waste) and other hazardous materials through a safe and environmentally friendly disposal of e-waste and other hazardous / toxic materials.

The NEMP also contains an objective to "*ensure that oil and gas activities are undertaken in a manner that conserves the environment and biodiversity*" and recognises the requirement to develop waste management regulations for oil and gas.

12.3.2 National Legislation

12.3.2.1 Occupational Safety and Health Act, 2006

Section 95 of the Occupational Safety and Health Act provides details of the necessary precautions for handling chemicals.

12.3.2.2 National Environment (Wetlands, River Banks, and Lakeshores Management) Regulations, 2000

Regulation 31 requires that, where a lake shore or riverbank is developed, the developer shall ensure:

(a) *Pre-treatment or full treatment of waste from the facility to prevent contamination of the water;*

(b) *Litter is cleared and disposed of in a manner in conformity with best environmental practices; and*

(c) River banks, lake shores or beaches are not degraded.

12.3.2.3 Penal Code, 1950

Section 176 states: "*Any person who voluntarily corrupts or fouls the water of any public spring or reservoir, so as to render it less fit for the purpose for which it is ordinarily used, commits a misdemeanour*".

12.3.2.4 Public Health Act, 1935

Section 57 states: "*Any noxious matter or waste water, flowing or discharged from any premises, wherever situated, into any public street, or into the gutter or side channel of any street, or into any gulley, swamp or watercourse, irrigation channel or bed thereof not approved for the reception of the discharge, constitutes a nuisance*".

12.3.2.5 The Petroleum (Exploration, Development and Production) (Health, Safety and Environment) Regulations, 2016

Section 29 states: "*The licensee shall handle, store, transport or dispose of hazardous substances in accordance with standards approved by the relevant authority, best petroleum industry practices, regulations made under section 3(8) of the Act, the National Environment Act and the Occupational Safety and Health Act, 2006*.

The licensee shall ensure that containers for transportation and storage of hazardous substances are colour-coded and labelled in accordance with standards approved by the relevant authority and best petroleum industry practices to ensure easy identification.

The licensee shall avoid using hazardous substances in the work place and where practicable, substitute the hazardous substance with another substance of less risk to human health and the environment.

The licensee shall keep a record of all hazardous substances contained at the facility or during petroleum activity including information on physical, chemical and hazardous properties; preventive safety measures and first aid treatment".

Section 30 states: "*The licensee shall ensure that warning signs are displayed at appropriate distance about the presence of hazardous substances in every area where hazardous substances are present or could cause a hazard to a person.*

The licensee shall, as far as practicable, provide automated warning and detection systems in areas where there is a likelihood of exposure to a hazardous substance.

The licensee shall manage safety hazards related to handling and storage of liquid or gaseous substances depending on the quantities and type where the liquid or substances are accidentally released".

Section 126 states: "*The licensee shall actively contribute to the exchange of information with neighbouring activities and facilities within a geographic area to ensure that the people affected by the petroleum activities and facilities have a full overview at all times of the amounts of hazardous substances being handled*."

12.3.2.6 National Environment Act, Cap 153, 1995

The National Environment Act (Ref. 12.5) sets out that each person has a duty to manage and minimise any waste generated in such a manner that does not cause ill health to the person or damage to the environment.

No person is to discharge any hazardous substance, chemical, oil or mixture containing oil in any waters or any segment of the environment except in accordance with guidelines prescribed by the National Environment Management Authority (NEMA).

Section 56 (1) of the Act states that "*no person shall discharge any hazardous substance, chemical, oil or mixture containing oil in any waters or any other segment of the environment except in accordance with guidelines prescribed by the authority in consultation with the lead agency.*"

12.3.2.7 The National Environment (Waste Management) Regulations, 1999

These regulations are made under Section 53 and Section 107 of the National Environment Act and outline the requirements for the management of hazardous and non-hazardous waste in Uganda including transport, storage, treatment, disposal, and licensing of waste contractors (Ref. 12.5).

These regulations require that only licensed waste contractors undertake transportation and disposal/treatment of hazardous waste, and waste producers are required to obtain permits for the temporary storage of waste. The licensing authority is NEMA.

The regulations also set out the classification codes for hazardous wastes and detail the criteria under which wastes will be considered hazardous. These classification codes and criteria reflect those set out under the Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Basel Convention), 1992. Hazardous wastes include those having certain general hazardous characteristics (as defined in the regulations), and also specific types of waste including *"waste oils/water, hydrocarbons/water mixtures, emulsions"*.

12.3.2.8 The National Environment (Waste Management) (Amendment) Regulations, 2014

These amendments to the National Environment (Waste Management) Regulations, 1999 include alterations to the periods of licence validity but do not significantly alter the 1999 regulations.

12.3.2.9 The National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations, 1999

These standards set out the maximum permissible limits for materials contained within the discharge of effluent or waste water onto land or in water (Ref. 12.6).

12.3.2.10 The Water Act Cap 152

Objectives of the Act include, among others, the promotion of rational management and use of the waters of Uganda; and the control of pollution and promotion of the safe storage, treatment, discharge and disposal of waste. Section 31 prohibits the discharge of waste into any natural waters unless authorised under the Act (Ref. 12.7).

12.3.2.11 The Water (Waste Discharge) Regulations, 1998

These regulations are made under Section 107 of the Water Act and prescribe limits for the discharge of waste into water resources, specifying among others restricted activities for which waste discharge permits must be acquired. The regulations stipulate that the proponent shall acquire a permit where the discharge of effluent or waste into water or on land is deemed necessary (Regulation 4 (1)) (Ref. 12.8). The permitting authority is Directorate of Water Resource Management (DWRM).

12.3.2.12 The Petroleum (Exploration, Development and Production) Act, 2013

Section 3 of the Act (Ref. 12.9) outlines the environmental principles to which all licensees shall comply including the duty to comply with the principles of the National Environment Act, the duty to:

- Manage waste arising out of petroleum activities in accordance with the National Environment Act and all applicable legislation; and
- Contract a separate entity to manage the transportation, treatment and disposal of waste arising out of petroleum activities.

12.3.2.13 Petroleum (Exploration, Development and Production) Regulations, 2016

Section 42 states: "*The licensee shall, before drilling any well, submit to the relevant authority, a well proposal and drilling programme, which includes the methods to be adopted for the disposal of waste including spent mud, cuttings and camp waste, from the location of the well".*

12.3.2.14 The Petroleum (Refining, Conversion, Transmission and Midstream Storage) Act, 2013

The Act establishes the legal framework for sustainable management of the midstream oil and gas sector. Section 3 outlines the duty of the Licensee to comply with environmental principles under the National Environment Act including management of transportation, storage, treatment and disposal of waste arising from midstream operations (Ref. 12.10).

12.3.2.15 The Draft Petroleum (Waste Management) Regulations, 2016 (Ref. 12.11)

These Regulations apply to a person involved in-

a) *the production, transportation, storage, treatment or disposal of waste arising out of petroleum activities or midstream operations; and*

b) *the construction and operation of petroleum waste management facilities.*

In addition, a person must also comply with the National Environment Act, the Petroleum (Exploration, Development and Production) Act, 2013, the Petroleum (Refining, Conversion, Transmission and Midstream Storage) Act, 2013, the National Environment (Waste Management) Regulations, the Occupational Safety and Health Act, 2006 and any other applicable law;

Waste not classified as petroleum waste[2] *shall be managed in accordance with the National Environment (Waste Management) Regulations.*

These regulations set out that: *"the licensee and the petroleum waste handler have a duty of care and shall take all reasonable and applicable measures:*

a) *to ensure that petroleum waste is managed appropriately and securely;*

b) *to ensure that any leakage or spillage of petroleum waste is quickly and reliably detected and handled; and*

c) *to ensure that spillages which may cause pollution are notified to the Authority and other relevant authorities."*

The Regulations also state that the licensee and the petroleum waste handler shall (amongst other things):

- *ensure that the different types of petroleum waste are segregated at source and at the petroleum waste management facility by way of waste stream and classification, to facilitate their appropriate handling and traceability;*
- *ensure that the classification of waste and the further handling and treatment of petroleum waste is not distorted by mixing or dilution of waste; and*
- *continuously improve the petroleum waste management practices as technology advances.*

12.3.2.16 Uganda Wildlife (Murchison Falls National Park) Regulations S.I. 200-3

The regulations set out guidelines of how to conduct activities within the park ranging from entry fees, permissible tourism activity, waste management, among others (Ref. 12.12). The proposed footprint of the Project covers parts of Murchison Falls National Park (MFNP).

12.3.2.17 Atomic Energy Act, 2008 and Atomic Energy Regulations, 2012

These include a range of provisions relating to the management of radioactive substances. Part XI of the Regulations sets out the regulations for the management of radioactive wastes, and Part XII sets out the regulations for the transport of radioactive materials.

[2] "Petroleum waste" is defined in the Regulations to include any substance or object arising from petroleum activities or midstream operations which is discarded or disposed of or intended or required by law to be disposed of, including substances listed in Schedule 1 to these Regulations.

12.3.2.18 Uganda Wildlife Authority (UWA) Operational Guidelines for Oil and Gas Exploration and Production in Wildlife Protected Areas, 2014

Section 5.4.3: Waste generation and management states that companies shall have approved waste management plans, storage facilities, transfer, and handle the waste generated in accordance with the National Environment (Waste Management) Regulations, 1999. Waste storage, transportation, and discharge permits shall be acquired before commencement of waste generating activities within a protected area.

a) Drill cuttings and drill waste water

i. Wastes generated during drilling (mud cuttings and waste water) shall be removed from the protected areas immediately after the drilling exercise and in any case not more than a period of one month. Such waste shall be disposed of outside Protected Areas using approved methods as may be recommended by NEMA.

b) Domestic waste

Waste generated as a result of human presence in the camps and at drill sites including sewage, laundry and kitchen water, solid garbage, plastics, tins, and bottles shall be managed according to National Environment (Waste Management) Regulations, 1999 and the National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations, 1999. In addition, the following guidelines shall complement the existing regulations while working inside wildlife protected areas.

i. Companies shall transfer all the non-biodegradable waste outside Protected Areas for appropriate recycling, reuse or final disposal.

c) Hazardous waste

This includes waste generated as a result of fuel and oil spills during vehicle servicing, repairs and washing within the base camps.

i. Companies shall treat the contaminated soil before disposal in case of oil spill or leakage.

ii. Companies shall sign agreements with approved waste handlers to transfer used oil, spent fuel and oil filters etc. for final disposal outside protected areas.

