Environmental and Social Impact Assessment for the Proposed Karuma – Gulu Water Supply Project

Reference Number: NWSC–HQRS/SRVCS/17-18/163587

Prepared for:

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ACRONYMS AND DEFINITIONS

Acronyms

AWE:	Air Water Earth (the consultant)
CAPEX:	Capital expenditure
DWRM:	Directorate of Water Resources Management
EIDC:	Engineering and Institutional Development Consultancy
ESIA:	Environmental & Social Impact Assessment
ESMP:	Environmental and Social Management Plan
GIS:	Geographical Information Systems
GMC:	Gulu Municipal Council
GoU:	Government of Uganda
IPILC:	Integrated Programme to Improve the Living Conditions in Gulu and Small Towns En Route in the Victoria Nile Catchment
IWMDP:	Uganda Integrated Water Management and Development Project
LC:	Local Council
MWE:	Ministry of Water and Environment
NEMA:	National Environment Management Authority
NWSC:	National Water and Sewerage Corporation
OHS:	Occupational Health and Safety
PCDP:	Public Consultation and Disclosure Plan
PEA:	Project Executing Agencies
ToR:	Terms of Reference
UBOS:	Uganda Bureau of Statistics
WB:	World Bank
WMDP:	Uganda Water Management and Development Project
WTP:	Water treatment plant

Units and measures

Ha:	hectare
km:	kilometre
m:	metre

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EXECUTIVE SUMMARY

1 PROJECT BACKGROUND

NWSC was established in 1972 as a government parastatal with the mandate of developing, operating and maintaining water supply and sewerage services in urban areas of Uganda. NWSC works under the Ministry of Water and Environment, and currently operates in about 255 towns.
NWSC has been operating under three-year renewable performance contracts with the Government of Uganda (GoU) since 2000. Each of the performance contracts defines activities, objectives and indicators that are to be achieved within the three-year contract period.

The MWE and the World Bank have prepared the Integrated Water Management and Development Project (IWMDP) as a successor to the Water management and Development project (WMDP) that came to an end in 2018. The development objective (PDO) of IWMDP is to improve (i) access to water supply and sanitation services and (ii) integrated water resources, planning, and management in Uganda. The IWMDP shall involve construction of Water Supply and Sanitation infrastructure in Rural Communities, Rural Growth Centres and in refugees and host communities. These infrastructures include; Large Gravity Flow Schemes, Rural Growth Centre Water Supply Systems and Sanitation Facilities. Under WMDP, NWSC implemented and completed water and sewerage infrastructure developments in Arua, Bushenyi and Gulu. The infrastructure developments in Gulu were co-financed by the German Development Bank (KfW).

In parallel to the WMDP that was on-going, NWSC and Gulu Municipal Council (GMC) as the Project Executing Agencies (PEA's) commenced the implementation of the Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en route in the Victoria Nile Catchment (IPILC) with financial support from the German Development Bank (KfW). The Engineering and Institutional Development (EIDC) consultancy for the IPILC was signed between NWSC and the joint venture between Fichtner Water & Transportation GmbH, RODECO Consulting GmbH, JV in association with M&E Associates Ltd. & Governance Systems International.

Under the Integrated Water Management and Development Project (IWMDP), NWSC has secured financing from the World Bank though Ministry of Finance Planning and Economic Development (MoFPED) to undertake water supply and sanitation infrastructure developments in Gulu-Karuma, Mbale and Adjumani. In addition, NWSC will undertake full-scale source protection measures in Bushenyi, Arua, Mbale, Gulu – Karuma and Adjumani.

2 SCOPE OF PROJECT

The scope of work under the IPILC will involve detailed design and construction supervision of water supply infrastructure for Gulu Municipality and six small towns between Gulu and Karuma based on River Nile at Karuma as a source of water, urban drainage and solid waste management, water and sanitation marketing campaigns and faecal sludge management. The duration of the consultancy services contract is 48 calendar months.

Under the IPILC, the EIDC Consultant will be required to prepare a detailed design, produce tender documents and supervise the construction works for the next phase of construction works which comprises construction of: an intake on River Nile at Karuma; a water treatment plant with station at Karuma; and a bulk water transmission line from Karuma to Gulu and branch off systems to supply at least six (6) small towns en-route from Karuma to Gulu.

3 OBJECTIVE OF THE ESIA

The main objective is to carry out a comprehensive environmental and social impact assessment for the proposed project works for provision of improved water supply services in Gulu Municipality and the six towns enroute, that is, Karuma, Kamdini, Minakulu, Bobi, Palenga and Koli Abili. The specific objectives included:

i) Establishment of the project's potential environmental and social impacts and propose measures to mitigate them;
ii) Assessment of the impacts of alternatives and advise the design consultant accordingly; and
iii) Determination of the actions required by NWSC and other stakeholders to satisfactorily address the impacts.

4 PROPONENTS' CONTACT AND PROJECT COST ESTIMATE

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The estimated project cost is **Twenty Million United States Dollars** (USD 20,000,000).

5 LOCATION OF PROJECT SITE

The project area with regard to water supply related physical investments can be categorised into three areas: Nile water transmission including the intake and water treatment plant; and six (6) towns en route (Table ES1).

Table ES1: Location of the proposed project components and their location

Project Component/ Town	Coordinates
Intake works	418820 E, 248514 N
Water treatment plant/works	418921 E, 249195 N
Transmission line	420264 E, 305622 N to 420264 E, 305622 N
Kamdini Town	425614 E, 248340 N
Minakulu	431003 E, 270411 N
Bobi Trading Centre	428561 E, 282394 N
Palenga	426115 E, 289205 N
Kolo Abili	423874 E, 298260 N
Custom's Corner (Reservoir)	420264 E, 305622 N

The intake is located along the northern embankment of the river Nile near the Karuma HPP, approximately 550 m upstream of the concrete dam. The proposed location is located in a dip between two steep walls facing each other, so that excavation quantities are minimized. Furthermore the inlet structure is protected from large floating matter (trees).

Table ES2: TM – Pipe lengths for intermediate design horizon 2025

Diameter (mm)	Nile WTP → Intermediate tank (m)	Intermediate tank → Customs Corner tank (m)	Total length (m)
DN 700	22,500	-	22,500
DN 600	18,980	24,920	43,900
DN 500	-	4,600	4,600
Total section	**41,480**	**29,520**	**71,000**

The transmission main shall be laid in a trench with a minimum cover of 1.20 m.

6 PROJECT ALTERNATIVES

a) 'No Project' Scenario

The water supply system in Gulu covers the entire municipality and part of its surrounding peri-urban communities and is operated by NWSC Gulu branch. Currently, only about one third of the total water demand of the population of Gulu can be provided. The remaining demand has to be drawn from around 300 alternative water sources such as boreholes, wells, protected and unprotected springs.

The "no project" scenario is neither a tenable nor beneficial alternative because sustainable safe water supply is required to support rapid socio-economic development within Gulu Municipality and the towns enroute. Without the project, it implies in the long term, Gulu will still be grappling with inadequate water to meet the demand given that it is soon gaining city status.

b) Alternatives Considered

Three options were assessed for the location of the intake and the water treatment plant, that is:

- Option A: Near the Karuma HPP, on northern embankment;
- Option B: Downstream of dam, beyond outlet of the Karuma HPP discharge pipes, within Murchison Falls National Park;
- Option C: Upstream of Karuma HPP dam.

Four options were compared for the actual transmission from Karuma to Gulu, that is:

- Option 1a: DN600 without intermediated reservoir
- Option 1b: DN700 / 600-600 with intermediated reservoir incl. pumping station
- Option 2a: DN500 without intermediated reservoir
- Option 2b: DN500-500 with intermediated reservoir incl. pumping station

The outcomes of the different assessments have been ranked and are summarised in the Table ES3.

Table ES3: Compilation and ranking of options

Part of Works	Assessment	Technical	Environmental	Social	Financial Investment Operation		Total ranking	Preferred option
Intake Options	A	1	1	1	1	1	**5**	√
	B	3	3	3	3	2	**14**	
	C	2	2	2	2	1	**9**	
Transmission main Options	1b	1	1	1	1	1	**5**	√
Karuma-Gulu	2b	1	1	1	2	2	**7**	
Transmission main Option in	1a	1	1	1	1	1	**5**	√
Gulu	2a	2	1	1	1	1	**6**	

(Ranking: 1 = best, 3 = worst)

Source: *Fichtner & GopaInfra, 2018*

From the above assessment, the following options were considered:

- To construct Intake and Water Treatment Plant near the Karuma HPP[]] (Option A);
- From a long-term perspective, Option 1b with DN700 / 600-600 is the preferrable option as it turns out to be the most economical solution;
- Taking into account limited investment funds, the transmission main could be realised as Option 2b with DN500-500.
- To install the transmission main in Gulu along Sira-Dongo Road (Option I).

However, in response to the Option Analysis NWSC instructed as follows:

- To proceed with Option 1b with DN700 / 600-600 but reduce the pipe diameter to DN500 along a short section beyond the intermediate tank and pumping station to fit investment costs into the budget.
- To elaborate 2 sets of bill of quantities for alternative pipe materials, namely ductile iron; and steel with spigot-socket connections, outer coating 3-Layer Polyethylene (3LPE), inner lining Fusion Bonded Epoxy.

7 POLICY, LEGAL AND INSTITUTIONAL FRAMEWORK

According to the World Bank's environmental categorisation, the proposed project is classified as EA Category B undertaking which requires detailed ESIA studies. The proposed construction and operation of the water supply and sanitation facilities will be restricted within the user-communities. Similarly, according to *Third Schedule of the National Environment Act, Cap. 153 (Section 4a: "storage dams, barrages and weirs", and Section 12c: "sewage disposal works")*, Ugandan environmental laws and regulations, require to undertake a full EIA for projects falling under this category. The World Bank requirements, policies and laws under which this ESIA was prepared and will be implemented are outlined below.

Box ES1: Policies and regulations reviewed

Policy framework:

- The National Environment Management Policy, 1994
- The National Water Policy, 1999
- The National Health Policy, 1999
- The National Policy for the Conservation and Management of Wetland Resources 1995
- The National Gender Policy, 1997
- HIV/ AIDS Policy, 1992
- Uganda Vision 2040
- Green Right Of Way Programme (GROW)

Legal framework:

- Constitution of the Republic of Uganda, 1995
- National Environment Act, Cap 153
- Local Governments Act, Cap 243
- Water Act, Cap 152
- Land Act, Cap 227
- Public Health Act, Cap 281
- Investment Code Act, Cap 92
- National Water and Sewerage Corporation Statute, 1995
- Employment Act, 2006
- Occupational Safety and Health Act (2006)
- Physical Planning Act, 2010
- Historical Monuments Act (1967)
- The Mining Act, Cap. 148 2003
- Children Act, Cap 59

Regulations/ Standards/ Guidelines:

- The Water Resources Regulations, 1998
- National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations, 1999
- National Environment (Noise Standards and Control) Regulations, 2003
- The National Environment (Wetlands, River Banks and Lakeshores Management) Regulations, 2000
- National Environment (Waste Management) Regulations, 1999
- Draft National Air Quality Standards, 2006
- The Water Supply Regulations, 1999
- National Environment (Audit) Regulations, 2006
- Uganda National Roads Authority (General) Regulations, 2017

Institutional framework:

- National Environmental Management Authority (NEMA)
- National Water and Sewerage Corporation (NWSC)
- Directorate of Water Resources Management (DWRM)
- Directorate of Water Development (DWD)
- Directorate of Environmental Affairs (DEA)
- Ministry of Water and Environment (MWE)
- Ministry of Gender, Labour & Social Development (MGLSD)
- District Local Administration Structures
- Uganda National Roads Authority (UNRA)
- Ministry of Tourism, Wildlife and Heritage

World Bank Safeguard policies:

- OP/BP 4.01 - Environmental Assessment

- OP/BP 4.04 - Natural Habitats
- OP/BP 4.36 – Forests
- OP/BP 4.11 - Physical Cultural Resources
- OP/BP 4.10 - Indigenous Peoples
- OP/BP 4.12 - Involuntary Resettlement
- OP/BP 7.60 - Disputed Areas
- OP/BP 4.37 – Safety of Dams

KfW Development Bank Sustainability Guidelines

WB - EHS Guidelines

International conventions and agreements:

- 1968 African Convention on the Conservation of Nature and Natural Resources:
- Convention on Wetlands of International Importance Especially as Waterfowl Habitat:
- 1987 Montreal Protocol on Substances that Deplete the Ozone Layer
- 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora
- 1992 Convention on Biological Diversity
- The Convention on Migratory Species of Wild Animals (CMS)

8 PUBLIC CONSULTATIONS AND DISCLOSURE

Consultation meetings were held with Nwoya, Oyam, Omoro and Gulu District Local Administration, Koro, Bobi, Minakulu, Myena, Kamdini and Layibi Sub-Counties and with the local communities within the project area. These were conducted by the ESIA Team. Stakeholder engagement constituted an important part of the ESIA process, in light of the Project's commitment to adhering to national requirements, as well as a best practice approach to public consultation, that is, an approach that encourages open and transparent dialogue, with as broad a range of stakeholder groups as possible.

A number of pertinent issues were raised from the meetings held with the different stakeholders. Some of the major issues raised during meetings with the project affected communities were employment, compensation issues and Corporate Social Responsibilities. A summary of the key findings from the institutional consultations is presented in Table ES4.

Table ES4: Key issues from institutional stakeholders

Institution	Issue(s) raised/ Suggestion(s) made	Remark(s)
Uganda National Roads Authority (UNRA)	i) NWSC need to apply for a permit if the water transmission line is to cross the UNRA road. During construction NWSC will need UNRA staff to monitor especially traffic and also give alternatives besides acquiring the permit. The road reserve is 14.5 metres from the centre and other roads is 7 metres from the shoulders especially when the road is approaching the town.	The permits and licenses required to facilitate implementation of the project have been indicated in Table 29 under Sub-section 3.11.
	ii) In order to quire right of way, NWSC need to find out if UNRA acquired the land and paid off the PAPs, because not all where UNRA roads pass land is acquired fully.	RAP study is being carried out and after identification of project affected people in the road reserves, consultations will be held with UNRA
	iii) NWSC should work with UNRA because there are plans to upgrade or rehabilitate the Kamudini – Lira road so there is need to match the schedules of the two planned activities.	
	iv) NWSC should make a request for access to the road reserve from UNRA and also refer to the regulations/ guidelines for use of the road reserves.	This requirement has been included in the institutional requirements with reference to UNRA (Sub-section 3.5.9)
	v) UNRA has a Green Right of Way (GROW) program of planting trees along the road reserve. This should be taken into consideration when planning the route of the transmission line along the Karuma – Gulu Highway.	Discussion were held with the design consultant and NWSC to take this into consideration
Uganda Wildlife Authority (UWA)	i) Proposed Project layout: It was noted that if the water transmission line from Karuma to Gulu is outside the Murchison Falls National Park (MFNP) and therefore no impacts to MNFP. However the water supply line may encroach on the MFNP if passed along the Karuma Bridge. It was suggested that to supply Karuma town, one option was to take the pipe along the Karuma HPP dam to avoid the park as much as possible.	
	ii) Murchison Falls National Park: In case there is need to pass the water supply line through the MNFP land, the following would be required:	The permits and licenses required to facilitate implementation of the project have been indicated in Table 29 under Sub-section 3.11.

Institution	Issue(s) raised/ Suggestion(s) made	Remark(s)
	▪ Waste management plan for material waste, food waste and human waste ▪ Follow park regulations ▪ Apply for park entry/ pewrmission to work within the park ▪ Open and reinstate pipe trenches as soon as possible. No trenches should be left open overnight ▪ Restoration plans especially for tress and vegetation and these should be indigenous species ▪ Activity schedule indicating time to spend in the MNFP area	
Directorate of Water Resources Management (DWRM)	i) With improved supply of water, consideration should also be given to provision of sanitation facilities	Recommendation was made as a mitigation measure for the wastewater generated as a consequence of improved water supply (Sub-sections: 8.3.1, 8.3.2 and 8.3.3).
	ii) NWSC should adopt the 2013 water supply design manual set for 20 -25 years of which 5 years are for planning and 20 years of implementation according the design manual for water supply projects.	
	iii) The water balance study should be taken into consideration the Karuma HPP being a water user not a consumer during the ESIA development.	The water resources assessment was conducted as part of this study and took into consideration the impacts that may arise from the Karuma HPP (Appendix B)
	iv) The Water Resources Assessment study should take into consideration Karuma HPP and other adjacent water users to ensure that they would not be affected. Although water abstraction is expected to be minimal, a water resources assessment report should be provided.	
	v) How far is the waste treatment plant from the water treatment plant and on which side of the river (Victoria Nile)? Where is the location of the discharge point and how far is the discharge point from the abstraction point?	Under the Karuma-Gulu project, there shall not be construction of a waste water treatment plant and hence no discharge point is expected near the water abstraction point at Karuma. The water treatment plant is located 1.2 km from the River bank.

Institution	Issue(s) raised/ Suggestion(s) made	Remark(s)
	vi) Was the water source protection component considered under this project?	The Water source protection is outside the scope of this assignment but usually the client engages a separate consultant to do the plans just like it has been handled with other projects.
	vii) How is the sludge generated during operation of the water treatment plant going to be handled?	NWSC will work with the concerned authorities to identify the most suitable way of disposing it off. If classified as hazardous, the option is to transport to Luweero Industries where there is an approved hazardous waste handling facility otherwise it could be disposed at a sanitary or municipal landfill. Mitigation mesures have been provided under sub-section 8.3.3.
	viii) As ESIA consultants, has the Karuma HPP study been taken into consideration so that the abstraction point is not within the back water curve region?	Yes, and for the same reason, it was agreed to extend the intake point 550 m further upstream of the Karuma HPP dam.
	ix) Taking into consideration UNRA's future plans about the expansion for the northern economic corridor, the consultant should engage UNRA about the metres between the road and the pipeline to save NWSC from future compensations	Consulations were held with UNRA (Appendix A)
	x) Why should the pipeline cross the main road at 3 points and the railway yet their other options like the bridges and culverts which cannot impair the structural integrity of the infrastructure?	Trenchless drilling is being proposed. Mitigation measures have been provided in Sub-section 8.3.9
Uganda Electricity Generation Company Limited (UEGCL)	i) Inquiring about the extent to which extent was land acquired for the Karuma Hydro Power Project (Karuma HPP) to avoid double compensation; UEGCL responded that the Resettlement Action Plan for the Karuma HPP was conducted by the Ministry of Energy and Mineral Development. It would therefore be good to directly consult with the Ministry. Any assistance in this regard will be availed to you.	During the RAP study which is still on-going, land already acquired by the Ministry of Energy was identified.
	ii) Requested the Design Consultant/ NWSC to share the technical designs with UEGCL so that they review all the scenarios for more comments or suggestions.	Request will be made to NWSC to share the documents
	iii) It was pointed out that the Karuma HPP is about to be commissioned towards the end of 2018 and advised that	This was already communicated to the consultant by the client, NWSC

Institution	Issue(s) raised/ Suggestion(s) made	Remark(s)
	construction of the intake should be done as soon as possible before the area is flooded.	
	iv) AWE (ESIA Consultant) inquired whether an Environmental Flow Study was conducted for the Karuma HPP and if yes, can it be shared for use for this study. In response: Yes, the agency did the study and it will be availed. Although the EF study determined an environmental flow of 50 m^3/s, DWRM made a recommendation of maintaining an environmental flow of 100 m^3/s to cater for other water uses being planned along River Nile.	Environmental Flow Report was shared and included (see Appendix H)
	v) As one of the mitigation measure to sustain the water resource, a catchment management plan is recommended and should be developed.	Development of a catchment management plan is a study on its own and given the expanse of the Victoria Nile catchment, it was not part of the scope of this study. However, NWSC develops source water project plans and it will be recommended as a mitigation measure to develop one.
	vi) Issue of where the waste to be generated during construction will be deposited was also raised.	NWSC and the Contractor will work with the respective district to identify the most appropriate sites for disposal of such waste. Mitigation measures provided in Sub-sections 8.3.1, 8.3.2 and 8.3.3

9 POTENTIAL ENVIRONMENTAL AND SOCIAL IMPACTS

To sustain the water supply in Gulu it is anticipated to draw water from the Victoria Nile near Karuma and transport it along the road Karuma-Gulu to Gulu town. It is currently planned to supply 6 towns along the route of this transmission main, namely Karuma, Kamdini, Minakulu, Bobi, Palenga and Koro Abili. This will improve access to safe and sustainable water supply not only to Gulu Municipality but also to towns/ communities enroute. Although water supply exists in the towns of Kamdini, Minakulu, Palenga and Koro Abili, the additional supply from NWSC will further boost the service level and reliable supply. This will translate in improvements in health, economic and social welfare of the community.

However, in addition to the many possible beneficial impacts, adverse impacts may arise from these improvements. In this chapter, prediction and analysis of possible positive and negative impacts of construction and operation of the water supply and sanitation project is presented, with main focus on the proposed new raw intake and water treatment plant in Karuma; water transmission line from Karuma to Gulu Customs Corner; and distribution systems within the 6 towns, that is, Karuma, Kamdini, Minakulu, Bobi, Palenga and Koro Abili. A summary of the positive and negative impacts of the project is presented in Table ES5.

Table ES5: Positive and negative impacts of the proposed project

Description of Impact	Enhancement/ Mitigation Measures	Significance of Impact
Positive Impacts		
Income to Material/ Equipment Suppliers and Contractors	Construction and operation	
Employment	Construction and operation	
Infrastructure improvement	Construction and operation	
Improved Health and Economic Status of Households and Communities	Construction and operation	
Negative Environmental Impacts		
Degradation of Soils	Construction of all project components and operation of water intake and treatment plant	**Moderate (9)**
Pollution of Water Resources	Construction of all project components	**Moderate (8)**
	Operation of water intake and treatment plant	**Minor (4)**
Improper Management of Waste	Construction of all project components	**Moderate (8)**
	Operation of water intake and treatment plant	**Minor (4)**
Disturbance or Destruction of Archaeological / Cultural Heritage	Construction of all project components	**Major (16)**
Introduction of Invasive Species	Construction of all project components	**Moderate (9)**
Deterioration of Landscape and Visual Quality	Construction and operation of all project components	**Moderate (6)**
Loss and Degradation of Natural Habitats	Construction of all project components	**Moderate (9)**

Description of Impact	Enhancement/ Mitigation Measures	Significance of Impact
Risk of seismic activity	Construction and operation of all project components	**Moderate (9)**
Impacts of Karuma HPP	Construction and operation of water intake and treatment plant	**Moderate (6)**
Negative Socio-economic impacts		
Risk of Accidents	Construction of all project components	**Major (12)**
Unsustainable Use of and Competition for Resources	Construction of all project components and operation of water intake and treatment plant	**Moderate (6)**
Damage to Existing Public Infrastructure	Construction of all project components	**Major (12)**
Social Misdemour of Workers	Construction of all project components	**Major (12)**
Gender-based Violence	Construction of all project components	**Major (12)**
Child Labour and School Dropout	Construction of all project components	**Moderate (8)**
Permanent Land-take	Pre-construction	**Moderate (6)**
Occupational Health and Safety (OHS) Risks	Construction and operation of all project components	**Major (12)**
Cummulative Impacts		
Disruption to Traffic Flow and Communication Routes	Construction	**Minor (4)**
Air Pollution	Construction	**Minor (4)**
Generation of Noise and Vibrations	Construction and operation	**Minor (4)**

10 ENVIRONMENTAL AND SOCIAL MANAGEMENT & MONITORING PLAN (ESMP)

This environmental and social management & monitoring plan, ESMP for proposed construction works and operation of the proposed water treatment and supply project, identifies the potential environmental and social aspects that should be managed and monitored. It identifies parties responsible for monitoring actions, associated costs, indicators and training or capacity building needs and reporting. Various aspects of the ESMP are detailed in sections below

Institutional Structure and Responsibilities: During the construction phase, the parties involved with the ESMP include: the client NWSC with ultimate responsibility for Environmental & Social performance on the project; the Supervising Engineer (with an Environment and Social Specialist on their team) responsible for monitoring and supervising the implementation of the ESMP and contract requirements by the contractor(s); and the the Contractor (with an Environmental Specialist, Social Development Specialist and Health & Safety Specialist) who has responsibility for implementing the ESMP. NWSC will ensure that both the Supervising Engineer and Contractor are doing their jobs effectively and that the ESMP is delivering the necessary environmental and social protection measures.

Therefore, the institutional responsibility of ensuring that this ESMP is implemented will rest with NWSC having a key role of reviewing consultants' reports for compliance with the ESMP, among others. The Project Manager shall have the ultimate responsibility for implementation of ESMP and will therefore ensure that resources are duly provided. Other roles will be:

- Monitoring implementation of mitigation actions by contractors
- Coordinating training and capacity building where planned

NWSC should ensure that all its personnel to be involved in implementation of this ESMP are adequately qualified and were appointed based on their qualification and suitability for respective roles. There is thus no training provided for them under this ESMP. Supervising Engineer is required to have an Environmental & Social Management Specialist by contractual obligation. The Contractor's Environmental Specialist, Social Development Specialist and Health & Safety Specialist will ensure that the provisions in this ESMP are implemented within the sites under their supervision and to collect and transmit relevant information to the Supervising Engineer.

Sub-contractors will be required by a condition of their sub-contract with the main contractor to actively manage environmental and social issues associated with their subcontract works and comply fully with all the applicable statutory regulations and the main contractor's environmental and social management plan (ESMP). Sub-contractors shall not develop their own ESMP but shall follow and abide by the main contractor's ESMP). The Resident Engineer in consultation with NWSC shall review the main Contractor's ESMP and approve it prior to commencement and implementation of the works.

The Municipal & District Environmental Officers (DEOs) in the project districts, that is, Gulu, Omoro, Oyam and Kiryandongo, are responsible for overseeing environmental protection on behalf of NEMA. The DEOs within the respective project districts will have monitoring roles during execution of this ESMP in their respective project areas. Usually, these officials lack adequate facilitation so the project will need to provide auxiliary financial assistance for them to have effective participation in this project.

The contractor will be required to prepare ESMPs setting out the measures that they will take to implement the ESIA ESMP during the construction. This requirement also applies to NWSC during the operation phase of the project in their respective areas of operation.

The Environmental and Social impact mitigation plan is presented in Table ES6 while the Environmental and Social Monitoring plan is presented in Table ES7.

Table ES6: Environmental and social mitigation plan

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
POSITIVE IMPACTS				
Construction and Operation phase	8.2.1 Income to material/ equipment suppliers and contractors	a) Project will promote local procurement where technically or commercially reasonable and feasible.	Contractor	Embedded in contractor's fees
		b) For earth materials, procurement will be made from legitimate sources to avoid encouraging environmental degradation	Contractor	
	8.2.2 Employment	a) NWSC shall ensure that all personnel to be involved in implementation of this ESMP are adequately qualified. A training programme for the NWSC staff to implement the ESMP shall be facilitated by the project to ensure that staff have the appropriate skills.	NWSC	25,000,000
		b) Unskilled labour will be recruited exclusively from local community, and semi-skilled labour will be recruited preferentially from such communities, provided that they have the requisite qualification, competence and desired experience.	Contractor	
		c) Contractors will be encouraged to pay a "living wage" to all workers.	Contractor	
		d) A training programme for artisans (builders, carpenters, plumbers) in the project area could be facilitated by the project to ensure skills transfer during the construction period.	NWSC/ Contractor	10,000,000
		e) Contractor will develop and implement Labour Influx Management Plan, Workers Camp Management Plan and Code of Conduct. An example of the code of conduct for contractors and sub-contractors is provided in Appendix G.	Contractor	11,100,000
	8.2.3 Infrastructure improvement	The extent to which development becomes a positive or negative impact will be determined by the effectiveness of the planning framework. Such induced developments should be of a type that is desirable and sustainable and for this to happen, all future developments must be undertaken within the framework of proactive government policy and strict planning and environmental enforcement by the responsible Local Government.	Developer	
	8.2.4 Improved Health and Economic Status of Households and Communities	a) Users will be educated on the proper use, regular cleaning and effective maintenance of both the household and public facilities. The communities will be sensitised about proper disposal of wastewater generated as a result of improved water supply and how to use water sparingly with minimal or no wastage	NWSC/ District Local Governments of Project Area	20,000,000
		b) Water tariffs will be set taking into consideration the different levels of users. The users should also be educated to avoid wasteful use of the resources	NWSC/ District Local Governments of Project Area	Within NWSC jurisdiction
NEGATIVE ENVIRONMENTAL IMPACTS				
Construction phase	8.3.1 Degradation of Soils	a) A waste management plan will be developed prior to start of construction activities.	Contractor	11,100,000
		b) Topsoil and subsoil removed from the site during site preparation will be stored properly (away from runoff and possible contaminants) for reuse elsewhere or for backfilling and reinstatement. Topsoil will be protected through separation from subsoil and storage in a manner that, as far as possible, retains the soil structure and minimises the risk of topsoil loss. For the water pipelines, the trenches will be subsequently backfilled with subsoil, followed by topsoil as soon as possible. In order to prevent loss of fertility and degradation of the seed bank within stored topsoil (where present), the topsoil will be stored for as short a time as possible, allowing for engineering constraints.	Contractor	Within contractor's bid budget
		c) Contractor will avoid use of old equipment and damaged equipment that is most likely to have oil leakages thus contaminate the soils and the Contractor will ensure that equipment is properly maintained and fully functional to avoid leakages that may contaminate soils.	Contractor	Within contractor's bid budget
		d) During reinstatement, the trench back-fill material will be compacted to a level similar to the original surrounding soils to avoid subsidence as a consequence of rain water channelling.	Contractor	Within contractor's bid budget
		e) Recreation of a stable landform that mirrors the pre-disturbed condition (e.g. contours, shape, level of compaction, etc.) as this will minimise the risk of preferential erosion and therefore facilitate natural revegetation.	Contractor during construction phase	Within contractor's bid budget
		f) Upon completion of subsoil and topsoil reinstatement, disturbed areas will be inspected jointly by the construction contractor and NWSC personnel for stability, relief, topographic diversity, acceptable surface water drainage capabilities, and compaction.		NWSC Supervisory budget
		g) All waste generated during site preparation and construction will be transported to an authorized disposal area. The contractor will seek guidance from the respective District Local Governments in project area on the final disposal point.	Contractor	To be included in the contractor's bid

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
		h) Waste shall not be taken out of the Site without a Waste Manifest.	Contractor	
		i) A Spill kit will be maintained onsite to clean-up any accidental spills.	Contractor	50,000,000
		j) Retention ditch will be provided such that runoff from the project site does not go directly into the Victoria Nile. It will only be released after quality assessment to ensure that it meets the national discharge standards.	Contractor	3,000,000
Operation phase		a) Cut-off drain will be provided around the waterworks to avoid intrusion of storm water and stormwater within the water works will be guided away from chemical storage areas using cut-off drains around them.	NWSC	7,000,000
		b) Staff operating the plant will be trained/ sensitised on proper management of waste associated with the operation of the water treatment plant to avoid soil contamination.	NWSC	20,000,000
		c) Periodic tests will be done to assure the quality of effluent from filter press or sludge conditioning basins and treated sludge meets the national effluent discharge standards (see sub-section 3.4.2), to avoid partially sludge from reaching the soils.	NWSC	24,000,000
Construction phase	8.3.2 Pollution of water resources	a) All construction equipment will be kept in good operating condition to avoid oil or fuel leakages that might contaminate water resources	Contractor	
		b) Workers' camp and associated facilities will be connected to septic tank or other wastewater systems which are appropriate and of sufficient capacity for the number of workers and local conditions. The facilities for this purpose will be inspected regularly to ensure proper functioning. Camp site selection shall involve several factors, including; the size and conditions of the site and availability of resources; the safety, security and protection it offers and cultural and social considerations. Choosing a site shall involve consideration of access, coexistence with surrounding communities, topography, trees and vegetation, the potential impact on the environment, environmental causes of disease and other public health issues. The Contractor shall conduct the necessary environmental and social assessments according to national and World Bank Environment and Social Safeguards Policies and acquire approvals from NEMA and the supervising engineer prior to establishment of new camp sites.	Contractor	25,000,000
		c) Stockpile areas for materials such as sand, gravel, stone, laterite, lime and topsoil, as well as overburden dumps will be located away from water courses and will be surrounded by perimeter or cut-off drains with sediment and other pollutant traps located at drain exits. Cut-off drains will be maintained throughout the subsequent operation phase	Contractor	-
		d) All hazardous wastes including material soiled with hazardous wastes and empty containers of hazardous materials shall be stored in a designated area on site for regular removal and disposal by a registered contractor in accordance with the National Environment (Waste Management) Regulations, 1999. All other wastes generated during site preparation and construction will be transported by the contractor or a company that has been specifically contracted to an authorized disposal area.	Contractor	15,000,000
		e) Fuel handling and oil spill measures will be implemented to prevent, control and address spill or leaks. Fuel storage and dispensing on site shall not be allowed. Fuel and oil handling will be assigned to trained personnel and procedures for fuel storage, operation of mobile fuel tankers and refuelling areas will be well defined. Impermeable sheets, spill mats, and drip trays will also be provided in the appropriate areas to curb fuel and oil leakage to the ground. This will be done at designated places at the contractor's camp and in accordance with relevant standards set by the Energy Regulation Board and Uganda Bureau of Standards.	Contractor	10,000,000
		f) Construction activities will largely be carried out during the dry season to avoid sediment transport to the nearby land, water courses and roads	Contractor	-
		g) Any cleaning and hydrotest water which could cause contamination of surface (or ground) waters will be tested and treated as necessary prior to discharge, including debris and sediment removal.	Contractor	5,000,000
		h) NWSC will ensure the contractor complies with its environmental management policies, ESIA recommendations and national regulations	NWSC	-
		i) In open waters, especially during construction of the intake, plastic curtains will beused to contain and confine resuspension of bottom silt to minimize turbidity in surrounding and downstream areas, using longer support spans and restricting construction to dry weather where possible.	Contractor	Within Contractor's bid budget
		j) The contractor shall ensure that appropriate monitoring of the water quality is done during the construction phase to prevent contamination of the Nile water when construction activities are being undertaken (both upstream and downstream the intake should be monitored and monthly reports produced)	Contractor	Within Contractor's bid budget
Operation phase		a) Daily/Monthly quality tests for raw waterfrom the Victoria Nile will be done to ensure that proper monitoring of the quality is monitored very well.	NWSC	Part of NWSC's operation's budget

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
		b) Vehicles and machinery/ equipment will be maintained, repaired and refuelled at an offsite garage/workshop.		
		c) NWSC shall ensure that it adheres to the specific conditions issued by the Directorate of Water Resources Management (DWRM) to ensure that the integrity of the water quality is maintained in line with the water abstraction permit issued to NWSC. For example, prevention of damage to the water source, ensuring that no activities on the land where the water is used results in accumulation of any substances that may render water less fit for use, efficiently using the water and making annual payment for use of the water.		
Construction phase	8.3.3 Improper management of waste	a) The Contractor will be required to prepare a Waste Management Plan.	Contractor	15,000,000
		b) The contractor and NWSC Area Management will work hand in hand with the respective Local governments to facilitate sound waste handling and disposal from the site. All wastes must be taken to the approved dumpsites.	Contractor	100,000,000
		c) Proof of delivery and safe disposal of waste will be provided and records maintained at all times.		-
		d) The contractor will provide his own facilities (e.g. mobile toilets) which should be adequate at construction sites.	Contractor	6,000,000
		e) Workers' camp and associated facilities will be connected to septic tank or other wastewater systems which are appropriate and of sufficient capacity for the number of workers and local conditions. The facilities for this purpose will be inspected regularly to ensure proper functioning.		Covered in 8.3.1
Operation phase		a) Adequate operation and management of the facilities will ensured to avoid improper management of waste and solid waste is collected by a firm licensed by NEMA and that the collected waste is disposed of at dumpsite or landfill approved by NEMA	NWSC	10,000,000
		b) NWSC together with the respective District Local Governments at the growth centres will ensure that the solid waste is collected by a firm licensed by NEMA and that the collected waste is disposed of at dumpsite or landfill approved by NEMA	NWSC	
		c) Adequate bins will be provided to prevent access by vermin at the WTP	NWSC	5,000,000
Construction phase	8.3.4 Disturbance or Destruction of Archaeological / Cultural Heritage	a) A 'chance find' procedure will be put in place to determine actions to be taken in the event that suspected archaeological artefacts or paleontological items are encountered and they should be handed over to Ministry of trade and industry- Department of Museums and Monuments.	Contractor	2,000,000
		b) Construction works will be designed to ensure no damage to any cultural sites or medicinal plants that may be encountered. Where such sites cannot be avoided, culturally appropriate measures will be agreed and implemented prior to the construction activities.		
		c) Compensation of the affected sites, especially the affected grave yards, will be undertaken before construction activities commence in accordance with World Bank and KFW requirements.	NWSC	To be determined in the RAP
Construction phase	8.3.5 Introduction of invasive species	a) Vehicles and equipment entering and leaving the project area will be inspected and cleaned to remove invasive species.	Contractor	-
		b) When invasive species are encountered, they will be removed and destroyed, for example, by burning.	Contractor	-
Construction phase	8.3.6 Deterioration of landscape and visual quality	a) Murram and subsoil will be obtained preferentially from a licensed source and in accordance with any terms of the license. "Licensed" means approved by NEMA or the respective Project District Local Governments. The contractor will provide a copy of the license to NWSC before the beginning of works at the murram/subsoil extraction location.	Contractor	Contractor's bid budget
		b) If no suitable licensed source of murram/subsoil is available in the area and the contractor plans to obtain the material from a private landowner, then the contractor will: ▪ Provide NWSC with a copy of the written agreement between the contractor and the owner of the murram/subsoil source in advance of the beginning of works at the location. The identity of the landowner will be certified by a certificate of ownership or a paper signed by the LC1 Chairperson and/ or Head of Clan; ▪ Engage and consult any households and/or communities in close proximity to the identified murram/topsoil source and provide evidence of these consultations to NWSC; ▪ Ensure adequate compensation on mutually agreed terms is made to people who are either physically or economically displaced by the activities of the contractor. The contractor will provide documentation of the compensation terms (minutes of consultation meetings, signed agreements with affected persons, compensation receipts etc.) to NWSC; ▪ Assess health and safety risks linked to murram/subsoil extraction and transport, and implement appropriate mitigation measures. The risk assessment will be provided to NWSC ahead of the beginning of works; and	Contractor	