12.3.2.19 NEMA Operational Waste Management Guidelines for Oil and Gas Operations, 2012

Unless advised by the Authority, the drilling wastes should be handled in the following manner:

(ii) Future Wastes (Exploration and production wastes):

(a) In order to reduce the quantities of waste produced and their corresponding toxicity, all the chemicals used shall be screened and their use monitored closely. Therefore, the companies are required to submit an undertaking on the types, quantities and purity of chemicals to be used before drilling can be done.

(b) All companies shall reduce the level of pollution from the source through substitution of more toxic chemicals with less toxic ones where applicable, and; optimum utilization of all inputs during the operations.

(c) The exploration companies are required to recycle and re-use the oil drilling mud waste.

(d) The companies are also required to characterize the drilling wastes immediately after drilling and submit an analysis report to NEMA within a week after completion of the drilling activity for authorization either for onsite burial or for transportation to waste treatment and disposal plant.

(e) If the wastes have pollutants that are within the acceptable standards, the waste shall be buried on site in lined pits otherwise, the waste shall be transported to the central waste treatment plant. In the absence of national standards, United Kingdom standards for solid disposal have been adopted for use until the Ugandan national standards have been developed.

(f) For production waste, especially produced water shall be re-injected back into the underground formations. The Oil companies will ensure that the re-injected waste does not contaminate usable aquifers and surface water.

(iii) Associated wastes

The other wastes associated with exploration and production activities shall be managed in accordance with the requirements of the National Environment Act, Cap 153 and National Waste Management Regulations, 1999.

12.3.3 International Conventions

12.3.3.1 Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Basel Convention), 1992

Uganda has acceded to the Basel Convention, which regulates transboundary movements of hazardous wastes and provides obligations upon its Parties to ensure that such wastes are managed and disposed of in an environmentally sound manner (Ref. 12.14). The main principles of the Convention are as follows:

- Transboundary movements of hazardous wastes should be reduced to a minimum, which is consistent with their environmentally sound management;
- Hazardous wastes should be treated and disposed of as close as possible to their source of origin; and
- Hazardous waste generation should be reduced and minimised at source.

Annexes I–VIII of the Basel Convention provide lists of waste categories requiring special consideration or controls, including disposal operations.

Annex I outlines a list of waste categories to be controlled, Annex II details waste categories requiring special consideration and Annex III provides a list of important hazardous characteristics.

12.3.3.2 Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa, 1991

Uganda has acceded to the Bamako Convention which bans the import of hazardous and radioactive wastes into Africa, as well as all forms of ocean disposal. The Convention requires that, for intra-African waste trade, parties must minimise the transboundary movement of wastes and only conduct it with consent of the importing and transit states, among other controls.

12.3.3.3 Convention on Persistent Organic Pollutants (Stockholm Convention), 2001

Uganda has acceded to the Stockholm Convention, which seeks to ensure the limitation of pollution by persistent organic pollutants (POPs) (Ref. 12.15). It defines the substances in question, whilst leaving open the possibility of adding new ones, and also defines the rules governing the production, importing and exporting of those substances.

12.3.4 International Guidelines

12.3.4.1 International Finance Corporation (IFC) (2007): General Environment Health and Safety (EHS) Guidelines: Environmental

Section 1.5 (Hazardous Waste Management) states that: *"Projects which manufacture, handle, use, or store hazardous materials should establish management programs that are commensurate with the potential risks present. The main objectives of projects involving hazardous materials should be the protection of the workforce and the prevention and control of releases and accidents. These objectives should be addressed by integrating prevention and control measures, management actions, and procedures into day-to-day business activities."*

Section 1.6 (Waste Management) states that "*Facilities that generate and store wastes should practice the following:*

- *establishing waste management priorities at the outset of activities based on an understanding of potential Environmental, Health, and Safety (EHS) risks and impacts and considering waste generation and its consequences;*
- *establishing a waste management hierarchy that considers prevention, reduction, reuse, recovery, recycling, removal and finally disposal of wastes;*
- *avoiding or minimizing the generation of waste materials, as far as practicable;*
- *where waste generation cannot be avoided but has been minimized, recovering and reusing waste;*
- *where waste cannot be recovered or reused, treating, destroying, and disposing of it in an environmentally sound manner*."

Further, the guidelines state that a waste management system should be implemented to address issues concerning waste minimisation, generation, transport, disposal and monitoring.

Section 1.1 emphasises that open burning of hazardous and non-hazardous solid wastes should be avoided and is not considered good practice.

Additional guidance on waste management is included in other IFC EHS Guidelines, as described in Chapter 2, has been taken into consideration in this assessment.

12.3.4.2 IFC (2007): EHS Guidelines: Waste Management

The EHS Guidelines for Waste Management (Ref. 12.16) cover facilities or projects dedicated to the management of municipal solid waste and industrial waste, including waste collection and transport; waste receipt, unloading, processing, and storage; landfill disposal; physico-chemical and biological treatment; and incineration projects. They provide guidelines on facility design, good operational practices, and emissions limits.

12.3.4.3 IFC Performance Standard (PS) 3: Resource Efficiency and Pollution Prevention

PS 3 states that the client will avoid generation of hazardous and non-hazardous materials, but where waste cannot be avoided, waste arisings will be reduced, recovered or reused before subjecting the materials to treatment and disposal in an environmentally sound manner (Ref. 12.17). Waste treatment or disposal should be at sites operating to acceptable standards and, where this is not the case, consideration should be given to alternative disposal options, including the development of facilities on site. The use and production of hazardous waste should be avoided as far as is possible and, where this is not practicable, material will be controlled and minimised. Good industry practice will be adopted in ensuring environmentally sound disposal.

12.3.4.4 IFC (2007): EHS Guidelines for Onshore Oil and Gas Development (Ref. 12.18)

The guidelines include the following requirements with respect to waste:

"Waste materials should be segregated into non-hazardous and hazardous wastes for consideration for re-use, recycling, or disposal. Waste management planning should establish a clear strategy for wastes that will be generated including options for waste elimination, reduction or recycling or treatment and disposal, before any wastes are generated. A waste management plan documenting the waste strategy, storage (including facilities and locations) and handling procedures should be developed and should include a clear waste tracking mechanism to track waste consignments from the originating location to the final waste treatment and disposal location.

12.3.4.4.1 Drilling Fluids and Drilled Cuttings

Non-Aqueous Drilling Fluids (NADF)[3]: Diesel-based fluids are also available, but the use of systems that contain diesel as the principal component of the liquid phase is not considered current good practice.

Feasible alternatives for the treatment and disposal of drilling fluids and drilled cuttings should be evaluated and included in the planning for the drilling program. Alternative options may include one, or a combination of, the following:

- *Injection of the fluid and cuttings mixture into a dedicated disposal well;*
- *Injection into the annular space of a well;*
- *Storage in dedicated storage tanks or lined pits prior to treatment, recycling, and / or final treatment and disposal;*
- *On-site or off-site biological or physical treatment to render the fluid and cuttings non-hazardous prior to final disposal using established methods such as thermal desorption in an internal thermal desorption unit to remove NADF for reuse, bioremediation, land farming, or solidification with cement and / or concrete. Final disposal routes for the non-hazardous cuttings solid material should be established, and may include use in road construction material, construction fill, or disposal through landfill including landfill cover and capping material where appropriate. In the case of land farming it should be demonstrated that subsoil chemical, biological, and physical properties are preserved and water resources are protected;*
- *Recycling of spent fluids back to the vendors for treatment and re-use;*
- *Consider minimising volumes of drilling fluids and drilled cuttings requiring disposal by:*
    - *Use of high efficiency solids control equipment to reduce the need for fluid change out and minimizing the amount of residual fluid on drilled cuttings;*
    - *Use of slim-hole multilateral wells and coiled tubing drilling techniques, when feasible, to reduce the amount of fluids and cuttings generated.*

Pollution prevention and control measures for spent drilling fluids and drilled cuttings should include:

- *Minimising environmental hazards related to residual chemicals additives on discharged cuttings by careful selection of the fluid system;*
- *Careful selection of fluid additives taking into account technical requirements, chemical additive concentration, toxicity, bioavailability and bioaccumulation potential; and*
- *Monitoring and minimizing the concentration of heavy metal impurities (mainly mercury and cadmium) in barite stock used in the fluid formulation.*

The construction and management measures included in this guideline for surface storage or disposal pits should also apply to cuttings and drilling fluid pits. For drilling pits, pit closure should be completed as soon as practical, but no longer than 12 months, after the end of operations. If the drilling waste is to be buried in the pit following operations (the Mix-Bury-Cover disposal method), the following minimum conditions should be met:

- *The pit contents should be dried out as far as possible;*
- *If necessary, the waste should be mixed with an appropriate quantity of subsoil (typically three parts of subsoil to one part of waste by volume);*
- *A minimum of one metre of clean subsoil should be placed over the mix;*
- *Topsoil should not be used but it should be placed over the subsoil to fully reinstate the area; and*

[3] Synthetic-based mud (SBM) is proposed for use in this project. SBM is a type of NADF.

- *The pit waste should be analysed and the maximum lifetime loads should be calculated. A risk based assessment may be necessary to demonstrate that internationally recognized thresholds for chemical exposure are not exceeded.*

12.3.4.4.2 Produced Sand

Produced sand should be treated as an oily waste, and may be treated and disposed of along with other oil contaminated solid materials (e.g. with cuttings generated when NADFs are used or with tank bottom sludges).

If water is used to remove oil from produced sand, it should be recovered and routed to an appropriate treatment and disposal system (e.g. the produced water treatment system when available).

12.3.4.4.3 Completion and Well Work-over Fluids

Feasible disposal options should be evaluated for these fluids. Alternative disposal options may include one, or a combination of, the following:

- *Collection of the fluids if handled in closed systems and shipping to the original vendors for recycling;*
- *Injection to a dedicated disposal well, where available;*
- *Inclusion as part of the produced water waste stream for treatment and disposal. Spent acids should be neutralized before treatment and disposal; and*
- *On-site or off-site biological or physical treatment at an approved facility in accordance with the waste management plan.*

12.3.4.4.4 Naturally Occurring Radioactive Materials (NORM)

Where NORM is present, a NORM management program should be developed so that appropriate handling procedures are followed. If removal of NORM is required for occupational health reasons, disposal options may include: canister disposal during well abandonment; deep well or salt cavern injection; injection into the annular space of a well or disposal to landfill in sealed containers.