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
		▪ Provide a restoration plan for review, and ensure that the actions of the restoration plan are implemented to the satisfaction of concerned authorities. Sign-off from the relevant authorities will be required and copies of the sign-off will be provided to NWSC.		
		c) Surface water run-off will be controlled during earthworks. Surface water features down-slope of the earthworks will be identified, and the necessary berms and drainage channels will be installed to ensure that run-off does not collect or pond in excavated areas or quarries.	Contractor	
		d) Restoration of borrow pits to as close to pre-project conditions as possible will be done immediately after use in cases where they are specifically opened up for this project. Native vegetation must be used for re-seeding the excavated site.	Contractor	
		e) The contractor will exercise prompt and effective response to environmental and social issues raised by supervision engineer.	Contractor	
		f) There will be close monitoring of impact on natural resources with enforcement of contract or legislative options.	DLGs/ NWSC	10,000,000
Construction phase	8.3.7 Loss and degradation of natural habitats	a) Construction activities should be restricted only to the areas that must be disturbed to avoid unnecessary disturbance. Destruction of trees in Opaka Central Forest reserve along the Karuma – Gulu Highway will be avoided as much as possible	Contractor	-
		b) All project workers should be sensitized to minimize damage to vegetation and flora	Contractor	Duty of EHS specialist hired by contractor
		c) Close monitoring and supervision of the construction operations to ensure compliance and avoid causing further damage to undesignated project areas	NWSC/ DWD	
		d) Where tree cutting is inevitable, replacement planting should be done wherever feasible. No trees of protected species *(Milicia excelsa woodlot at 36N 424999E 294543N and Khaya anthotheca woodlot at 36N 429530E 277069N)* will be cut. Any trees specie to be cut will need to be replaced in public lands in the project area. The project will implement a restoration program that can be implemented in the wetlands, rivers, riparian areas. Liason with UNRA shall also me made such that any tree restoration along the transmission line sections that shall be located in the road reserve is done jointly with UNRA.	Contractor/ NWSC	
		e) The use of cut wood (and charcoal) in camp is prohibited. Instead all camps will use propane or electricity for cooking	Contractor	-
		f) Critically endangered fish include Labeo victorianus and Oreochromis esculentus in Minakulu, Ogada, Myene and Alek swamps. The contractor shall ensure that the fish habitat is not destructed while undertaking works in wetland areas (especially in Minakulu, Ogada, Myene and Alek swamps where critically endangered fish species were found)by planning for working in waters to protect fish eggs, spawning adults, organisms upon which they feed by maintaining an undisturbed vegetation buffer zone and preventing soil compaction in such areas. Construction in these sections of the pipeline shall not be carried out in the month of August since it is the wettest season and fish spawning takes place during the high rains that occur in August of every year. g) The contractor should ensure that the waterflow direction is not obstructed when the pipeline is installed to ensure that fish movement routes are not destroyed, and if these fish species are potamodrometic that they can continue their movements towards the main river.	Contractor	-
Pre-construction phase	8.3.8 Risk of seismic activity	a) The structures should be designed to exhibit some amount of ductility to tolerate dynamic loads generated from seismic activity. Reinforced concrete structures are recommended for such purposes. Pre-stressed concrete structures are also useful, but do not perform as well as reinforced concrete under earthquake conditions.	NWSC	Part of the Design Consultant's work
		b) Appropriate design codes have been followed to reduce risks of damage to health and property	NWSC	
Pre-construction phase	8.3.9 Impacts of Karuma HPP	a) Where possible, NWSC should ensure that construction works of the intake are completed before commissioning of the Karuma HPP; and not a contractor with experience of working in deep waters will be hired.	NWSC	-
		b) Measures will be instituted at the intake to ensure that when the water levels approach the minimum of 1028 m, the pumps switch themselves off automatically	NWSC	-
NEGATIVE SOCIO-ECONOMIC IMPACTS				
Construction and operation phase	8.4.1 Risk of traffic accidents	a) The contractor will prepare and implement a traffic management plan to be approved by supervision engineer	Contractor	11,100,000
		b) Contractor will adopt best transport safety practices (Journey Management Plans (JMPs)) with the goal of preventing traffic accidents and minimizing injuries suffered by project personnel and the public by: employing safe traffic control measures, including road signs and flagmen/traffic guides to warn of dangerous conditions and children crossings; and setting speed limits on all access roads in the project area	Contractor	-

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
		and towns/ trading centres will be 40km/h for light vehicles and 30km/h for heavy vehicles; and not more than 80 km/h on the Karuma – Gulu Highway.		
		c) The Contractor shall provide dedicated site entrances and exits for personnel, which shall be manned 24 hours per day, 7 days per week including holidays.		-
		d) Some roads in Gulu Municipality were recently surfaced and others are being surface under the Uganda Support to Municipality Infrastructure Development (USMID) Project. NWSC should contact Gulu Municipality early enough and request for service ducts to be installed at points where water mains will cross roads to avoid cutting through roads that have just been upgraded.	NWSC	-
		e) The Contractor will have a community liaison Officer (CLO) to get feedback/complaints from communities regarding activities of the project and issues the communities think are not being done in a proper manner. The CLO would also be responsible for informing project-affected communities of the timing and duration of the construction activities across access roads and any uncertainties or potential for change.	Contractor	-
		f) All workers, including sub-contractors and casual labourers, will undergo an environmental, health and safety induction before commencing work on site. This will include a full briefing on site safety and rules.	Contractor	Duty of the EHS specialist hired by contractor
		g) Restrictions on hours of driving (including night time restrictions where sensitive receptors may be affected) and timing of vehicle movements will be emphasized to avoid busy periods in urban areas, particularly the start and end of school and the working day.	Contractor	-
		h) No drivers or personnel under the influence of alcohol or any drug abuse will be allowed onsite	Contractor	-
		i) The water treatment plant and intake sites will be fenced and signalization put in place with security personnel to stop unauthorised people from accessing the site.	Contractor	50,000,000
		j) The contractor will hire drivers trained in defensive driving and all drivers will be trained in road and safety	Contractor	-
		k) Strict adherence to safety measures and procedures are required to minimise (or eliminate) risks of accidents or hazardous developments occurring and ensure healthy and safe conditions for all persons working on the site and the project-affected communities. To ensure occupational health and safety on construction sites, the Contractor shall be obliged to comply with all applicable Ugandan construction Health and Safety Standards as required by the Occupational Safety and Health Act of 2006. These include provisions of the Factories Act, Labour Unions Act and Workman's Compensation Act.	Contractor	-
		l) Materials will be preferentially sourced locally to minimize transport distances.	Contractor	Part of contractor's bid budget
Construction phase	8.4.2 Unsustainable use of resources	a) Through inductions and tool box meetings, the contractor will ensure that staff and contractors are conversant with resource conservation practices in all project activities. Conservation awareness will focus on water use efficiency and general day-to-day measures such as turning engines and air conditioning units off when machinery and offices or dwelling quarters are not in use.	Contractor NWSC DWD	-
		b) The Contractor will acquire water abstraction permits with conditions to guide the amount of water to be abstracted as stipulated in the Water Supply Regulations (1999). Water abstraction will comply with rates allowed by the DWRM permit that will be obtained.	Contractor NWSC/MWE	5,000,000
		c) Earth materials will be sourced from a NEMA-approved source in a manner that reduces environmental and social impacts. Murram will be sourced in accordance with a NWSC approved murram/ subsoil extraction plan, which will be provided by the contractor prior to the start of works.	Contractor	-
		d) Any new borrow pits established by the project and would not be used later, shall be restored to as close to pre-project conditions as possible immediately after use. Native vegetation must be used for re-seeding the excavated site.		To be determined by contractor
		e) The contractor's Worker Code will include clauses of conduct on water and electricity consumption		-
Operation phase		a) Catchment management plans are being developed with the aim of conserving and allowing recharge of water resources.	NWSC	
		b) Water conservation measures will be encouraged: saving water is an efficient way of reducing the overuse of ground water resources. It is not only decreases the amount of the water withdrawn, but may also reduce the threat of pollution	NWSC	
		c) NWSC should adhere to the stipulated limits in the water abstraction permit obtained from DWRM.	NWSC	-

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
Construction phase	8.4.3 Damage to Existing Public Infrastructure	a) Trucks ferrying materials will be loaded commensurate with the recommended axle load for a given road to avoid or minimize damage.	Contractor	
		b) Locally sourced materials will be used, whenever possible, to minimize travel distances and expanse of road damaged.		
		c) Special permission will have to be sought from Uganda National Roads Authority (UNRA) and Gulu District Local Government before activities at road crossing are carried out. A typical drawing for a road / highway crossing is presented in drawing WS_CD_9_4_02 in Appendix J. Similarly permission from Uganda Railways Authority will be sought for the railway crossing at Sira Dongo Road.	NWSC	
		d) The trenchless technology will be used at the road and railway crossing to avoid damaging them.	Contractor/ NWSC	Within the contractor's bid budget
Construction phase	8.4.4 Social Misdemour by Workers	a) The contractor will be required to develop a Labor Influx Management Plan and/or a Workers' Camp Management Plan. These will include sanctions for workers involved in criminal activities		Covered under 8.2.2
		b) As a contractual obligation, contractors shall be required to have an HIV/AIDS policy and a framework (responsible staff, action plan, etc.) to implement during project execution.	Contractor	-
		c) All construction workers shall be oriented and sensitized about responsible sexual behaviour in project communities.	Contractor	
		d) The contractors will develop and follow a code of conduct. The information regarding Worker Code of Conduct will be provided in local language(s).		Already covered
		e) The contractors will develop and follow a code of conduct. An example is provided in Appendix G		Already covered
		f) The contractor will conduct cultural sensitization training for workers regarding engagement with local community.		
		g) The contractor will endeavour to provide entertainment and events for workers within camp to reduce incentives for mixing with local community.		5,000,000
		h) Workers will be encouraged to get vaccinated against common and locally prevalent diseases		20,000,000
		i) The contractor, where need arises, will engage an HIV service provider to be available on-site who should conduct campaigns on STDs among the workers and local community; educate workers and the community about the transmission of diseases; and implement HIV/AIDS education program and provision of condoms.		25,000,000
Construction phase	8.4.5 Gender-based violence	a) The contractor will conduct mandatory and repeated training and awareness raising for the workforce about refraining from unacceptable conduct toward local community members, specifically women		Duty of Contractor's Social safeguard specialist
		b) Workers will be informed about national laws and funder's policies that make sexual harassment and gender-based violence a punishable offence which is prosecuted		
		c) Worker Code of Conduct will be part of the employment contract, and including sanctions for non-compliance (for example, termination)		Already covered
		d) The contractor, where a case arises, will cooperate with law enforcement agencies in investigating complaints about gender-based violence		10,000,000
Construction phase	8.4.6 Child labour and school dropout	a) The contractor and NWSC will ensure that children and minors are not employed directly or indirectly on the project		-
		b) The contractor will communicate the hiring criteria, minimum age and applicable laws (for example, Children Act, Cap 59) in his ESMP		-
Pre-construction phase	8.4.7 Permanent land take	a) NWSC will ensure that the project-affected persons identified through the Resettlement Action Plan study of the project are compensated for the land and property on it in time and fairly.		Amounted to be determined in the RAP
		b) Land will be acquired in accordance with Uganda's Land Access and Compensation Procedure taking into consideration the Development Partner's requirements. Amongst others, this requires: sensitisation of community members whose property will be affected; Completion of a full inventory of privately registered and/or cultivated and grazed or other uses of the land that will be taken for the project as well as structures and graves along the access road; compensation to be paid in line with mandated rates agreed in consultation with District officials before commencement of construction activities; and ensuring that the Chief Government Valuer approves the valuation rates.	NWSC/MWE	
	8.4.8 Occupational health safety (OHS) Risks	a) A qualified Health and Safety Officer will be recruited by the Contractor to oversee OHS matters on a daily basis.	Contractor	

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
Construction and operation phase		b) All construction workers will be oriented on safe work practices and guidelines and ensure that they adhere to them all the time.	Contractor's EHS Specialist	
		c) Appropriate signage will be used to warn staff and/ or visitors that are not involved in construction and operation activities in dangerous places	Contractor	5,000,000
		d) Regular drills will be constantly followed on various possible incidences. This will test the response of the involved stakeholders. Such drills will keep them alert and they will become more responsive in case of incidences.	Contractor	-
		e) Training will be conducted on how to prevent and manage incidences. This should involve proper handling of electricity, water etc. and sensitization on various modes of escape, conduct and responsibility during such incidences. All must fully be aware and mentally prepared for potential emergency	Contractor's EHS Specialist	-
		f) Personnel will only undertake tasks for which they are trained/ qualified. A formal 'permit to work' system will be in place and strict instructions will be given for operators of equipment.	Contractor during construction; NWSC during operation	-
		g) Strict instructions will be given to drivers of heavy equipment and operators of equipment/ machinery. Ensure electrical safety at fabrication workshops by putting in place secure electrical connections and providing adequate insulation. All temporary electrical installations in use on site such as generators and welding sets should be adequately and effectively earthed at all times during operation	Contractor	-
		h) Supervision of works will be done regularly to ensure that safety conditions are met while any deviation from safety regulations is immediately reclaimed following the best practices regarding safety at work equipment.	NWSC & Supervision Consultant	
		i) Clear communication line shall be ensured between workers and drivers of heavy equipment.	Contractor	-
		j) Evacuation procedures to handle emergency situations will be developed	Contractor's EHS Specialist	
		k) Adequate OHS personnel protective gear will be provided to the employees.	Contractor/ NWSC	100,000,000
		l) Strict adherence to safety measures and procedures are required to minimise (or eliminate) risks of accidents or hazardous developments occurring and ensure healthy and safe conditions for all persons working on the site. To ensure occupational health and safety on construction sites, the Contractor shall be obliged to comply with all applicable Ugandan construction Health and Safety Standards as required by the Occupational Safety and Health Act of 2006. These include provisions of the Factories Act, Labour Unions Act and Workman's Compensation Act.	Contractor	-
		m) First aid boxes will be available at all active construction sites and at accessible locations at the water treatment plant during the operation phase.		3,000,000
		n) An Accident log will be maintained onsite to register all injuries and to investigate their causes during both the construction and operation phases of the project.	NWSC	-
		o) Emergency resources (e.g., fire extinguishers, stocked First Aid kits, Emergency Contacts, Doctor on Call, etc.) will be maintained at all active construction sites and at the water treatment facilities during operation.	NWSC	10,000,000
		p) The Contractor shall ensure that all areas requiring access including platforms, under platforms, underpasses, excavations, etc. have enough illumination.	Contractor and NWSC	-
		q) Excavations and rock blasting activities will be undertaken under strict guidance to avoid chances of collapse and injury, respectively.	Contractor	-
		r) The manufacturer's instructions and Material Safety Data Sheets (MSDS) shall be followed for the storage of all chemicals used in water treatment. Storage must conform to compatibility restrictions.	NWSC	-
		s) All construction workers will be oriented on safe work practices and guidelines especially regarding work in confined spaces and it will be ensured that they adhere to them.		-
		t) The Contractor shall provide a signal man, barricades and safety sign boards around the excavations.		-
		u) Routine maintenance will be carried out at sites (removal of garbage, removal of screenings and grit, slashing around the embankments, repair of damages to the fence, etc.).		5,000,000
		v) Regular fumigation of the WTP and contractor's/ workers' camp will be undertaken to kill disease vectors such as mosquitoes	Contractor/ NWSC	3,000,000

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
NEGATIVE CUMULATIVE IMPACTS				
Construction phase	8.5.1 Disruption of traffic and communication routes	a) The trenchless technology will be used at major crossings like roads to avoid disruption of traffic flow.		-
		b) Appropriate signage will be used and impacted owners will be informed ahead of disruption	Contractor/ NWSC	Already covered
		c) Disruptions to public access shall be identified in the Contractor's Traffic Management Plan, under which suitable notice of intending delays and closures are given to all concerned parties and approved prior to commencing work. All road closures shall be separately notified and agreed with the Local gov't administration.	Contractor/ NWSC	-
		d) Where access to or from an individual property is closed for a period of 2 hours or more, the owner shall be informed at least 24 hours in advance.	Contractor/ NWSC	-
		e) Vehicular access to and from hospitals, police stations and fire stations shall be maintained through the use of steel road plates over open trenches. Pedestrian access to schools, health facilities, and other premises frequently accessed by the public will be maintained with the use of walking boards.	Contractor/ NWSC	-
		f) The laying of pipelines, backfilling and temporary reinstatement shall follow trench excavation as quickly as possible and trenches will not be left open for extended periods.	Contractor	-
Construction and operation phase	8.5.2 Air pollution	a) Construction work will be undertaken by an experienced and duly registered contractor with a verifiable sense of environmental awareness and responsibility	Contractor	-
		b) Travel speeds of construction vehicles along the road especially at trading/ business centres will be controlled using humps and setting travel speeds not exceeding 40km/h	Contractor	-
		c) A maintenance programme for equipment and vehicles will be implemented, to ensure air emissions like particulates, SO_2 and NO_2 are minimised.	Contractor	-
		d) Trucks will be covered during haulage of construction materials to reduce on spillage of materials	Contractor	
		e) Workers will be provided with PPE and the use of PPE shall be enforced	Contractor	Already covered
		f) All surfaced roads shall be subject to road cleaning and un-surfaced roads to dust suppression, the methodology and frequency of which shall be included in the Contractor's Traffic Management Plan	Contractor	-
Construction and operation phase	8.5.3 Generation of noise and vibrations	a) Care will be exercised when selecting the working equipment to avoid use of old equipment or damaged equipment with high level of noise emissions that would have a negative impact on the environment. Equipment will be properly maintained and kept fully functional. Servicing of all construction vehicles and machinery will be done regularly and during routine servicing operations, the effectiveness of silencing equipment (e.g. exhaust silencers) will be checked and if found defective will be replaced.	Contractor	-
		b) Construction workers will be made aware of the silent nature of workplaces they are operating in and advised to limit verbal noise or other forms of noise. For example, metallic objects or tools can be passed on to a colleague rather than dropping or throwing them with loud bangs.	Contractor	-
		c) All generators and heavy duty equipment will be insulated or placed in enclosures to minimize disrupting ambient noise levels. Pumps, generators and other mobile equipment will be sited as far as practicable from housing and other noise sensitive locations. Regular maintenance, monitoring and, where necessary, the use of silencing equipment will be employed with the aim of reducing noise emissions	Contractor	-
		d) The contractor will submit detailed information on the noise levels which will be generated by the specific methods and equipment proposed and the actions that will be taken to minimise the noise impact. Equipment shall be operated within their specifications and capacity (for example, avoid overloading machines).	Contractor	
		e) Noise levels emanating from machinery, vehicles and noisy construction activities will kept at a minimum (within the national noise level limits) for the safety, health and protection of people in the nearby buildings. The vehicles that are excessively noisy shall not be operated until corrective measures have been taken.	Contractor	40,000,000
		f) During periods of inactivity, equipment will be switched off whenever possible. Where appropriate, residents living in the vicinity of where construction activities are taking place will be kept informed of the contractor's proposed working schedule (through implementation of the Community Liaison Management Plan) and will be advised on the times and duration of any abnormally noisy activity likely to cause concern.	Contractor	-
		g) Project vehicles will have a restricted speed limit of 40 km/h through settlements and trading centres to minimise noise.	Contractor	-
		h) No construction activities will take place at night for sites where the closest residence is within less than 150 m from the project site, the operations on site shall be restricted to the hours 6.00 -22.00.	Contractor	

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
		i) The noise due to blasting operation lasts for a very short period. Primary blasting shall be carried out with adequate preventive measures to control the noise to the permissible limits. Consideration for the nearest habitation shall be at a distance of 500 m from the site boundary. Before blasting is undertaken all the relevant permissions shall be obtained from the Ministry of Internal Affairs Uganda.	Contractor	20,000,000
		j) Sequential timer blast machine or other approved methods shall be used for primary blasting and there shall be no secondary blasting. The boulders shall be broken using a hydraulic rock breaker. Proper maintenance of the noise generating parts of the machines shall be undertaken. Air silencers of suitable type that can modulate the noise of the engines of machinery can shall also be put in use and maintained effectively.	Contractor	5,000,000
		k) Ear muffs shall be given to all the workers operating or working close to any machine and full PPE for any persons participating in blasting activities. Periodical monitoring of noise levels and blast vibrations will be practiced and the contract shall ensure that the necessary noise/vibration meters for taking measurements are available.	Contractor	10,000,000
		l) The contractor shall also use control measures like wet drilling to avoiding blasting during high wind speed and development of green belt within the safety barrier of the specific project site and shall ensure that there is no impact of blasting activity in the surrounding area.	Contractor	15,000,000
		m) Construction activities in the identified sensitive areas *(Bobi Health Centre III (N428086.2, E284815.65), St Thomas O.T.T Primary School (N428498.25, E280335.42), Bobi Sub-county (N428512.54, E282704.61), Ministry of Energy Offices (N421542.49, E248677.74), Koro Abili C.O.U Primary School (N423536.66, E299479.75), St. Peter Paul Catholic Church (N428598.34, E280554.22), MTN Mast (N423534.44, E299676.99) St. Joseph Catholic Church (N429801.34, E276378.46), Minakulu Primary School (N430713.94, E272720.91) Jeroline School (N425855.36, E289522.13), St Baptist Church (N422771.5, E303450.33), Adel Primary School (N431255.18, E270057.49) and St Thomas More Primary School- Minakulu (N423038.87, E302369.94))* shall be scheduled during weekends, stockpiling supplies and materials shall also be done during noncritical times to minimize transport nose. The maximum allowed noise level should be 45dBA for night and 55dBA for evening and day. Measurement of noise level should be performed before the start up with the working activities and during work peaks (of particular importance when project activities take place in the immediate vicinity of the primary school). Restriction or suspension of pipe laying activities during critical times (such as school exam or test times) shall be abided to. .	Contractor	
		ESTIMATED GRAND TOTAL COST		***744,200,000***

Table ES7: Environmental and social monitoring plan

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
POSITIVE IMPACTS							
8.2.1 Income to material/ equipment suppliers and contractors	a) Project will promote local procurement where technically or commercially reasonable and feasible.	Number of local businesses benefiting from construction related procurement	Gulu, Omoro, Oyam and Karuma project areas	Review of project procurement documents	Before and during commencement of construction	NWSC/ District Local Governments of Project Area.	To be catered for partly under the project meetings Faciltation for the District officials 10,000,000
	b) For earth materials, procurement will be made from legitimate sources to avoid encouraging environmental degradation	All quarries from which materials (sand, stone) are obtained are licensed by the local authorities	Gulu, Omoro, Oyam and Karuma project areas	Review of project procurement documents	Before and during construction	NWSC/MWE/ District Local Governments of Project Area	
8.2.2 Employment	a) NWSC shall ensure that all personnel to be involved in implementation of this ESMP are adequately qualified. A training programme for the NWSC staff to implement the ESMP shall be facilitated by the project to ensure that staff have the appropriate skills.	Number of NWSC staff trained to implement the ESMP	Project Area	Review of training records	Before and during construction	MWE	
	b) Unskilled labour will be recruited exclusively from local community, and semi-skilled labour will be recruited preferentially from such communities, provided that they have the requisite qualification, competence and desired experience.	Number of local people (unskilled and semi-skilled) employed during construction phase	Gulu, Omoro, Oyam and Karuma project areas	Review of employee list and key informat interviews with employees	Before and during construction	NWSC/ District Local Governments of Project Area	
	c) Contractors will be encouraged to pay a "living wage" to all workers.	Record of contractors' employment activities on a monthly basis, including number of jobs created by employment type (skilled / semi-skilled / unskilled); number of jobs by gender, employment type and geographical area; total man hours and wages paid, by employment type, gender and geographical area; and rate of employee turnover by gender and area.	Gulu, Omoro, Oyam and Karuma project areas	Review of workers' payment schedules and interviews with workers' heads or leaders	Before and during construction	NWSC/ District Local Governments of Project Area	
	d) A training programme for artisans (builders, carpenters, plumbers) in the project area could be facilitated by the project to ensure skills transfer during the construction period.	Number of local people trained during construction phase	Gulu, Omoro, Oyam and Karuma project areas	Review of records	Before and during construction	NWSC/ District Local Governments of Project Area	
	e) Contractor will develop and implement Labour Influx Management Plan, Workers Camp Management Plan and Code of Conduct. An example of the code of conduct for contractors and sub-contractors is provided in Appendix G.	Number of cases reported	Gulu, Omoro, Oyam and Karuma project areas	Review of plans and their mode of implementation. Interview with workers about their awareness of the respective plans	Throughout construction	NWSC/ District Local Governments of Project Area	
8.2.3 Infrastructure improvement	The extent to which development becomes a positive or negative impact will be determined by the effectiveness of the planning framework. Such induced developments should be of a type that is desirable and sustainable and for this to happen, all future developments must be undertaken within the framework of proactive government policy and strict planning and environmental enforcement by the responsible Local Government.	Number of complaints	Project area	Visual observation and project documents related to the said infrastructure	Prior to commencement of construction	District Local Governments of Project Area	5,000,000
8.2.4 Improved Health and	a) Users will be educated on the proper use, regular cleaning and effective maintenance of both the household and public facilities. The communities will be	Clinical records of reported cases.		Review of Clinical records of reported cases.		NWSC/ District Local Governments of Project Area	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
Economic Status of Households and Communities	sensitised about proper disposal of wastewater generated as a result of improved water supply and how to use water sparingly with minimal or no wastage	Reduced incidences of illness at household level.					
	b) Water tariffs will be set taking into consideration the different levels of users. The users should also be educated to avoid wasteful use of the resources	Number of new connections; public majority comfortable water tariffs.	NWSC Offices/ Consumer bills		Regularly as need arises	NWSC/ District Local Governments of Project Area	
NEGATIVE ENVIRONMENTAL IMPACTS							
8.3.1 Degradation of Soils	**Construction phase**						
	a) A waste management plan will be developed prior to start of construction activities.	Number of complaints of poor management of waste from communities around the site and road; and complaints from authorities	Supervisor's Office / District Environmental Office	Review of complaints records	Before construction	NWSC/ District Local Governments of Project Area	Covered in 8.2.2
	b) Topsoil and subsoil removed from the site during site preparation will be stored properly (away from runoff and possible contaminants) for reuse elsewhere or for backfilling and reinstatement. Topsoil will be protected through separation from subsoil and storage in a manner that, as far as possible, retains the soil structure and minimises the risk of topsoil loss. For the water pipelines, the trenches will be subsequently backfilled with subsoil, followed by topsoil as soon as possible. In order to prevent loss of fertility and degradation of the seed bank within stored topsoil (where present), the topsoil will be stored for as short a time as possible, allowing for engineering constraints.	Reported cases of top soil or overburden dumped at non-designated sites	Project sites & Contractor's/ Supervisor's Office	Review of complaints records	Throughout construction	NWSC/ District Local Governments of Project Area	
	c) Contractor will avoid use of old equipment and damaged equipment that is most likely to have oil leakages thus contaminate the soils and the Contractor will ensure that equipment is properly maintained and fully functional to avoid leakages that may contaminate soils.	Soil quality parameters	Project sites & Contractor's/ Supervisor's Office	Review of records or reports	Maintenance of equipment throughout construction	NWSC/ District Local Governments of Project Area	
	d) During reinstatement, the trench back-fill material will be compacted to a level similar to the original surrounding soils to avoid subsidence as a consequence of rain water channelling.	Absence or Presence of gullies or channels	Project sites and sources of materials	Direct observations		NWSC	
	e) Recreation of a stable landform that mirrors the pre-disturbed condition (e.g. contours, shape, level of compaction, etc.) as this will minimise the risk of preferential erosion and therefore facilitate natural revegetation.	Visual appearance of the landscape	Project sites and sources of materials	Direct observations	Through out construction activities and during operation (maintenance activities)	NWSC/ District Local Governments of Project Area	
	f) Upon completion of subsoil and topsoil reinstatement, disturbed areas will be inspected jointly by the construction contractor and NWSC personnel for stability, relief, topographic diversity, acceptable surface water drainage capabilities, and compaction.	Visual appearance of landscape in comparison with undisturbed areas	Project sites and sources of materials	Direct observations	At completion of the project activity	NWSC/ District Local Governments of Project Area	
	g) All waste generated during site preparation and construction will be transported to an authorized disposal area. The contractor will seek guidance from the respective District Local Governments in project area on the final disposal point.	Complaints from communities around the site and road of poor management of waste.	Project sites & Contractor's/ Supervisor's Office	Review of complaints records	Throughout construction	NWSC/District Local Governments of Project Area	See 8.2.2
	h) Waste shall not be taken out of the Site without a Waste Manifest.	Waste Manifest	Project sites & Contractor's/ Supervisor's Office	Review of records and reports	Throughout construction	NWSC/District Local Governments of Project Area	
	i) A Spill kit will be maintained onsite to clean-up any accidental spills.	Presence of spill kits at all project sites where there is potential of accidental spills	Project sites	Site and project office inspection	Throughout construction	NWSC/District Local Governments of Project Area	
	j) Retention ditch will be provided such that runoff from the project site does not go directly into the Victoria Nile. It will only be released after quality assessment to ensure that it meets the national discharge standards.	Water/ stormwater quality	Project sites & Contractor's/ Supervisor's Office	Review of monthly reports	During construction whenever it rains	NWSC/DWRM/ District Local Governments of Project Area	
	Operation phase						

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	a) Cut-off drain will be provided around the waterworks to avoid intrusion of storm water and stormwater within the water works will be guided away from chemical storage areas using cut-off drains around them.	Victoria Nile water quality data upstream and downstream of the water treatment plant effluent discharge point	NWSC Area Office/ DWRM Zonal Office/ District Environmental Office	Review of water quality reports and site inspection; Sampling and laboratory analysis at an independent laboratory, e.g NEMA laboratory	Monthly throughtout operation of the plant	DWRM/ NEMA	8,000,000
	b) Staff operating the plant will be trained/ sensitised on proper management of waste associated with the operation of the water treatment plant to avoid soil contamination.	Records of staff training	NWSC Area Office	Review of record and interview of staff randomly	Before commissioning of the water treatment plant		
	c) Periodic tests will be done to assure the quality of effluent from filter press or sludge conditioning basins and treated sludge meets the national effluent discharge standards (see sub-section 4.4.2), to avoid partially sludge from reaching the soils.	Effluent/ Sludge quality data	NWSC Area Office / District Environmental Office	Review of water quality and environmental audit reports	Throughout operation of water treatment plant	DWRM/ NEMA/ District Local Governments of Project Area	
8.3.2 Pollution of water resources	**Construction phase**						
	a) All construction equipment will be kept in good operating condition to avoid oil or fuel leakages that might contaminate water resources	Water quality data	Contractor's/ Supervisor's Office	Review of maintenance records and physical state of equipment/ vehicles	Throughout construction	NEMA/NWSC/ District Local Governments of Project Area	12,000,000
	b) Workers' camp and associated facilities will be connected to septic tank or other wastewater systems which are appropriate and of sufficient capacity for the number of workers and local conditions. The facilities for this purpose will be inspected regularly to ensure proper functioning. Camp site selection shall involve several factors, including; the size and conditions of the site and availability of resources; the safety, security and protection it offers and cultural and social considerations. Choosing a site shall involve consideration of access, coexistence with surrounding communities, topography, trees and vegetation, the potential impact on the environment, environmental causes of disease and other public health issues. The Contractor shall conduct the necessary environmental and social assessments according to national and World Bank Environment and Social Safeguards Policies and acquire approvals from NEMA and the supervising engineer prior to establishment of new camp sites.	Presence of properly operating sanitation facilities on site	Workers' camp and sites for the different project components	Site inspection	Throughtout construction	NWSC/ District Local Governments of Project Area (District Health Inspector and DEO)	
	c) Stockpile areas for materials such as sand, gravel, stone, laterite, lime and topsoil, as well as overburden dumps will be located away from water courses and will be surrounded by perimeter or cut-off drains with sediment and other pollutant traps located at drain exits. Cut-off drains will be maintained throughout the subsequent operation phase	Presence of well functioning cut-off drain and banded storage area located away from water courses	Contractor's/ Supervisor's Office	Site inspection	Throughout construction	NWSC/DWRM/ District Local Governments of Project Area (DEOs and DNRO)	
	d) All hazardous wastes including material soiled with hazardous wastes and empty containers of hazardous materials shall be stored in a designated area on site for regular removal and disposal by a registered contractor in accordance with the National Environment (Waste Management) Regulations, 1999. All other wastes generated during site preparation and construction will be transported by the contractor or a company that has been specifically contracted to an authorized disposal area.	Collection and disposal records	Project sites & Contractor's/ Supervisor's Office	Site inspection and review of waste collection and disposal manifest	Throughout construction	NWSC/ District Local Governments of Project Area (DEOs and DNRO)	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	e) Fuel handling and oil spill measures will be implemented to prevent, control and address spill or leaks. Fuel storage and dispensing on site shall not be allowed. Fuel and oil handling will be assigned to trained personnel and procedures for fuel storage, operation of mobile fuel tankers and refuelling areas will be well defined. Impermeable sheets, spill mats, and drip trays will also be provided in the appropriate areas to curb fuel and oil leakage to the ground. This will be done at designated places at the contractor's camp and in accordance with relevant standards set by the Energy Regulation Board and Uganda Bureau of Standards.	Water quality data as per effluent discharge standards	Project sites & Contractor's/ Supervisor's Office	Review of water quality and environmental audit reports	Monitoring throughout construction	NEMA/NWSC/ District Local Governments of Project Area	
	f) Construction activities will largely be carried out during the dry season to avoid sediment transport to the nearby land, water courses and roads	Schedule of construction activities	Project sites & Contractor's/ Supervisor's Office	Review of activity schedules	Throughout construction phase	NWSC/DWRM/ NEMA/ District Local Governments of Project Area (DEOs and DNRO)	
	g) Any cleaning and hydrotest water which could cause contamination of surface (or ground) waters will be tested and treated as necessary prior to discharge, including debris and sediment removal.	Material data sheets and water quality tests and points of discharge	Project sites & Contractor's/ Supervisor's Office	Review of water quality and environmental audit reports	During pipe testing	NWSC/ District Local Governments of Project Area (DEOs and DNRO)	
	h) NWSC will ensure the contractor complies with its environmental management policies, ESIA recommendations and national regulations	General working environment/ Monitoring reports	All project sites	Review of environmental monitoring and audit reports; site inspection	Monthly throughout the construction phase	NWSC/ District Local Governments of Project Area (DEOs and DNRO)	
	i) In open waters, especially during construction of the intake, plastic curtains will beused to contain and confine resuspension of bottom silt to minimize turbidity in surrounding and downstream areas, using longer support spans and restricting construction to dry weather where possible.	Water quality during construction activities	Intake site and along wetlands/swamps	Review of water quality and environmental audit reports	Throughout construction phase	NWSC/DWRM/ NEMA/ District Local Governments of Project Area (DEOs and DNRO)	
	j) The contractor shall ensure that appropriate monitoring of the water quality is done during the construction phase to prevent contamination of the Nile water when construction activities are being undertaken (both upstream and downstream the intake should be monitored and monthly reports produced)	Water quality during construction activities	Intake site and along wetlands/swamps	Review of water quality and environmental audit reports	Throughout construction phase	NWSC/DWRM/ NEMA/ District Local Governments of Project Area (DEOs and DNRO)	
	k) Vehicles and machinery/ equipment will be maintained, repaired and refuelled at an offsite garage/workshop.		Project sites	Review of water quality and environmental audit reports	Throughout construction phase	NWSC/DWRM/ NEMA/ District Local Governments of Project Area (DEOs and DNRO)	
	Operation phase						
	a) Monthly quality tests for raw water abstracted from the Victoria Nile will be undertaken by NWSC to properly monitor the quality with time	Water quality data	NWSC Office/ WTP	Review of water quality and environmental audit reports	Throughout Operation	NEMA/DWRM	5,000,000
	b) Vehicles and machinery/ equipment will be maintained, repaired and refuelled at an offsite garage/workshop.						
8.3.3 Improper management of waste	**Construction phase**						
	a) The Contractor will be required to prepare a Waste Management Plan.	Record/ Evidence of Waste management Plan being used by Contractor	Project sites & Contractor's/ Supervisor's Office	Review of environmental monitoring reports	Throughout construction	NWSC/ District Local Governments of Project Area	10,000,000
	b) The contractor and NWSC Area Management will work hand in hand with the respective Local governments to facilitate sound waste handling and disposal from the site. All wastes must be taken to the approved dumpsites.	Record of waste types and estimated quantity disposed/ diverted for reuse	Project sites & Contractor's/ Supervisor's Office	Review of environmental monitoring reports	Throughout construction	NEMA/NWSC/ District Local Governments of Project Area	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	c) Proof of delivery and safe disposal of waste will be provided and records maintained at all times.				Throughout construction	NEMA/NWSC/ District Local Governments of Project Area	
	d) The contractor will provide his own facilities (e.g. mobile toilets) which should be adequate at construction sites.	Presence of mobile toilets at construction sites/ sanitary hire agreements	Project sites & Contractor's/ Supervisor's Office	Site inspection	Throughout construction	NEMA/NWSC/ District Local Governments of Project Area	
	e) Workers' camp and associated facilities will be connected to septic tank or other wastewater systems which are appropriate and of sufficient capacity for the number of workers and local conditions. The facilities for this purpose will be inspected regularly to ensure proper functioning.	Presence of properly operating sanitation facilities on site	Workers' camp and sites for the different project components	Site inspection	Throughtout construction	NWSC/ District Local Governments of Project Area (District Health Inspector and DEO)	
	Operation phase						
	a) Adequate operation and management of the facilities will ensured to avoid improper management of waste and solid waste is collected by a firm licensed by NEMA and that the collected waste is disposed of at dumpsite or landfill approved by NEMA	No accumulation of waste in facilities' vicinity. No complaint of littered waste from community and authority; internal and external Environmental Audit reports	NWSC Area Office	Abrupt site inspection	Throughout operation of the facilities	NEMA/ Oyam District Local Government (DEO)	2,000,000
	b) NWSC together with the respective District Local Governments will ensure that the solid waste is collected by a firm licensed by NEMA and that the collected waste is disposed of at dumpsite or landfill approved by NEMA						
	c) Adequate bins will be provided to prevent access by vermin at the WTP	Presence of vermin free bins and/ or skips at the water treatment plant	WTP site	Abrupt site inspection	Throughout operation	Oyam District Local Government (DEO)	
8.3.4 Disturbance or Destruction of Archaeological / Cultural Heritage	**Construction phase**						
	a) A 'chance find' procedure will be put in place to determine actions to be taken in the event that suspected archaeological artefacts or paleontological items are encountered and they should be handed over to Ministry of trade and industry-Department of Museums and Monuments.	Record of cases with the Department of Museums and Monuments	Department of Museums and Monuments, Kampala		Throughout the construction phase	NWSC/ Ministry of trade and industry- Department of Museums and Monuments	5,000,000
	b) Construction works will be designed to ensure no damage to any cultural sites or medicinal plants that may be encountered. Where such sites cannot be avoided, culturally appropriate measures will be agreed and implemented prior to the construction activities.	Contractor's schedule and workplans	Project sites	Review of Contractor's schedule and workplans	Before commencement of construction activities	NWSC	-
	c) Compensation of the affected sites, especially the affected grave yards, will be undertaken before construction activities commence in accordance with World Bank and KFW requirements.	Proof of compensation and relocation	Project office; Project affected person's home		Before construction activities commence	District Local Governments of the affected persons/ community	20,000,000
8.3.5 Introduction of invasive species	**Construction phase**						
	a) Vehicles and equipment entering and leaving the project area will be inspected and cleaned to remove invasive species.			Check for presence of invasive species in the area and review environmental audit reports	Throughout the construction phase	NWSC/ District Local Governments of Project Area – SEOs	2,000,000
	b) When invasive species are encountered, they will be removed and destroyed, for example, by burning.				Throughout the construction phase	NWSC/ District Local Governments of Project Area – SEOs	
8.3.6 Deterioration of landscape and visual quality	**Construction phase**						
	a) Murram and subsoil will be obtained preferentially from a licensed source and in accordance with any terms of the license. "Licensed" means approved by NEMA or the respective Project District Local Governments. The contractor will provide	Copy of license(s)		Check for the license and carryout site inspection of	Before extraction of materials	NEMA/ NWSC/ District Local Governments of Project Area – SEOs	Already catered for under other activities above

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	a copy of the license to NWSC before the beginning of works at the murram/subsoil extraction location.			sources of materials/ borrow pits			
	b) If no suitable licensed source of murram/subsoil is available in the area and the contractor plans to obtain the material from a private landowner, then the contractor will: ▪ Provide NWSC with a copy of the written agreement between the contractor and the owner of the murram/subsoil source in advance of the beginning of works at the location. The identity of the landowner will be certified by a certificate of ownership or a paper signed by the LC1 Chairperson and/ or Head of Clan; ▪ Engage and consult any households and/or communities in close proximity to the identified murram/topsoil source and provide evidence of these consultations to NWSC; ▪ Ensure adequate compensation on mutually agreed terms is made to people who are either physically or economically displaced by the activities of the contractor. The contractor will provide documentation of the compensation terms (minutes of consultation meetings, signed agreements with affected persons, compensation receipts etc.) to NWSC; ▪ Assess health and safety risks linked to murram/subsoil extraction and transport, and implement appropriate mitigation measures. The risk assessment will be provided to NWSC ahead of the beginning of works; and ▪ Provide a restoration plan for review, and ensure that the actions of the restoration plan are implemented to the satisfaction of concerned authorities. Sign-off from the relevant authorities will be required and copies of the sign-off will be provided to NWSC.	Copy of Agreement Evidence of compensation and Reinstatement Plan	Affected Person and Contractor's office	Check for agreement, consult with landowner and inspect the source	Before extraction of materials or commencement of construction activities	NEMA/ NWSC/ District Local Governments of Project Area – SEOs	-
	c) Surface water run-off will be controlled during earthworks. Surface water features down-slope of the earthworks will be identified, and the necessary berms and drainage channels will be installed to ensure that run-off does not collect or pond in excavated areas or quarries.	Signs of ponding of water	Project sites and Sources of materials	Site inspection	During construction and after construction activities	NEMA/ NWSC/ District Local Governments of Project Area – SEOs	
	d) Restoration of borrow pits to as close to pre-project conditions as possible will be done immediately after use in cases where they are specifically opened up for this project. Native vegetation must be used for re-seeding the excavated site.	Borrow pits restored to pre-project condition with native vegetation and vegetation growing well	Project sites and Sources of materials		After extraction of materials or construction activities	NEMA/ NWSC/ District Local Governments of Project Area – SEOs	
	e) The contractor will exercise prompt and effective response to environmental and social issues raised by supervision engineer.	Corrective measures taken in timely manner	Project sites and Sources of materials	Site inspection and response matters arising		Supervising Engineer/NWSC	
	f) There will be close monitoring of impact on natural resources with enforcement of contract or legislative options.		Project sites and Sources of materials	Site inspection and response matters arising		NEMA/ NWSC/ District Local Governments of Project Area – SEOs	5,000,000 as facilitation for district officials
8.3.7 Loss and degradation of natural habitats	**Construction phase**						
	a) Construction activities should be restricted only to the areas that must be disturbed to avoid unnecessary disturbance. Destruction of trees in Opaka Central Forest reserve along the Karuma – Gulu Highway will be avoided as much as possible	Area of restored habitat that had been disturbed.	Project sites and Sources of materials	Site inspection and consultations with stakeholders	During Construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's, District Engineers	
	b) All project workers should be sensitized to minimize damage to vegetation and flora	Record of worker sensitization about vegetation and flora.	Project sites and Sources of materials	Check for the sensitisation record and also interact with workers about the sensitisation	During Construction	NWSC/ District Local Governments of Project Area –	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
						SEO's, CDO's, District Engineers	
	c) Close monitoring and supervision of the construction operations to ensure compliance and avoid causing further damage to undesignated project areas	Record monitoring and supervision of the construction operations about project footprint.	Project office		During Construction	District Local Governments of Project Area – SEO's, CDO's, District Engineers	
	d) Where tree cutting is inevitable, replacement planting should be done wherever feasible. No trees of protected species *(Milicia excelsa woodlot at 36N 424999E 294543N and Khaya anthotheca woodlot at 36N 429530E 277069N)* will be cut. Any trees specie to be cut will need to be replaced in public lands in the project area. The project will implement a restoration program that can be implemented in the wetlands, rivers, riparian areas. Liason with UNRA shall also me made such that any tree restoration along the transmission line sections that shall be located in the road reserve is done jointly with UNRA.	Number of community planted trees and grew in relation to the project.	Project sites and Sources of materials	Site inspection	During Construction and operation	District Local Governments of Project Area – DNROs & CDOs	
	e) The use of cut wood (and charcoal) in camp is prohibited. Instead all camps will use propane or electricity for cooking				During Construction and operation	District Local Governments of Project Area – DNROs & CDOs	
	f) Critically endangered fish include Labeo victorianus and Oreochromis esculentus in Minakulu, Ogada, Myene and Alek swamps. The contractor shall ensure that the fish habitat is not destructed while undertaking works in wetlnd areas (especially in Minakulu, Ogada, Myene and Alek swamps where critically endangered species were found) by planning for working in waters to protect fish eggs, spawning adults, organisms upon which they feed by maintaining an undisturbed vegetation buffer zone and preventing soil compaction in such areas. Construction in these sections of the pipeline shall not be carried out in the month of August since it is the wettest season and fish spawning takes place during the high rains that occur in August of every year. g) The contractor should ensure that the waterflow direction is not obstructed when pipeline is installed to ensure that fish movement routes are not destroyed, and if these fish species are potamodrometic that they can continue their movements towards the main river.	Fish habitat area left untempered	Fish habitat areas ((Minakulu, Ogada, Myene and Alek swamps).	Site inspection	During construction	NEMA/ NWSC/ District Local Governments of Project Area – SEOs	
8.3.8 Risk of seismic activity	**Pre-construction phase**						
	a) The structures should be designed to exhibit some amount of ductility to tolerate dynamic loads generated from seismic activity. Reinforced concrete structures are recommended for such purposes. Pre-stressed concrete structures are also useful, but do not perform as well as reinforced concrete under earthquake conditions.	Design report	NWSC and Design Consultant's Offices	Review of design reports and drawings	Before construction	NWSC	-
	b) Appropriate design codes have been followed to reduce risks of damage to health and property						
8.3.9 Impacts of Karuma HPP	**Pre-construction phase**						
	a) Where possible, NWSC should ensure that construction works of the intake are completed before commissioning of the Karuma HPP; and not a contractor with experience of working in deep waters will be hired.		Water intake site	Consultation with UEGCL	Before commissioning of Karuma HPP	NWSC Project Manager/ Director of Capital Development and Planning	-
	b) Measures will be instituted at the intake to ensure that when the water levels approach the minimum of 1028 m, the pumps switch themselves off automatically	Water levels at intake area	Water intake	Review of recorded water levels	Throughtout operation phase	DWRM	6,000,000
NEGATIVE SOCIO-ECONOMIC IMPACTS							
	Construction phase						

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
8.4.1 Risk of traffic accidents	a) The contractor will prepare and implement a traffic management plan to be approved by supervision engineer	Traffic management plan		Effectiveness and suitability of the plan	Before construction activities commence	NWSC/ Traffic Police Office at the project area	5,000,000
	b) Contractor will adopt best transport safety practices (Journey Management Plans (JMPs)) with the goal of preventing traffic accidents and minimizing injuries suffered by project personnel and the public by: employing safe traffic control measures, including road signs and flagmen/traffic guides to warn of dangerous conditions and children crossings; and setting speed limits on all access roads in the project area and towns/ trading centres will be 40km/h for light vehicles and 30km/h for heavy vehicles; and not more than 80 km/h on the Karuma – Gulu Highway.	Record of traffic related accidents in each month of construction duration	Contractor's/ Supervisor's Office	Check for records and consult with traffic police in charge of the respective area	During construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	c) The Contractor shall provide dedicated site entrances and exits for personnel, which shall be manned 24 hours per day, 7 days per week including holidays.	Location of entry and presence of personnel manning it	Project sites		Before and during construction	NWSC	-
	d) Some roads in Gulu Municipality were recently surfaced and others are being surface under the Uganda Support to Municipality Infrastructure Development (USMID) Project. NWSC should contact Gulu Municipality early enough and request for service ducts to be installed at points where water mains will cross roads to avoid cutting through roads that have just been upgraded.	Permission to carryout activities across the infrastructure/ presence of service ducts	Contractor's/ Supervisor's Office	Check for permission and consultations with the district/ municipality authorities	Before construction activities commence	Gulu District Local Government/ Municipality	-
	e) The Contractor will have a community liaison Officer (CLO) to get feedback/complaints from communities regarding activities of the project and issues the communities think are not being done in a proper manner. The CLO would also be responsible for informing project-affected communities of the timing and duration of the construction activities across access roads and any uncertainties or potential for change.	Availability of the CLO and his/ her qualifications	Contractor's/ Supervisor's Office	Check for qualifications and records of activitity with communities	Thorughout the construction phase	NWSC	-
	f) All workers, including sub-contractors and casual labourers, will undergo an environmental, health and safety induction before commencing work on site. This will include a full briefing on site safety and rules.	Record of induction; interviewing a sample of workers on environmental, health and safety issues	Contractor's/ Supervisor's Office	Check for records of induction carried out	Before construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	g) Restrictions on hours of driving (including night time restrictions where sensitive receptors may be affected) and timing of vehicle movements will be emphasized to avoid busy periods in urban areas, particularly the start and end of school and the working day.	Activity schedule and journey management plans	Contractor's/ Supervisor's Office	Consultations with stakeholders	During construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	h) No drivers or personnel under the influence of alcohol or any drug abuse will be allowed onsite	Records of cases	Contractor's/ Supervisor's Office	Consultations with stakeholders	During construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	i) The water treatment plant and intake sites will be fenced and signalization put in place with security personnel to stop unauthorised people from accessing the site.	Presence of a sound fence all around the site	Contractor's/ Supervisor's Office	Visual observation	During construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	j) The water treatment plant and intake sites will be fenced and signalization put in place with security personnel to stop unauthorised people from accessing the site.	Presence of a fence with security personnel	Water treatment plant and intake	Quality of the fence and number of security personnel	Throughout construction	NWSC	
	k) Strict adherence to safety measures and procedures are required to minimise (or eliminate) risks of accidents or hazardous developments occurring and ensure healthy and safe conditions for all persons working on the site and the project-affected communities. To ensure occupational health and safety on construction sites, the Contractor shall be obliged to comply with all applicable Ugandan construction Health and Safety Standards as required by the Occupational Safety and Health Act of 2006. These include provisions of the Factories Act, Labour Unions Act and Workman's Compensation Act.	Documentation of instructions	Contractor's/ Supervisor's Office	Check records and availability of procedures to workers	Throughout construction	MGLSD – OHS Department /NWSC/ District Local Governments of Project Area – SEO's, CDO's	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	l) Materials will be preferentially sourced locally to minimize transport distances.	Location of material sources and schedule of material hauling		Check procurement records or documentation	Throughout construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
8.4.2 Unsustainable use of resources	**Construction phase**						
	a) Through inductions and tool box meetings, the contractor will ensure that staff and contractors are conversant with resource conservation practices in all project activities. Conservation awareness will focus on water use efficiency and general day-to-day measures such as turning engines and air conditioning units off when machinery and offices or dwelling quarters are not in use.	Record of water usage and conservation measures being implemented	Contractor's/ Supervisor's Office	Review of water abstracted and treated records	During construction	District Local Governments of Project Area – SEO's, CDO's	
	b) The Contractor will acquire water abstraction permits with conditions to guide the amount of water to be abstracted as stipulated in the Water Supply Regulations (1999). Water abstraction will comply with rates allowed by the DWRM permit that will be obtained.	Record of water abstracted	Contractor's/ Supervisor's Office	Check for availability of abstraction permit and records of water abstracted	During construction	DWRM	
	c) Earth materials will be sourced from a NEMA-approved source in a manner that reduces environmental and social impacts. Murram will be sourced in accordance with a NWSC approved murram/ subsoil extraction plan, which will be provided by the contractor prior to the start of works.	Approval from NEMA	Contractor's/ Supervisor's Office	Check for presence of NEMA permit/ license and site inspection of the sources of materials	ESIA for probable sources of materials before construction	NEMA/ NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	d) The Contractor and NWSC will acquire water abstraction permits with conditions to guide the amount of water to be abstracted as stipulated in the Water Supply Regulations (1999).			Check for availability of abstraction permit and records of water abstracted			
	e) The contractor's Worker Code will include clauses of conduct on water and electricity consumption	Content of code	Contractor's/ Supervisor's Office	Review of code	Before commencement of construction activities	NWSC	
	Operation phase						
	a) Catchment management plans are being developed with the aim of conserving and allowing recharge of water resources.	Increase in volumes of water in existing water resources – water levels	NWSC & DWRM Zonal Offices	Check for availability and use of the plans	Throughout operation	NWSC/ District Local Governments of Project Area – SEO's, District Engineer's, Water Officers'	30,000,000
	b) Water conservation measures will be encouraged: saving water is an efficient way of reducing the overuse of ground water resources. It is not only decreases the amount of the water withdrawn, but may also reduce the threat of pollution	Record of water usage and conservation measures being implemented	NWSC Area Office		Throughout operation	NWSC/ District Local Governments of Project Area – SEOs, District Engineer's, Water Officers'	
	c) NWSC should adhere to the stipulated limits in the water abstraction permit obtained from DWRM.	Records of water quantities abstracted daily		Check record of water abstracted and treated	Throughout operation	DWRM	Covered
8.4.3 Damage to Existing Public Infrastructure	**Construction and operation phases**						
	a) Trucks ferrying materials will be loaded commensurate with the recommended axle load for a given road to avoid or minimize damage.	Complaints from District Local Governments and communities/ Trafiic offences committed	Respective Project District Offices/ Nearest Police station/ post	Consultations with UNRA zonal office and Office of the District Engineer	During construction	Traffic Police Officers/ District Local Governments of Project Area – District Engineers	
	b) Locally sourced materials will be used, whenever possible, to minimize travel distances and expanse of road damaged.	Location of sources of materials		Site inspection and documents of procurement of materials	Before and during construction	NWSC	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	c) Special permission will have to be sought from Uganda National Roads Authority (UNRA) and Gulu District Local Government before activities at road crossing are carried out. A typical drawing for a road / highway crossing is presented in drawing WS_CD_9_4_02 in Appendix J. Similarly permission from Uganda Railways Authority will be sought for the railway crossing at Sira Dongo Road.	Evidence of permission from UNRA/Gulu Municipality/ URA	Project Office	Check for availability of permission from UNRA and URA in cases where the trenchless method was not employed	Before construction commences	UNRA/ Gulu Municipality/ URA	
	d) The trenchless technology will be used at the road and railway crossing to avoid damaging them. However, the method requires considering soil characteristics; the loads applied to the surface especially traffic and the level of water table to prevent the danger of surface caving in.	Quality of roads and railaway crossings	Road and railway crossings	Site inspection at cross points		NWSC/ UNRA/ Gulu Municipality/ URA	
8.4.4 Social misdemeanour by construction workers	**Construction phase**						
	a) The contractor will be required to develop a Labor Influx Management Plan and/or a Workers' Camp Management Plan. These will include sanctions for workers involved in criminal activities.	Presence of labour Influx Management plan		Content of the plan	Before construction commences	NWSC	
	b) As a contractual obligation, contractors shall be required to have an HIV/AIDS policy and a framework (responsible staff, action plan, etc.) to implement during project execution.	All construction workers living in a camp adhere to “No fraternization” and comply with latest entry time into camp set to avoid prostitution; and monitor complaints from the community	Workers’ camp and Contractor’s Office	Check for policy and interview/ consult with workers about the policy	Development of policy before construction	NWSC/ District Local Governments of Project Area – SEO’s, CDO’s	
	c) All construction workers shall be oriented and sensitized about responsible sexual behaviour in project communities.	All construction workers are aware of HIV/AIDS risk and responsible living.	Workers’ camp and Contractor’s Office	Check for policy and interview/ consult with workers about the policy	Before construction	NWSC/ District Local Governments of Project Area – SEO’s, CDO’s	
	d) The contractors will develop and follow a code of conduct. An example is provided in Appendix G			Check for availability of code of conduct, signed coipes by workers and interview workers about the applicabilition and appreciation of the code			
	e) The contractors will develop and follow a code of conduct. An example is provided in Appendix G				Before construction phase	NWSC	
	f) The contractor will conduct cultural sensitization training for workers regarding engagement with local community.	Records of sensitisation	Project/ contractor’s office	Review of records and interview of workers	During mobilisation stage	NWSC	
	g) The contractor will endeavour to provide entertainment and events for workers within camp to reduce incentives for mixing with local community.			Inspection of workers camp	During construction	NWSC	
	h) Workers will be encouraged to get vaccinated against common and locally prevalent diseases	Number of workers vaccinated	Project/ contractor’s office	Review of records	Before and during construction	NWSC/ CDO’s	
	i) The contractor, where need arises, will engage an HIV service provider to be available on-site who should conduct campaigns on STDs among the workers and local community; educate workers and the community about the transmission of diseases; and implement HIV/AIDS education program and provision of condoms.	Campaigns conducted, evidence of program implemented and availability of condoms	Project sites and workers’ camp	Review of records, Inspection and interview of workers	Before and during construction	NWSC/ CDO’s	
8.4.5 Gender-based violence	**Construction phase**						
	a) The contractor will conduct mandatory and repeated training and awareness raising for the workforce about refraining from unacceptable conduct toward local community members, specifically women	Records for training and awareness	Project sites and workers’ camp	Review of records and interview of workers	Before and during construction	NWSC/ District Local Governments of Project Area – SEO’s, CDO’s	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	b) Workers will be informed about national laws and funder's policies that make sexual harassment and gender-based violence a punishable offence which is prosecuted	Evidence that information was received by the workers	Project sites and workers' camp	Review of records and interview of workers	Before and during construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	c) Worker Code of Conduct will be part of the employment contract, and including sanctions for non-compliance (for example, termination)	Employment contract	Contractor's office	Review of employment contracts	Before and during construction	NWSC/ District Local Governments of Project Area – CDO's	
	d) The contractor, where a case arises, will cooperate with law enforcement agencies in investigating complaints about gender-based violence	Complaints handled	Contractor's office	Consultations with law enforcers and review of records	During construction	NWSC/ District Local Governments of Project Area – CDO's	
8.4.6 Child labour and school dropout	**Construction phase**						
	a) The contractor and NWSC will ensure that children and minors are not employed directly or indirectly on the project	Visual and employee's details	Contractor's office	Review of workers' details	Before and during construction	NWSC/ District Local Governments of Project Area – CDO's	
	b) The contractor will communicate the hiring criteria, minimum age and applicable laws (for example, Children Act, Cap 59) in his ESMP		Contractor's office	Review of workers' details	Before and during construction	NWSC/ District Local Governments of Project Area – CDO's	
8.4.7 Permanent Land take	**Pre-construction phase**						
	a) NWSC will ensure that the project-affected persons identified through the Resettlement Action Plan study of the project are compensated for the land and property on it in time and fairly.			Consult with compensation record or RAP implementation report			
	b) Land will be acquired in accordance with Uganda's Land Access and Compensation Procedure taking into consideration the Development Partner's requirements. Amongst others, this requires: sensitisation of community members whose property will be affected; Completion of a full inventory of privately registered and/or cultivated and grazed or other uses of the land that will be taken for the project as well as structures and graves along the access road; compensation to be paid in line with mandated rates agreed in consultation with District officials before commencement of construction activities; and ensuring that the Chief Government Valuer approves the valuation rates.	List of fully compensated PAPs against Monies paid out to them.	Project Office	Consult with compensation record or RAP implementation report	Prior to commencement of construction.	NWSC/ CGV Independent Hired External Monitor	25,000,000
8.4.8 Occupational health safety (OHS) Risks	**Construction and operation phases**						
	a) A qualified Health and Safety Officer will be recruited by the Contractor to oversee OHS matters on a daily basis.						
	b) All construction workers will be oriented on safe work practices and guidelines and ensure that they adhere to them all the time.	Records of workers' orientation	Project sites & Contractor's/ Supervisor's Office/ NWSC WTP	Review of records of training	At the beginning of construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	c) Use signage to warn staff and/ or visitors that are not involved in construction activities of dangerous places.	Presence of signage	Project sites & Contractor's/ Supervisor's Office	Site inspection	During construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	d) Regular drills should constantly follow on various possible incidences. This will test the response of the involved stakeholders.	Record of drills	Project sites & Contractor's/ Supervisor's Office	Records of drills	Throughout construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	e) Training will be conducted on how to prevent and manage incidences. This should involve proper handling of electricity, water etc. and sensitization on various modes of escape, conduct and responsibility during such incidences. All must fully be aware and mentally prepared for potential emergency	Records of training and details of staff trained	Project sites & Contractor's/ Supervisor's Office	Check of records of training	At the beginning of and during construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	f) Personnel will only undertake tasks for which they are trained/ qualified. A formal 'permit to work' system will be in place and strict instructions will be given for operators of equipment.	Permits for works and their qualifications	Project sites & Contractor's/ Supervisor's Office	Check workers' permits and random sampling of workers	Throughout construction and operation phases	MGLSD	
	g) Strict instructions will be given to drivers of heavy equipment and operators of equipment/ machinery. Ensure electrical safety at fabrication workshops by putting in place secure electrical connections and providing adequate insulation. All temporary electrical installations in use on site such as generators and welding sets should be adequately and effectively earthed at all times during operation	Documentation of instructions	Project sites & Contractor's/ Supervisor's Office	Site and office inspection for instructions	Throughout construction	Traffic Officers, NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	h) Supervision of works will be done regularly to ensure that safety conditions are met while any deviation from safety regulations is immediately reclaimed following the best practices regarding safety at work equipment.	Supervision record	Project sites		During construction	MGLSD/ District Local Governments of Project Area – SEO's, CDO's	15,000,000
	i) Clear communication line shall be ensured between workers and drivers of heavy equipment.	Presence of radio calls/Megaphones being utilised	Project sites		During construction	NWSC	
	j) Evacuation procedures to handle emergency situations will be developed	Presence of a documented evacuation procedure	Project sites	Check procedures and interview workers whether they are aware about the procedures	During construction	MGLSD/ NWSC	
	k) Adequate OHS personnel protective gear will be provided to the employees.	Record of PPE provided and staff; use of PPE on site	Project sites	Site inspection	During construction and operation phases	MGLSD	
	l) Strict adherence to safety measures and procedures are required to minimise (or eliminate) risks of accidents or hazardous developments occurring and ensure healthy and safe conditions for all persons working on the site. To ensure occupational health and safety on construction sites, the Contractor shall be obliged to comply with all applicable Ugandan construction Health and Safety Standards as required by the Occupational Safety and Health Act of 2006. These include provisions of the Factories Act, Labour Unions Act and Workman's Compensation Act.	Documentation of instructions	Project sites	Check for documentation	Throughout construction	NWSC/ GDLG/ GMC	
	m) First aid boxes will be available at all active construction sites and at accessible locations at the water treatment plant during the operation phase.		Project sites	Visual inspection	During construction and operation phases	NWSC	
	n) An Accident log will be maintained onsite to register all injuries and to investigate their causes during both the construction and operation phases of the project.	Monthly accident log available	Project sites & Contractor's/ Supervisor's Office	Check on records	During operation	MGLSD – OHS Department	
	o) Emergency resources (e.g., fire extinguishers, stocked First Aid kits, Emergency Contacts, Doctor on Call, etc.) will be maintained at all active construction sites and at the water treatment facilities during operation.	Existence of first aid kits and communication facilities	Contractor's/ Supervisor's Office	Site inspection	At start and replemishment when need arised during of operation	MGLSD – OHS Department	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	p) The Contractor shall ensure that all areas requiring access including platforms, under platforms, underpasses, excavations, etc. have enough illumination.	Record of cases and light measurement records	Contractor's/ Supervisor's Office	Site inspection and measurement of light levels	During construction and operation phases	MGLSD – OHS Department	
	q) Excavations and rock blasting activities will be undertaken under strict guidance to avoid chances of collapse and injury, respectively.	Record of cases and light measurement records	Contractor's/ Supervisor's Office	Site inspection	During construction	NWSC/ MGLSD – OHS Department	
	r) The manufacturer's instructions and Material Safety Data Sheets (MSDS) must be followed for the storage of all chemicals used in water treatment. Storage must conform to compatibility restrictions.	Easily accessible and clear instructions and Material Data Sheets	Contractor's/ Supervisor's Office		Throughout operation of facilities	MGLSD – OHS Department	
	s) Regular fumigation of the WTP and contractor's/ workers' camp will be undertaken to kill disease vectors such as mosquitoes	Record of fumigation of facilities	Contractor's/ Supervisor's Office	Check for records of fumigation	Quarterly or as need arises	District Local Governments of Project Area where camp is located and Oyam – SEOs	
NEGATIVE CUMMULATIVE IMPACTS							
8.5.1 Disruption of traffic and communication routes	**Construction phase**						
	a) The trenchless technology will be used at major crossings like roads to avoid disruption of traffic flow.			Site inspection			
	b) Appropriate signage will be used and impacted owners will be informed ahead of disruption	Complaints from property owners	Local authorities/ communities	Consult with community members of property was affected	Before and during construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	c) Disruptions to public access shall be identified in the Contractor's Traffic Management Plan, under which suitable notice of intending delays and closures are given to all concerned parties and approved prior to commencing work. All road closures shall be separately notified and agreed with the Local gov't administration.	Minimal or no interruption in pedestrian and traffic flow	Local authorities/ communities	Consultations with local authorities	Before and during construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	d) Where access to or from an individual property is closed for a period of 2 hours or more, the owner shall be informed at least 24 hours in advance.	Complaints from property owners	Local authorities/ communities	Consult with community members of property was affected	Before and during construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	e) Vehicular access to and from hospitals, police stations and fire stations shall be maintained through the use of steel road plates over open trenches. Pedestrian access to schools, health facilities, and other premises frequently accessed by the public will be maintained with the use of walking boards.	Minimal or no interruption in pedestrian and traffic flow to public facilities	Nearest Police Station/ Post – Traffic Department	Consultation with the affected facility authorities/ administrators	Before and during construction	NWSC/ District Local Governments of Project Area – SEO's and CDO's	
	f) The laying of pipelines, backfilling and temporary reinstatement shall follow trench excavation as quickly as possible and trenches will not be left open for extended periods.	Complaints from affected communities	Project Office	Site inspection	Before and during construction	NWSC/ District Local Governments of Project Area – SEO's and CDO's	
8.5.2 Air pollution	**Construction phase**						
	a) Construction work will be undertaken by an experienced and duly registered contractor with a verifiable sense of environmental awareness and responsibility	Record of environmental responsiveness of the contractor/ Environmental Management Plan	Project sites & Contractor's/ Supervisor's Office	Review of qualifications of the contractor's employee in charge of EHS	During construction	NWSC/ District Local Governments of Project Area	
	b) Travel speeds of construction vehicles along the road especially at trading/ business centres will be controlled using humps and setting travel speeds not exceeding 40km/h	Number of accidents and/ or complaints reported/ Journey management records	Project sites & Contractor's/ Supervisor's Office	Review of records of traffic related accidents	During construction	NWSC	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	c) A maintenance programme for equipment and vehicles will be implemented, to ensure air emissions like particulates, SO_2 and NO_2 are minimised.	Emissions data (NOx, SO_2, CO, CO_2 and PM, etc) as per the national air quality guidelines Strict maintenance program	Project sites & Contractor's/ Supervisor's Office	Records of maintenance and inspection of vehicles/ equipment	During construction	NWSC/ District Local Governments of Project Area	
	d) Trucks will be covered during haulage of construction materials to reduce on spillage of materials	Recognition of locales of contractor's efforts to minimise dust nuisance.	Project sites & Contractor's/ Supervisor's Office		During construction	NWSC/ District Local Governments of Project Area	
	e) Workers will be provided with PPE and the use of PPE shall be enforced	Complaints of excessive fumes	Project sites & Contractor's/ Supervisor's Office	Direct observation and consultations with workers	During construction	NWSC/ District Local Governments of Project Area	
	f) All surfaced roads shall be subject to road cleaning and un-surfaced roads to dust suppression, the methodology and frequency of which shall be included in the Contractor's Traffic Management Plan	Air quality data (NOx, SO_2, CO, CO_2 and PM, etc as per the national air quality guidelines) / Environmental monitoring report	Project sites & Contractor's/ Supervisor's Office	Consultations with the local authorities - environmental officers	Monthly throughout construction	NWSC/ District Local Governments of Project Area	
8.5.3 Generation of noise and vibrations	**Construction and operation phases**						
	a) Care will be exercised when selecting the working equipment to avoid use of old equipment or damaged equipment with high level of noise emissions that would have a negative impact on the environment. Equipment will be properly maintained and kept fully functional. Servicing of all construction vehicles and machinery will be done regularly and during routine servicing operations, the effectiveness of silencing equitment (e.g. exhaust silencers) will be checked and if found defective will be replaced.	Number of complaints from the communities and authorities/ record of noise levels	Neighbouring communities	Review of complaints records and consultations with nearby communities	Before and during construction	NWSC	-
	b) Construction workers will be made aware of the silent nature of workplaces they are operating in and advised to limit verbal noise or other forms of noise. For example, metallic objects or tools can be passed on to a colleague rather than dropping or throwing them with loud bangs.	Record of noise measurements	Project sites & Contractor's/ Supervisor's Office	Review of environmental monitoring reports	Throughout construction	NWSC	-
	c) All generators and heavy duty equipment will be insulated or placed in enclosures to minimize disrupting ambient noise levels. Pumps, generators and other mobile equipment will be sited as far as practicable from housing and other noise sensitive locations. Regular maintenance, monitoring and, where necessary, the use of silencing equipment will be employed with the aim of reducing noise emissions	Complaints from the communities and authorities/ record of noise levels	Project sites & Contractor's/ Supervisor's Office	Review of complaints records and consultations with nearby communities	Before construction begins	NWSC	-
	d) The contractor will submit detailed information on the noise levels which will be generated by the specific methods and equipment proposed and the actions that will be taken to minimise the noise impact. Equipment shall be operated within their specifications and capacity (for example, avoid overloading machines).	Record of noise measurements/ Environmental Monitoring reports	Project sites & Contractor's/ Supervisor's Office	Review of environmental monitoring reports	Throughout construction	NWSC/ District Local Governments of Project Area	
	e) Noise levels emanating from machinery, vehicles and noisy construction activities will kept at a minimum (within the national noise level limits) for the safety, health and protection of people in the nearby buildings. The vehicles that are excessively noisy shall not be operated until corrective measures have been taken.	Record of noise measurements/ Environmental Monitoring reports	Project sites & Contractor's/ Supervisor's Office	Review of environmental monitoring reports	Throughout construction	NWSC/ District Local Governments of Project Area	5,000,000
	f) During periods of inactivity, equipment will be switched off whenever possible. Where appropriate, residents living in the vicinity of where construction activities are taking place will be kept informed of the contractor's proposed working schedule (through implementation of the Community Liaison Management Plan) and will be advised on the times and duration of any abnormally noisy activity likely to cause concern.	Record of noise measurements/ Environmental Monitoring reports	Project sites & Contractor's/ Supervisor's Office	Review of environmental monitoring reports	Throughout construction	NWSC/ District Local Governments of Project Area	
	g) Project vehicles will have a restricted speed limit of 40 km/h through settlements and trading centres to minimise noise.	Complaints from communities about night time construction activities	Villages close of Project sites & Contractor's/ Supervisor's Office	Review of complaints records and consultations with nearby communities	Throughout construction	NWSC	-

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	h) No construction activities will take place at night for sites where the closest residence is within less than 150 m from the project site, the operations on site shall be restricted to the hours 6.00 -22.00.	Complaints from communities about night time construction activities	Project sites & Contractor's/ Supervisor's Office	Review of complaints records and consultations with nearby communities	Throughout construction	NWSC	
	i) The noise due to blasting operation lasts for a very short period. Primary blasting shall be carried out with adequate preventive measures to control the noise to the permissible limits. Consideration for the nearest habitation shall be at a distance of 500 m from the site boundary. Before blasting is undertaken all the relevant permissions shall be obtained from the Ministry of Internal Affairs Uganda.	Complaints from communities about blast activities	Project sites & Contractor's/ Supervisor's Office	Review of complaints records and consultations with nearby communities	Throughout construction	NWSC/ District Local Governments of Project Area	
	j) Sequential timer blast machine or other approved methods shall be used for primary blasting and there shall be no secondary blasting. The boulders shall be broken using a hydraulic rock breaker. Proper maintenance of the noise generating parts of the machines shall be undertaken. Air silencers of suitable type that can modulate the noise of the engines of machinery can shall also be put in use and maintained effectively.	Complaints from communities about blast and vibration producing activities	Project sites & Contractor's/ Supervisor's Office	Review of complaints records and consultations with nearby communities	Throughout construction	NWSC/ District Local Governments of Project Area	
	k) Ear muffs shall be given to all the workers operating or working close to any machine and full PPE for any persons participating in blasting activities. Periodical monitoring of noise levels and blast vibrations will be practiced and the contract shall ensure that the necessary noise/vibration meters for taking measurements are available.	Complaitns from workers concerning negative impacts of blasting/vibration activities to their health	Project sites & Contractor's/ Supervisor's Office	Review of complaints records and consultations with nearby communities	Throughout construction	NWSC/ District Local Governments of Project Area	
	l) The contractor shall also use control measures like wet drilling to avoiding blasting during high wind speed and development of green belt within the safety barrier of the specific project site and shall ensure that there is no impact of blasting activity in the surrounding area.	Complaints from communities about blast activities	Project sites & Contractor's/ Supervisor's Office	Review of complaints records and consultations with nearby communities	Throughout construction	NWSC/ District Local Governments of Project Area	
	m) Construction activities in the identified sensitive areas *(Bobi Health Centre III (N428086.2, E284815.65), St Thomas O.T.T Primary School (N428498.25, E280335.42), Bobi Sub-county (N428512.54, E282704.61), Ministry of Energy Offices (N421542.49, E248677.74), Koro Abili C.O.U Primary School (N423536.66, E299479.75), St. Peter Paul Catholic Church (N428598.34, E280554.22), MTN Mast (N423534.44, E299676.99) St. Joseph Catholic Church (N429801.34, E276378.46), Minakulu Primary School (N430713.94, E272720.91) Jeroline School (N425855.36, E289522.13), St Baptist Church (N422771.5, E303450.33), Adel Primary School (N431255.18, E270057.49) and St Thomas More Primary School- Minakulu (N423038.87, E302369.94))*shall be scheduled during weekends, stockpiling supplies and materials shall also be done during noncritical times to minimize transport nose. The maximum allowed noise level should be 45dBA for night and 55dBA for evening and day. Measurement of noise level should be performed before the start up with the working activities and during work peaks (of particular importance when project activities take place in the immediate vicinity of the primary school). Restriction or suspension of pipe laying activities during critical times (such as school exam or test times) shall be abided to.	Complaints from communities, especially from schools	Project sites	Review of complaints records and consultations with nearby schools	Throughout construction	NWSC	
ESTIMATED GRAND TOTAL							***170,000,000***

11 CONCLUSION

The proposed project has potential to significantly improve quality of life in the Project District Local Government of Gulu, Oyam, Omoro and Kiryadongo and especially the towns/ municipality being directly served. The long term socio-environmental benefits of a reliable supply of potable water include, but not limited to, reduced morbidity and increased productivity of households; and increased enrolment of children in educational institutions. In addition, project development and operation in the municipality and towns enroute will provide considerable economic opportunity and attraction of other services.