Sludge, scale, or NORM-impacted equipment should be treated, processed, or isolated so that potential future human exposures to the treated waste would be within internationally accepted risk-based limits. Recognized industrial practices should be used for disposal. If waste is sent to an external facility for disposal, the facility must be licensed to receive such waste.

12.3.4.5 International Association of Oil and Gas Producers (IOGP) Guidelines for Waste Management with Special Focus on Areas with Limited Infrastructure (Report No. 413, rev1.1 September 2008 (updated March 2009)

This document provides fundamental guidance on waste management in exploration and production operations.

Practices discussed include:

- Taking a ‘life cycle approach’ to waste management in oil and gas projects and incorporating a systematic waste management planning framework. Using this approach, waste management considerations can be taken into account at the early stages of a project. Many companies now have management tools to communicate expectations and provide consistency in implementing common management practices;
- Applying a hierarchy of pollution prevention elements to attempt to reduce waste production: Principles of the waste management hierarchy are provided and examples of reduction at source, reuse, recycling/recovery and residue treatment are discussed. Also included is a list of potentially higher risk wastes which operators should consider avoiding;
- Applying a risk-based approach to waste management: An example of a general framework for risk-based decision making is outlined which can be applied to a range of waste management activities;

- Evaluating existing waste management capacity early and use a risk-based approach: This includes evaluating available facilities and identifying gaps. A list of considerations is provided for assessing third party sites for potential use;
- Collecting, segregating, storing and transferring waste in a way that reduces risk of escape to the environment: Some practical guidance is included for this aspect of waste management;
- Taking into account critical site-specific environmental characteristics, regulatory environment, logistical challenges and community outreach: Due to the potential lack of infrastructure for oil and gas operations in developing areas, it may be necessary to make arrangements for waste management facilities to be constructed. Information on how to evaluate a location for a new waste site includes preliminary reconnaissance, detailed field studies and the development of a community outreach strategy. Community support is a key consideration in the development of a new waste management facility; and
- Considering waste measurements and performance reporting as valuable tools to evaluate environmental performance and to help others understand the industry: Appropriate environmental performance indicators will take into consideration key drivers, coordination in planning and timeline for data collection, and good practices leading to a more proactive approach to use of information.

12.4 Spatial and Temporal Boundaries

This ESIA Chapter considers the potential impacts pertaining to waste management associated with all phases of the Project on a local, regional, national, and where necessary, international scale. This recognises the fact that waste is managed in accordance with the suitability of receiving facilities, which may be geographically remote from the Project. Therefore, the assessment has been undertaken by taking into account available data on the locations, types and capacities of the existing waste management infrastructure present in Uganda at the time of writing this report.

The proposed timescales for the different phases of the Project are set out in ***Chapter 4: Project Description and Alternatives***. A brief summary of the timescales are provided below:

- Site Preparation and Enabling Works Phase expected to take approximately 5 years;
- Construction and Pre-Commissioning is expected to take up to 7 years;
- Commissioning and Operations is expected to commence approximately 36 months after effective date of the main construction contract award. The lifetime of the Project is 25 years; and
- Decommissioning is planned for the end of the 25 year operation.

The phases overlap and in total the duration through all phases will be approximately 28 years. The duration of activities which may lead to potential waste related impacts differ between short and long term episodes, all of which are described within the assessment as necessary.

12.5 Baseline Section

12.5.1 Baseline data

12.5.1.1 Primary Data - 2017 Early Works Baseline Study

Information on waste generation and management practices within the Project Area is mainly based on data collected and referred to in the Early Works Project Brief (PB) (Ref. 12.19) along with information provided within the three waste reports prepared on behalf of the Project Proponents (Ref. 12.1, Ref. 12.2 and Ref. 12.3).

A range of methods were used to collect baseline data regarding waste management in the Project Area. These included interviews with community members, professional expertise, observations and document reviews to obtain quantitative and qualitative data. A summary of the waste management data collated is provided below.

The per capita per day generation at household level within the Project Area is predicted at approximately (115 – 102) grams (g) which is less than the national average waste generation rate of 0.55 kilogram (kg)/capita/day (low income 0.3 kg/capita/day and high income 0.66 kg/capita/day) (Okot-Okumu and Nyenje, 2011). The waste composition of the existing infrastructure present in the Project Area of influence is estimated at 82% organic and putrescible materials, 5.12% plastics, 5.83% paper/paper products, 0.12% metal and 0.36% textile.

Most of the areas were found to be clean, with limited occurrences of littering. The major waste stream in the area is domestic waste. Besides homestead rubbish collection pits and pit latrines, waste disposal facilities were not observed at community level during the survey. Some households were composting waste for fertilizers used in their gardens. In public places such as markets, town centres, churches and community schools; open burning was the most common waste management activity practised by communities. However, reuse of waste like plastic mineral water bottles was also observed among the communities as these were used for stocking and selling Kerosene and automobile fuel.

Community participation in waste management is mostly informal and there are no clear avenues for active formal participation. The councils are also unable to enforce existing waste management laws because of lack of resources and political interference.

Waste is managed at household level. Some homesteads have rubbish collection pits and latrines while others scatter rubbish at the end of the compound. Most domestic waste is burnt when the pit fills up. Homesteads without rubbish collection pits instead gather their rubbish in heaps and regularly burn the heaps to reduce the volumes.

A copy of the Executive Summary of the Early Works PB is contained within Appendix C.

12.5.1.2 Waste Facilities

Information on waste facilities has been based on the waste reports provided by the Project Proponents (Ref. 12.1, Ref. 12.2 and Ref. 12.3).

Table 12.2 presents a snapshot of the available data and status of the hazardous and non-hazardous waste management facilities available in Uganda based on the findings from the waste reports (Ref. 12.1, Ref. 12.2 and Ref. 12.3).

The Table also includes a provisional assessment of whether or not the facilities are likely to comply with good international industry practice (GIIP) for the types of facility and the types of waste accepted. Indicative GIIP requirements for a range of waste facilities is provided in the IFC EHS Guidelines for Waste Management and for Onshore Oil and Gas Development.

The provisional assessment is based on information about the design, technology and operation of each facility provided in the waste reports provided by the Project Proponents: these waste reports did not include full GIIP compliance assessment of each facility, and hence the provisional assessment will be confirmed by audits carried out by the Project Proponents on Facilities that have successfully completed the Call For Tender Process and prior to sending any waste to those.

Hazardous and Non-Hazardous waste management facilities locations are also identified within Figure 12-1.

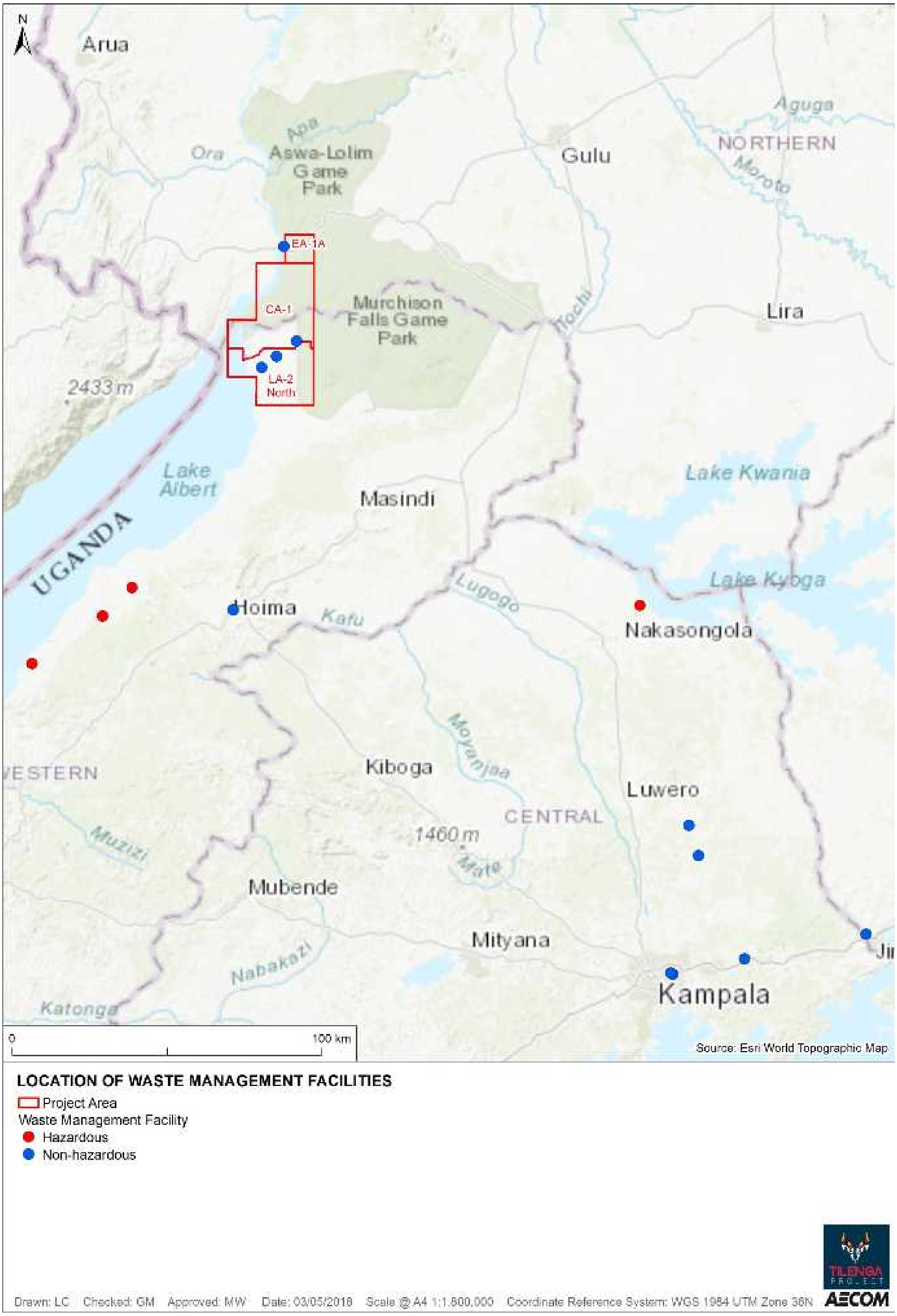

Figure 12-1: Location of Waste Management Facilities

Table 12.2: Waste Management Facilities

Number	Location	Facility Type	Waste Types	Notes	Capacity/throughput	Compliance with GIIP
1	On-site at TUOP/TEPU facilities	Enclosed composting reactor (Project's Proponents')	Food waste	Not operational as of November 2017.	0.15 - 0.25 tonnes /day (8-13 tonnes / annum)	Potentially (subject to further audit)
2	2 kilometres (km) from Pakwach town	Municipal waste disposal site	Food waste Paper Cardboard	No engineered lining system. Open burning of wastes and odours. No direct discharges observed, but pooling of contaminated water. Site unlined so potential groundwater contamination.	Unknown	Unlikely
3	Buliisa District (Ngwedo)	Non-hazardous landfill	General non-hazardous waste	Non-engineered site, in close proximity to farms and settlements. NEMA licenced. Open burning of wastes. Low risk of surface water contamination but potential for contamination of groundwater resources due to lack of liner.	Design Capacity 927 cubic metres (m^3)	Unlikely
4	Hoima District (Kibati village)	Non-hazardous landfill and composting facility.	General and organic waste	Facility is reported to be in poor condition and with minimal environmental controls.	Design capacity 70 tonnes / day	Unlikely

Number	Location	Facility Type	Waste Types	Notes	Capacity/throughput	Compliance with GIIP
5	Hoima District (Nyamasoga)	Liquid waste treatment facility – ultrafiltration and reverse osmosis.	Drilling fluids and other liquid wastes.	Reported that liquid discharge to river meets Ugandan River Discharge standards.	Design capacity 10 m^3/hour.	Potentially (subject to further audit)
		Hazardous waste landfill	All hazardous wastes except radioactive waste	Reported to be designed to Standard - H:H/Class A (South African landfill design standard), and including closed loop drainage system, multiple liner profile for subsoil drainage, leak detection, primary protection and leachate drainage, and leachate control system.	1 million m^3, of which only a small proportion has been used to date.	Potentially (subject to further audit)
6	Nakasongola District	Incinerator (Dual-chamber rotary kiln)	Combustible hazardous wastes	No information available on environmental performance.	Not known	Potentially (subject to further audit)
		Hazardous waste landfill	Hazardous waste – specific waste types not known.	No information available	Design capacity 50,000 m^3, of which about half has been used to date	

Number	Location	Facility Type	Waste Types	Notes	Capacity/throughput	Compliance with GIIP
7	Luwero District (Ziroobwe)	Incinerator	Hazardous waste – specific waste types not known.	Reported to have: • 850°C pyrolytic chamber, with 1,300°C and above temperatures for post combustion chamber • Automatic loading system • Residence time of at least 2 seconds • Wet scrubber to clean flue gas from the incineration process • Secondary combustion • Landfill of ash at Engineered landfill	3.2 tonnes per day	Potentially (subject to further audit)
8	Hoima District	Liquid waste treatment facility – coagulation and flocculation.	Drilling fluids and other liquid wastes.	No information available	No information available	Potentially (subject to further audit)
		Biodegradation	Drill cuttings	Regulatory Authorities had previous compliance challenges with the facility. The resulting treated cuttings did not meet Ugandan standards for reuse and the material was consequently landfilled.	50,000 tonnes per year	Potentially (subject to further audit)
		Hazardous waste landfill	Not known	Reported to be designed to H:H/Class A (South African) standards.	15,000 m^3	Potentially (subject to further audit)

Number	Location	Facility Type	Waste Types	Notes	Capacity/throughput	Compliance with GIIP
9	Hoima District	Biodegradation (Currently Under Construction)	Drill cuttings	No information on performance.	There is reported to be a 50,000 tonnes per annum (tpa) facility in operation, with an additional 7,000 tpa facility under construction. The capacity of this specific facility is not known.	Potentially (subject to further audit)
		Hazardous waste landfill	Not known	Reported to be designed in accordance with Basel Convention Technical Guidelines on Specially Engineered Landfill (D5) / Environmental Permitting Guidance: The Landfill Directive (England and Wales).	11,200 m^3	Potentially (subject to further audit)
10	Iganga District	Incinerator Waste Stabilisation Landfill	Hazardous and Non Hazardous Waste	No information available	No information available	Potentially (subject to further audit)
11	Kampala	Plastic Recycling	Plastic bottles	Fully permitted. No issues observed. Waste water treatment (WWT) plant installed and commissioned at the site. Some direct discharges observed during site visit. No issues observed. Good general standards observed. High level of noise within the buildings.	Unknown	Potentially (subject to further audit)

Number	Location	Facility Type	Waste Types	Notes	Capacity/throughput	Compliance with GIIP
12	Kampala	High-density polyethylene (HDPE) Recycling	HDPE Plastic bags	Hard plastics are cleaned, shredded and washed and made into plastic crumb to be used as raw material for piping and tanks. Informal visit noted no environmental concerns.	Unknown	Potentially (subject to further audit)
13	Namataba, Mukono District	Paper/ Cardboard recycling	White paper, cardboard	No blue paper accepted	Confirmed capacity to accept paper/cardboard products from Project	Potentially (subject to further audit)
14	Jinja District	Paper/ Cardboard recycling	Paper, cardboard	None	Unknown	Potentially (subject to further audit)

The Hazardous Waste Study has also identified 6 existing organisations in Uganda who are reported to hold the necessary authorisations and equipment for transportation of hazardous waste.

The combined capacity of these companies to transport hazardous waste is identified within Table 12.3. It is reported in Reference 12-2 that in total, there is capacity to transport 840 tonnes of drill cuttings, 513 m^3 of drilling fluids, and 137 tonnes of general hazardous waste. These figures relate to the overall capacity of the fleet (i.e. capacity of each vehicle x number of vehicles) and the actual transport capacity (in terms of tonnes per day) would depend on the transport distance and hence the number of trips that each vehicle is able to make in a given period of time. The capacity for transportation of non-hazardous wastes is not known at this stage.

Table 12.3: Overview of Uganda Hazardous Waste Transporters

Type of Waste	Type of Vehicle	Number of Vehicles	Average Capacity of Vehicles
Drill cuttings	Modified dump truck	56	15 tonnes
Drilling fluids	Vacuum tanker	27	19 m^3
General hazardous waste	Box-body truck	21	6.5 tonnes

12.5.2 Data Assumptions and Limitations

Baseline data on existing facilities is based on reports provided by the Project Proponents (Ref. 12.1, Ref. 12.2 and Ref. 12.3).

These reports do not contain sufficient information to determine whether the existing facilities currently comply with GIIP and therefore whether their use would be in compliance with the recommendations of the IFC Performance Standards for waste management.

The provisional assessment presented here and used in support of the impact assessment will be confirmed by facility audits carried out by the Project Proponents prior to sending waste to any facility.

12.6 Impact Assessment Methodology

The waste study assessment framework differs from other technical studies in this ESIA Report in that it is not focused on defining and assessing the sensitivity of external receptors and assessing impacts on these receptors before and after mitigation. This is because the avoidance of potential waste impacts on external receptors at the Project planning and design stage as far as practicable, is considered to be fundamentally good practice, and required by both local regulations and international guidelines. The potential impacts associated with waste management are covered in multiple chapters including ***Chapter 6: Air Quality and Climate***, ***Chapter 8: Geology and Soils***, ***Chapter 10: Surface Water***, ***Chapter 16: Social***, and ***Chapter 18: Health and Safety***. Potential impacts associated with accidental releases of waste are addressed separately under ***Chapter 20: Unplanned Events.***

The methodology focuses on identifying appropriate measures for managing waste, given the type and quantities of wastes likely to be produced by the Project, and then identifying and assessing any potential residual impacts depending whether or not suitable management routes are available. Embedded mitigation measures (i.e. measures built intrinsically into the design of the Project) are also identified relating to how waste is handled, stored and transported.

The waste impact assessment method comprises the following steps:

- Estimate the types and quantities of waste likely to be generated by the Project;
- Identify the potential management route for each waste stream (including the facilities that are available for recycling, recovery or disposal of the waste);
- Identify appropriate embedded mitigation measures; and
- Assess any potential impacts based on consideration of waste types and the suitability of the available waste management facilities.

The magnitude of the impacts for each waste stream is assessed based on the:

- Volume and hazardous properties of wastes produced;
- Treatment and disposal methodology for hazardous waste
- Capacity of identified waste management facilities for managing the waste in compliance with relevant guidelines; and
- Degree of certainty regarding the availability of these facilities.

Table 12.4 outlines the impact assessment criteria used for the various categories of waste, according to the proposed method of managing that waste type. As discussed above, this impact criteria differs from that standard methodology presented within ***Chapter 3: ESIA Methodology*** and is unique to the assessment of waste.

These criteria recognise that the highest potential impacts would be associated with managing hazardous wastes where suitable facilities are either not available or have not been identified. Suitable facilities are those which are licensed by the relevant regulatory authorities and are operating in accordance with GIIP as set out in IFC EHS Guidelines, publications such as IOGP guidance documents, and regulatory requirements in developed countries such as the United States and European Union. Following additional mitigation, moderate and high impacts are assessed as being **Significant**. Low and Insignificant impacts are assessed as being **Non-Significant**; although professional judgement can be used in some cases to further define whether or not impacts are significant based on a more detailed consideration of specific waste types and quantities. GIIP applies to all facilities, including recycling facilities.

From the preliminary assessment defined in 12.5.1.2, where specific types of facilities are proposed to be used, it is assumed that facilities categorised as "*Unlikely to be GIIP Compliant*" are unsuitable facilities whereas those "*potentially*" compliant are suitable facilities. When there is more than one facility available of same type (e.g. more than one landfill) with different degrees of compliance to GIIP (Table 12.2); the impact assessment considers the "lowest" degree of GIIP Compliance in order to remain conservative. In the case of recycling vendors for non-hazardous wastes, the assessment assumes that these facilities can achieve GIIP since for these facilities GIIP largely comprises good site housekeeping.