However, development of the project can also bring with it negative impacts. Where there is adequate and reliable supply of water, for example, there is always generation of wastewater. The key significant negative impacts will mainly arise during construction of the project. NWSC should use their vast experience in their respective areas of jurisdiction in supervising the contractor such that the negative impacts are minimised. Operating and maintaining of the water treatment facility should also be done such that adverse effects arising from inadequate management of water treatment residue or wastes are avoided.

If the project is developed and infrastructure put in place operated in conformity with the legal requirements and annual audits conducted following suggestions provided in the ESMPs, the benefits of this project to the nation would by far outweigh potential negative effects.

1 INTRODUCTION

1.1 BACKGROUND

NWSC was established in 1972 as a government parastatal with the mandate of developing, operating and maintaining water supply and sewerage services in urban areas of Uganda. NWSC works under the Ministry of Water and Environment, and currently operates in about 255 towns. NWSC has been operating under three-year renewable performance contracts with the Government of Uganda (GoU) since 2000. Each of the performance contracts defines activities, objectives and indicators that are to be achieved within the three-year contract period.

The MWE and the World Bank have prepared the Integrated Water Management and Development Project (IWMDP) as a successor to the Water management and Development project (WMDP) that came to an end in 2018. The development objective (PDO) of IWMDP is to improve (i) access to water supply and sanitation services and (ii) integrated water resources, planning, and management in Uganda. The IWMDP shall involve construction of Water Supply and Sanitation infrastructure in Rural Communities, Rural Growth Centres and in refugees and host communities. These infrastructures include; Large Gravity Flow Schemes, Rural Growth Centre Water Supply Systems and Sanitation Facilities. Under WMDP, NWSC implemented and completed water and sewerage infrastructure developments in Arua, Bushenyi and Gulu. The infrastructure developments in Gulu were co-financed by the German Development Bank (KfW).

In parallel to the WMDP that was on-going, NWSC and Gulu Municipal Council (GMC) as the Project Executing Agencies (PEA's) commenced the implementation of the Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en route in the Victoria Nile Catchment (IPILC) with financial support from the German Development Bank (KfW). The Engineering and Institutional Development (EIDC) consultancy for the IPILC was signed between NWSC and the joint venture between Fichtner Water & Transportation GmbH, RODECO Consulting GmbH, JV in association with M&E Associates Ltd. & Governance Systems International.

Under the Integrated Water Management and Development Project (IWMDP), NWSC has secured financing from the World Bank though Ministry of Finance Planning and Economic Development (MoFPED) to undertake water supply and sanitation infrastructure developments in Gulu-Karuma, Mbale and Adjumani. In addition, NWSC will undertake full-scale source protection measures in Bushenyi, Arua, Mbale, Gulu – Karuma and Adjumani.

1.2 SCOPE OF PROJECT

The scope of work under the IPILC will involve detailed design and construction supervision of water supply infrastructure for Gulu Municipality and six small towns between Gulu and Karuma based on River Nile at Karuma as a source of water, urban drainage and solid waste management, water and sanitation marketing campaigns and faecal sludge management. The duration of the consultancy services contract is 48 calendar months.

Under the IPILC, the EIDC Consultant will be required to prepare a detailed design, produce tender documents and supervise the construction works for the next phase of construction works which comprises construction of: an intake on River Nile at Karuma; a water treatment plant with station at Karuma; and a bulk water transmission line from Karuma to Gulu and branch off systems to supply at least six (6) small towns en-route from Karuma to Gulu.

1.3 OBJECTIVE OF THE ESIA

The main objective is to carry out a comprehensive environmental and social impact assessment for the proposed project works for provision of improved water supply services in Gulu Municipality and the six towns enroute, that is, Karuma, Kamdini, Minakulu, Bobi, Palenga and Koli Abili. The specific objectives included:

i) Establishment of the project's potential environmental and social impacts and propose measures to mitigate them;
ii) Assessment of the impacts of alternatives and advise the design consultant accordingly; and
iii) Determination of the actions required by NWSC and other stakeholders to satisfactorily address the impacts.

2 WATER SUPPLY AND SANITATION

Gulu Municipality has safe water coverage of 71.8% with 77,770 people out of 152,276 people in Gulu Municipality is served by NWSC. The rest of the populace get water from point sources. A number of these point sources have water quality problems as they are prone to surface and ground contaminations. The district currently has a functionality of about 83%. The hydrology of the springs is variable. Some springs are perennial and some do not have water during the dry season. Most of the springs are located along the rivers (Pece, Oyitino, etc.). Some of them are not springs in a hydrological sense, but 'waterholes' which were excavated manually in those areas, where groundwater is very close to the surface. The water of the springs is basically used by people, who can't afford to buy clean water from NWSC water supply. A number of boreholes too have broken down. Over 370 water points in Gulu district have been recommended for decommissioning (Mostly in former IDP camps) have been capped or closed because people have returned home and they are no longer being used. NGOs used to play a great role in borehole rehabilitation, phasing out of their activities has had a negative impact on functionality.

The present main raw water source for Gulu water supply and the only one delivering water to the water treatment plant is the Oyitino River. The facilities consist of the intake, a pumping station and a transmission main to the drinking water treatment plant in Gulu Municipality.

During some dry years the water level of the reservoir recedes and available quantities are not sufficient to supply water continuously. Additionally, alternative sources in Gulu Municipality, for instance springs, also run dry, so that demand for water from Oyitino reservoir in those times is even higher. There is already an on-going project funded by World Bank to improve water supply and sanitation in the Gulu Municipality under the Water Development and Management Project – Phase I. This is a short-term measure to meet water requirements because Oyitino dam used to dry up during the dry spells (Photo 1) leaving the municipality with no water supply.

Photo 1: State of the Oyitino dam during one of the dry spells with community members collecting fish

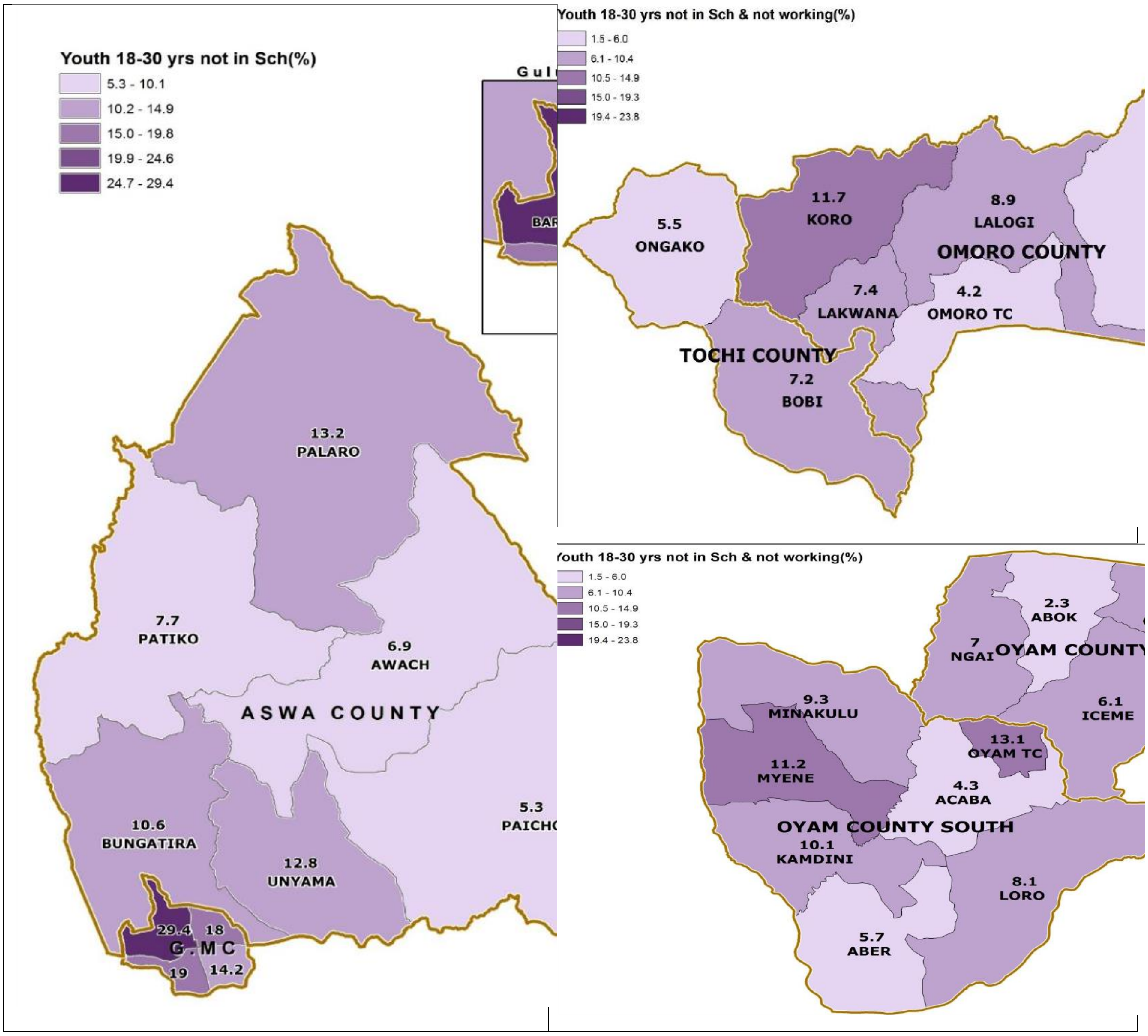
The access rates in Omoro vary from 85 % in Ongako Sub-County to 95 % in Bobi Sub-County. Omoro has 696 domestic water points which serve a total of 169,059 people – 148,618 in rural areas. 180 water points have been non-functional for over 5 years and are considered abandoned. Omoro has 8 piped schemes. The access rates in Oyam vary from 45 % in Kamdini Sub-County to 95 % in Abok Sub-County. Oyam has 1,147 domestic water points which serve a total of 301,956 people – 295,988 in rural areas. 117 water points have been non-functional for over 5 years and are considered abandoned. Oyam has 9 piped schemes. The access to safe water and functionality of the water supply sources in Gulu and Oyam districts is presented in Figure 1. Piped water supply exists in the towns of Kamdini, Minakulu, Palenga and Koro Abili. The remaining centres are served by point water sources such as wells and boreholes.

The piped water supply in Kamdini was designed to provide water supply in internally displaced persons (IDP) camps in Northern Uganda. It consists of a single powered borehole, an elevated tank (see Photo 41) and a distribution system. The system is under the management of the Northern Uganda Water and Sewerage Authority (overseen by WSDF-N). The water tariff is set using a business plan designed to finance operation and maintenance expenses through revenue collected. The water tariff is UGX 2,692 per m^3 and at water kiosks it is Ug.Shs 50 per 20 litres. The water kiosk price is increased to Ug.Shs 100 per 20 litres during the dry season.

At the time of design and construction, the available borehole had a yield of 8.3 m^3/h and fed into a transmission main (about 1.2 km, OD 63 HDPE) towards an elevated tank (capacity 60 m^3, 15 m above mean ground level (AMGL)); the distribution network comprised of some 8.0 km of OD 75 HDPE pipes and a provision for 75 connections at the time of commissioning, comprising of public stand pipes, yard taps and house connections. Currently, the distribution system has undergone a series of expansions to cater for 160 service connections. A new production well with a yield of 9.0 m^3/h is supplying the system since the old well dried up.

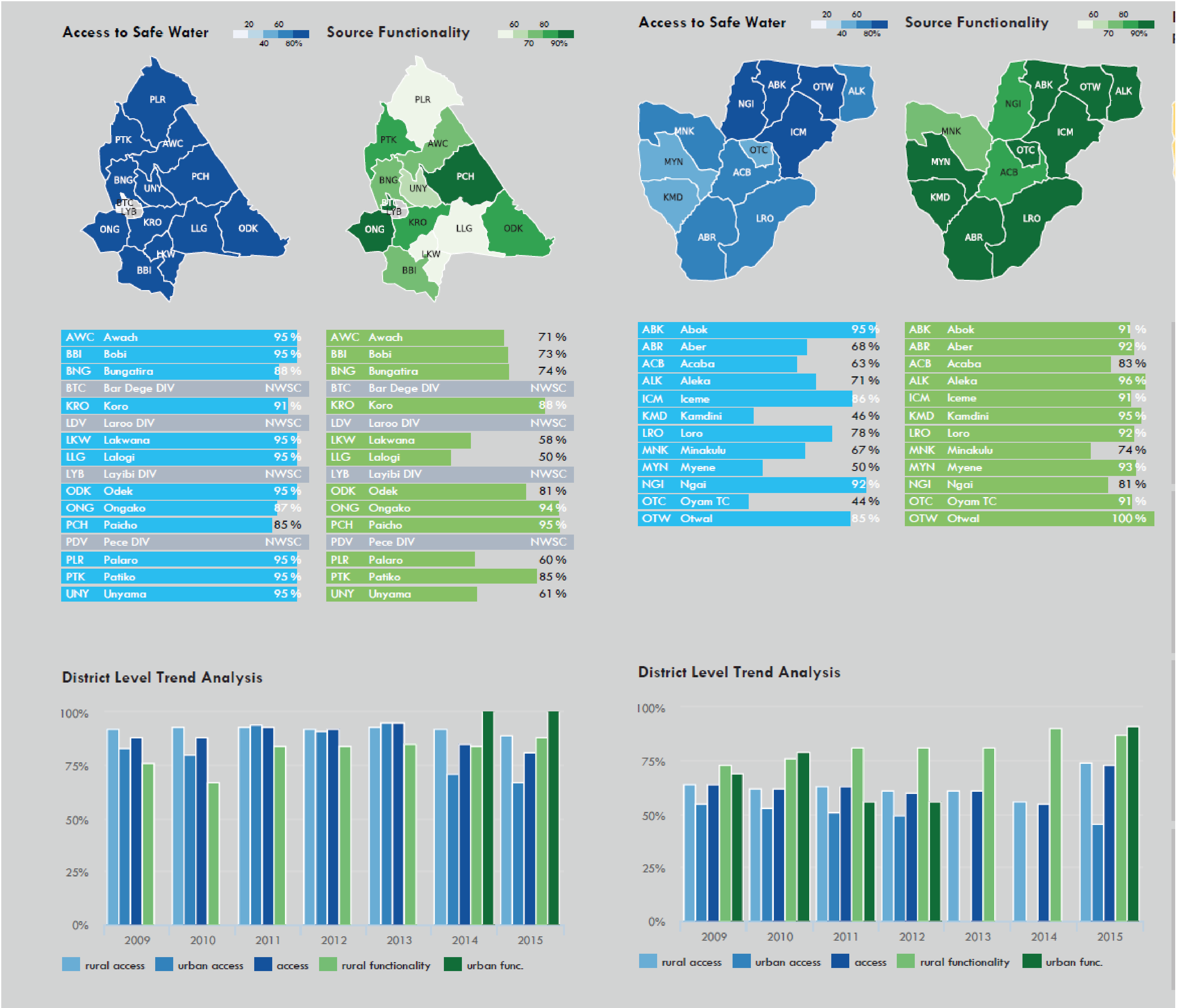
Photo 2: Existing elevated tank in Kamdini

The piped water supply in Minakulu was constructed in the year 2008/2009 to provide water supply in refugee camps in Northern Uganda. It has the same general setup as the system in Kamdini, comprising of a single powered borehole, an elevated storage tank and a distribution system. The system was first managed by the Minakulu sub-county office and is currently under the management of the Northern Uganda Water and Sewerage Authority (overseen by WSDF-N). Like for Kamdini, the water tariff is set using a business plan designed to finance operation and maintenance expenses through revenue collected. The water tariff is Ug.Shs 2,500 per m^3 and at public water kiosks it is Ug.Shs 200 per 20 litres.



Source: DWD, Ministry of Water and Environment, 2017

Figure 1 Percentage distribution of youth population aged 18 – 30 years, not in school and not working in the project districts



Gulu Oyam

Source: DWD, Ministry of Water and Environment, 2017

Figure 2 Access to safe water and water source functionality in Gulu and Oyam districts

At the time of design and construction, the borehole had a yield of 10.4 m^3/h; the transmission line of about 850 m OD 63 HDPE fed into the elevated storage tank (60 m^3 capacity, 15 m AMGL). From here a distribution network of about 8.6 km (DN 125 uPVC to OD 50 HDPE) started with some 75 service connections consisting of stand pipes, yard taps and house connections.

Palenga town has a small water supply system that is managed by the community leaders of Palenga and powered by solar energy. The system consists of a powered borehole and two elevated tanks, 10 m^3 each. Reportedly, the water is pumped every three days to the elevated tanks, depending on the demand which increases during dry season. Water at public stand posts is sold at a price of Ug.Shs 100 per 20 litres.

Photo 3: Existing elevated tank in Minakulu

Koro sub-county has a borehole that supplies water to a reservoir at Layibi (average production 20 m^3/h). The borehole and pumping station were constructed in early 2016 and are operated and managed by NWSC Gulu. The pump is powered by generators and is operated by an attendant as per instruction from NWSC Gulu. The surrounding areas of Koro sub-county are thus supplied by NWSC.

The water quality results at some of the sources sampled is presented in Table 1 and Appendix C. The bacteriological quality of water from some of the water supply points did not meet the required standard (Appendix C).

Table 1: In situ water quality measurements

#	Sampling point	pH	Temperature (°C)	Conductivity (µS/cm)	Total Dissolved Solids (mg/l)	Salinity	Dissolved Oxygen (mg/L)
1	Oyitino Dam	6.49	25.5	209	105	0.10	12.8
2	Layibi Gulu BH	6.54	26.0	144	92	0.07	13.3
3	Tochi Swamp	6.37	22.1	55	28	0.02	14.6
4	Bobi health	6.25	25.0	164	82	0.08	13.7
5	Minalulu swamp	6.55	22.3	68	34	0.03	13.6

#	Sampling point	pH	Temperature (°C)	Conductivity (µS/cm)	Total Dissolved Solids (mg/l)	Salinity	Dissolved Oxygen (mg/L)
6	Minakulu BH	6.40	25.5	110	55	0.05	13.0
7	Myene swamp	6.25	24.2	68	34	0.03	12.4
8	Karuma intake	6.18	26.6	17	46	0.04	11.4
9	Karuma down	6.06	26.6	102	51	0.05	13.0

3 PROJECT DESCRIPTION

3.1 PROPONENTS' CONTACT AND PROJECT COST ESTIMATE

Name and address:

NATIONAL WATER AND SEWERAGE CORPORATION

The Senior Manager - Projects

Plot 3 Nakasero Road,

P.O. Box 7053, Kampala, Uganda

T: +256-31-3315100

E: info@nwsc.co.ug

The estimated project cost is **Twenty Million United States Dollars** (USD 20,000,000).

3.2 LOCATION OF PROJECT SITE

The project area with regard to water supply related physical investments can be categorised into three areas: Nile water transmission including the intake and water treatment plant; and six (6) towns en route (Table 2).

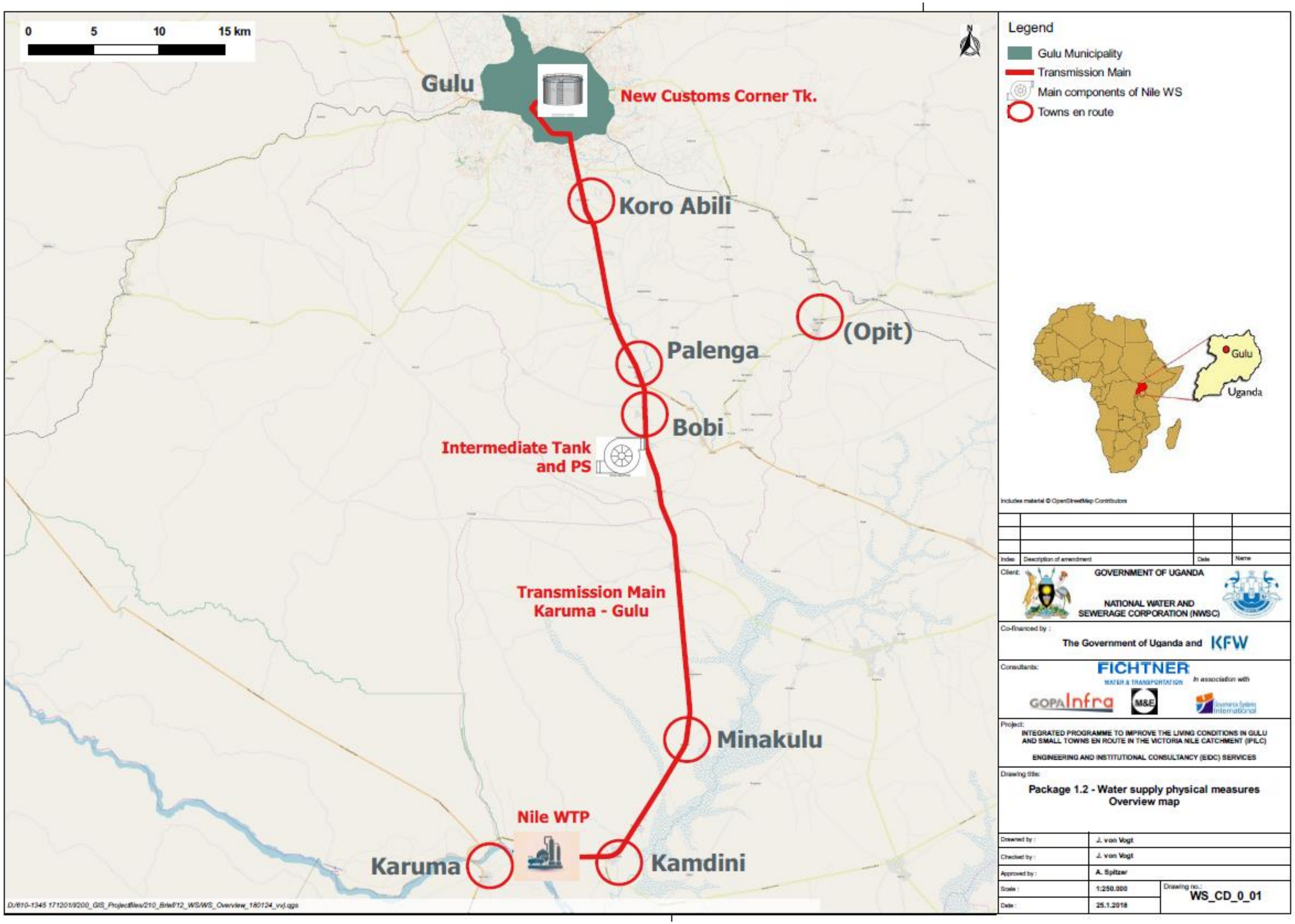
Table 2: Location of the proposed project components

Project Component/ Town	Coordinates (Arc1960, WGS84 System)
Intake works	418820 E, 248514 N
Water treatment plant/works	418921 E, 249195 N
Transmission line	420264 E, 305622 N to 420264 E, 305622 N
Kamdini Town	425614 E, 248340 N
Minakulu	431003 E, 270411 N
Bobi Trading Centre	428561 E, 282394 N
Palenga	426115 E, 289205 N
Kolo Abili	423874 E, 298260 N
Custom's Corner (Reservoir)	420264 E, 305622 N

The intake is located along the northern embankment of the river Nile near the Karuma HPP, approximately 500 m upstream of the concrete dam.

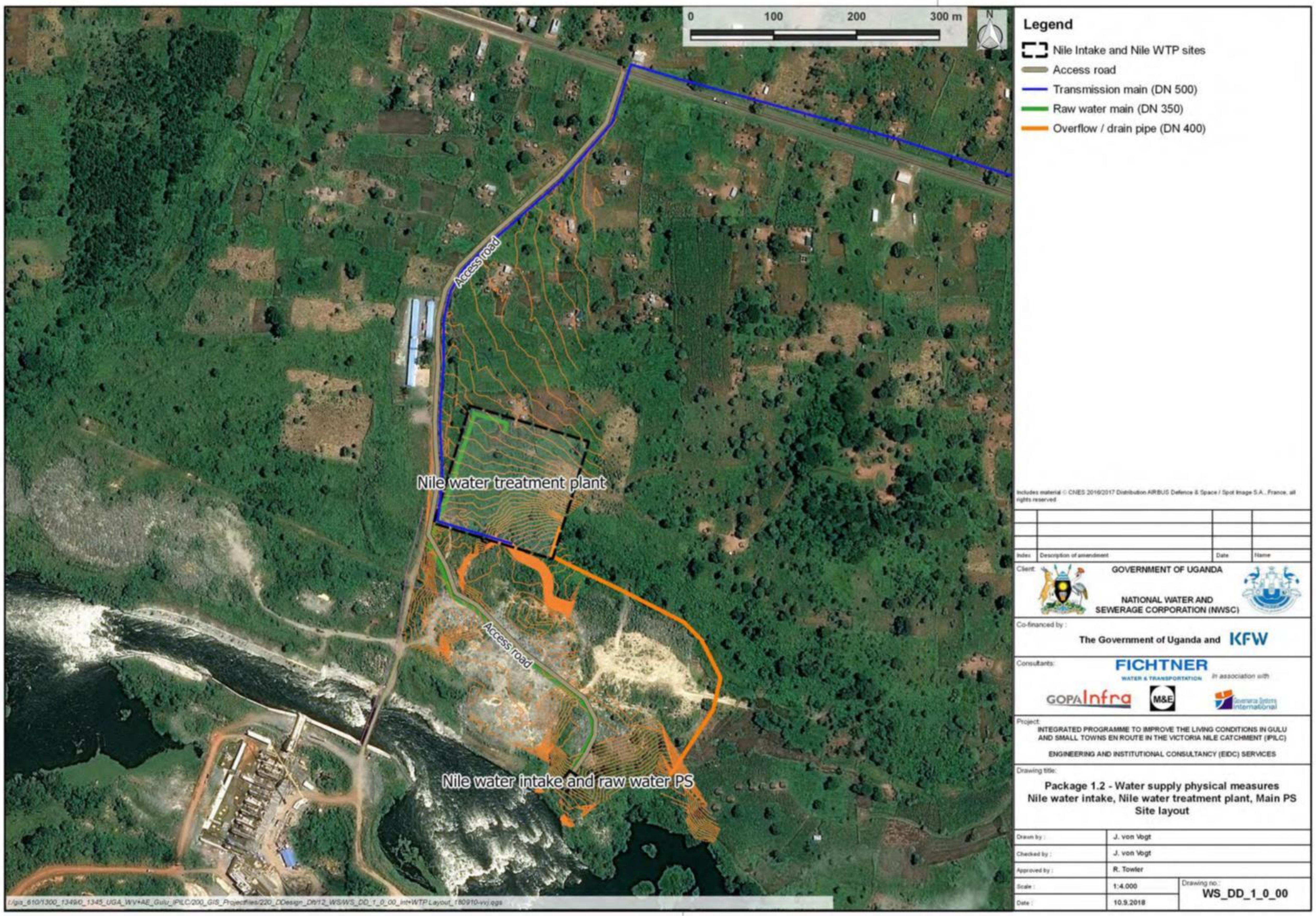
To minimize earthworks and to make use of natural topographic conditions the WTP will be constructed in an area of a well-defined natural slope which allows for a gravity-driven treatment process within the plant. The WTP will be located 230 m north-east of the Karuma HPP's diversion channel and with an approximate area of 150 m $\times$ 50 m.

The area of the Nile water transmission system extends from the northern embankment of the River Nile (Figure 3) between Kamdini and Karuma up to the existing Customs Corner Reservoir in Gulu. The transmission main routing basically follows the main road Karuma-Gulu (Figure 4). Six (6) small towns along the route of the transmission main, namely – from South to North – Karuma, Kamdini, Minakulu, Bobi, Palenga and Koro-Abili, will also be supplied by the Nile water transmission system.