Table 12.4: Waste Management Impact Magnitude Criteria

Management Route for Project Waste	Type of Waste		
	Inert	**Non-hazardous**	**Hazardous**
Suitable facilities available with sufficient capacity to manage the quantities of wastes generated.	**Insignificant**	**Insignificant**	**Low**
Suitable facilities available but capacity to accept waste from Project may be constrained due to size of facility or distance from site.	**Low**	**Moderate**	**Moderate**
Facilities are unavailable or unsuitable; or means of management is uncertain.	**Moderate**	**Moderate**	**High**

The definition of hazardous waste includes any wastes specifically designated as hazardous within applicable Ugandan legislative requirements. For the purposes of this ESIA Report, hazardous wastes are also defined in terms of the IFC General EHS Guidelines for Waste Management, i.e. wastes that share the properties of a hazardous material (e.g. ignitability, corrosivity, reactivity, or toxicity), or other physical, chemical, or biological characteristics that may pose a potential risk to human health or the environment if improperly managed.

Inert waste is not defined in the Ugandan National Environment (Waste Management) Regulations, but is recognised in IFC guidelines and is defined in the European Union (EU) Landfill Directive such that *"waste is considered inert if:*

1. It does not undergo any significant physical, chemical or biological transformations;

2. It does not dissolve, burn or otherwise physically or chemically react, biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm to human health; and

3. Its total leachability and pollutant content and the ecotoxicity of its leachate are insignificant and, in particular, do not endanger the quality of any surface water or groundwater."

In practice, inert waste typically comprises surplus excavated soil and rock, and waste construction materials such as brick and concrete.

For the purposes of this assessment, non-hazardous waste is waste that is neither inert nor hazardous.

12.7 Waste Types and Quantities

12.7.1 NORM

Based on available data, the Project Proponents do not expect that waste containing Low Specific Activity (LSA) / naturally occurring radioactive materials (NORM) will be generated by the Project. LSA/NORM monitoring strategy shall be developed and implemented for development drilling and production phases. In the event that presence is detected, a suite of management procedures shall be developed to ensure that any LSA/NORM contaminated materials and wastes are stored and managed appropriately.

12.7.2 Drilling fluids and cuttings

The largest single waste stream is expected to be drill cuttings, and the properties of this waste vary depending on the type of drilling fluid used. Information on the drilling fluids and cuttings is provided in ***Chapter 4: Project Description and Alternatives***. The types and quantities of waste arising from drilling fluids and cuttings is set out in Table 12.5 below.

12.7.3 Other waste

Provisional waste arisings estimates have been provided by the Project Proponents and are presented in Table 12-5 below. This waste arisings data is based on preliminary estimates available at the time the ESIA Report was prepared. Waste arisings estimates for the decommissioning phase are not available at this time, although embedded mitigation measures to be adopted during decommissioning are included in section 12.9.6.

Table 12.5: Estimated Waste Arisings (all figures in tonnes per year unless stated)

Waste Type	Category	Site Preparation and Enabling Works Phase and Construction and Pre-commissioning Phase	Commissioning and Operations
Chemicals	Hazardous	119	197*
Drill Cuttings			
Water Based Mud (WBM) Cuttings	Hazardous	42,000 (total)	
Synthetic Based Mud (SBM) Cuttings	Hazardous	77,000 (total)	
Cement	Non-hazardous	1,000 (total)	
Horizontal Directional Drilling (HDD) Cuttings	Non-hazardous	2,000 tonnes (total)	
Drilling Fluids			
WBM Drilling Fluids	Hazardous	34,000 (total)	
SBM Drilling Fluids	Hazardous	4,000 (total)	
Workover Fluids	Hazardous	-	1,566
HDD Fluids	Non-hazardous	3,000 tonnes (total)	
Electrical Equipment			
Batteries	Hazardous	7	2*
Electronic waste	Hazardous	19	9*
Light bulbs	Hazardous	4	4*
Food	Non-hazardous	744	744*
Used cooking oil	Hazardous	151	151*
General Waste	Non-hazardous	1877	1,442*
Glass	Non-hazardous	255	251*
Medical waste	Hazardous	68	7*
Metal Drums	Non-hazardous	980	1,885
Cables	Hazardous	10	0

Waste Type	Category	Site Preparation and Enabling Works Phase and Construction and Pre-commissioning Phase	Commissioning and Operations
Oily Waste			
Lab Drainage	Hazardous	10	20*
Oil - Used Lube Oil	Hazardous	10	62
Oily Rags/Absorbent Materials	Hazardous	71	95*
Oily Water & Tank Slops	Hazardous	14,400 (drilling period)**	3,020*
Pigging Wastes	Hazardous	0	9,100
Sludge	Hazardous	1,045	2,595*
Paper & Cardboard	Non-hazardous	815	815*
Plastic (clean)	Non-hazardous	1,268	611*
Plastic (contaminated)	Hazardous	12	0
Sanitary waste	Hazardous	0.5	0.2
Jetting sand (clean)	Non-hazardous	0	1
Jetting sand (oily)	Hazardous	0	0.1
Soil and rock***	Inert	778,268 (for the whole Project)	0
Contaminated soil	Hazardous	31	31*
Tyres & Rubber	Non-hazardous	66	32*
Wood (untreated, including bush)	Non-hazardous	23,208	100*
Wood (treated, including packaging)	Hazardous	550	2,212*
Bitumen	Hazardous	1,751	0
Insulation Foam	Non-hazardous	180	4*

*Peak quantity is indicated

** Total for entire drilling period is 72,000 tons

*** Unused material will be reused within the Project footprint or used to restore borrow pits as much as practicable.

12.8 Waste management routes

The proposed management routes for Project wastes have been determined based on the principles of the waste management hierarchy (Avoid, Reduce, Reuse, Recycle, Recover, Dispose), and in consideration of the available existing facilities in Uganda and Best Available Techniques (BAT).

Figure 12-2: Waste Management Hierarchy

12.8.1 Management of Drill Cuttings and Fluids

The Project Proponents have evaluated the options for management of waste fluids, drill cuttings and oily mixtures (such as rig wash down water and well pad drainage). The options considered were:

- **Bioremediation;**

  This process involves the mixing of drill cuttings with a substrate, soil or sawdust, adding nutrients (fertilizers), (Inoculation with Microbes) and naturally occurring microbes and water. Under controlled temperature and pH the organic contaminant/pollutants in the drilling waste are slowly digested and consumed by microbes. The mixture is regularly turned mechanically or manually and once the contaminants levels drop to an environmentally acceptable threshold then the end product is harmless and can be used as a soil conditioner.

- **Thermal desorption followed by landfill;**

  The SBM cuttings are heated to evaporate and to recover the synthetic base fluid and water, these are separated from the drilled solids. Thermal treatment process result into a very low oil-on-cutting, which is considered inert in most countries. Recovered base fluid from thermal treatment can be recycled into drilling fluid, while water (generally briny) is either recycled or treated via a waste water treatment plan and disposed of. Recovered dried drilled solids are landfilled in a licensed engineered landfill.

- **Cuttings reinjection (CRI);**

  Drill cuttings are grinded, screened via a shale shaker to calibrate size of particles, then slurrified with addition of water (to adjust slurry density), viscosified (if required) and injected via a dedicated plant into specifically engineered wells.

- **Stabilisation followed by landfill;**

  Wet drill cuttings, either drilled with WBM or SBM, can be inerted by addition of cement for WBM and a mix of lime and cement for SBM drill cuttings. The stabilised cuttings are then disposed of in a licensed engineered landfill.

- **Stabilisation followed by re-use; and**

  Wet drill cuttings, either drilled with WBM or SBM, can be inerted by addition of cement for WBM and a mix of lime and cement for SBM drill cuttings. The stabilised cuttings can be used as a construction material to make brick, or as additive in concrete

- **Water treatment (for oily mixtures only).**

Effluents, contaminated liquid are to be treated through a physico-chemical treatment plus ultra-filtration and/or reverse osmosis.

The following the methods were assessed for management of drilling waste as per the Table 12.6 below

Table 12.6: Assessment of drilling waste alternatives available

Treatment method	WBM cuttings	SBM cuttings	Effluents
Bioremediation	Yes	No	No
Thermal treatment & landfill	No	Yes	No
Cutting reinjection	Yes	Yes	Yes
Stabilization & landfill	Yes	Yes (*)	No
Stabilization & re-use	Yes	No	No
Waste water treatment	n/a	n/a	Yes
*cuttings with low oil content			

Table 12.7: Evaluation criteria for drilling waste treatment methods

	Bioremediation	Thermal treatment & landfill	CRI	Stabilisation & Landfill	Stabilization & re-use	Waste water treatment
Covered by existing and proposed National regulations	No	Yes	No	Yes	No	Yes
Technical challenges	High	Low	High	Low	Low	Low
Availability of in-country waste management facilities	No	No	No	Yes	No	Yes
Treatment effectiveness	Low	high	High	High	Low	High
Potential Environmental, Health, safety and social impacts/liability	High	Low	High	Low	High	Low
Land requirements	High	High	Low	High	Low	Low
Energy requirement	N/A	High	Low	N/A	N/A	Low
Costs	Dependent on quantities to be treated	Dependent on quantities to be treated	Independent of quantities and type	Dependent on quantities to be treated	Dependent on quantities to be treated	Dependent on quantities to be treated

Table 12.7 above presents an evaluation criteria used to guide the selection of the treatment methods. Conventional waste treatment methods of Waste water treatment, Stabilisation & Landfill, Thermal treatment & landfill are recommended for the Tilenga development, and are assessed further.

Two final options have been assessed by the Project Proponents for disposal of drilling cuttings and fluids. These are:

1. Cuttings Re-Injection (CRI), whereby cuttings and fluids would be injected via a dedicated plant into specifically engineered wells located on part of the Industrial area; and

2. Conventional treatment of waste, whereby cuttings and fluids would be transported offsite for dedicated treatment and disposal in a dedicated facility.

In consideration of the geological uncertainties associated with injecting large volumes of cuttings and fluids into the relatively shallow sedimentary rock system above the basement granite, the conventional treatment solution has been selected.

Details for this option are provided in ***Chapter 4: Project Description and Alternatives*** and assessment provided below.

12.8.1.1 Conventional Drill Cuttings and Fluids Waste Management

The total amount of cuttings and fluids to be generated is estimated to be approximately 230,000 tonnes and equals to 140 tons of drilling waste per day for 4,5 years.

Drilling muds will be reused wherever practicable and a dedicated spread of equipment will be mobilised to ensure the treatment and reuse of the drilling muds.

Used WBM and SBM will be transported to external facilities for treatment and disposal as described below.

- WBM fluid and cuttings will be transported to a suitable landfill facility for stabilisation and disposal
- SBM fluid and cuttings will be transported to a suitable facility to be treated by Thermal Desorption Unit (TDU) to maximize fluid separation from cuttings, subject to efficiency of cuttings dryer on site. The fluid will be either re-used or disposed, and the treated cuttings will be landfilled.