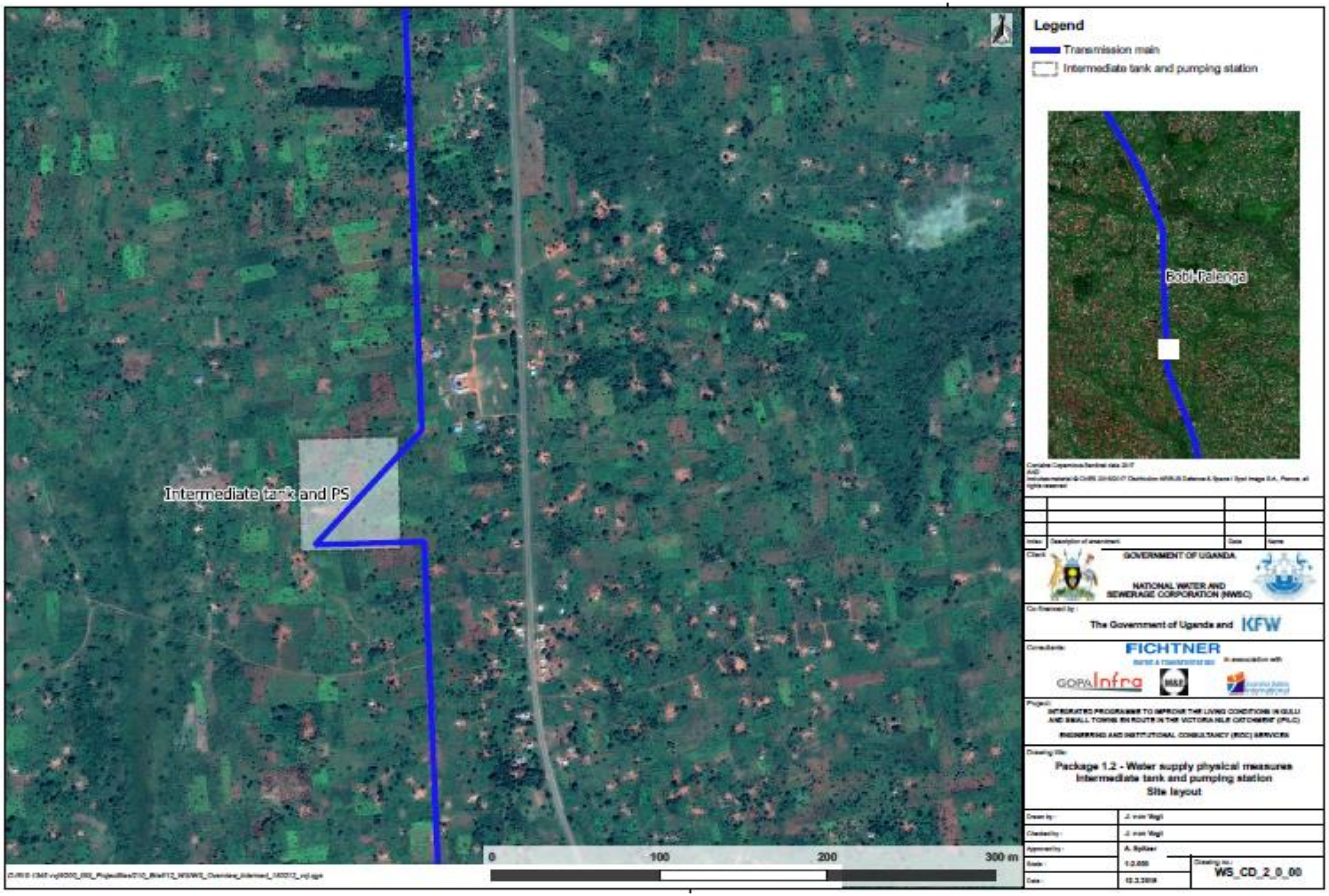
Source: Fichtner & GopaInfra, 2018

Figure 3 Towns en route the transmission main



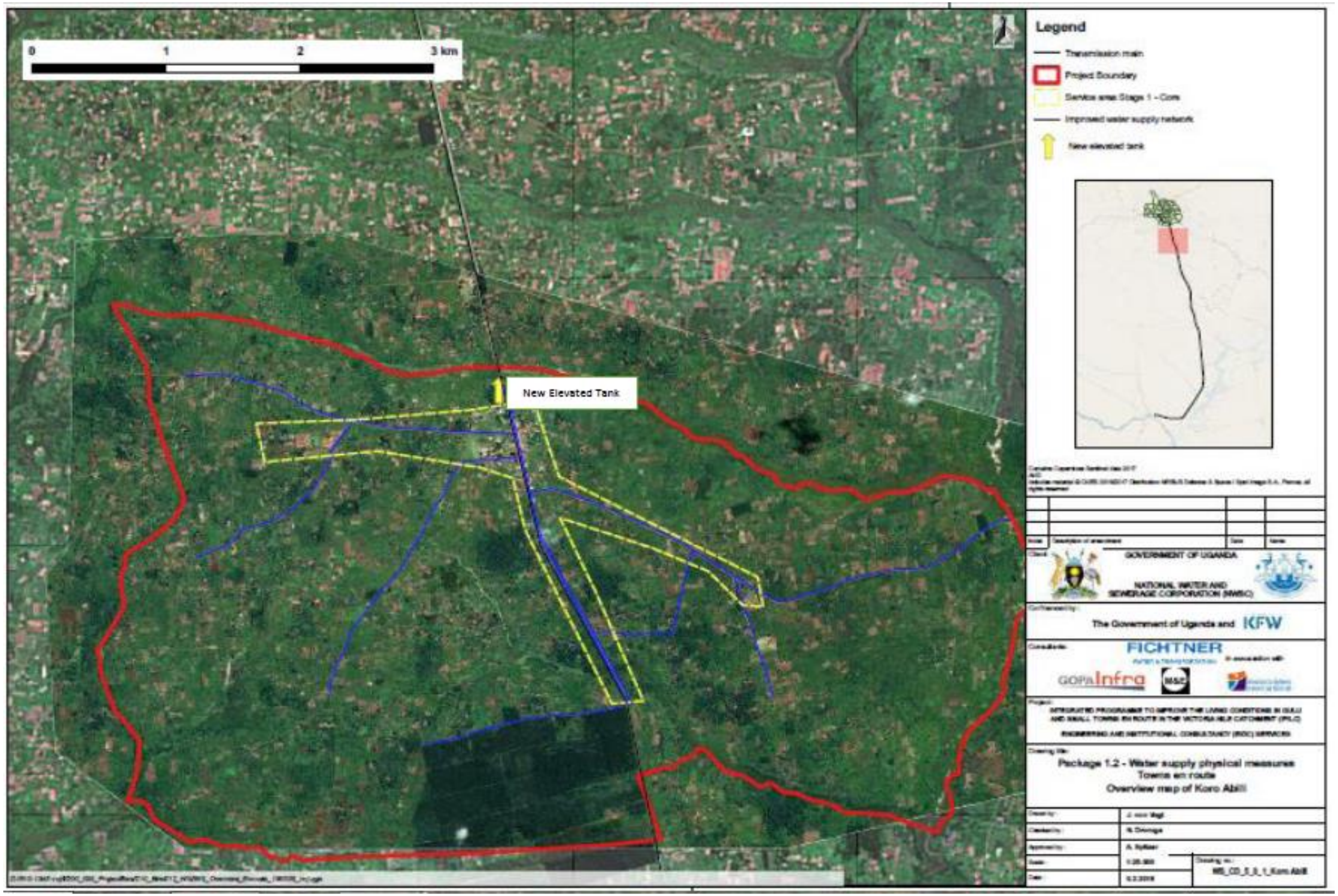
Source: Fichtner & GopaInfra, 2018

Figure 4 Location of the intake and water treatment plant on the northern bank of the Victoria Nile



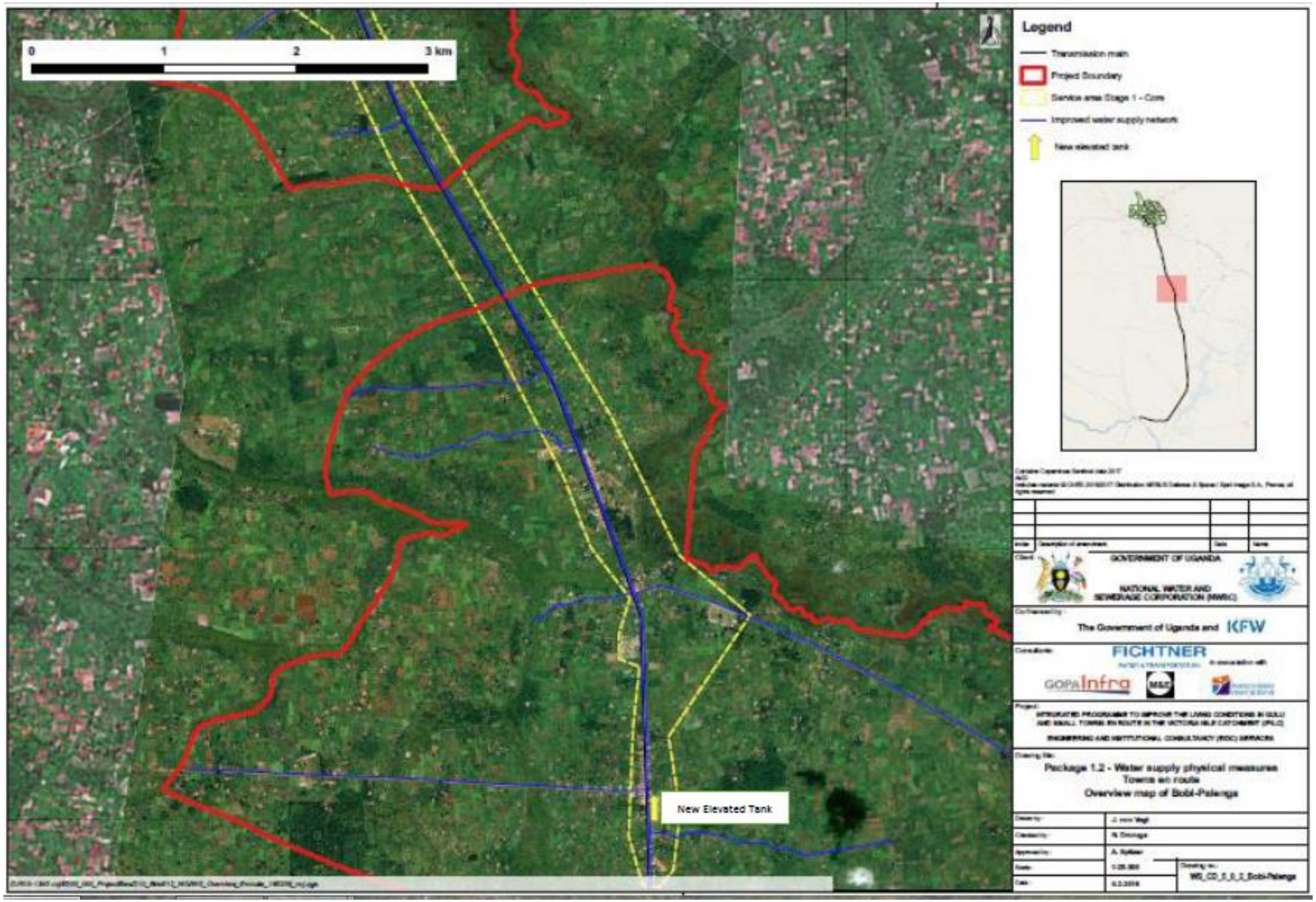
Source: Fichtner & GopaInfra, 2018

Figure 5 Location of the intermediate tank and pumping station at Bobi-Palenga



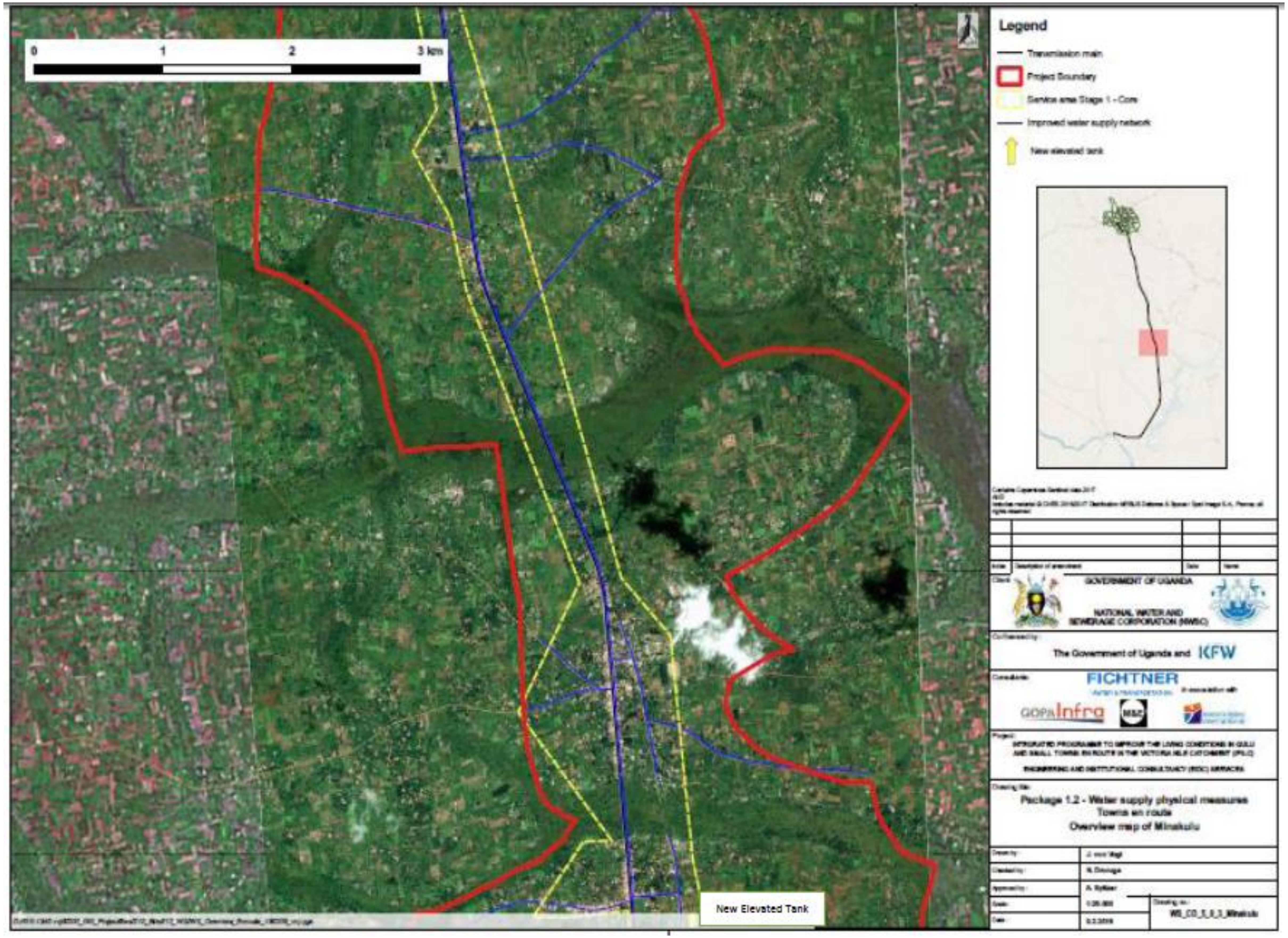
Source: Fichtner & GopaInfra, 2018

Figure 6 Location of the new elevated water tank



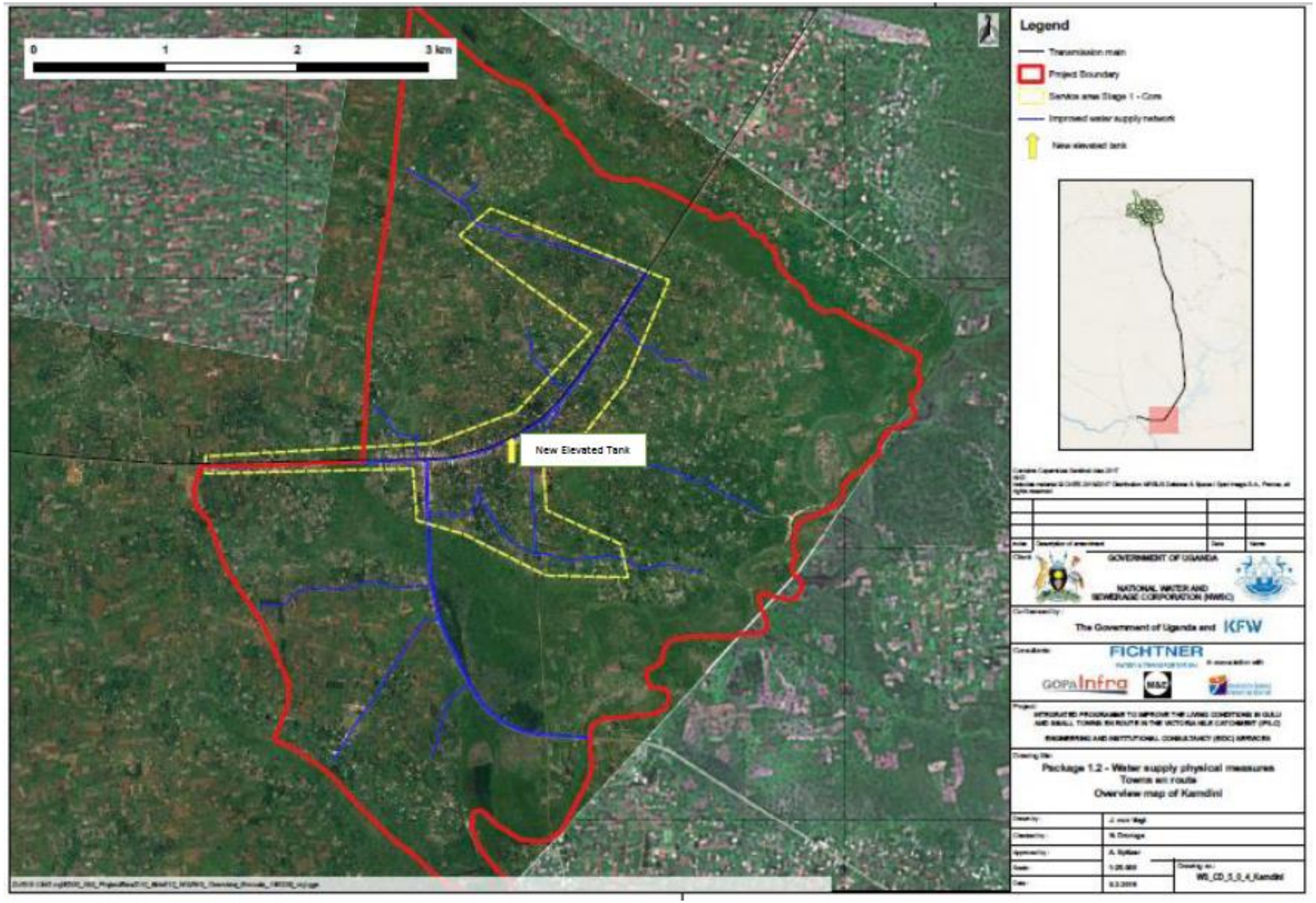
Source: Fichtner & GopaInfra, 2018

Figure 7 Location of another new elevated tank



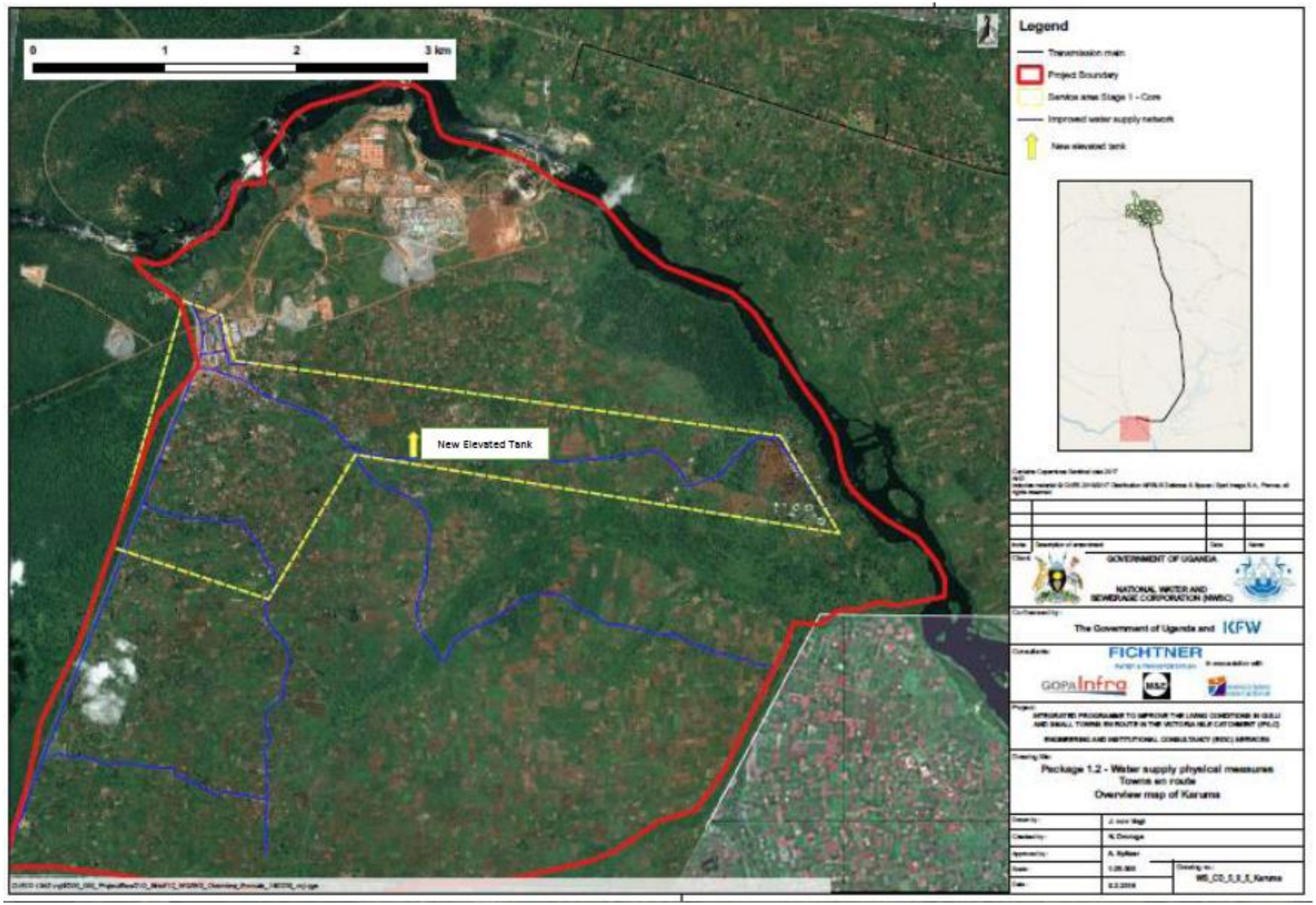
Source: Fichtner & GopaInfra, 2018

Figure 8 Location of another new elevated tank



Source: Fichtner & GopaInfra, 2018

Figure 9 Location of another new elevated tank



Source: Fichtner & GopaInfra, 2018

Figure 10 Location of another new elevated tank

3.3 PROJECT COMPONENTS

3.3.1 Nile Water Intake and Raw Water Pumping Station

The intake structure shall be designed to allow for abstraction of the 2040 design flow of 30000 m^3/day. The electro-mechanical equipment to be installed at this stage shall allow for the 2025 design flow of 15000 m^3/day. The raw water extraction structure consists of 2 inlet channels with screens and 2 pump chambers. The redundant design ensures safe water extraction from the River Nile.

a) Height and structural arrangement

The height classification is determined by the planned water levels of the dam:

- Design and normal water level 1030 masl
- Dead water level 1028 masl

The minimum water level (dead water level) is only a theoretical value and means that there is no reserve capacity. Therefore, it is expected that in normal operation the water level will vary between above 1029 and 1030 masl.

Furthermore, the following heights have been considered:

- Dam crest 1032 masl
- Measured current water level approximately 1025 masl
- Bottom sill elevation 1013 masl

In order to prevent the entry of floating matter, the upper level of the inflow channels was pre- set to 1028 masl while the bottom of the channels is set at a height of 1027 masl.

b) Structure

The intake structure comprises two inlet channels (box profile with width $\times$ height = 2.0 $\times$ 3.6 m and 3.0 $\times$ 4.6 m). Channels are about 25 m long and divert raw water to the pump sump. The pump sump comprises two chambers which are interconnected, with one of the chambers having two submersible pumps (1 operation + 1 standby) and the other chamber with one submersible pump (1 operation). The pump sump shall have total dimensions of about length $\times$ width $\times$ height: 11.0 $\times$ 4.5 $\times$ 5.0 m.

c) Screens

In each inlet channel, the following sequence of equipment is provided for the retention of floating matter:

<u>Inlet openings to the channels – coarse deflector:</u> A coarse deflector is placed and consists of robust steel square bars, which are installed at a distance of 300 mm. This is to prevent the penetration of large propellants, which could damage the subsequent equipment.

<u>Automated coarse screen:</u> The coarse screen consists of cable-operated cleaner for bar screens with a bar distance of 40 mm. The cleaning will be done with claw grippers with electrical swivelling and lifting drive. For emergency cases / system failure, a manual operation with crank is foreseen, the respective equipment shall be provided.

Fine screen: The fine screen consists of a rake with a bar distance of 10 mm. Cleaning is done with revolving chain screen.

Fine screen-circulating performed belt (optional): To protect the raw water pumps no further pre-treatment is required. An additional fine screen can optionally be provided for the WTP. This consists of a rotating belt system. The plates are provided with holes diameter 0.8 mm. The operation is programmable based on:

- Time settings;
- Water level measurement before and after the fine screen; or
- Manual operation.

It needs to be noted that – despite automated operation - a fine screen requires constant and intense maintenance.

Pump protection: In the pump sump, a wire basket with a mesh size of 20 × 20 mm is installed to protect pumps. Wire baskets are made of steel and can be pulled up for cleaning.

d) Barriers

For decommissioning of inlet channels and / or pump chambers the following equipment is provided:

- Channel penstocks
- Stop logs

e) Raw water pumps and raw water line

Submersible pumps in block design with free-flow impellers are used as raw water pumps. These are designed with elbow and rope technology for easy assembly and disassembly. The pressure line to the Nile water treatment plant is equipped with backflow preventer, gate valve and manometer, all installed above ground.

The pumps are switched on via soft starter. A control of the flow rate through frequency inverters is not provided. Consequently, the WTP can be operated with 50 or 100 % of the treatment capacity.

Technical parameters of pumps:

- Number 3 pieces: 2 in operation, 1 standby
- Flow of one pump: 330 m^3/h
- Delivery head: 3.6 bar
- Power demand: 65 kW
- Electric motor: 80 kW
- Power supply: 400 V or 690 V
- Efficiency of pump: 50 %

The raw water pipeline is designed in the dimension DN 400. In the area of intake a wash out is arranged. The raw water pipeline will be laid along the access road to the WTP. Layout and sections of the structure itself are presented in Annex D.

f) Source protection of Nile water intake

The entire catchment area of the Victoria Nile is extremely large and its conservation and protection is way beyond the scope of this project. However, NWSC is developing water source protection plans for 1 km section upstream of the intake.

Security of supply in terms of water quality has to be provided through the Nile Water Treatment Plant. However, the immediate intake area shall be fenced off to restrict access for animals and unauthorized persons. A permanent guard is required. In addition, an environmental management plan will be implemented in the fenced off area, ensuring that the environmental impact of the operations are minimised.

Inside the fenced area no potentially environmentally adverse activities shall be allowed, such as

- Installation of pit latrines,
- Agriculture,
- Livestock grazing,
- Disposal of any kind of waste,
- Storage and handling of fuel, oil or any other hazardous substances.

3.3.2 Nile Water Treatment Plant and Processes

The Nile water treatment plant (Nile WTP) will be constructed in two stages, with the first stage having a capacity of 15000 m³/day and the second stage (approximately due in 2040) will expand the plant's total capacity to 30000 m³/day.

The water treatment processes will comprise of:

- Pre-chlorination using chlorine gas (inline mixer in raw water pipe);
- Flocculation using aluminium sulphate in a mixing basin equipped with fast-running mixers;
- Dosing of polyelectrolyte as coagulation agent in a mixing basin equipped with slowly- running mixers, accompanied by pH-adjustment through addition of lime milk;
- Contact chamber with recirculated sludge (from tube settler) to foster formation of macro- flocs even at lower turbidity of raw water;
- Tube settler for sedimentation;
- Filtration through single-medium filters;
- Increase of hardness of treated water by dosing of carbon dioxide and lime milk; and
- Final chlorination by dosing of chlorine gas.

The sludge obtained from the treatment process will be treated as follows:

Sludge from filter wash:

- Sludge from filter wash will be collected in a buffer basin;
- Downstream of the buffer basin, polyelectrolytes will be dosed before processing the sludge in a flocculation reactor; and
- Flocculated sludge is received in sedimentation basin in which separation of clear phase (discharge to river Nile) and settled sludge is achieved (to be treated jointly with sludge from tube settlers).

Sludge from tube settlers:

- Sludge from tube settlers will be constantly evacuated by sludge pumps;
- Evacuated sludge will be pumped to sludge conditioning basins (which as well receive settled sludge from filter wash);
- Dewatering of sludge will be realized using chamber filter presses;
- Water obtained from chamber filter presses will be pumped to the buffer basin from filter wash;
- After dewatering, the solid sludge must be disposed at a landfill.

a) Pre-Chlorination

Pre-chlorination is required to prevent potential contamination by microbiological growth within the treatment plant. This primarily concerns the filter system. If the filter material is loaded with biologically active microorganisms, the filter bed operates as a fixed bed reactor and, as a result, microorganisms can multiply very quickly.

Furthermore, the pre-chlorination is used for the oxidation of ammonium and iron. The use of calcium or sodium hypochlorite should be avoided as it produces undesirable reaction by- products. Therefore, pre-chlorination will be realized using chlorine gas.

b) Coagulation, flocculation, pH-adjustment and sedimentation

The raw water contains settleable, filterable and non-filterable solids. The non-filterable sus- pended solids are called colloids. Colloids do not settle as they repel each other due to their surface charge and, because of their small diameter, they cannot be directly filtered either.

By adding a metal salt (aluminium sulphate or iron-III chloride) the colloids' surface charge is neutralized and the colloids start forming micro flocs. However, these micro flocs still do not settle. At low contents of suspended solids (up to around 30 mg/l), micro flocs can be filtered directly and thus removed from the water.

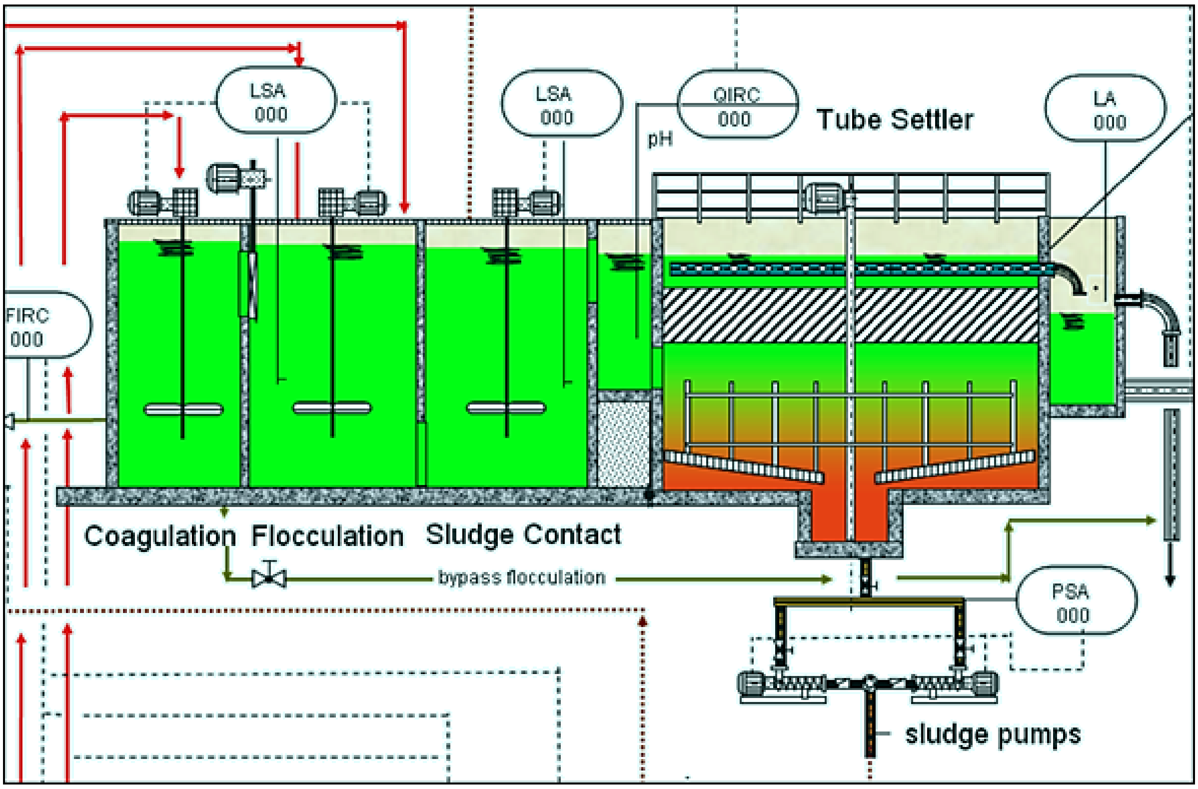
Usually dosing of 40 – 60 mg/l aluminium sulphate is necessary to destabilise the colloids. Dosing of aluminium sulphate causes the formation of aluminium hydroxide, which increases sus- pended solids contents in the water. Considering these additional concentrations of suspended solids, a filter system would block quickly and, thus, very high amounts of treated water for filter back wash would be required. Therefore, in the present case, suspended solids need to be primarily removed via a sedimentation stage upstream of the filter stage.

In order to make colloids settable, the micro flocs caused by dosing of aluminium sulphate need to form bigger macro flocs. This happens by dosing polyelectrolytes in a flocculation chamber right after the coagulation chamber.

On the other hand, low concentrations of suspended solids need to be considered as well. Low concentrations of suspended solids make coagulation very difficult since the distance between the flocs is large. Hence, triggering of coagulation requires high amounts of polyelectrolyte.

This is why, after coagulation and flocculation, a sludge contact chamber needs to be installed to guarantee a sufficient concentration of flocs. From the sedimentation tank (tube settler), the required amount of sludge / flocs is returned to the contact chamber to foster the formation of macro flocs without dosing excessive amounts of polyelectrolyte.

The corresponding process is visualized in Figure 11.



Source: Fichtner & GopaInfra, 2018

Figure 11 Overview on the process for coagulation, flocculation and sedimentation

However, it has to be considered that dosing of aluminium sulphate $Al_2(SO_4)_3$ results in the formation of hydrogen, as indicated by the following chemical equation:

$Al_2(SO_4)_3 + 6\ H_2O \rightarrow 2Al(OH)_3 + 3SO_4^{2-} + 6\ H^+$

Alternatively to aluminium sulphate, poly-aluminium chlorides (PAC) can be used, which results in the formation of hydrochloric acid:

$Al_2(OH)_3Cl_3 + 3H_2O \rightarrow 2Al(OH)_3 + 3HCl$

Surface water often has a low alkalinity and, therefore, a low buffering capacity. In the case of such water properties the pH value also changes rapidly even at low dosing of acid or alkali. Besides, chlorination of the water additionally tends to cause a decrease in pH value. It must be considered that aluminium, like other metals, remains only sparingly soluble in a certain pH range, as indicated in the Figure 12.

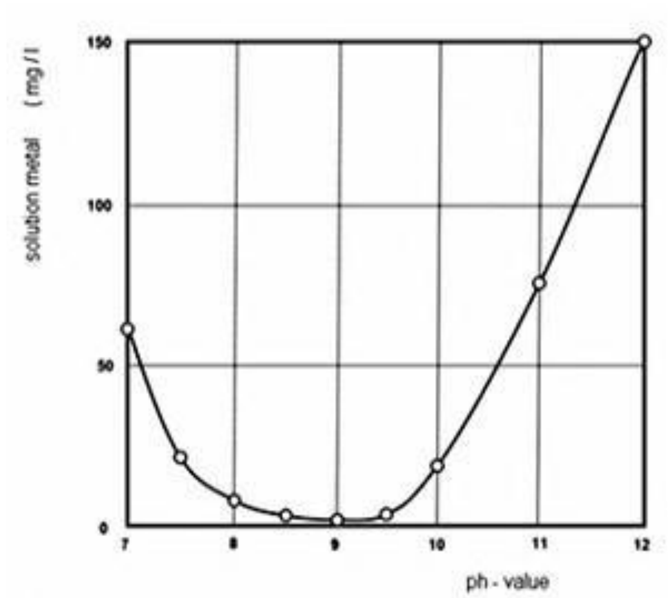


Figure 12 Solubility of metals depending on pH value

As a matter of course, aluminium can only facilitate formation of stable micro flocs if it remains undissolved after dosing. If the admissible pH range is exceeded or undershot, aluminium is dissolved. Once dissolved, aluminium is not retained in the filter and it remains in the drinking water. This is a common problem in numerous drinking water treatment plants and, although controversially discussed for decades, the ingestion of aluminium is believed to be linked to the occurrence of Alzheimer's disease.

Hence, in order to avoid a rapid decrease of pH value during flocculation it is absolutely necessary to correct the pH value by dosing of lime milk.

From the sludge contact chamber, the water flows to the sedimentation tank where the sludge flocs are separated from the water. To save space a tube settler is recommended; the permissible hydraulic load of a tube settler (ideally square-shaped) is 3 to 5 times higher than that of an ordinary sedimentation tank.

In lamella / tube settlers, the water flows through lamellae / tubes from the bottom to the top. As with ordinary settling tanks, the force resulting from upward force and gravity causes the sus- pended solids to settle. Each space between the lamellae represents a settling unit. As soon as the solids settle onto the inclined area they slide down in counter-current direction towards the sludge hopper and the thickening section at the bottom of the structure.

The surface of the lamellae / tubes should be perfectly smooth so that the sludge can slide down easily. The rising clear water is drawn off via a system of perforated pipes that is placed above the lamellae or tubes.

At the bottom, the sludge is drawn off via eccentric screw pumps. A portion of the sludge is transferred back to the contact chamber (see above). The excessive sludge is pumped to the sludge treatment stage. Thanks to the high water column in the tube settler the sludge is thickened well enough, avoiding the need of an additional sludge thickener. After sedimentation, the water should have a remaining solids content of maximum 5 mg/l. If dosing of aluminium and polyelectrolytes is performed correctly, colour and turbidity may even reach the values close to zero.

c) Filter plant

From the sedimentation stage, the water is gravity-fed to the filter plant. If coagulation / flocculation is performed correctly, the time between two filter washings (filter running time) can be ex- tended up to several days, which allows minimizing the wash water and energy consumption. The filter contains a sand layer with grain sizes between 0.7 and 1.2 mm. Below the filter sand is a gravel layer as supporting material. The gravel (thickness 30 cm to 35 cm) helps to equally distribute the water over the filter bottom. The bottom is made from concrete and contains holes which are covered by nozzles. Per square meter, around 70 – 90 filter nozzles are installed (see Photo 4).

Photo 4: Nozzles at bottom of filter (left), and filter filled with sand (right)

The water flows through the filter cell from top to bottom. The filtered water is collected l in a chamber underneath the filter bottom and then transferred via the clear water pipe to the treated water tank. While the filter is operated, suspended solids are retained in the filter sand, increasing head losses in the filter material. To overcome the loss in pressure, the water level above the filter sand rises. As soon as the water level has reached a certain height above the filter layer (around 2 m), filter washing is required.

d) Washing of filters and treatment of filter wash water

The filter washing process combines water washing (with filtered water) and air flushing. Automatic filter washing is recommended in order to minimize water losses. The specific wash water consumption should not exceed 6% of the filtered water. If the washing is performed manually, water consumption amounts to between 8% and 10% of the throughput capacity. The following wash water velocities were assumed:

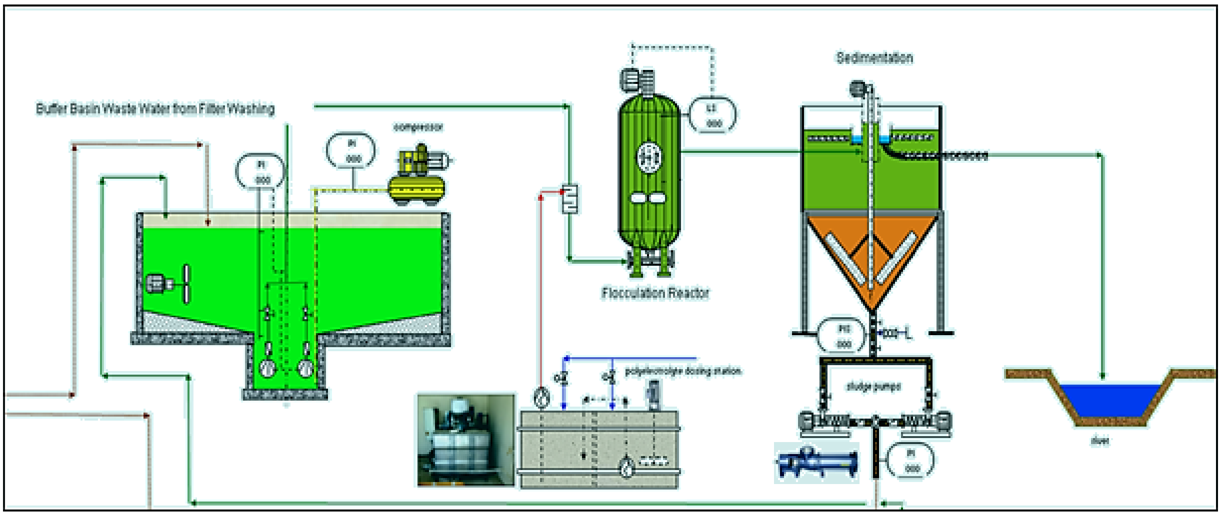
<u>Phase 1 – Combined water / air washing:</u>

- Water velocity: 10 m/h – 15 m/h,
- Air velocity: 70 m/h – 80 m/h.