12.8.1.2 Pre-treatment at Well Pads

There will be no treatment of drill cuttings at well pads, other than the use of shale-shakers and cuttings dryer (optional) to separate mud from cuttings to allow for recirculation back down the well and to minimise the retained fluid on the cuttings which are transported away from the well pad.

Temporary storage of cuttings and fluids at waste consolidation sites (for the collection of wastes from rig sites) pending permanent disposal may be considered as an option. Cuttings and used fluids will be transported to the treatment and disposal facility in sealed containers or sealed trucks.

12.8.2 Management of Other Wastes

Management routes identified by the Proponents for other types of waste are presented in Table 12.9.

The Project Proponents plan to recycle non-hazardous wastes (such as uncontaminated wood, metal, plastic, paper) where suitable facilities can be identified.

As a base case, topsoil and subsoil from Site Preparation and Enabling Works and pipeline installation activities during the Construction and Pre-commissioning Phase will be either stored locally and later used in the construction of bunds around the facilities or in the restoration of construction areas, and/or removed and used for borrow pit restoration subject to detailed information on the material suitability.

A dedicated waste management facility will be located at the Industrial Area for collection, temporary storage and any necessary pre-treatment of hazardous and non-hazardous wastes.

Table 12.8: Proposed Waste Management Routes

Waste Type	Category	Management Route
Chemicals	Hazardous	High-temperature incineration
Electrical Equipment		
Batteries	**Hazardous**	Hazardous waste landfill
Fluorescent lightbulbs	**Hazardous**	Hazardous waste landfill
Electronic waste	**Hazardous**	Recycling
Food	Non-hazardous	On-site composting
Used cooking oil	**Hazardous**	Landfill
General Waste	Non-hazardous	Landfill
Glass	Non-hazardous	Recycling
Medical waste	**Hazardous**	High-temperature incineration
Metal drums	Non-hazardous	Recycling
Cables	**Hazardous**	Hazardous waste landfill
Oily Waste		
Lab Drainage	**Hazardous**	High-temperature incineration
Oil - Used Lube Oil	**Hazardous**	High-temperature incineration
Oily Rags/Absorbent Materials	**Hazardous**	High-temperature incineration
Oily Water - Tank Slops	**Hazardous**	High-temperature incineration
Pigging Wastes	**Hazardous**	High-temperature incineration
Sludge	**Hazardous**	High-temperature incineration
Paper & Cardboard	Non-hazardous	Recycling
Plastic (clean)	Non-hazardous	Recycling
Plastic (contaminated)	**Hazardous**	High-temperature incineration
Sanitary waste	**Hazardous**	Hazardous waste landfill
Jetting sand (clean)	Non-hazardous	Landfill
Jetting sand (oily)	**Hazardous**	Hazardous waste landfill
Soil and rock	Inert	Used for landscape/screening bunds where feasible. Residual waste landfilled.
Contaminated soil	**Hazardous**	Hazardous waste landfill
Tyres & Rubber	Non-hazardous	Landfill
Wood (untreated)	Non-hazardous	Recycling
Wood (treated)	**Hazardous**	High-temperature incineration
Bitumen	**Hazardous**	Hazardous waste landfill
Insulation Foam	Non-hazardous	Landfill

12.9 Embedded In Design Mitigation

Measures embedded in the design to mitigate potential waste management impacts are presented in the following section. Additional embedded mitigation measures are presented in ***Chapter 4: Project Description and Alternatives*** of this ESIA.

12.9.1 Waste Management Planning

Mitigation measures for waste management are being developed as part of the design dossier during Front End Engineering Design (FEED). As part of the design dossier, the following documents are under development and will address the management of wastes for each phase of the project:

- Tilenga Project Waste Management Strategy;
- Tilenga Project Waste Map;
- Contractor specific waste management plans for construction and operations;
- Contractor specific supplier specifications and procurement plans;
- Contractor specific Construction Execution Plans; and
- Contractor specific Construction Environmental and Social Management Plans.

In addition to the above, a competitive call for tender has been launched for the provision of hazardous and non-hazardous waste management services. As part of this process, the Waste Management Plan will be completed when the waste contractor selection process is completed and it will provide guidance on:

- Waste minimisation and prevention;
- Identification and segregation of waste materials at source;
- Recycling or reuse of suitable materials;
- Treatment and disposal of specific waste streams (particularly drill cuttings, fluids and oily mixtures); and
- Duty of Care and auditing procedures for waste management contractors and waste receiving facilities.

The waste management elements of the ESMP and Waste Management Plan will reflect the waste hierarchy, placing priority on waste minimisation, followed by recycling or reuse if economically practicable, then by environmentally sound methods of waste treatment and/ or disposal.

12.9.2 Waste Minimisation

12.9.2.1 Drill cuttings and fluids

The drilling strategy is planned in line with the waste minimisation strategy considering that the slim hole architecture reduces drill cuttings (waste) volumes by 30% (compared to standard well dimensions).

Whenever possible, the selection of chemicals for drilling fluids will be based on E (Gold) or D (Silver) rated products in the OCNS (Oil Chemical National Scheme) classification which classify chemicals used in the UK and Netherlands offshore petroleum industry. The ranking is evaluated through the CHARM (Chemical Hazard and Risk Management) assessment which includes toxicity, biodegradation and bioaccumulation assessments. The lowest hazardous chemicals are ranked E (Gold) or D (Silver).

In order to facilitate the management of drill cuttings, drilling fluids used for the Project will be:

- free of chlorides; the upper limit will be 2% by weight;
- free of aromatic hydrocarbon, the upper limit is fixed at 300 parts per million (ppm); and
- No asphalt, no gilsonite, nor equivalent so called ”black” products will be permitted in the drilling fluids and cementing formulations.

Reuse: Drilling fluids recycling and reuse is favoured by the use of SBM. At least five wells can be drilled with an SBM prior to the fluid requiring replacement, whilst only two wells can be drilled with WBM before the fluid needs to be replaced.

Separation equipment will be used as part of the drilling fluid management process in order to allow drilling fluids to be separated from cuttings as the well is drilled, and then recirculated within the well. This reduces the amount of spent drilling fluid that needs to be discarded along with the cuttings.

12.9.2.2 Other waste types

Processes will be designed and operated by the selected competent contractors that accord with national laws and GIIP to prevent or minimise the quantities of wastes generated as much as practicable, and hazards associated with generated wastes, in accordance with the following strategy:

- Substituting raw materials or inputs with less hazardous or toxic materials or with those where processing generates lower waste volumes;
- Instituting good housekeeping and operating practices, including inventory control to reduce the amount of waste resulting from materials that are out-of-date, off-specification, contaminated, damaged, or excess to plant needs;
- Instituting procurement measures that recognise opportunities to return usable materials such as containers and which prevents the over ordering of materials; and
- Minimising hazardous waste generation by implementing stringent waste segregation to prevent the commingling of non-hazardous and hazardous waste to be managed.

Specific measures adopted during FEED to minimise waste generation include:

- Removal of requirement to insulate entire pipeline network during construction of pipeline (substantial reduction in insulation);
- Reuse of topsoil and subsoil during site preparation, enabling works and construction for on-site structures (berms) and borrow pit restoration;
- Re-use and re-injection of hydrotest water (substantially reducing the amount of hydrotest water to be treated and disposed of), considered as base case for the ESIA;
- Procurement procedures with strict guidelines to ensure packaging is minimised and recyclable wherever possible; and
- Re-injection of all produced water for enhanced oil recovery purposes.

12.9.3 Waste Recycling

Consideration will be given to the following measures in order to maximise the amount of Project waste that can be recycled:

- Evaluation of waste production processes and identification of potentially recyclable materials;
- Identification and recycling of products that can be reintroduced into the manufacturing process or industry activity at the site. E.g. options considered to recycle oily wastes in process streams wherever possible (pigging wastes to process, contaminated drainage water back to water injection system);
- Investigation of external markets for recycling by other industrial processing operations located in the neighbourhood or region of the Project; and
- Establishing recycling objectives and formal tracking of waste generation and recycling rates.

12.9.4 Waste Storage and Transport

All wastes will be stored in suitable containers which are appropriate for the materials in question and which are clearly labelled.

Hazardous waste will be stored so as to prevent or control accidental releases to air, soil, and water resources and in accordance with the following measures:

- Waste will be stored in a manner that prevents the commingling or contact between incompatible wastes, and allows for inspection between containers to monitor leaks or spills. Examples include sufficient space between incompatibles or physical separation such as walls or containment curbs;
- Store in closed containers away from direct sunlight, wind and rain;
- Secondary containment systems will be constructed with materials appropriate for the wastes being contained and adequate to prevent loss to the environment. Secondary containment is included wherever liquid wastes are stored in volumes greater than 220 litres. The available volume of secondary containment will be at least 110% of the largest storage container, or 25% of the total storage capacity (whichever is greater), in that specific location

Provide adequate ventilation where volatile wastes are stored. Healthcare waste will be temporarily stored in fit-for-purpose containers in a closed room with restricted access for staff until transport off-site by an approved and licensed contractor to a dedicated waste management facility.

Hazardous waste storage activities will also be subject to special management actions, conducted by employees who have received specific training in handling and storage of hazardous wastes:

- Provision of readily available information on chemical compatibility, including labelling each container to identify its contents;
- Limiting access to hazardous waste storage areas to employees who have received proper training only;
- Clearly identifying and demarcating waste storage areas, including documentation of locations on a facility map or site plan;
- Conducting periodic inspections of waste storage areas and documenting the findings;
- Preparing and implementing spill response and emergency plans to address accidental releases; and
- Avoiding underground storage tanks and underground piping of hazardous waste.

On-site and off-site transportation of waste will be conducted so as to prevent or minimise spills, releases, and exposures to employees and the public. All waste containers designated for off-site shipment will be secured and labelled with the contents and associated hazards, be properly loaded onto transport vehicles before leaving the Project Area, and be accompanied by a shipping paper (i.e. manifest) that describes the load and its associated hazards.

Drilling waste will be transported in sealed containers. Estimated number of transportation means that should be available during drilling for transporting liquid (including mud) and cuttings is 50 units.