<u>Phase 2 – Only water washing:</u>

- Water velocity: 22 m/h – 25 m/h.

The waste water that results from the filter cleaning flows intermittently into a buffer basin. Until the next filter washing, there is time for processing the waste water from the buffer basin. Downstream of the buffer basin, polyelectrolyte will be dosed before processing the sludge in a flocculation reactor. Flocculated sludge is received in sedimentation basin to separate the clear phase, which is discharge to River Nile, and settled sludge, which is to be treated jointly with sludge from tube settlers.



Source: Fichtner & GopaInfra, 2018

Figure 13 Treatment of water from filter wash

e) Treatment of sludge from tube settler

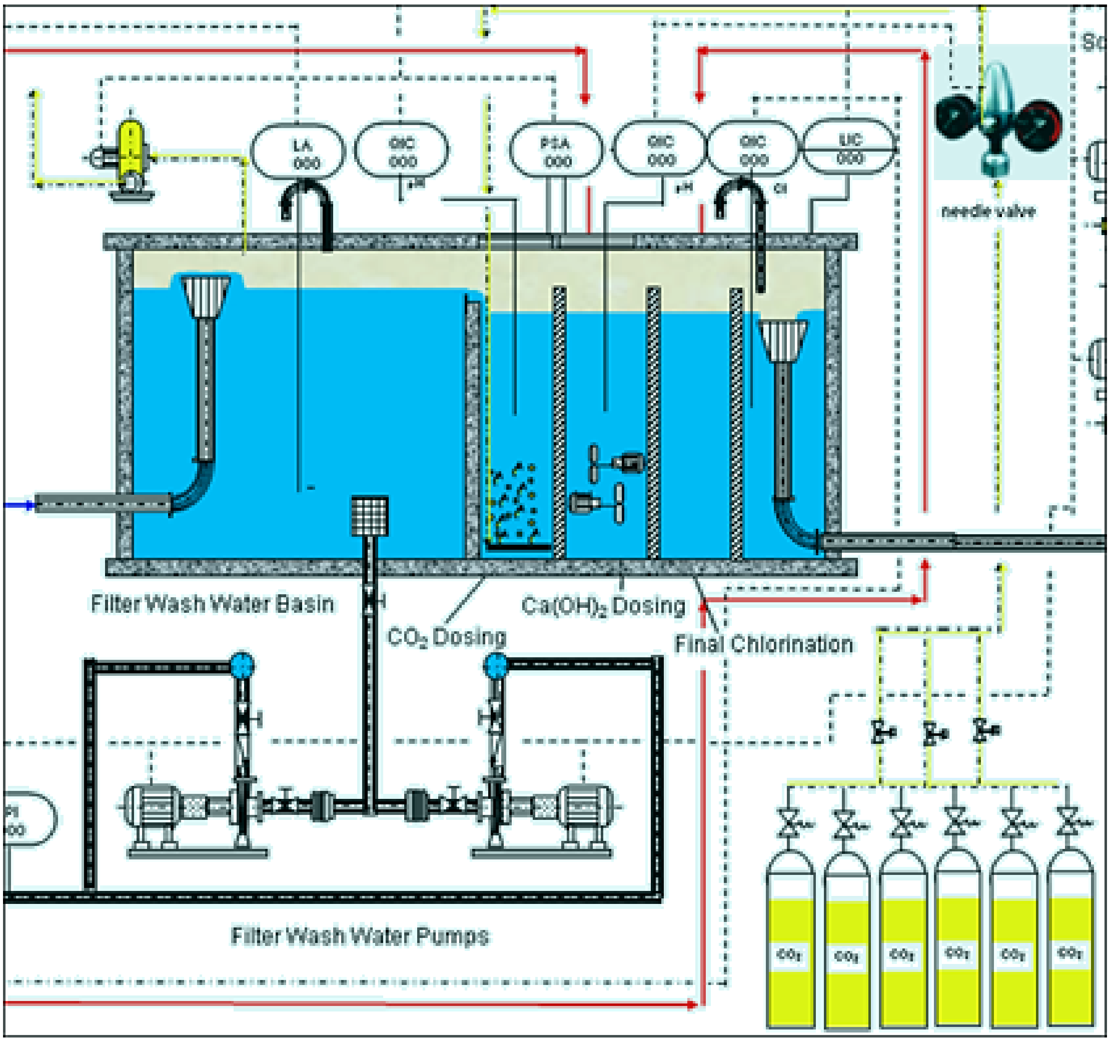
Sludge from tube settlers will be constantly evacuated by sludge pumps, and the evacuated sludge is pumped to sludge conditioning basins (which as well receive settled sludge from filter wash). Dewatering of sludge will be realized using chamber filter presses. The water obtained from chamber filter presses will be pumped back to the buffer basin from filter wash. After de- watering, the solid sludge must be disposed at a landfill.

f) Mineralization of treated water

As stated above, usually the carbonate hardness of surface water is low. Depending on the pH value, there is an interaction between carbonate hardness and carbon dioxide (CO_2) in the water. If at a given pH value the CO_2 concentration equals the carbonate hardness, the water is balanced. If the CO_2 concentration is lower, lime precipitates. In contrast, if the CO_2 concentration is high- er, lime is dissolved in the water to restore the balance. The excessive CO_2 in the surface water results in carbonic acid which is aggressive and can cause corrosion in the pipes. This is particularly dangerous for long transmission pipes. There- fore, the balance between lime and carbonic acid in the water needs to be ensured before pumping it into the pipe network.

In the present case, the raw water shows low values of both pH (around 6.3) and alkalinity (approximately 52 mg/l $CaCO_3$ eq, 2.9 °dH, 1.05 mval/l), which corresponds to a balanced pH value which is much higher than the one observed. For balanced conditions a pH value of around 8.1 would be required. In consequence, the water acts corrosive (and dosing of aluminium and chlorination would cause the pH value to drop even further). The lime carbonic acid equilibrium in the treated water is achieved by increasing its carbonate hardness, which is realized by dosing of carbon dioxide and lime milk (Figure 14). The carbon dioxide reacts with the lime milk and produces bicarbonate. The process must be monitored and regulated.

$2\ CO_2 + Ca(OH)_2 \rightarrow Ca(HCO_3)_2$



Source: Fichtner & GopaInfra, 2018

Figure 14 Hardening of treated water by dosing of CO_2 and lime milk

The recommended alkalinity before pumping is about 134 mg/l $CaCO_3$,eq (7.50 °dH, 2.68 mval/l), which requires a value of free carbonic acid of approximately 4.20 mgCO_2/l and a pH value of approximately 7.90.

g) Final chlorination

To protect the pipes from germs and to avoid recontamination, a final chlorination is required before the water is pumped to Gulu and towns enroute. The dosage of chlorine (chlorine gas) depends on the water throughput and the chlorine concentration will be monitored.

h) Chemical dosing building

Preparation and mixing of the chemicals dosed in the water treatment process will be realized in a central building, as visualized Photo 5.

Source: Fichtner & GopaInfra, 2018

Photo 5: Typical chemical dosing building

i) Clear water tank

The clear water tank will receive water from the Nile WTP. The tank and the subsequent main pumping station are located in the south-eastern part of the site, as this area is the lowest. The water reservoir is designed for approximately 2 hours delivery of the pumps. The technical parameters of clear water reservoir are:

- Shape: Rectangular
- Structure material: Reinforced concrete
- Capacity: $2 \times 625 = 1{,}250$ m³
- Number of chambers: 2
- Dimension of chambers (width × length): 9.6 m × 13 m
- Maximum water level: 5 m

j) Main pumping station

The main pumping station (Main PS) draws water from the clear water tank. To ensure a pre- pressure on the pumps, the upper edge of the base plate is placed approximately 1.00 m below the surface of the terrain.

Horizontal pumps with radial or semi-radial impellers and low NPSH are used as clear water pumps. The pressure pipes are equipped with backflow preventer, gate valve and manometer.

Pumps are switched on via soft starter. A control of the flow rate through frequency inverters is not provided. Consequently, the main PS can be operated with 50 or 100 % of the pump capacity. The difference between the clear water inflow from the WTP and the pump flow will be equalised by the clear water tank.

The pressure level and length of the transmission main to Gulu make surge protection equipment mandatory. Such shall be located outside the building.

Technical parameters of pumps:

- Number: 3 pieces (2 in operation, 1 standby)
- Flow of one pump: 350 m^3/h
- Efficiency of pump: 78 - 80 %

Technical parameters of building:

- Shape: rectangular
- Structure material: reinforced concrete, walls made of brick
- Dimension of building: width x length = 11 m $\times$ 23 m
- Access Gate: width 2.5 m

3.3.3 Nile Water Transmission System

The Nile water transmission system comprises of the following elements:

- Transmission main (TM);
- Intermediate tank; and
- Intermediate pumping station.

The transmission system will allow for conveyance of 15,000 m^3/day required until the intermediate design horizon. For the second stage (approximately due in 2025, demand 30,000 m^3/d), additional electro-mechanical equipment will be required in the intermediate pumping station but no additional pipe laying works become necessary.

TM - Pipe lengths and general requirements: The length of the transmission main measures approximately 71 km of different diameters as shown in Table 3.

The transmission main shall be laid in a trench with a minimum cover of 1.20 m.

TM - Pipe material and jointing: The transmission main shall be of ductile cast iron (DI), internally protected with cement mortar suitable for drinking water; external coating shall be of Zinc.

Alternatively – in line with the decision taken by NWSC (refer to chapter 9.1) - the design shall allow for installation of steel pipes with spigot-socket connections. Typical drawings will be elaborated to allow for connection of appurtenances along the pipeline.

Table 3: TM – Pipe lengths for intermediate design horizon 2025

Diameter (mm)	Nile WTP → Intermediate tank (m)	Intermediate tank → Customs Corner tank (m)	Total length (m)
DN 700	22,500	-	22,500
DN 600	18,980	24,920	43,900
DN 500	-	4,600	4,600
Total section	**41,480**	**29,520**	**71,000**

Source: Fichtner & GopaInfra, 2018

TM - Transmission main alignment: The alignment of the transmission main follows the main road from Karuma to Gulu; the pipeline shall be laid along the outer edge of the western road reserve. In Gulu the pipeline branches off into Sira - Dongo Road and follows it up to Customs Corner (still on the left side of the street). At the petrol station it turns into the Arua - Gulu road and follows it on the right hand side (south of the road) up to the existing Customs Corner Tank. Typical cross sections, indicating the location of the pipeline in relation to the main road are presented in Annex D (Drawing WS_CD_9_4_01).

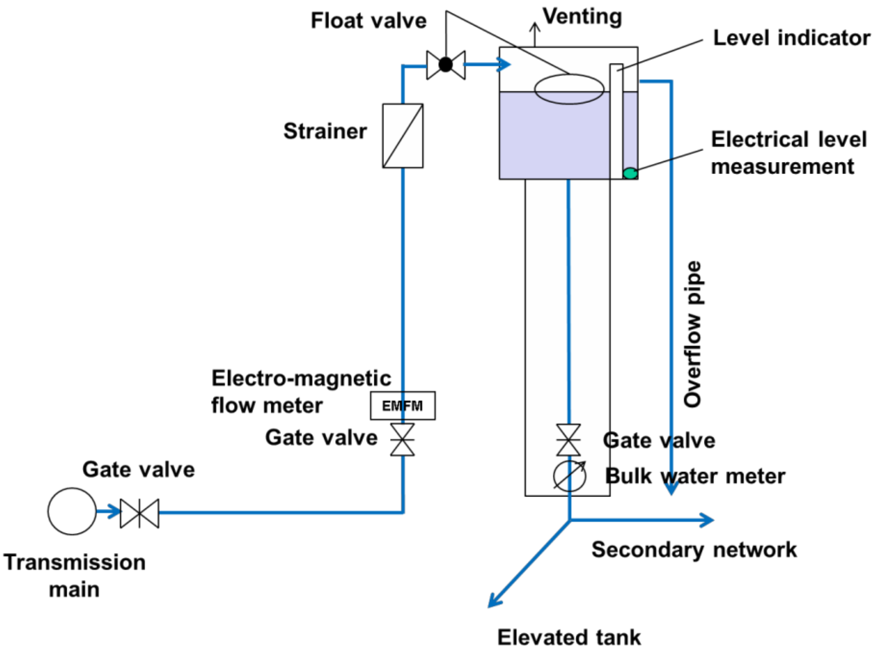
TM – Pipeline appurtenances: Sectional valves are placed at wash outs and/or branches to towns en route. Sectional valves are designed as buried valves equipped with an extension spindle and protected by a surface box.

Air valves are provided at dedicated high points and have to be installed in chambers. Air valve chambers in traffic areas will be flush-finished with the road surface, whereas chambers in open space shall protrude from the prevailing ground level.

Wash outs are provided at dedicated low points. Wash out branches are equipped with buried gate valves. Where necessary, wash outs shall drain into drainage chambers which have to be emptied with submersible pumps. Drainage chambers in traffic areas will flush with the road surface, whereas chambers in open space shall protrude from the prevailing ground level.

At points of change of direction thrust blocks shall be installed to restrain the forces from flow change in the transmission main in line with DVGW GW 310 or equivalent.

TM - Branches to towns en route: Six (6) branches shall be installed along the transmission main to allow for the supply of towns en route, namely for Karuma, Kamdini, Minakulu, Bobi and Palenga, and Koro Abili. An additional branch shall be installed to allow for the potential supply of Opit in the future. Each branch is equipped with a shut-off valve. The schematic from the branch-off to the elevated tank is shown in Figure 15.



Source: Fichtner & GopaInfra, 2018

Figure 15 Typical setup at branch to town en-route

<u>TM - Wetland crossing:</u> Several wetlands have to be crossed on the way from the river Nile to Gulu. Whereas the main road is typically raised on a flood-proof embankment, the transmission main shall be bridged on concrete pillars. A typical drawing for a wetland crossing by pipe supports is presented in Appendix J (Drawing WS_DD_4_3_STD_E)) and below

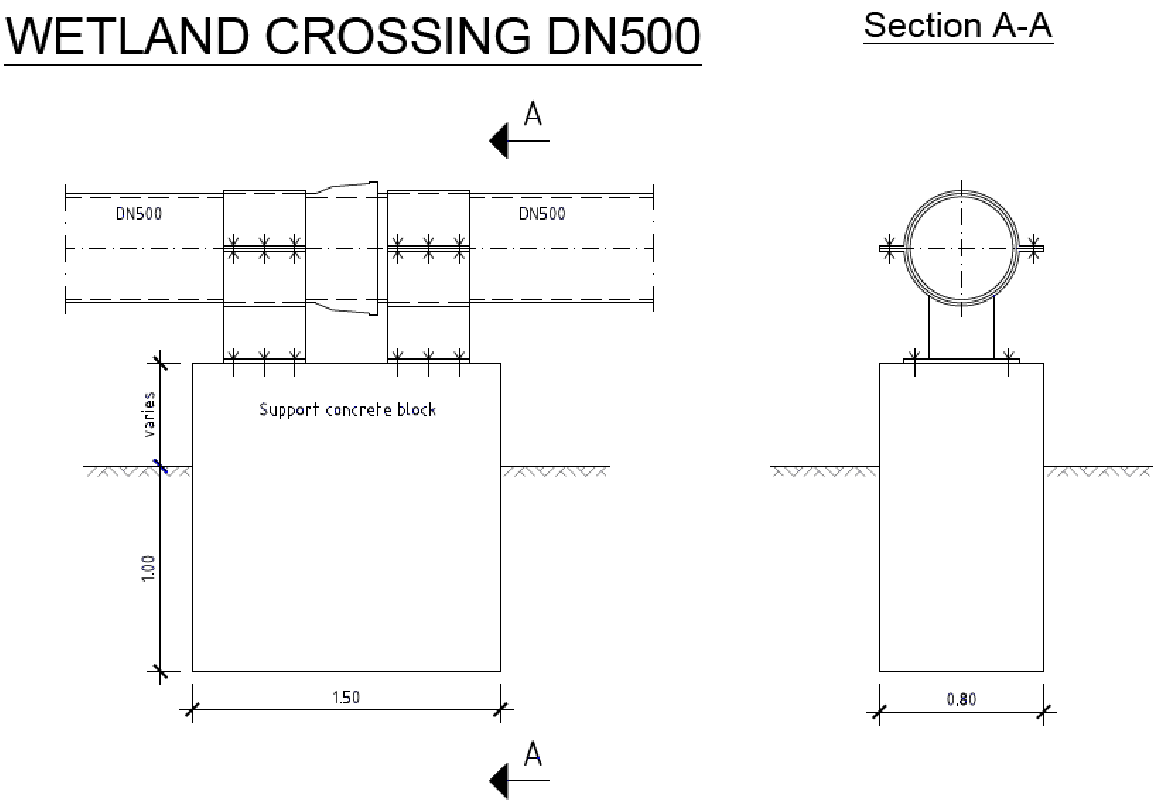


Figure 16: Cross-section of a pipe support

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TM - Road and railway crossings: The transmission main crosses main roads 3 times, that is, at the southern start near the water treatment plant to reach its intended alignment along the right edge of the road reserve (when heading from Karuma towards Gulu); in Gulu near the petrol station crossing Sira Dongo Road; and in Gulu, near the existing Customs Corner Tank crossing the Arua-Gulu Road.

Special permission will have to be sought from Uganda National Roads Authority (UNRA). A typical drawing for a road / highway crossing is presented in drawing WS_CD_9_4_02 (Appendix J). Further, in Gulu along Sira Dongo Road a railway crossing is required, equally requiring special permission and guidance from the relevant authority (Uganda Railway Authority). A typical drawing for a railway crossing is presented in drawing WS_CD_9_4_03 (Appendix J).

Intermediate tank with pumping station: Approximately 2.5 km south of Bobi, the transmission main shall be interrupted by an intermediate tank and pumping station. This allows operation of the transmission system at lower pressures and is deemed more economical. The area is located close to the highway and offers sufficient space for future extension.

Intermediate tank: The intermediate tank receives water from the transmission main. The tank is designed for approximately 2 hours delivery of the pumps. The inlet height of the transmission main allows for above-ground arrangement of the water tank plate. Technical parameters of intermediated water reservoir are presented below:

- Shape: Rectangular
- Structure material: Reinforced concrete
- Capacity: $2 \times 625 = 1,250$ m³
- Number of chambers: 2
- Dimension of chambers: width x length = 9.6 m $\times$ 13 m
- Maximum water level: 5 m

Intermediate pumping station: The intermediate pumping station receives water from intermediate water tank. To ensure sufficient pre-pressure on the pumps, the upper edge of the base plate is placed approximately 1.00 m below the surface of the terrain.

Horizontal pumps with radial or semi-radial impeller and low NPSH shall be installed. The pressure pipe is equipped with backflow preventer, gate valve and manometer.

The pumps will be switched on via soft starter. A control of the flow rate through frequency inverters is not provided. Consequently, the intermediate PS can be operated with 50 or 100 % of the pump capacity. The difference between the water inflow from the main PS and the pump flow will be equalised by the intermediate water tank.

Technical parameters of pumps:

- Number: 3 pieces (2 in operation, 1 standby)
- Flow of one pump: 330 m³/h
- Efficiency of pump: 78 … 80 %

Technical parameters of building:

- Shape: Rectangular
- Structure material: Reinforced concrete, walls made of brick
- Dimension of building: Width x length = 12 m x 24 m
- Access Gate: Width 2.5 m

Layout and sections are presented in drawings WS_CD_2_2_01 to _03 in Annex D.

Customs Corner tank 2: According to the findings during the Feasibility Study, it will be necessary to add additional storage capacity at Customs Corner of 5,300 m^3 next to the existing tank of 5,300 m^3 with the same top water level. Unlike the existing storage tank, it will be a single compartment tank. It will be sited east of the existing tank where land acquisition is expected to be easier.

Technical parameters:

- Nominal capacity: 5,300 m^3
- Concrete class: C30, reinforced
- Length (external): 50.6 m
- Width (external): 26.3 m
- Maximum water level: 4.4 m
- Inlet pipe: 1 No DN 600
- Outlet pipe: 1 No DN 600 connected to existing tank outlets
- Overflow: 1 No DN 700
- Drain: 1 No DN 100
- Roof level breathers: DN 100
- Access manholes: 2 No 0.8m x 0.8 m
- Electrical level measurement 3 pcs (1 in new tank and 2 in existing tank)
- Electro-magnetic flow meter 4 pcs (2 in new tank and 2 in existing tank, each at inlet and outlet)

The site pipework at the whole site will be rationalised to allow for:

- Both tanks to be fed from either source of supply (that is, Nile WTP or Gulu WTP);
- Ensure that the tanks operate at the same level at all times so that the whole site functions as a single storage site unless one tank is taken out of service (e.g. for maintenance);
- Rationalise the outflow pipework so that there is single metering from the entire site,
- Install communication equipment so that the site communicates with the treated water pumping stations and un-necessary overflows are avoided.

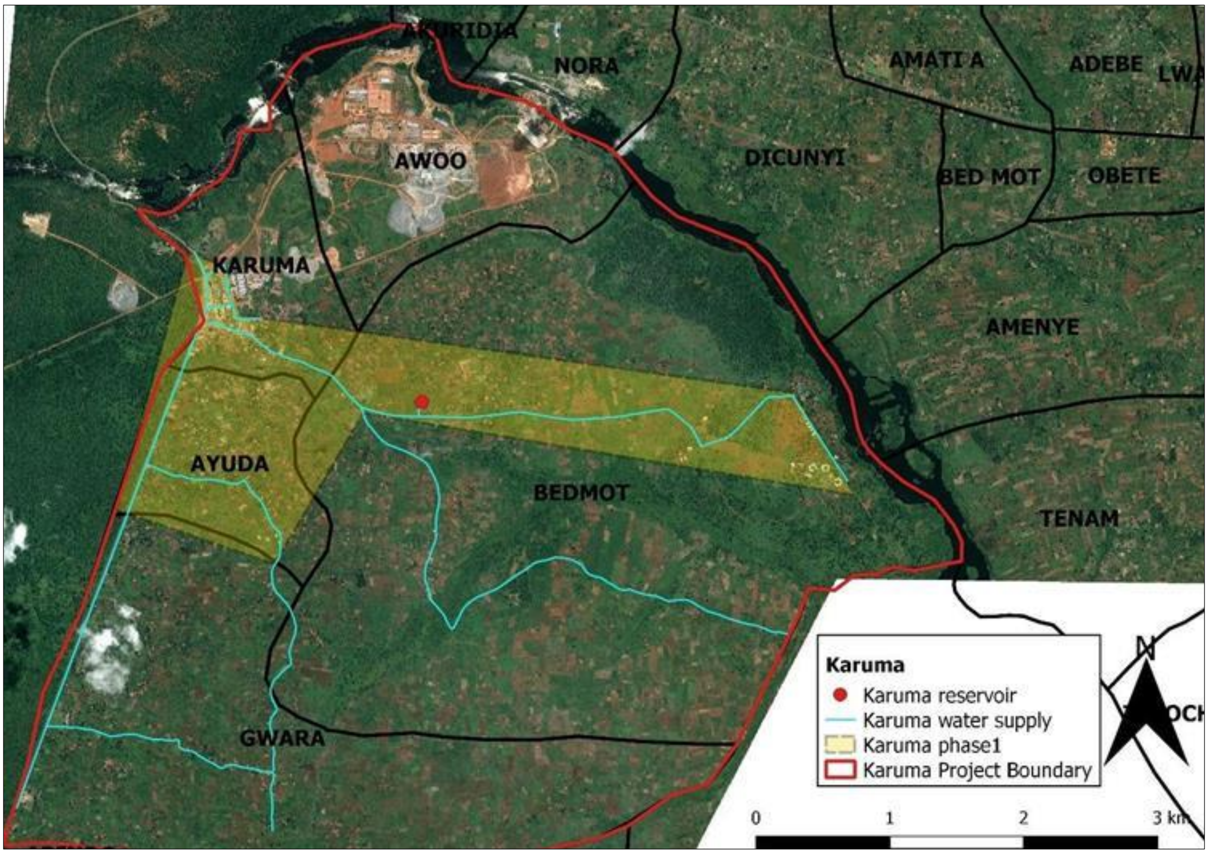
If required – depending on the flow and retention time – repeated chlorination will be added here.

3.3.4 Supply of Towns En route

The six towns en route shall be connected to the transmission main via branch-offs which – via a feeder line – deliver water to an elevated tanks. From here the distribution systems shall be supplied. In line with WSDF-N each system shall have an administrative block. To cater also for the poorer segments of the population public stand pipes with prepaid metering technology shall be installed in centres. In the overview maps (Figures 16 to 20), the yellow-hatched areas illustrate Stage 1 cores, and only the pipe lines covered within these cores are to be constructed during this first stage. The red borders draw the lines for future expansion of the supply areas. Once connected to the Nile water transmission main the systems shall be operated and managed by NWSC Gulu.

a) Karuma distribution system

The branch-off from the transmission main to Karuma is situated at chainage 0+435, just before the transmission main crosses the main road Karuma-Gulu. From here a feeder line DN 150 will follow the main road back to Gulu for about 8.7 km, crossing the Nile at the Karuma Bridge and delivering water to the elevated tank at Karuma (Volume = 500 m^3, height 15 m above mean ground level (AMGL)). The core of the Karuma supply area covers Karuma town, Ayuda village as well as the route to Restoration Centre in Bedmot (Figure 17) and a summary of the components for the distribution system in Stages 1 and 2 is presented in Table 4.



Source: Fichtner & GopaInfra, 2018

Figure 17 Karuma water supply stage 1

Table 4: Components of Karuma water supply

Component	Unit	DN	Stage 1	Stage 2	Total
Feeder line	[m]	160	8700	0	8,700
Elevated tank	[m³]		500		500
Distribution network	[m]	50	1,200	1,100	2,300

	[m]	63	1,750	3,600	5,350
	[m]	75	0	0	0
	[m]	90	500	1,700	2,200
	[m]	110	5,000	4,900	9,900
	[m]	160	1,400	0	1,400
	[m]	250	570	0	570
Network intensification	[sum]		1		1
Service connections	[sum]		1		1
Water office	[sum]		1		1
Total length	**[m]**		**19,120**	**11,300**	**30,420**

Source: Fichtner & GopaInfra, 2018

b) Kamdini distribution system

The branch to the elevated tank in Kamdini (volume = 300 m^3, height 15 m AMGL) is proposed approximately 640 m after the turn-off to Lira (looking northbound). The tank shall be on the same plot as the existing tank (60 m^3); at this stage and depending on the outcome of detailed hydraulic modelling it is proposed to interconnect the two tanks.

The core of the Kamdini supply area covers population that is situated along the Karuma – Gulu highway as well as areas of high population density in Obari and Pida villages as shown in Figure 18 and a summary of the components for the distribution system in Stages 1 and 2 is presented in Table 5.

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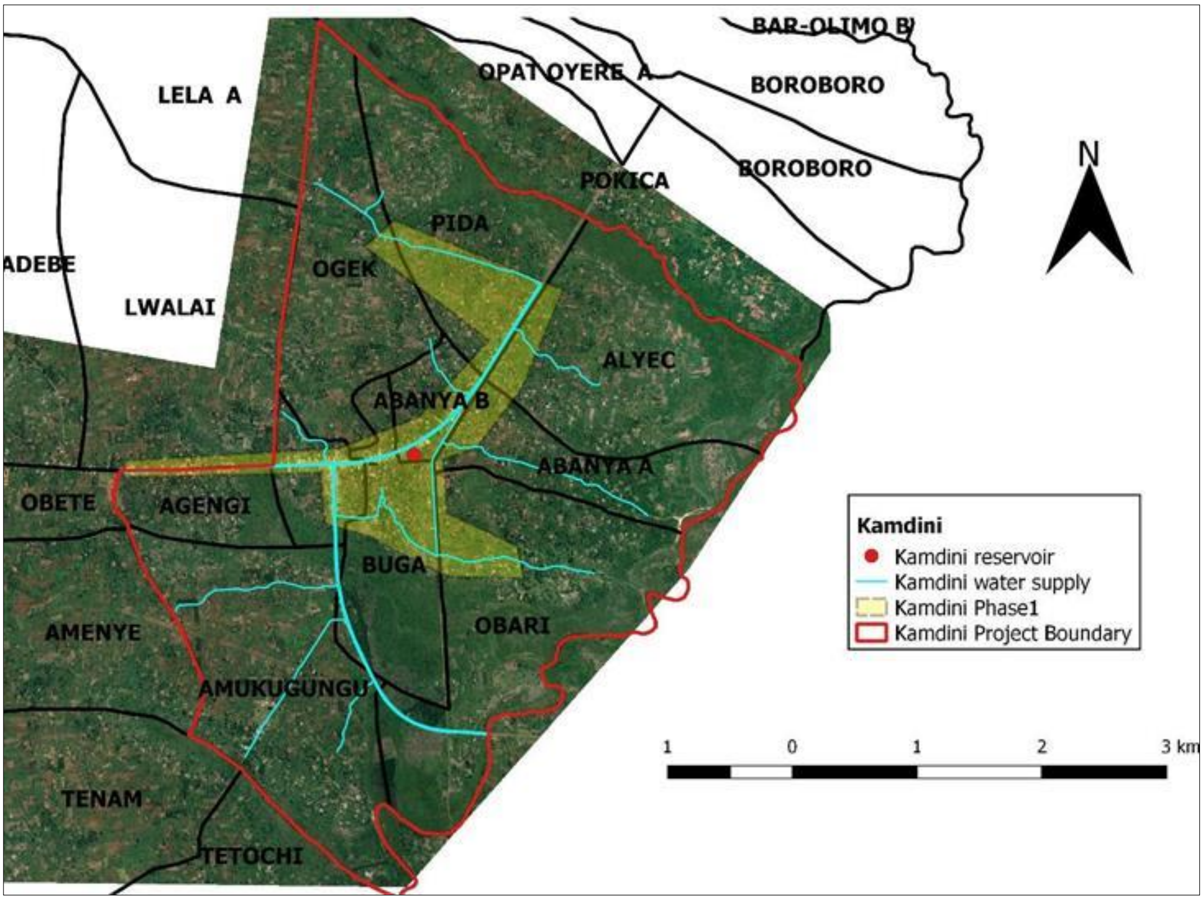


Source: Fichtner & GopaInfra, 2018

Figure 18 Kamdini water supply Stage 1

Table 5: Components of Kamdini water supply

Component	Unit	DN	Stage 1	Stage 2	Total
Feeder line	[m]	160	80	0	80
Elevated tank	[m³]		300		300
Distribution network	[m]	50	3,700	7,000	10,700
	[m]	63	5,850	5,950	11,800
	[m]	75	2,250	800	3,050
	[m]	90	20	0	20
	[m]	110	30	0	30
	[m]	160	740	0	740
	[m]	250	0	0	0
Network intensification	[sum]		1	0	1

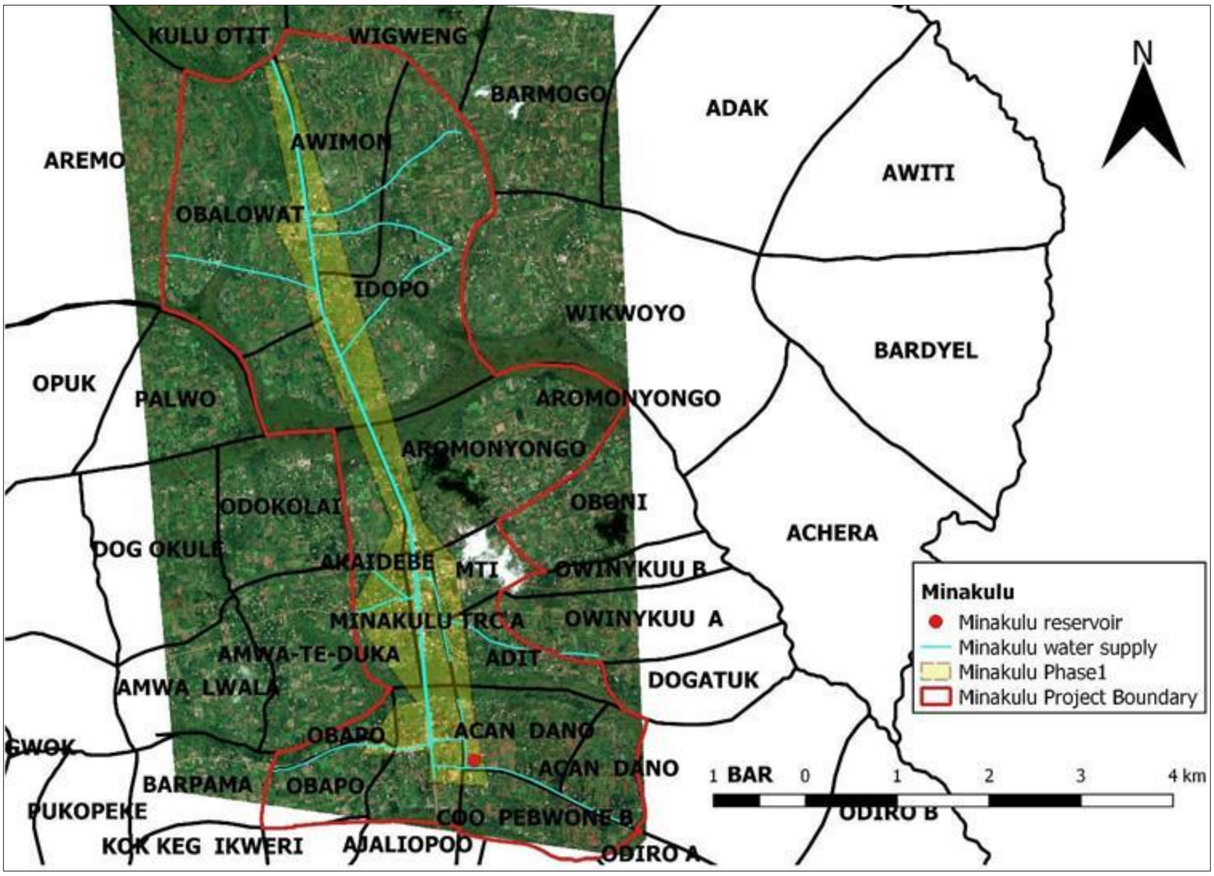
Component	Unit	DN	Stage 1	Stage 2	Total
Service connections	[sum]		1	0	1
Water office	[sum]		0	0	0
Total length	**[m]**		**12,670**	**13,750**	**26,420**

The existing system, of about 8.0 km of OD 75 HDPE pipes, shall be integrated into the new system to the best possible extent. The borehole shall be taken out of operation.

c) Minakulu distribution system

The branch to the elevated tank in Minakulu (volume = 300 m^3, height 15 m AMGL) is at chainage 24+000 after the turn-off to Lira. As in Kamdini, the new tank shall be situated next to the existing tank which alone is too small in volume. The borehole shall be abandoned.

The area to be served within the investment phase 1 is an approximately 8 km long and 500 to 1,000 m wide stretch along the Karuma - Gulu main road where the majority of the population is situated until date (Figure 19). The existing network of about 8.6 km of DN 125 uPVC to OD 50 HDPE pipes will be incorporated into the new system.



Source: Fichtner & GopaInfra, 2018

Figure 19 Minakulu water supply stage 1

A summary of the components for the distribution system in Stages 1 and 2 is presented in Table 6.

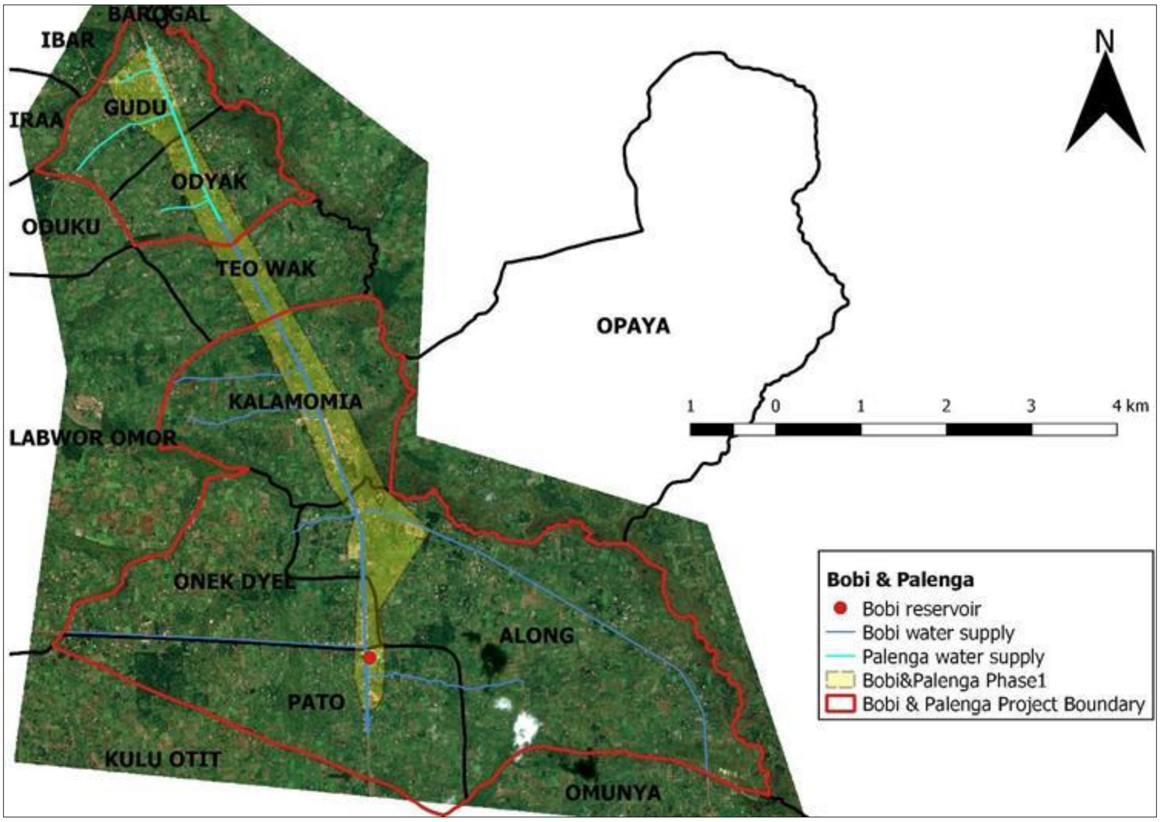
Table 6: Components of Minakulu water supply

Component	Unit	DN	Stage 1	Stage 2	Total
Feeder line	[m]	160	540	0	540
Elevated tank	[m3]		300		300
Distribution network	[m]	50	1550	9700	11,250
	[m]	63	6400	4800	11,200
	[m]	75	400	0	400
	[m]	90	4950	0	4,950
	[m]	110	6000	0	6,000
	[m]	160	600	0	600
	[m]	250	100	0	100
Network intensification	[sum]		1	0	1
Service connections	[sum]		1	0	1
Water office	[sum]		0	0	0
Total length	**[m]**		**20,540**	**14,500**	**35,040**

Source: Fichtner & GopaInfra, 2018

d) Bobi and Palenga distribution system

The branch to the elevated tank for the system Bobi-Palenga will be located about 2,400 m north of the intermediate pumping station. The elevated tank is designed with a capacity of 300 m^3. The Phase 1 supply area stretches for about 8 km along the Karuma-Gulu main road where most of the population are settling, as shown in Figure 20. The small pumping scheme in Palenga will have to be abandoned.



Source: Fichtner & GopaInfra, 2018

Figure 20 Bobi-Palenga water supply stage 1

A summary of the components for the distribution system in Stages 1 and 2 is presented in Table 7.

Table 7: Components of Bobi-Palenga water supply

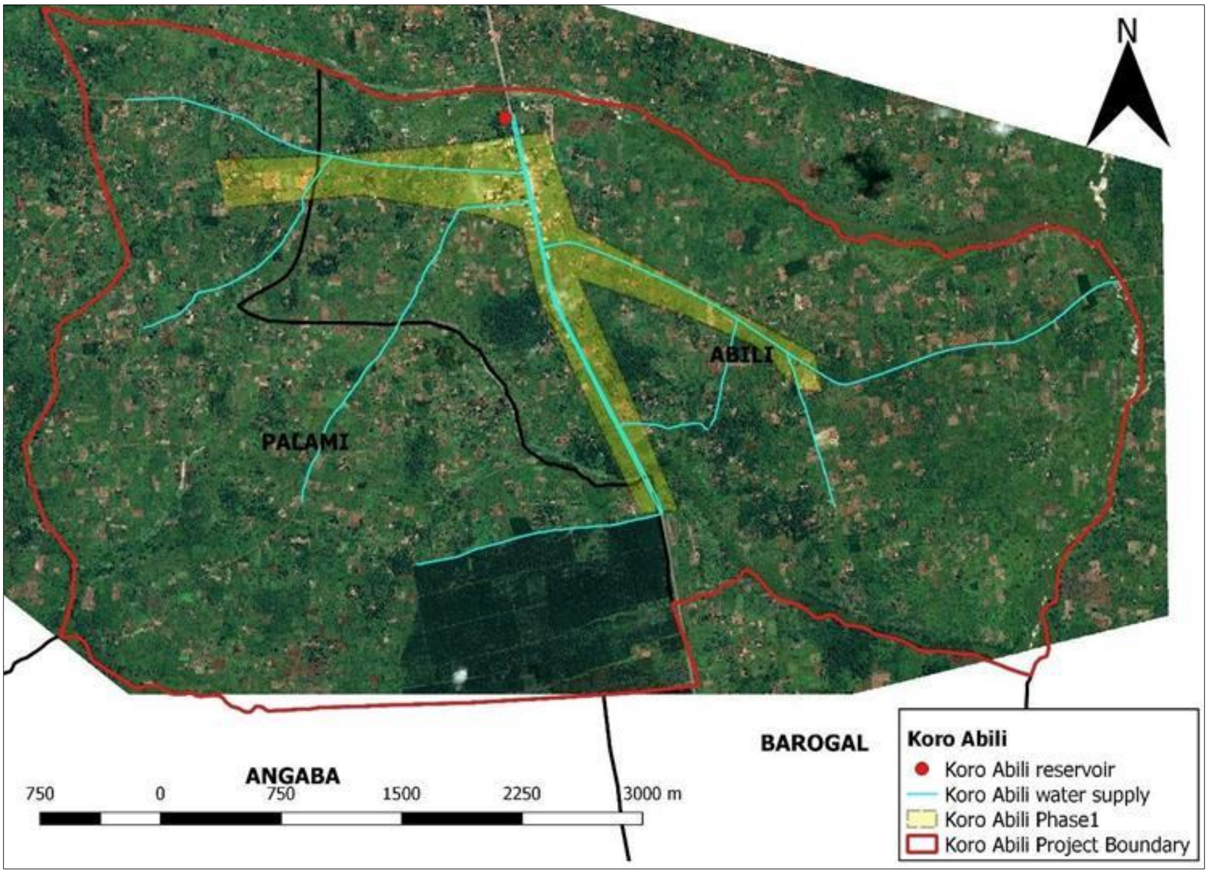
Component	Unit	DN	Stage 1	Stage 2	Total
Feeder line	[m]	160	60	0	60
Elevated tank	[m3]		300		300
Distribution network	[m]	50	4550	4200	8,750
	[m]	63	2500	11500	14,000
	[m]	75	3050	1100	4,150
	[m]	90	2150	0	2,150
	[m]	110	3800	0	3,800
	[m]	160	2000	0	2,000
	[m]	250	100	0	100
Network intensification	[sum]		1		1

Component	Unit	DN	Stage 1	Stage 2	Total
Service connections	[sum]		1		1
Water office	[sum]		1		1
Total length	**[m]**		**18,210**	**16,800**	**35,010**

Source: Fichtner & GopaInfra, 2018

e) Koro Abili distribution system

The branch to Koro Abili elevated tank (100 m^3) is about 4.8 km south of the Gulu round-about. The core of the Koro Abili supply area covers population that is situated along the Karuma – Gulu highway as well two roads that branch off from the highway as shown in Figure 21.



Source: Fichtner & GopaInfra, 2018

Figure 21 Koro Abili water supply stage 1

A summary of the components for the distribution system in Stages 1 and 2 is presented in Table 8.

Table 8: Components of Koro Abili water supply

Component	Unit	DN	Stage 1	Stage 2	Total
Feeder line	[m]	160	50	0	50
Elevated tank	[m3]		100	0	100
Distribution network	[m]	50	2,800	10,850	13,650
	[m]	63	6,000	0	6,000
	[m]	75	400	0	400
	[m]	90	0	0	0
	[m]	110	0	0	0
	[m]	160	0	0	0
	[m]	250	0	0	0
Network intensification	[sum]		1		1
Service connections	[sum]		1		1
Water office	[sum]		1		1
Total length	**[m]**		**9,250**	**10,850**	**20,100**

Source: Fichtner & GopaInfra, 2018

The existing small pumping scheme is already operated by NWSC and is likely to be taken out of operation once the Nile water transmission system and the Koro Abili system are in place and functional.

3.4 KARUMA HPP OPERATION IN RELATION TO THE KARUMA – GULU PROJECT

Karuma Hydropower Project (Karuma HPP) is being developed mainly for power generation. The Project has a total installed capacity of 600 MW. The diversion structure associated with the Project is a 14 m high gated concrete gravity dam (Figure 22). Permanent water retaining and water releasing structures are of Grade 2 structures. The Victoria Nile River upstream of the reservoir is very flat. The dam creates a backwater that is confined to the river channel but which extends for a distance of more than 50 km upstream of the dam site. The proposed water intake for the Karuma – Gulu WSP is located 550 m upstream from the dam.

The intake structure has six openings on the left bank, immediately upstream of the dam and will draw water into the powerhouse about 100 m below the river level (Figure 23). Downstream of the powerhouse complex, water will flow in twin 8.6 km long and 13 m diameter concrete lined tunnels back into the Victoria Nile River.

The normal water level of Karuma HPP is 1030 m with a corresponding storage of normal water level of 79.87 million cubic metres while the dead water level is 1028 m with a corresponding storage capacity is 34.34 million cubic metres. This all corresponds to a regulating storage of 45.53 million cubic metres and the reservoir will have a daily regulation performance. This called for the need for NWSC to kick start the construction of the intake structure (scope funded under KFW) before final commissioning of the Karuma HPP dam in order avoid working under floods as the wier for the water intake was designed at 1028m above sea level.

Commissioning of the Karuma HPP was originally scheduled for December 2019 while construction of the Karuma-Gulu Water Supply Project was anticipated to start no earlier than June 2020. This necessitated NWSC to kick start the construction of the intake structure for the Karuma-Gulu Water Supply Project (part of scope funded under KFW) before final commissioning of the Karuma HPP dam in order to avoid working under water when the dam reservoir is filled, which would render the construction of the intake very expensive.

To-date; Karuma HPP is nearly complete with commissioning anticiptated for December 2020 and the intake civil works for the Karuma-Gulu Water Supply Project have been completed. The Contractor shall be required to reuse the water supply intake site office for use in the construction of the Water Treatment Plant and the nearby transmission line.

Figure 22 Pictorial view of the dam and intake structures of the Karuma HPP

The permanent water retaining and releasing structures and powerhouse were designed basing on flood of 10,000 years with the peak flood flow of design flood of 4660 m^3/s. The flood sluices, arranged at the main riverbed, have a total length of 118 m and maximum height of 13 m divided into 9 dam sections (Figure 23). The 9 gate openings are arranged with opening dimensions of 10 m width by 8 m height. The open type practical weir type was adopted with the weir crest elevation being 1022.0 m and the length along the flow direction being 26 m.

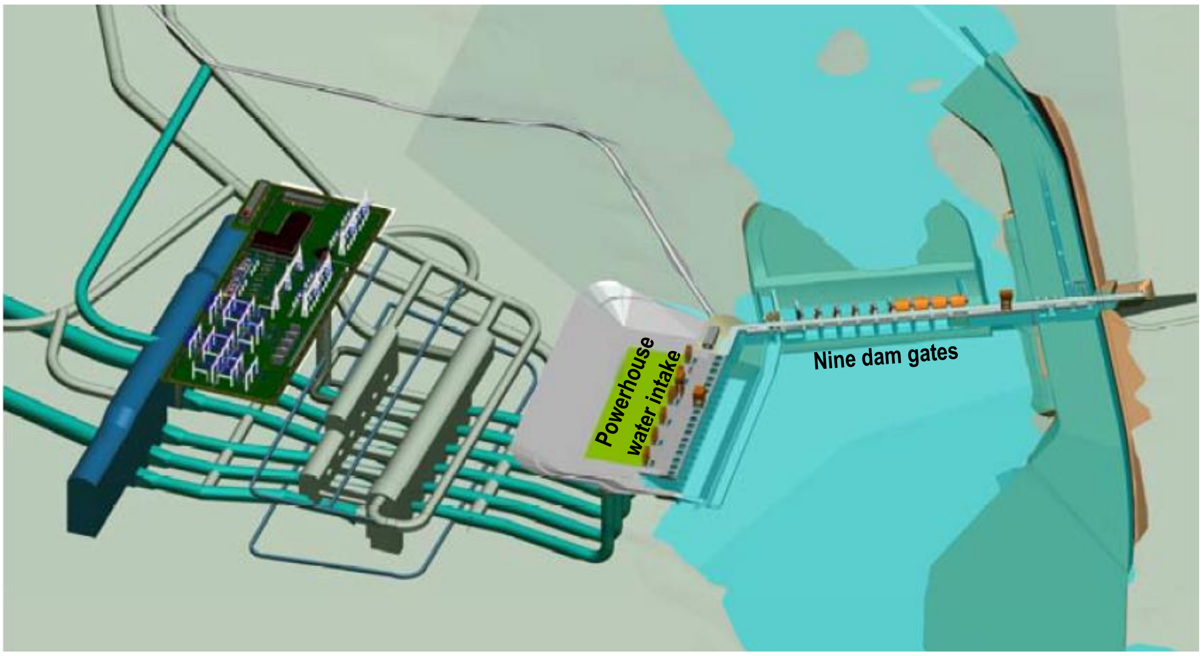


Figure 23 Pictorial view of the powerhouse intake structure of Karuma HPP

According to the hydraulic model test results, when reservoir water level is 1030.0 m, and when flood sluice, trash sluice, flushing sluice and ecological flow release outlet are all open, the total discharge capacity reaches 4969 m^3/s. This implies that when the dam suffers from 10000-year flood, both the normal pool level and design flood level should remain unchanged at 1030.0 m. Therefore the water intake for the Karuma – Gulu WSP would not be affected by the 10,000 year flood.

Sediment transport: Since most of the water of the Victoria Nile River is from Lake Victoria, most of sediments carried in the water flow settle down in Lake Kyoga when it flows through Kyoga Nile. Therefore, the sediment in the Nile River reach at Karuma is mainly sourced from the discharge from Lake Kyoga and the medial basin between Lake Kyoga and Karuma. The vegetation on the basin upstream Karuma HPP site is in good condition, the sediment yield in the basin is low.

Risk of dambreak: Damage associated with failure of the Karuma HPP dam is likely to be concentrated in the area between the dam and the bridge 4 km downstream. Downstream of the dam, the river flows into the Murchison Falls National Park and is generally inaccessible, so damage in this area is likely to be to the environment, not to people or property. The outflow from the power station re-joins the river about 5 km downstream of the bridge and increases the flow in the river by the magnitude of the operating flow at this location.

According to Entura (2018), the "full" failure of the Karuma HPP dam under "sunny day" conditions would result in a peak discharge of about 1660 m^3/s which would come about 5 ½ hours after the initial failure. This peak discharge is about 500 m^3/s more than the normal river discharge and would result in increases in water levels of about 1.9 m near the dam, 4.0 m at the bridge and 0.4 m at the tailrace outfall. In this scenario, the water level at the powerhouse intake would drop below the normal minimum operating level of the power station (RL 1028.0 m) five minutes after initiation of the breach. This should signal the power station to shut down immediately to prevent damage to equipment. The shut-down would also mean discharge from the tailrace ceases over a period of time. The shut-down would allow the water levels to get back to the normal river flow with with full failure of the dam hence minimal or no impact to the operations of the Karuma – Gulu WSP.

3.5 PROJECT ALTERNATIVES

3.5.1 'No Project' Scenario

The water supply system in Gulu covers the entire municipality and part of its surrounding peri-urban communities and is operated by NWSC Gulu branch. Currently, only about one third of the total water demand of the population of Gulu can be provided. The remaining demand has to be drawn from around 300 alternative water sources such as boreholes, wells, protected and unprotected springs.

Gulu water supply system is currently significantly augmented through physical investments under Phase 1a of the IPILC: Works are financed through World Bank under the Water Management and Development Project (WMDP) and aim among others at increased and improved access to water supply services.

However, for sustainable water supply in Gulu it is anticipated to draw water from the Victoria Nile near

Karuma and transport it along the road Karuma-Gulu to Gulu town. It is currently planned to supply 6 towns along the route of this transmission main, namely Karuma, Kamdini, Minakulu, Bobi, Palenga and Koro Abili. Piped water supply exists in the towns of Kamdini, Minakulu, Palenga and Koro Abili at least in parts financed through the Water and Sanitation Development Facility – North (WSDF-N). The remaining centres are served by point water sources such as wells and boreholes..

The "no project" scenario is neither a tenable nor beneficial alternative because sustainable safe water supply is required to support rapid socio-economic development within Gulu Municipality and the towns enroute. Without the project, it implies in the long term, Gulu will still be grappling with inadequate water to meet the demand given that it is soon gaining city status.

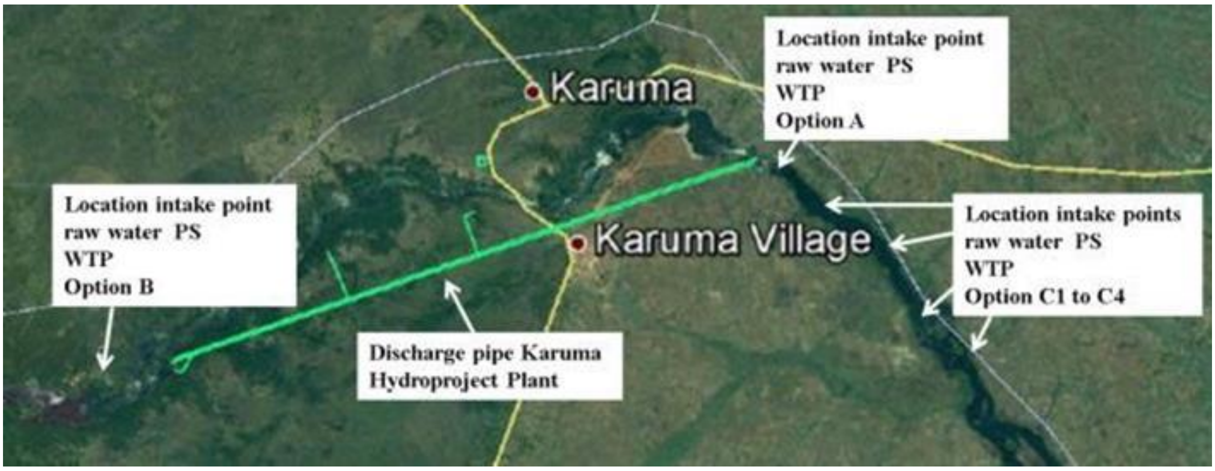
3.5.2 Alternatives Considered

In order to identify the most viable and sustainable solution for the Nile water supply system, an option analysis was undertaken for the water intake and treatment plant location and transmission main alignment, backed by an environmental screening assessment. Several options were developed and subsequently analysed with regard to their technical, environmental, social and financial impact.

3.5.2.1 Intake site

Three options (Figure 24) were assessed for the location of the intake and the water treatment plant, that is:

- Option A: Near the Karuma HPP, on northern embankment;
- Option B: Downstream of dam, beyond outlet of the Karuma HPP discharge pipes, within Murchison Falls National Park;
- Option C: Upstream of Karuma HPP dam.



Source: Fichtner & GopaInfra, 2018

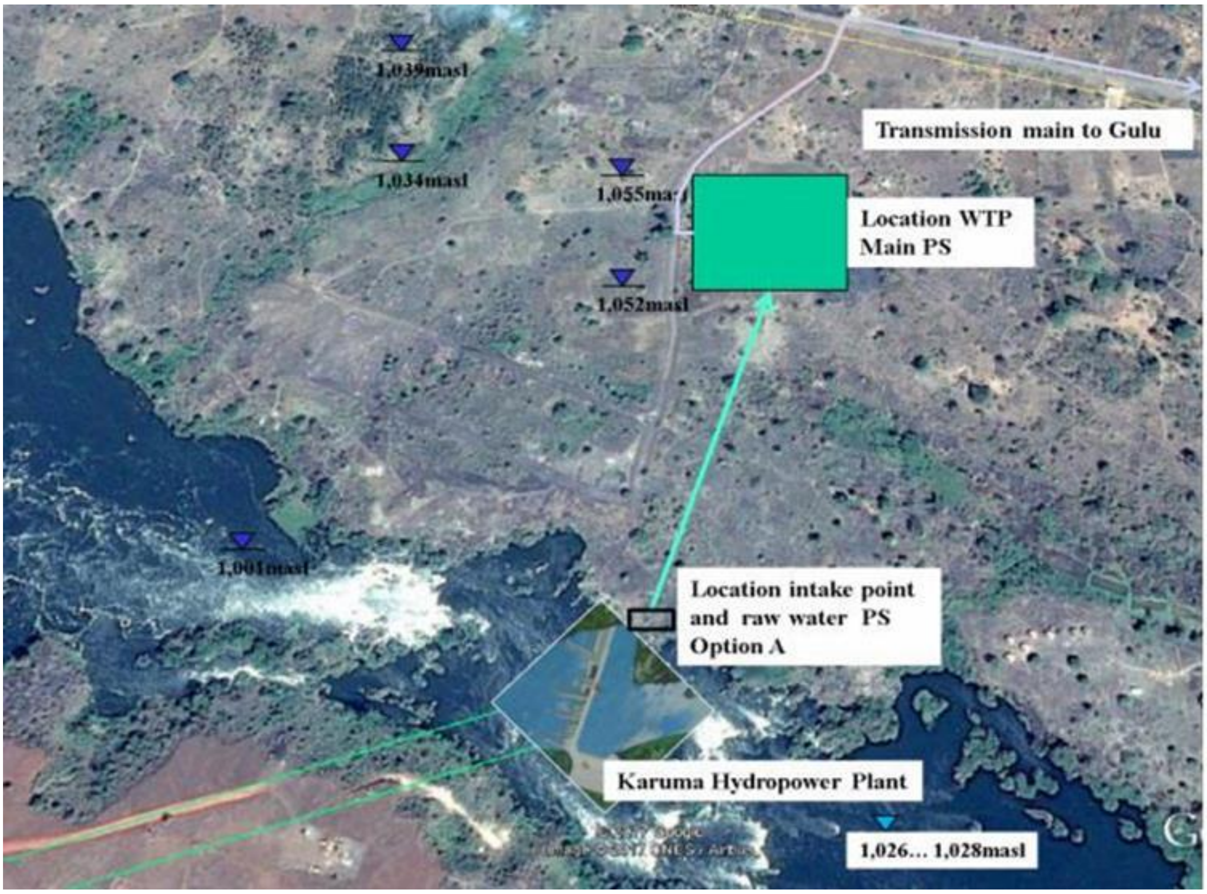
Figure 24 Intake point options A, B and C

a) Option A: Intake near Karuma HPP

Option A was to withdraw water from the diversion channel of Karuma HPP at a point located on the northern bank of Victoria Nile embankment (Figure 25).

The access to this site from the Karuma-Gulu Highway is through an existing good weather road (Photo 6). This road is currently being used by the communities to access the stone quarrying sites, but also access for trucks collecting stones from these sites. While the road is in a fairly bad condition, it could be improved to accommodate the different project activities.

The site was generally degraded with little vegetation present. The specific location of the water intake site was already acquired by Karuma HPP project and was used to dump debris that was extracted from the HPP tunnel construction. The merits and demerits of this option are presented in Table 10.



Source: Fichtner & GopaInfra, 2018

Figure 25 Option A: Intake near Karuma HPP

Photo 6: Existing road from Karuma-Gulu highway to option A site

Source: Fichtner & GopaInfra, 2018

Photo 7: Vegetation at the proposed Option A site

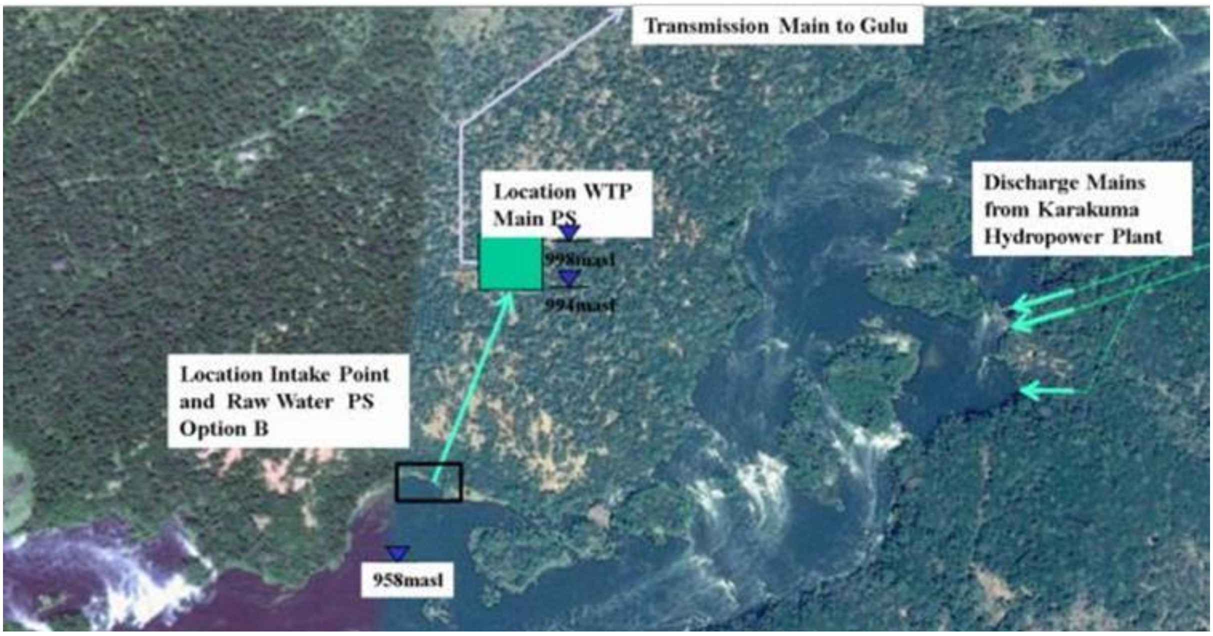
Source: Fichtner & GopaInfra, 2018

Photo 8: Stone crashing near the site

b) Option B: Downstream of dam, beyond outlet of Karuma HPP discharge pipe

For this option, the intake point would be moved upstream of the Karuma HPP, in Murchison Falls National Park beyond the outfall of the discharge mains from Karuma HPP (Figure 26). Extraction would be from the northern side of Victoria Nile embankment. There is no access to the site and this would therefore require constructing a road within the National Park for access to the different project components.

Option B is located within the Murchison Falls National Park. The site vegetation is pristine riverine forest plant community along the Nile River banks. The riverine vegetation is mainly dominated by Albiziazygia, Acacia hockii, Acacia polyacantha and Rhusnatalensis.



Source: Fichtner & GopaInfra, 2018

Figure 26 Intake site option B downstream of dam and beyond outlet of HPP discharge pipe

Source: Fichtner & GopaInfra, 2018

Photo 9: View from south to intake point at site option B

c) Option C: Upstream of Karuma HPP dam

The area upstream of the dam was screened in order to move the intake entirely out of the Karuma HPP zone of influence. This however proved not economically feasible as the dam's backwater curve measures at least 35 km upstream as per the Basic Design Report for Karuma HPP. The length of the transmission main would thus be increased by at least 50 % to a total length of around 107 km. Nevertheless, assessment was considered for locations approximately 5 to 7 km upstream of the dam, taking into consideration the topography of the river banks, existence of swamps along the bank and at the same time keeping distance to the main road Karuma-Gulu as well as Karuma HPP at a minimum. The potential intake points are indicated in Figure 27. The vegetation of the sites upstream is mostly dominated by papyrus swamp. For the options between 5 to 7 km, the swamp will be submerged during the operation of the Karuma HPP.

Source: Fichtner & GopaInfra, 2018

Photo 10: Vegetation cover at option C

3.5.2.2 Options for the transmission main

Two options had been identified for the transmission main passing through Gulu:

- Option 1 along the Sira-Dongo road
- Option 2 along / through railway station

Option I runs mainly along the Sira-Dongo Road, serving as ring road around Gulu town. Option II leads mainly along unpaved paths, but partially passes along/through railway reserve.

Four options were compared for the actual transmission from Karuma to Gulu, that is:

- Option 1a: DN600 without intermediate reservoir
- Option 1b: DN700-600 with intermediate reservoir including pumping station
- Option 2a: DN500 without intermediate reservoir
- Option 2b: DN500 with intermediate reservoir including pumping station

Further, advantages and disadvantages of possible pipeline materials (steel, ductile iron, glass- fibre reinforced plastics) were assessed.

Source: Fichtner & GopaInfra, 2018

Figure 27 Location of intake upstream of dam (Option C)

a) Options 1a and 2a: Karuma-Gulu without intermediate tank

The pipeline shall be designed for future water demand in 2040 and implemented in one construction phase. Routing will follow the western road reserve area of the main road Karuma-Gulu.

b) Options1b and 2b: Karuma-Gulu with intermediate tank

These options were considered to evaluate the possibility of placing an intermediate tank about half way along the transmission main route near Bobi.

The pipeline shall be designed for future water demand in 2040 and implemented in one construction phase.

The arrangement of an intermediate tank would have the advantage that the pipeline could be divided into 2 sections and that the Main PS as well as the pipeline itself could be designed to considerably lower pressures. However, a second pumping station would be required after the intermediate tank.

3.5.3 Analysis of Alternatives

3.5.3.1 Technical evaluation of alternatives

a) Options of intake sites

Table 9: Technical data of intake options

Subject	Option A	Option B	Option C
Area	Outside Karuma	Inside Murchison Falls NP	South of Kamdini
Investment needs Length of T M to Kamdini	7.2 km	19.0 km	6.5…7 km
Length of principle main to Karuma	4.0 km	10.0 km	6.5…7 km
Length access road to Karuma-Gulu Rd	0.4 km	10 km	1.2 … 3.6 km
Length of power supply line	1 km	12.0 km	2.0 … 4.0 km
Operating needs			
Power consumption	smallest amount	~ 40% more than Option A & C	similar to Option A
Technical data			
Water level at intake point	1,026…1,028 masl (dam profile)	958 masl (Google earth)	1,033 masl (Google earth)
Water level range at intake point	1,026…1,028 masl (dam profile)	unknown	unknown
Bottom profile at intake point	1,020.5 masl (dam profile)	unknown	unknown
Dependencies on Karuma HPP			
Power supply	Yes	yes	yes
Construction of intake point	Yes	no	no

Source: Fichtner & GopaInfra, 2018

Table 10: Merits and demerits of intake options

	Merit(s)	Demerit(s)
Option A: Intake near Karuma HPP	▪ Good, short access from Karuma-Gulu Road (approximately 500 m); ▪ Short principle main for the supply of Karuma, en route supply of future dam utility (approximately 1 km); ▪ Favourable subsoil conditions; ▪ High flow velocity in river, reducing sediments in intake channels; ▪ Water levels in reservoir are stable during operation of the HPP; ▪ Short power line (approximately 1 km).	None
Option B: Downstream of dam, beyond outlet of HPP	Reasonable flow velocity in river	▪ Significant fluctuations in water level due to HPP operation to be expected ▪ No access ▪ Extended power line for power supply (approximately 12 km) ▪ Long principle main for the supply of Karuma (approximately 10 km) or additional branch from transmission main with Nile river crossing; ▪ Intake option has the least geodetic height and thus requires additional pumping of about 70 m (compared to Option A) ▪ Located within National Park, thus involving numerous stipulations which will increase costs and delay progress.
Option C: Upstream of dam	Slightly smaller difference in geodetic height to be covered from Intake to Customs Corner Tank (about 5 m)	▪ Long power line (approximately 2 to 4 km, depending on final location) ▪ Long principle main for the supply of Karuma(approximately 6.5 to 7 km, depending on final location); ▪ Low flow velocity, will further reduce to HPP reservoir (backwater effects)

b) Options for transmission main

For the transmission main options, rough and preliminary hydraulic calculations were carried out in order to determine the required pressure of pumps, flow velocities, nominal pressure of pipes, fittings and armatures, and power demand.

i) Pressure stages and operating pressures

Option 1a DN600: Pressure stage PN32: Pressure stage PN32 and higher make investments expensive and operation difficult. Therefore, the option 1a DN600 without an intermediate tank/booster pumping station was excluded.

Option 1b DN700/600-600: Pressure stage PN16: The pressure stages of PN16 for the main pumping station and PN16 for the booster pumping station are commonly used by NWSC, pipe materials and fittings are generally produced in that class.

Option 2a DN500: Pressure stage PN25: A pressure stage of PN25 (max operating pressure 20 bar) will be required for the main pumping station. However, high operating pressure cannot be recommended for safety reason of staff and pipe system. Therefore, this option was excluded too.

Option 2b DN500-500: Pressure stage PN16/PN10: The pressure stages of PN16 for the main pumping station and PN10 for the booster pumping station are commonly used by NWSC, pipe materials and fittings are generally produced in that class.

ii) Intermediate tank and booster pumping station

In both remaining options, Option 1b and 2b, the treated water is pumped in two stages from the Nile to Gulu. This requires the arrangement of a buffer as a water reservoir for the pressure booster station.

The reservoir shall be located at a high point just before Bobi. This means that the common elevated tank for Bobi and Palenga can be easily filled via a separate small pumping system in the central pressure booster station.

For the supply of Opit a further separate small pumping plant shall be provided, so that the supply of Opit can take place independently from the main line. Pressures at branches to elevated water tanks are in the range from 2.4 up to 12.1 bars, suitable for installation of float valves for filling of elevated tanks.

Table 11: Water pressure at branches to towns en route

Settlement	Option 1b: DN700/600-600				Option 2b: DN500-500			
	masl	bar	masl	Bar	masl	bar	masl	bar
Junction Karuma	1,114	6.6	1,169	12.1	1,162	11.4	1,164	11.6
Junction Kamdini	1,112	5.1	1,161	10.0	1,150	8.9	1,149	9.0
Junction Minakulu	1,101	2.8	1,111	3.2	1,110	3.7	1,103	2.4
Junction Bobi	1,150	6.6	1,185	9.7	1,172	8.4	1,169	8.0
Junction Palenga	1,150	5.2	1185	8.3	1,172	7.1	1170	6.6
Junction Opit	1149	8.8	1181	12.0	1,169	10.8	1166	10.5
Junction Karo-Abili	1141	4.3	1153	5.6	1148	5.1	1147	5.0

Source: Fichtner & GopaInfra, 2018

From Table 11 and the technical point of view, both options 1b and 2b could be regarded as similar.

iii) Evaluation of different pipe materials

Installation of various pipe materials for the transmission main was assessed as indicated in Table 12. The preferred material for the transmission main, taking into account technical parameters, was ductile cast iron.

iv) Technical evaluation of transmission main route within Gulu

At this stage Option I along the Sira-Dongo Road was considered preferable due to clear and straight routing.