12.9.5 Waste Monitoring

Monitoring activities associated with the management of hazardous and non-hazardous waste will include:

- Regular visual inspection of all waste storage collection and storage areas for evidence of accidental releases and to verify that wastes are properly labelled and stored. When significant quantities of hazardous wastes are generated and stored on site, monitoring activities should include:
    - Inspection of vessels for leaks, drips or other indications of loss;
    - Identification of cracks, corrosion, or damage to tanks, protective equipment, or floors;
    - Verification of locks, emergency valves, and other safety devices for easy operation (lubricating if required and employing the practice of keeping locks and safety equipment in standby position when the area is not occupied);
    - Checking the operability of emergency systems; and

  - Documenting any changes to the storage facility, and any significant changes in the quantity of materials in storage.
- Regular audits of waste segregation and collection practices;
- Tracking of waste generation trends by type and amount of waste generated, preferably by facility departments;
- Characterising waste at the beginning of generation of a new waste stream, and periodically documenting the characteristics and proper management of the waste, especially hazardous wastes;
- Keeping manifests or other records that document the amount of waste generated and its destination;
- Periodic auditing of third party waste handlers involved in transportation, treatment and disposal services including re-use and recycling facilities; and
- Regular monitoring of soil and groundwater quality in cases of Hazardous Waste on site storage and/or pre-treatment and disposal.

Monitoring records for hazardous waste collected, stored, or shipped should include:

- Name and identification number of the material(s) composing the hazardous waste;
- Physical state (i.e., solid, liquid, gaseous or a combination of one, or more, of these);
- Quantity (e.g., kilograms or litres, number of containers);
- Waste shipment tracking documentation to include, quantity and type, date dispatched, date transported and date received, record of the originator, the receiver and the transporter; and
- Method and date of storing, repacking, treating, or disposing at the facility, cross-referenced to specific manifest document numbers applicable to the hazardous waste.

12.9.6 Waste Management during Decommissioning

Decommissioning will be undertaken in accordance with the Ugandan legislation, international standards and best practice, and a developed Decommissioning Plan including a detailed waste management plan regarding waste types, quantities and recycling, treatment technologies and identification of facilities required for waste management.

Measures to avoid and minimise the generation of wastes have been studied during FEED and will continue to be explored during the Detailed Engineering phases. The design shall consider the need to facilitate future decommissioning and adopt waste minimisation strategies accordingly. Examples of this include the use of process system to recycle hydrocarbon contaminated waste streams where technically feasible and the use of modularised process equipment which can be disconnected, removed and transported away from the site for dismantling and decommissioning. The design shall also allow for routine monitoring and inspection to ensure that there is sufficient information on the in-situ condition to support decommissioning practice. Assuming there is no other use for field facilities, all structures including production, processing, treatment, storage, pumping, power, and related infrastructure facilities will be dismantled and removed. Decommissioning is implemented after each facility has ceased operation and piping and equipment have been deactivated.

With regard to the treatment and disposal of contaminated materials and residues, each site with the potential for hydrocarbon contamination will be identified, characterised, and assessed. This information will be used to create the Waste Management Plan for decommissioning. Waste treatment options will be selected based on proven and effective technologies that will eliminate, minimise and/or reduce the potential for environmental impact.

Containers such as empty drums, portable tanks, and storage bins will be returned to vendors; cleaned and recycled; cleaned and crushed for scrap; or landfilled. Fluids and/or sludge from process vessels, storage tanks, and pipelines will be recovered and properly treated and disposed of. Any hazardous materials will be packaged, labelled, and taken to the Project's selected hazardous waste facilities for disposal.

12.10 Assessment of Impacts

12.10.1 Potential Impacts and Significance

Potential impacts have been assessed in accordance with Table 12.1. At this stage, waste facilities have not been audited for GIIP compliance, and the waste vendors and actual facilities to be used have not been identified.

For wastes which will be managed by landfill (hazardous or non-hazardous), high-temperature incineration, thermal desorption or recycling where there are no known vendors within Uganda, the potential impacts have been assessed with reference to Table 12.4 as "*facilities are unavailable or unsuitable or means of management is uncertain*", and hence potential impacts before additional mitigation are either Moderate or High (depending on whether the waste is hazardous or non-hazardous).

For wastes which will be recycled (and where there are known to be recycling vendors within the country which are potentially GIIP-compliant), impacts have been assessed with reference to Table 12.4 as "*suitable facilities available with sufficient capacity to manage the quantities of wastes generated*" and hence impacts before additional mitigation are either Insignificant or Low (depending on whether the waste is hazardous or non-hazardous).

Following additional mitigation, moderate and high impacts are assessed as being **Significant**. Low and Insignificant impacts are assessed as being **Non-Significant**. A list of the identified potential impacts are included within Table 12.9.

Table 12.9: Proposed Waste Management Routes and Impacts – Pre Mitigation

Waste Type	Category	Management Route	Facility	Potential Impact Significance
Chemicals	Hazardous	High-temperature incineration	To be determined	High Adverse
Drill Cuttings				
WBM Cuttings	**Hazardous**	Hazardous waste landfill	To be determined	High Adverse
SBM Cuttings	**Hazardous**	Hazardous waste landfill	To be determined	High Adverse
Cement	Non-hazardous	Landfill	To be determined	Moderate Adverse
HDD Cuttings	Non-hazardous	Landfill	To be determined	Moderate Adverse
Drilling Fluids				
WBM Drilling Fluids	**Hazardous**	Liquid waste treatment facility	To be determined	High Adverse
SBM Drilling Fluids	**Hazardous**	Liquid waste treatment facility	To be determined	High Adverse
Workover Fluids	**Hazardous**	Liquid waste treatment facility	To be determined	High Adverse
HDD Fluids	Non-hazardous	Liquid waste treatment facility	To be determined	Moderate Adverse
Electrical Equipment				
Batteries	**Hazardous**	Hazardous waste landfill	To be determined	High Adverse

Waste Type	Category	Management Route	Facility	Potential Impact Significance
Fluorescent lightbulbs	**Hazardous**	Hazardous waste landfill	To be determined	High Adverse
Electronic waste	**Hazardous**	Recycling	To be determined	High Adverse
Food	Non-hazardous	On-site composting	Composting facilities to be provided at camps	Insignificant
Used cooking oil	**Hazardous**	Landfill	To be determined	High Adverse
General Waste	Non-hazardous	Landfill	To be determined	Moderate Adverse
Glass	Non-hazardous	Recycling	National/local recycling vendors	Insignificant
Medical waste	**Hazardous**	High-temperature incineration	To be determined	High Adverse
Metal	Non-hazardous	Recycling	National/local recycling vendors	Insignificant
Cables	**Hazardous**	Hazardous waste landfill	To be determined	High Adverse
Oily Waste				
Lab Drainage	**Hazardous**	High-temperature incineration	To be determined	High Adverse
Oil - Used Lube Oil	**Hazardous**	High-temperature incineration	To be determined	High Adverse
Oily Rags/Absorbent Materials	**Hazardous**	High-temperature incineration	To be determined	High Adverse
Oily Water - Tank Slops	**Hazardous**	High-temperature incineration	To be determined	High Adverse
Pigging Wastes	**Hazardous**	High-temperature incineration	To be determined	High Adverse
Sludge	**Hazardous**	High-temperature incineration	To be determined	High Adverse
Paper & Cardboard	Non-hazardous	Recycling	National/local recycling vendors	Insignificant
Plastic (clean)	Non-hazardous	Recycling	National/local recycling vendors	Insignificant
Plastic (contaminated)	**Hazardous**	High-temperature incineration	To be determined	High Adverse
Sanitary waste	**Hazardous**	Hazardous waste landfill	To be determined	High Adverse
Jetting sand (clean)	Non-hazardous	Landfill	To be determined	Moderate Adverse
Jetting sand (oily)	**Hazardous**	Hazardous waste landfill	To be determined	High Adverse
Soil and rock	Inert	Used for landscape/screening bunds where feasible. Residual waste landfilled or	Predominantly used on site or for capping local landfills or backfilling borrow pits.	Insignificant

Waste Type	Category	Management Route	Facility	Potential Impact Significance
		used to backfill borrow pits		
Contaminated soil	**Hazardous**	Hazardous waste landfill	To be determined	High Adverse
Tyres & Rubber	Non-hazardous	Landfill	To be determined	Moderate Adverse
Wood (untreated)	Non-hazardous	Recycling	National/local recycling vendors or informal sector	Insignificant
Wood (treated)	**Hazardous**	High-temperature incineration	To be determined	High Adverse
Bitumen	**Hazardous**	Hazardous waste landfill	To be determined	High Adverse
Insulation Foam	Non-hazardous	Landfill	To be determined	Moderate Adverse

12.10.2 Additional Mitigation

The reports provide a snapshot of the available waste management infrastructure in Uganda. Also a tender for the provision of hazardous and non-hazardous waste management services is ongoing. For drilling waste. preliminary assessment has confirmed feasibility of conventional treatment in country.

However it is recognised that detailed information on the capacity and capability of the industry to service the waste management needs of the Tilenga Project still needs to be obtained.

The remaining gaps will be addressed during the FEED, detailed engineering phases of the Project:

- Completion of comprehensive waste mapping exercise for each Project phase during FEED to accurately identify waste types, quantities, transportation, treatment and disposal options;
- Waste mapping information will be shared as part of the waste management competitive call for tenders to determine available expertise and capacity of prospective waste management providers;
- Proposals will be developed to address any gaps related to expertise and capacity of waste management providers; and
- Detailed information regarding facility compliance with Uganda national regulatory requirements, IFC and GIIP will be obtained as part of a series of site visits for prospective waste management providers.

  During the Project execution periodic audits of the waste management contractors and their facilities will be undertaken and adaptive management implemented when required.

As indicated in 12.7.1, based on available data, the Project Proponents do not expect that waste containing LSA materials / NORM will be generated by the Project. However a monitoring strategy shall be developed and implemented for development drilling and production phases. In the event that presence is detected, a suite of management procedures shall be developed to ensure that any LSA / NORM contaminated materials and wastes are stored and managed appropriately.

12.10.3 Residual Impacts and Conclusions

With implementation of the design and additional mitigation measures described in this chapter and the Project Proponent's waste management strategy, there are not anticipated to be any significant waste management impacts. Table 12-8 provides a summary of the anticipated residual impacts.

Table 12.10: Residual Impacts after Mitigation

Waste Type	Category	Management Route	Facility	Residual Impact Significance
Chemicals	Hazardous	High-temperature incineration	GIIP-compliant facility to be provided	**Low Adverse**
Drill Cuttings				
WBM Cuttings	**Hazardous**	Hazardous waste landfill	GIIP-compliant facility to be provided	**Low Adverse**
SBM Cuttings	**Hazardous**	Hazardous waste landfill	GIIP-compliant facility to be provided	**Low Adverse**
Cement	Non-hazardous	Landfill	GIIP-compliant facility to be provided	**Insignificant**
HDD Cuttings	Non-hazardous	Landfill	GIIP-compliant facility to be provided	**Insignificant**
Drilling Fluids				
WBM Drilling Fluids	**Hazardous**	Liquid waste treatment facility	GIIP-compliant facility to be provided	**Low Adverse**
SBM Drilling Fluids	**Hazardous**	Liquid waste treatment facility	GIIP-compliant facility to be provided	**Low Adverse**
Workover Fluids	**Hazardous**	Liquid waste treatment facility	GIIP-compliant facility to be provided	**Low Adverse**
HDD Fluids	Non-hazardous	Liquid waste treatment facility	GIIP-compliant facility to be provided	**Insignificant**
Electrical Equipment				
Batteries	**Hazardous**	Hazardous waste landfill	GIIP-compliant facility to be provided	**Low Adverse**
Fluorescent lightbulbs	**Hazardous**	Hazardous waste landfill	GIIP-compliant facility to be provided	**Low Adverse**
Electronic waste	**Hazardous**	Recycling	GIIP-compliant recycling route to be determined	**Low Adverse**
Food	Non-hazardous	On-site composting	Composting facilities to be provided at camps	**Insignificant**
Used cooking oil	**Hazardous**	Landfill	GIIP-compliant facility to be provided	**Low Adverse**
General Waste	Non-hazardous	Landfill	GIIP-compliant facility to be provided	**Insignificant**
Glass	Non-hazardous	Recycling	National/local recycling vendors	**Insignificant**
Medical waste	**Hazardous**	High-temperature incineration	GIIP-compliant facility to be provided	**Low Adverse**
Metal	Non-hazardous	Recycling	National/local recycling vendors	**Insignificant**
Cables	**Hazardous**	Hazardous waste landfill	GIIP-compliant facility to be provided	**Low Adverse**
Oily Waste				
Lab Drainage	**Hazardous**	High-temperature incineration	GIIP-compliant facility to be provided	**Low Adverse**

Waste Type	Category	Management Route	Facility	Residual Impact Significance
Oil - Used Lube Oil	**Hazardous**	High-temperature incineration	GIIP-compliant facility to be provided	**Low Adverse**
Oily Rags/Absorbent Materials	**Hazardous**	High-temperature incineration	GIIP-compliant facility to be provided	**Low Adverse**
Oily Water - Tank Slops	**Hazardous**	High-temperature incineration	GIIP-compliant facility to be provided	**Low Adverse**
Pigging Wastes	**Hazardous**	High-temperature incineration	GIIP-compliant facility to be provided	**Low Adverse**
Sludge	**Hazardous**	High-temperature incineration	GIIP-compliant facility to be provided	**Low Adverse**
Paper & Cardboard	Non-hazardous	Recycling	National/local recycling vendors	**Insignificant**
Plastic (clean)	Non-hazardous	Recycling	National/local recycling vendors	**Insignificant**
Plastic (contaminated)	**Hazardous**	High-temperature incineration	GIIP-compliant facility to be provided	**Low Adverse**
Sanitary waste	**Hazardous**	Hazardous waste landfill	GIIP-compliant facility to be provided	**Low Adverse**
Jetting sand (clean)	Non-hazardous	Landfill	GIIP-compliant facility to be provided	**Insignificant**
Jetting sand (oily)	**Hazardous**	Hazardous waste landfill	GIIP-compliant facility to be provided	**Low Adverse**
Soil and rock	Inert	Used for landscape/screening bunds where feasible. Residual waste landfilled.	Predominantly used on site or for capping local landfills	**Insignificant**
Contaminated soil	**Hazardous**	Hazardous waste landfill	GIIP-compliant facility to be provided	**Low Adverse**
Tyres & Rubber	Non-hazardous	Landfill	GIIP-compliant facility to be provided	**Insignificant**
Wood (untreated)	Non-hazardous	Recycling	National/local recycling vendors or informal sector	**Insignificant**
Wood (treated)	**Hazardous**	High-temperature incineration	GIIP-compliant facility to be provided	**Low Adverse**
Bitumen	**Hazardous**	Hazardous waste landfill	GIIP-compliant facility to be provided	**Insignificant**
Insulation Foam	Non-hazardous	Landfill	GIIP-compliant facility to be provided	**Low Adverse**

12.11 In-Combination Effects

As described in ***Chapter 4: Project Description and Alternatives***, the Project has a number of supporting and associated facilities that are being developed separately (i.e. they are subject to separate permitting processes and separate ESIAs or Environmental Impact Assessments (EIAs)). These facilities include:

- Tilenga Feeder Pipeline;
- East Africa Crude Oil Export Pipeline (EACOP);
- Waste management storage and treatment facilities for the Project;
- 132 kV Transmission Line from Tilenga CPF to Kabaale Industrial Park; and
- Critical oil roads.

As these facilities are directly linked to the Project and would not be constructed or expanded if the Project did not exist, there is a need to consider the potential in-combination impacts of the Project and the supporting and associated facilities. This is distinct from the Cumulative Impact Assessment (CIA) which consider all defined major developments identified within the Project's Area of Influence (and not just the associated facilities) following a specific methodology which is focussed on priority Valued Environmental and Social Components (VECs) (see ***Chapter 21: Cumulative Impact Assessment***).

The in-combination impact assessment considers the potential joint impacts of both the Project and the supporting and associated facilities. The approach to the assessment of in-combination impacts is presented in ***Chapter 3: ESIA Methodology***.

Following application of additional mitigation, there are not expected to be any significant waste management impacts. The supporting and associated facilities will generate their own waste streams, for which details are currently not available. Project Proponents will however invite other developers to participate in joint planning initiatives with local government and other relevant stakeholders, and will continue to share best practices to allow other developers to learn from successful implementation of mitigation measures addressing waste. Where feasible, other developers will be invited to invest expertise or resources in the joint implementation of initiatives addressing these potential impacts.

As part of their permitting and environmental management processes, the supporting and associated facilities will be required to identify (and if necessary develop) suitable facilities to manage their waste.

It is possible that the supporting and associated facilities may use the same waste management facilities that are identified or developed for the Project. If this is the case there is a risk that there is insufficient capacity to manage the combined amounts of waste. To help avoid any potential adverse in-combination impacts, the Project Proponents will collaborate with other developers of the supporting and associated facilities to ensure that:

- Facilities are suitable for the intended waste types; and
- Facilities have sufficient capacity to manage waste from the supporting and associated facilities, in addition to the waste generated by the Project.

12.12 Unplanned Events

Further general information relating to unplanned events in relation to waste is included within ***Chapter 20: Unplanned Events***.

12.13 Cumulative Impact Assessment

Chapter 21: Cumulative Impact Assessment provides an assessment of the potential cumulative effects of the Project together with other defined developments in the Project AoI. The CIA focussed on VECs that were selected on the basis of set criteria including the significance of the potential effects of the Project, the relationship between the Project and other developments, stakeholder opinions and the status of the VEC (with priority given to those which are of regional concern because they are poor or declining condition). On the basis of the selection process, Waste was not considered to be a priority VEC and is not considered further in the CIA as no significant impacts are anticipated.

12.14 Conclusions

The Project will generate a range of different types of waste. Existing waste management facilities in Uganda are limited, and in many cases they either do not comply with GIIP, or their compliance status is uncertain.

Various embedded mitigation measures have been identified to ensure that waste is recorded, collected, stored and transported in accordance with national regulations and GIIP requirements. The Project will seek to apply the waste hierarchy and prioritise waste minimisation, reuse and recycling in order to reduce the quantities of waste requiring disposal.

Since GIIP-compliant facilities have yet to be confirmed for all waste streams, the potential impacts before additional mitigation are, in some cases, significant.

As an additional mitigation measure, the Project Proponents commit to managing Project waste using facilities compliant with national requirements, GIIP and IFC. A procurement exercise is currently underway to identify suitable waste vendors, and as part of the call for tender exercise the GIIP status of selected waste management facilities that are proposed for use will be assessed by the Project Proponents, and where necessary, facilities will either be upgraded or new facilities will be provided to comply with GIIP. This will reduce the residual impacts such that they are not expected to be significant.

12.15 References

Ref. 12.1 Atacama Consulting (2017) Non-Hazardous Waste Management Infrastructure Concept Study for the Integrated Development of the Lake Albert Oil Fields

Ref. 12.2 Golder Associates (2017) Consultancy Services to Develop Ugandan Capacity to Manage Hazardous Waste from Oil Fields

Ref. 12.3 Burnhead Environmental (2014) Waste Management Compliance Audit and Site Assessment

Ref. 12.4 The National Environmental Act, Cap 153, 1995

Ref. 12.5 The National Environment (Waste Management) Regulations 1999 Statutory Instrument (S.I.) No 52/1999

Ref. 12.6 The National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations 1999 S.I. No 5/1999

Ref. 12.7 The Water Act Cap 152 1997

Ref. 12.8 The Water (Waste Discharge) Regulations 1998 S.I. No 38/1998

Ref. 12.9 The Petroleum (Exploration, Development and Production) Act, 2013

Ref. 12.10 The Petroleum (Refining, Conversion, Transmission and Midstream Storage) Act, 2013

Ref. 12.11 The Draft Petroleum (Waste Management) Regulations, 2016

Ref. 12.12 Uganda Wildlife (Murchison falls National Park) Regulations S.I. No 200-3

Ref. 12.13 National Environment Management Authority (NEMA), (2014) National Environment Management Policy for Uganda

Ref. 12.14 Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Basel Convention), 1992

Ref. 12.15 Convention on Persistent Organic Pollutants (Stockholm Convention) 2004

Ref. 12.16 International Finance Corporation (IFC) (2007) Environmental, Health, and Safety (EHS) Guidelines: Waste Management.

Ref. 12.17 IFC (2012) Performance Standard 3: Resource Efficiency and Pollution Prevention

Ref. 12.18 IFC (2007): Environmental, Health, and Safety Guidelines for Onshore Oil and Gas Development

Ref. 12.19 Tilenga Project Early Works Project Brief (2017), AWE Ltd