Table 12: Evaluation of pipe materials

No	Technical and technological parameter	Welded steel pipes	Spigot and socket steel pipes	Ductile iron pipes	GRP pipes
1	Areas where material is commonly used	Europe, North Amerika, Asia, South Africa	Africa	Europe, North Amerika, Asia, Africa	Middle East, South Africa
2	Execution	Spiral welded steel pipes according to EN10219 or similar including inspection certificate 3.1 according to EN10204, length 12 m, external polyethylene coating, internal cement lining for drinking water according to EN 10298 or similar, welding on site, pressure class up to PFA 100	Steel pipes length 12 m, externally epoxy coating or polyethylene coating, internal cement lining, pressure class up to PN25, with socket and spigot as flexible joint	Polyester, Epoxy, Vinyl Ester	
3	Technology for restrained joints	By welding	By thrust blocks	Special joints as standard version	Lamination of both pipe ends on site
4	Lifetime	Longer than 100 years with catodic corrosion protection	Since decades in Uganda used, no special information available	Longer than 100 years	Since decades in Middle East used, no specials information available
5	Strength – drive over	From laying depth of 60 cm to the high point of the pipe, a truck can be driven over	From laying depth of 60 cm to the high point of the pipe, a truck can be driven over	From laying depth of 60 cm to the high point of the pipe, a truck can be driven over	Additional calculations and civil measures are required
6	Requirement for pipe surrounding	Filling material 0/6 mm, permitted largest grain 8 mm, bedding layer at least 100 mm	No information available, refer comparable coatings with epoxy of valves demand: filling material:	Filling material: 0/32 mm, permitted largest grain 50 mm	Classification soils: SC1 and SC2, filling material: 0/10 mm, permitted largest grain 15 mm,

No	Technical and technological parameter	Welded steel pipes	Spigot and socket steel pipes	Ductile iron pipes	GRP pipes
			0/6 mm, permitted largest grain 8 mm		bedding layer at least 100 mm
7	Requirement for installations	Strict regulations for welding quality and subsequent treatment of the welded seam areas from inside and outside	Simple instructions mainly to check the socket with rubber and spigot	Simple instructions mainly to check the socket with rubber and spigot	Simple instructions mainly to check both pipe ends and cuppler with two gaskets
8	Allowable joint angular deflection	Cutting of pipe ends and welding	Instruction for permissible deflection of 5°	Clear instruction for deviation for each diameter	No angular deflection allowed for
9	Roughness coefficient of cement lining	This depends on the manufacturer, for example, European manufacturer supply a smooth wall roughness of 0.4 mm	Standards: AWWA C205 AWWA C303 EN 10298 DIN 2614 DIN 2880 NF A 49-701	This depends on the manufacturer, for example, European manufacturer supply a smooth wall roughness of 0.4 mm	A wall roughness coefficient of 0.1 mm is the main advantage of this material

Source: Fichtner & GopaInfra, 2018

3.5.3.2 Environmental assessment of options

The Uganda Guidelines for ESIA (NEMA, 1997) formed the basis for conducting environmental screening. In addition, due consideration was also given to international procedures for water supply projects.

a) Options of intake site

The environmental advantages and disadvantages of the intake options are presented in Table 13.

Table 13: Advantages and disadvantages of the intake options with respect to the environment

	Advantage(s)	Disadvantage(s)
Option A	▪ The area around here was encroached/disturbed area and currently being used for stone crashing. Therefore, there would be minimal environmental impact. ▪ The area is also easily accessible, and would therefore not require construction of a new road. ▪ No pristine vegetation was present in this area, hence low biodiversity significance levels.	▪ The proposed water intake point is within the river and while the impact is anticipated to be minimal, there is likely to be some impacts especially during the construction phase of the project water intake and WTP. ▪ The WTP will require a large are of about 4 acres, which will necessitate clearing of vegetation.
Option B	None	▪ Some project components will be located within Murchison Falls National Park with high biodiversity (fauna and flora); ▪ There will be need for a long, new access road required on northern side of river which will require more vegetation clearing and likely to have a high impact on the fauna ▪ Construction of the power supply structures crossing the river or along new access road will have an impact on the flora and fauna of the park;
Option C	The proposed sites are outside the project area. Hence the impact on the different environmental aspects might be lower than that of Option B.	▪ The area upstream is mostly dominated by a permanent papyrus wetland which might be habitat some flora and fauna of conservation importance. ▪ The extra-long transmission main would necessitate more clearing of vegetation. ▪ It would be necessary to expand the existing road which would

	Advantage(s)	Disadvantage(s)
		likely increase the impact on the ecology.

Basing on the above preliminary information collected from the field visits as well as data gathered from the different documentation, Options for the Intake and water treatment plant (WTP) were rated on a scale of 0 to 100; 0 being least impact and 100 being very high impact. For instance, it was anticipated that Option B would have a very high impact on biodiversity; hence, a score of 100 was given. The colour scale is from white to red signifying less to very high significant impact, respectively. Different scores were given for the different options with regards to different environmental aspects as shown in Table 14.

Table 14: Environmental screening of intake options

Aspect	Option A	Option B	Option C
1. Ecological Considerations			
(a) Biological diversity including:			
Impact on number, diversity, breeding habits, etc. of wild animals and vegetation.	20	100	40
Terrestrial flora	20	100	20
Wetlands	0	20	50
Terrestrial fauna	20	80	20
Butterflies	20	80	20
Small Mammals	30	80	30
Large Mammals	10	90	10
Herpetofauna	30	80	30
(b) Sustainable use including:			
Impact on soil fertility.	0	0	0
Impact on breeding populations of fish and game or wild animals.	10	80	10
Natural regeneration of woodland and sustainable yield.	0	0	0
Wetland resource degradation or wise use of wetlands.	10	20	50
(c) Ecosystem maintenance including:			
Impact on food chains.	10	60	30
Nutrient cycles.	10	10	10
Impact on aquifer recharge, water run-off rates, etc.	10	10	10

Aspect	Option A	Option B	Option C
Impact on real extent of habitats.	10	10	20
Impact on fragile ecosystems.	10	70	30
2. Social considerations including:			
Impact on generation/reduction of employment in the area.	60	60	60
Impact on social cohesion /disruption.	30	30	30
Impact on human health.	10	10	10
Impact on immigration or emigration.	10	10	10
Communication -			
roads opened up	30	50	30
roads closed	0	0	0
roads re-routed.	0	0	0
Impact on local economy.	20	20	20
Effects on culture and objects of cultural value.	10	10	10
3. Landscape:			
Impact on views			
views opened up	10	40	10
views closed	10	40	10
Visual impacts (features, removal of vegetation, etc.)	20	80	40
Compatibility with surrounding area.	20	60	30
Impact on amenities e.g. Recreation			
Amenities opened up	0	0	0
Amenities closed	0	0	0
4. Land uses:			
Impact on current land uses and land use	20	40	40
Possibility of multiple use.	10	10	10
Impact on surrounding land uses and land use potentials	10	40	10
TOTAL SCORE	**490**	**1390**	**700**

Source: Fichtner & GopaInfra, 2018

From Table 14, Option A was assessed to likely have the least impact on the environment, followed closely by Option C. Option B was found to likely have very significant impact due to its proximity to sensitive habitats within the Murchison Falls National Park.

b) Transmission main route

Both routes are mostly located in disturbed areas along the Karuma – Gulu highway, environmental aspects do not differ significantly and can be neglected. Differences in environmental impact of the options for transmission main routing are negligible.

3.5.3.3 Social evaluation of options

a) Intake options

The social advantages and disdvantages of the intake site options are presented in Table 15.

Table 15: Socio-economic advantages and disadvantages of the intake site options

	Advantage(s)	Disadvantage(s)
Option A	There is already a high influx of external workers already through construction of the Karuma HPP hence this project is likely not to have such an impact on the social cohesion.	There were about 200 locals (mostly women) crashing stone close to this site. This therefore means there might be need for compensation for the livelihood lost in case there is need to acquire this land.
Option B	There are less people settled upstream and hence the compensation would be minimal.	Reducing the quality of the National Park may have effects on income generated from tourism;
Option C	▪ New access road and improved power supply may economically boost the area ▪ Income generation (during and after construction)	Relative traditional and remote farm land, influx of external workers may have adverse effects;

Social impact for both Options of the transmission main along the Karuma – Gulu highway was rated to be equal.

The outcomes of the different assessments have been ranked and are summarised in the Table 16. Ranking 1 indicates best and 3 worst.

Table 16: Compilation and ranking of options

Part of Works	Assessment	Technical	Environmental	Social	Financial Investment Operation		Total ranking	Preferred option
Intake Options	A	1	1	1	1	1	**5**	√
	B	3	3	3	3	2	**14**	
	C	2	2	2	2	1	**9**	
Transmission main Options	1b	1	1	1	1	1	**5**	√
Karuma-Gulu	2b	1	1	1	2	2	**7**	
Transmission main Option in	I	1	1	1	1	1	**5**	√
Gulu	II	2	1	1	1	1	**6**	

Source: Fichtner & GopaInfra, 2018

From the above assessment, the following options were considered:

- To construct Intake and Water Treatment Plant near the Karuma HPP] (Option A);
- From a long-term perspective, Option 1b with DN700 / 600-600 is the preferrable option as it turns out to be the most economical solution;
- Taking into account limited investment funds, the transmission main could be realised as Option 2b with DN500-500.
- To install the transmission main in Gulu along Sira-Dongo Road (Option I).

However, in response to the Option Analysis NWSC instructed as follows:

- To proceed with Option 1b with DN700 / 600-600 but reduce the pipe diameter to DN500 along a short section beyond the intermediate tank and pumping station to fit investment costs into the budget.
- To elaborate 2 sets of bill of quantities for alternative pipe materials, namely ductile iron; and steel with spigot-socket connections, outer coating 3-Layer Polyethylene (3LPE), inner lining Fusion Bonded Epoxy.

4 POLICY, LEGAL AND INSTITUTIONAL FRAMEWORK

4.1 INTRODUCTION

In Uganda, the key legislation governing an ESIA study includes the National Environmental Act (Cap 153) of the laws of Uganda and the Environmental Impact Assessment Regulations (1998). National Environmental Act established NEMA and entrusts it with the responsibility to ensure compliance with ESIA process and procedures in planning and execution of development projects. The procedures require that a project proponent prepares an EIS with a clear assessment of relevant potential impacts, based on terms of reference (TORs) developed from a scoping exercise. This requires that the ESIA addresses potential direct and indirect socio-environmental impacts during the pre-construction, construction, operation and decommissioning phases together with attendant environmental and social management plan (ESMP).

Policies, legal and institutional framework considered relevant to this proposed project are discussed in this section. Various laws here reviewed relate to minimum acceptable construction operational requirements, environmental quality, land use, public health, occupational safety, labour standards and international legal obligations.

4.2 POLICY FRAMEWORK

4.2.1 The National Environment Management Policy, 1994

The overall goal of this policy is the promotion of sustainable economic and social development mindful of the needs of future generations and the EIA is one of the vital tools it considers necessary to ensure environmental quality and resource productivity on a long-term basis. It calls for integration of environmental concerns into development policies, plans and projects at national, district and local levels. Hence, the policy requires that projects or policies likely to have significant adverse ecological or social impacts undertake an EIA before their implementation. This is also reaffirmed in the National Environment Act, Cap 153 which makes EIA a requirement for eligible projects (Third Schedule).

<u>Relevance</u>: *At the national policy level, environment and development are interrelated and this policy requires that environmental aspects are considered in all development projects such as the proposed Karuma – Gulu water supply project. This ESIA is being developed inline with the requirements of this policy and will be submitted to the lead agencies key to the project for review to ensure that all social and environmental aspects taken into consideration.*

4.2.2 The National Water Policy, 1999

The goal of this policy is to provide guidance on development and management of the water resources of Uganda in an integrated and sustainable manner, so as to secure and provide water of adequate quantity and quality for all social and economic needs, with full participation of all stakeholders and mindful of the needs of future generations. The policy aims to:

- Promote rational use of water;

- Control pollution and promote safe storage, treatment and disposal of waste, which could pollute water and impact public health; and
- Promotion of awareness of water management and development issues and capacity building.

Relevance: This policy is relevant to the project since it will promote rational use of source water and avoidance of contamination of water course. The policy advocates for integrated and sustainable development management and use of water resources with full participation of all the key stakeholders. NWSC has already acquire a water abstraction permit and will waste discharge permit from the Directorates of Water Resources Management intended to fulfil this requirement (See Sub-section 3.11).

4.2.3 The National Health Policy, 1999

The overall objective of this policy is to reduce mortality, morbidity and fertility, and the disparities therein.

Relevance: By ensuring availability of safe water supply, the project will contribute to the reduction of water borne diseases thereby improving on the health of communities, especially the girl child and mothers who are mainly involved in collection of water. This project is in line with the strategies of this policy.

4.2.4 The National Policy for the Conservation and Management of Wetland Resources 1995

To curtail the rampant loss of wetland resources and ensure that benefits from wetlands are sustainable and equitably distributed. Wetlands acting as sources of water supply and wastewater treatment should be fully protected.

Relevance: The transmission line traverses a number of wetlands therefore NWSC will ensure that these ecosystems are not affected during implementation of the project. Interventions in this regard are provided in the Environmental and Social Monitoring and Management Plan (ESMP) presented in section 8 of this report.

4.2.5 The National Gender Policy, 1997

The goal of this policy is to mainstream gender issues in the national development process in order to improve the social, legal/civic, political, economic and cultural conditions of the people of Uganda, particularly women. The policy recognizes women and children as the main carriers and users of water and related sanitation facilities. It anchors the importance of gender responsiveness in terms of planning, implementation and management of water and sanitation initiatives.

Relevance: This policy would especially apply in the recruitment process of labour, both during construction and operation phase. Men and women should have equal opportunities for available jobs. This policy also requires provision of a work environment that is safe and conducive to women, as it is for men, considering gender-disaggregated differences and vulnerabilities. For example, women should have separate facilities from men's at workers' camps. The Contractor for this project will be required to *develop a Gender Action Plan and a Code of Conduct to ensure that the requirements of this policy are fulfilled.*

4.2.6 HIV/ AIDS Policy, 1992

Current effort to combat HIV/AIDS is characterized by a policy of openness by Government and this has, to a large extent, been emulated by civil society, political and social institutions, and workplaces. HIV/AIDS is recognized by Ministry of Health as a considerable risk in construction of infrastructure projects and it (together with the Ministry of Gender, Labour and Social Development) encourages employers to develop in-house HIV/AIDS policies, provide awareness and prevention measures to workers and avoid discriminating against workers living with or affected by HIV/AIDS. To ensure HIV/AIDS is addressed in the workplace, the policy encourages employee awareness and education on HIV/AIDS. To protect the infected and affected persons from discrimination, employers are required to keep personal medical records confidential. Employees living with, or affected by, HIV and AIDS, and those who have any related concerns, are encouraged to contact any confidant within the organization to discuss their concerns and obtain information. It is anticipated that during the construction phase, there may be an influx of people into the project area possibly resulting into sexual fraternisation and a risk of HIV/AIDS spread. The policy also guides about HIV/AIDS management including awareness and provision of condoms in workplaces.

<u>Relevance:</u> *The requirements of this policy are expected to be fulfilled by the construction contractors or their subcontractors, especially in regard to having an in-house HIV Policy, worker sensitisation and provision of free condoms. This policy is relevant to the project if implementation of proposed construction activities leads to in-migration into the project area by people seeking construction jobs and indulging in prostitution or irresponsible sexual fraternisation associated with HIV/AIDS risk. The Contractor for this project will be required to develop a HIV/AIDS and Workplace Policy to ensure that the requirements of this policy are fulfilled.*

4.2.7 Occupational Health and Safety (OHS) Policy

This policy seeks to:

- Provide and maintain a healthy working environment;
- Institutionalize OHS in the power-sector policies, programs and plans; and
- Contribute towards safeguarding the physical environment.

The OHS Policy Statement is guided by the Constitution of the Republic of Uganda and other global, national and sector regulations and policies. The OHS Policy also takes into consideration the Health Sector Strategic Plan, all of which aim to improve the quality of life for all Ugandans in their living and working environment.

<u>Relevance:</u> *This policy will be especially relevant for OHS of construction crews and subsequently, operation and maintenance personnel in the Gulu-Karuma water project. This ESIA proposes in the ESMP measures to prevent, mitigate and compensate potential incidents, accidents and ensure safety in all project area in compliance with this policy. It will also have relevance in mitigation measures that in*

order to protect the workers and the public from health and safety impacts as a result of project construction and subsequent operation and maintenance activities. Contractors and NWSC will be responsible for acquiring insurance and provide personal protection equipment and first aid to all workers during construction and operation, respectively.

4.2.8 Uganda Vision 2040

In 'Vision 2040', Uganda sets goals to achieve by the year 2040 ranging from political, economic, social, energy, water, and environment. With respect to environmental goals, Ugandans aspire to have sustainable social-economic development that ensures environmental quality and preservation of the ecosystem. Vision 2040 recognises water and sanitation infrastructure as a key driver of the economic development and notes that for Uganda to shift from a peasantry to an industrialized and urban society, it must develop its infrastructure. The 2040 vision acknowledges that the slow accumulation of infrastructure i.e. water among others retards the economic development. It must be propelled by water as a factor of production in agricultural and industrial sectors. It estimates that Uganda's water consumption using 2010 as a baseline stands at 26 m^3 per capita and will require it to be raised to 600 m^3 per capita by year 2040 and this can only be achieved by raising percentage of population with access to safe piped water from 15 to 100 by 2040.

Relevance: *To provide the necessary stimulus to the economy, the government through NWSC in partnership with WB and KFW has embarked on the improvement of water supply infrastructure of which Karuma – Gulu Water Supply Project is part. Vision 2040 notes that in order to improve access and availability of water to the rural and urban areas, especially to economic zones and other productive areas, new water supply lines should be established at an accelerated rate. Therefore, the proposed project is in line with aspirations of Vision 2040.*

4.3 LEGAL FRAMEWORK

4.3.1 Constitution of the Republic of Uganda, 1995

The Constitution places obligations on both the state and the citizens of Uganda to among other things: a) protect the environment; b) protect important natural resources including land, water, wetlands and fauna and flora; c) promote sustainable development and conserve natural resources in a balanced manner for the benefit of the present and future generations and to prevent damage to natural resources resulting from pollution and other causes.

Article 39 and 41 of the Constitution of 1995 provide that everyone has a duty to maintain a sound environment. It also stipulates that every person in Uganda has a right to a healthy and clean environment and as such can bring legal action for any pollution or disposal of wastes. Chapter III, Section 245 stipulates that the Parliament shall by law provide measures intended to protect and preserve the environment from abuse, pollution and degradation. The articles detailed above place project development within the constitutional framework.

Relevance to this project: *In Uganda this is the cardinal law requiring protection and conservation of the environment. Preparation of this ESIA is in line with requirements of Constitution of the Republic of Uganda.*

4.3.2 National Environment Act, Cap 153

The National Environment Act (Chapter 153 of Laws of Uganda) establishes and defines functions of NEMA as a body responsible for management, monitoring and supervision of all environmental conservation activities (Section 4). This act provides for various strategies and tools for environment management, which also includes the EIA (Section 19) for projects likely to have significant environmental impacts. The Act also mandates NEMA with a leading role to review environmental impact statements. NEMA sets multimedia environmental standards (Sections 24-32) to prevent contamination of air, water and soil resources. The Act also mandates NEMA with responsibility for in-situ and ex-situ conservation of biological fauna and flora resources either on land or in water (Sections 42 and 43). Section 48 empowers NEMA, district environment committees and local environment committees to be responsible for monitoring of local land-use plans, which should be in conformity with national land-use plan. Section 106 outlines provisions to enable compliance with obligations of international environmental conventions. Section 35 entrusts NEMA, lead agencies and local government environment committees with powers to protect the environment from human activities that could adversely affect it. Section 56 prohibits discharge of hazardous substances, chemicals, oil, etc. into the environment except in accordance with guidelines prescribed by NEMA. Section 12 on the Schedule requires that projects related to sewage disposal should undertake a full EIA. This Act also formed the basis for enactment of the Environmental Impact Assessment Guidelines, 1997 and Environmental Impact Assessment Regulations, 1998 which together prescribe the EIA process in Uganda. The process is schematically presented in NEMA's Environmental Impact Assessment (EIA) Reference Manual as shown in Figure 28.

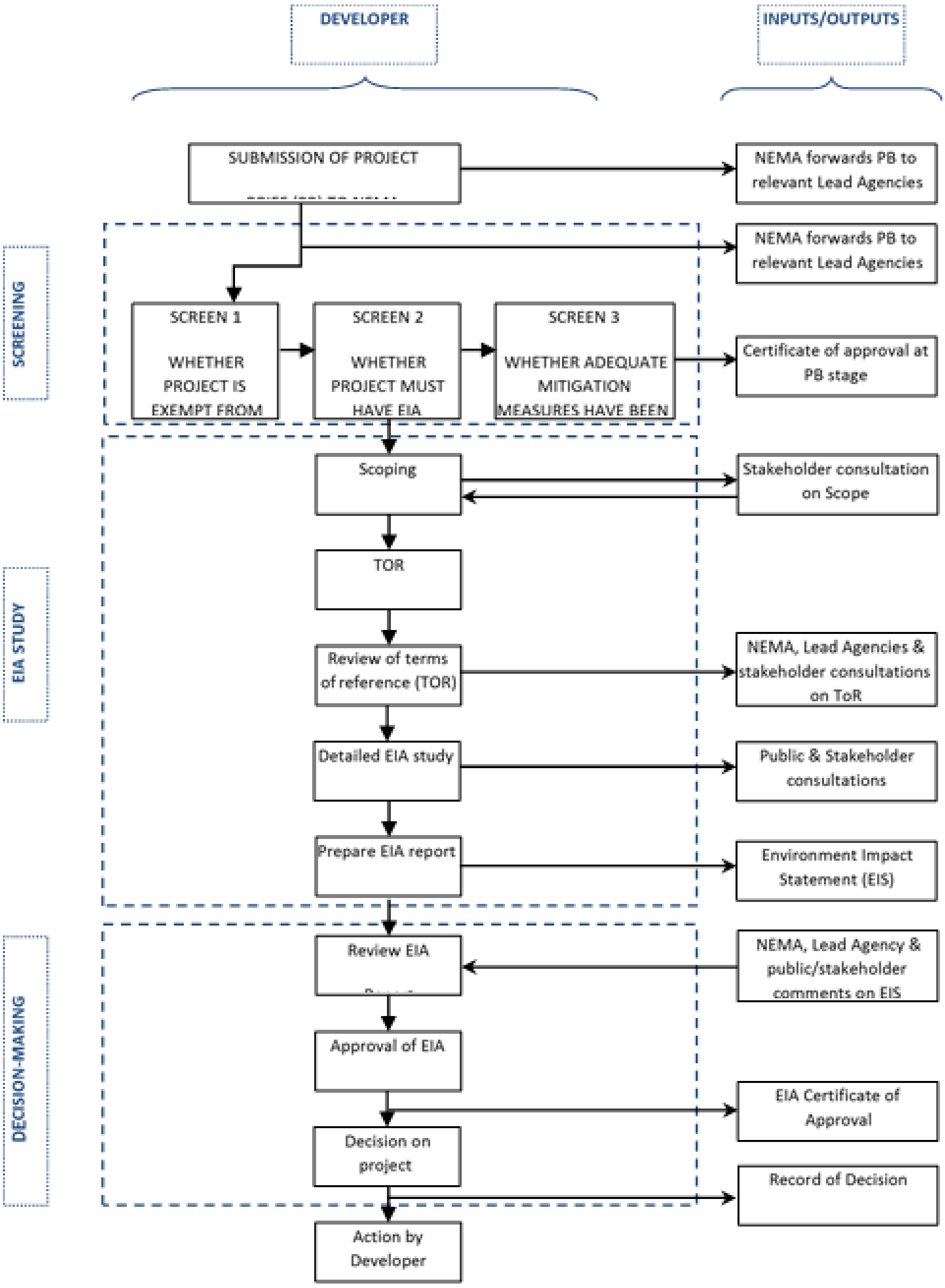


Figure 28 ESIA process in Uganda

<u>Relevance:</u> The Act governs and guides environmental management in Uganda. This ESIA is prepared to conform to the Act's requirement that projects likely to have significant environmental impact undertake an ESIA before they are implemented. The Gulu-Karuma water project will present this ESIA to obtain the certificate by NEMA and will implement all measures requested by it. The ESIA will also apply requirements of this regulation in the construction per requirements included in the bidding and contract documents of its contractors and subcontractors.

4.3.3 Local Governments Act, Cap 243

This Act provides for decentralized governance and devolution of central government functions, powers and services to local governments that have own political and administrative set-ups. According to Section 9 of the Act, a local government is the highest political and administrative authority in its area of jurisdiction and shall exercise both legislative and executive powers in accordance with the Constitution.

Relevance: The project will be under jurisdiction of Gulu, Omoro, Oyam and Kiryandongo District Local Governments, which are mandated under the Local Governments Act, Cap 243 to sanction and oversee development projects in their respective local governments. The Environmental Officers for the Districts, the Gulu Municipality and project towns are mandated to inspect and monitor environmental considerations for development projects in their areas of jurisdiction.

4.3.4 Water Act, Cap 152

The Act provides for use, protection and management of water resources and supply; to provide for the constitution of water and sewerage authorities; and to facilitate the devolution of water supply and sewerage undertakings. The act provides for hydraulic works and use of water. Under this section 18(2), a person wishing to construct any works or to take and use water may apply to the Director of Water Development Directorate (DWD).

Relevance: The Act provides guidance for requirements of implementation of water supply projects. As required by Section 18(2) of this Act, NWSC will apply to DWRM and DWD for permits for abstracting water from River Nile and discharging effluents from the sludge drying beds to the environment, respectively.

4.3.5 Land Act, Cap 227

The 1995 Constitution restored all private land tenure regimes (which had previously been abolished under the Land Reform Decree, 1975). It divested the state and the Uganda Land Commission of radical title to land that was expropriated in 1975, and vested it directly in the citizens of Uganda. The constitution provides for, inter alia:

- The right of every Ugandan to a clean and healthy environment (Article 39);
- The responsibility of government to enact laws that protect and preserve the environment from degradation and to hold in trust for the people of Uganda such natural assets as lakes, rivers, wetlands, game reserves and national parks [Article 237(2)];
- The right of every Ugandan to fair and adequate compensation in instances of land acquisition.

The Constitution provides that every person has a right to own property and that no person shall be compulsorily deprived of property or any interest in or right over property without prompt payment of fair and adequate compensation, prior to the taking of possession or acquisition of the property.

On land tenure regimes and transfer of land, the Constitution prescribes tenure regimes in accordance with rights and interests held in land. Article 237 of the Constitution, 1995, vests land in the citizens of Uganda and identifies four land tenure systems, namely: *customary*, *freehold*, *mailo* and *leasehold*.

Understanding these systems (detailed in section 4 of the Land Act, 1998) is vital for compensation of households to be affected by the project. These tenure systems are outlined below:

Customary tenure: In this tenure, land is owned in perpetuity and tenure is governed by rules generally accepted as binding and authoritative by the class of persons to which it applies (that is, "customary regime is not governed by written law"). Customary occupants are occupant of former public land, and occupy the land by virtue of their customary rights; they have proprietary interest in the land and are entitled to certificates of customary ownership. Certificates for customary ownership are issued by the District Land Board, through application to the Parish Land Committee.

Freehold tenure: This tenure derives its legality from the Constitution. It involves the holding of land in perpetuity or for a period less than fixed by a condition and enables the holder to exercise, subject to the law, full powers of ownership.

Leasehold tenure: Lease tenure is created either by contract or by operation of the law. It is a form of tenure under which the landlord or lessor grants the tenant or lessee exclusive possession of the land, usually for a defined period and in return for a rental fee. The tenant has security of tenure and a proprietary interest in the land. The Constitution and the Land Act also protect "*rights of spouses and children"* with regard to land transactions. The head of household must acquire the consent of spouse and children prior to any sale of land on which the family ordinarily resides.

Mailo land tenure: The Mailo land tenure system is a feudal ownership introduced in Buganda by the British in 1900 under the Buganda Agreement. "Mailo" is a *Luganda* word for "mile" as the original grants under the agreement were measured in square miles. Prior to the 1975 Land Reform Decree, Mailo land was owned in perpetuity by individuals and by the Kabaka (hereditary King). Since no section of the proposed line traverses Buganda region, this type of tenure does not apply to the project.

Relevance: These tenure systems will be important during resettlement planning. Detail of land take and compensation are addressed in the line project resettlement action plan (RAP).

4.3.6 Public Health Act, Cap 281

The Public Health Act aims at avoiding pollution of environmental resources that support health and livelihoods of communities. It gives local authorities powers (Section 103) to prevent pollution of watercourses in interest of public good.

Relevance: Improved water supply leads to improved economic activities but also to generation of wastewater. NWSC will ensure that the wastewater generated in the service areas under them is appropriately managed so as to prevent risk to public health, in line with the provisions of this Act.

4.3.7 Investment Code Act, Cap 92

Section 18(2) (d) of the Act requires an investor to take necessary steps to ensure that development and operation of an investment project do not cause adverse ecological and socio-economic impacts.

Relevance: NWSC is the implementing agency for the project that received funding from the World Ban and KFW. This ESIA is in partial fulfilment of the requirements of this Act, since adverse ecological and socio-economic impacts as a result of the project implementation have been identified and mitigation measures developed.

4.3.8 National Water and Sewerage Corporation Statute, 1995

Section 3 of this statute, states that the NWSC shall operate and provide water and sewerage services in areas entrusted to it under the Water Statute of 1995.

<u>Relevance:</u> *Some of the functions that are mentioned in the NWSC Statute include (a) management of water resources in ways which are beneficial to the people of Uganda (b) provision of water and sewerage services (c) development of water and sewerage systems in urban centres and big National Institutions throughout the country. NWSC is therefore fulfilling one of its mandates to supply water to the Gulu Municipality and the towns en route from Karuma to Gulu.*

4.3.9 Employment Act, 2006

Employment Act, 2006 repeals the Employment Act (Cap 219) enacted in 2000. This Act is the principal legislation that seeks to harmonize relationships between employees and employers, protect workers interests and welfare and safeguard their occupational health and safety through:

i) Prohibiting forced labour, discrimination and sexual harassment at workplaces (Part II; Part IV).
ii) Providing for labour inspection by the relevant ministry (Part III).
iii) Stipulating rights and duties in employment (weekly rest, working hours, annual leave, maternity and paternity leaves, sick pay, etc. (Part VI).
iv) Continuity of employment (continuous service, seasonal employment, etc. (Part VIII).

This Act is relevant to the project both during the construction and operational phase.

<u>Relation to the project:</u> *The Act will govern labour type and conditions under which persons hired by the project work. It prohibits Child labour (a condition the contractor must comply with) as well as providing guidance on work rights during the post-construction phase. NWSC will ensure that no child labour is used by Contractor and sub-contractors on this project during construction by monitoring the recruitment process.*

4.3.10 Occupational Safety and Health Act (2006)

The Act replaces the Factories Act (1964). It departs from the original listing of "don'ts" and adopts a scientific approach in which technical measures required for protection of workers are prescribed, hence taking on a "preventive approach". The Act provides for prevention and protection of persons at all workplaces from injuries, diseases, death and damage to property. It covers not just the "factory" (as did the Factories Act) but also any workplace where persons are employed and its provisions extend not just to employees but to any other persons that may be legitimately present in a workplace and are at risk of injury or disease. Employers must protect workers from adverse weather and provide clean and healthy work environment, sanitary conveniences, sanitary and protective gear.

<u>Relation to the project:</u> *This Act will be especially relevant for OHS of construction crews and subsequently, operation and maintenance personnel in the Gulu-Karuma water project. This ESIA proposes in the ESMP measures to prevent, mitigate and compensate potential incidents, accidents and ensure safety in all project area in compliance with this Act. It will also have relevance in mitigation*

measures that in order to protect the workers and the public from health and safety impacts as a result of project construction and subsequent operation and maintenance activities. Contractors and NWSC will be responsible for acquiring insurance and provide personal protection equipment and first aid to all workers during construction and operation, respectively.

4.3.11 Physical Planning Act, 2010

This Act replaced the Town and Country Planning Act, Cap 246 which was enacted in 1951 and revised in 1964 but is now inconsistent with contemporary government system in Uganda. The 1951 Act was enacted to regulate and operate in a centralised system of governance where physical planning was carried out at national level through the Town and Country Planning Board. Implementation of the Act was supervised by local governments, especially the urban local governments.

Uganda has since gone through many social, political and economic changes. For example, promulgation of the 1995 Constitution established a decentralised system of governance which divulged powers and functions including physical planning, finance and execution of projects from the central government to local governments. This therefore created a need to enact a physical planning legislation which is consistent with this Constitutional requirement. The Physical Planning Act, 2010 establishes district and urban physical planning committees, provides for making and approval of physical development plans and applications for development.

Section 37 of The Physical Planning Act, 2010 requires an EIA permit for developments before they are implemented. It states:

"Where a development application related to matters that require an environmental impact assessment, the approving authority may grant preliminary approval subject to the applicant obtaining an EIA certificate in accordance with the National Environment Act".

<u>Relevance to the project:</u> NWSC shall use established guidelines for planning schemes, to acquire land and compensate for acquired lands, as well as safeguarding the natural environment, in line with the provisions of this Act. This ESIA is being conducted in fulfilment of Section 37 of the Act.

4.3.12 Historical Monuments Act (1967)

This Act was assented to on 21st October 1967, and came into force on 15th May 1968. It provides for preservation and protection of historical monuments and objects of archaeological, paleontological, ethnographical and traditional interest. According to this Act, the responsible Minister may, by statutory instrument, declare any object of archaeological, paleontological, ethnographical, traditional or historical interest to be a protected object. Once thus declared, the Act adds, no person whether owner or not shall do any of the following:

- Excavate soil so as to affect to its detriment, any object declared to be preserved or protected.

- Make alteration, addition to, or repair, destroy, deface or injure any object declared to be preserved or protected.

Sub-section 12(1) requires that any portable object discovered in the course of an excavation shall be surrendered to the Minister who shall deposit it in the Museum. The Act adds that, notwithstanding provisions of the subsection, where any object is discovered in a protected site, place, or monument, the owner of the protected site, place, or monument shall be entitled to reasonable compensation.

Relevance: This Act requires that any chance finds encountered during project construction shall be preserved by the Department of Monuments and Museum in the Ministry of Tourism, Wildlife and Heritage. A Chance Finds Procedure has been attached to this report (Appendix F) to guide NWSC and the Contractor in fulfilling the requirement of this Act.

4.3.13 The Mining Act, Cap. 148 2003

Stone quarry sites and gravel borrow pits will be necessary for materials needed to construct the concrete works of the project components. Therefore applicable licenses shall be obtained from the Commissioner of the Geological Survey and Mines. The Mining Act of 2003 regulates mining developments including set up of new quarries and/or sandpits. Relevant environmental studies required for this license application are described in Part XI. The extraction of stone/aggregate and murram materials will be undertaken in line with the provisions of this Act. Issues of restoration of the sites after extraction of murram will be of key importance after construction of the proposed project.

Relevance: This Act will apply to the project's contractors who will be required to obtain license for extraction of stone/ aggregate and murram materials required for construction as indicated in Sub-section 3.11.

4.3.14 Children Act, Cap 59

The Act provides for the reform and consolidation of the law relating to children; to provide for the care, protection and maintenance of children; to provide for local authority support for children; to establish a family and children court; to make provision for children charged with offences and for other connected purposes. Part I section 5 states that: (1) it shall be the duty of a parent, guardian or any person having custody of a child to maintain that child and, in particular, that duty gives a child the right to— education and guidance; immunisation; adequate diet; clothing; shelter; and medical attention; and (2) any person having custody of a child shall protect the child from discrimination, violence, abuse and neglect. Part I, Section 8 protects children against harmful employment. No child shall be employed or engaged in any activity that may be harmful to his or her health, education or mental, physical or moral development.

Relevance: During the construction and operation phases child labour must not be used as required by this law.

4.4 REGULATIONS/ STANDARDS/ GUIDELINES

4.4.1 The Water Resources Regulations, 1998

With regard to water abstraction, Part II: Section 3 Sub-section (1) of these regulations requires application for Water Permits by anyone who: (a) Occupies or intends to occupy any land; (b) Wishes to construct, own, occupy or control any works on or adjacent to the land referred to in regulation 10; may apply to the Director for a water permit.

Relevance: NWSC intends to construct an intake and abstract water from River Nile (Victoria Nile) and should therefore fulfil the requirements of these regulations. NWSC and the Contractor will apply to DWRM for permits for abstracting water from River Nile.

4.4.2 National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations, 1999

Section 6 (2) details maximum permissible limits for 54 regulated contaminants which must not be exceeded before effluent is discharged into water or on land. For this project, this standard is applicable to liquid waste from the water treatment works.

Table 17: National discharge standards for selected pollutants

Parameter	National discharge standards
BOD_5 (mg/l)	50
Suspended solids (mg/l)	100
Faecal coliforms (counts/ 100ml)	10,000
Chlorine residual (mg/l)	1
pH	6-8
Phenols (mg/l)	0.2
Oil and grease (mg/l)	10
Total Phosphorus (mg/l)	10
Temperature (^oC)	20-35

Source: The National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations, 1999.

Relevance: Effluent discharged from the water treatment works should conform to these regulations. Since the project is funded by World Bank/ KFW, the one that is more strigent, that is, Uganda regulations or IFC/WB General EHS Guidelines (Table 18) will override. NWSC and the Contractor for this project will apply to DWD for permits for discharging effluents from the sludge drying beds and construction activities, respectively, to the environment.

Table 18: Indicative values for treated sanitary sewage discharges

Pollutant	Unit	Guideline Value
pH	mg/l	6 – 9
BOD	mg/l	30
COD	mg/l	125
Total nitrogen	mg/l	10
Total phosphorus	mg/l	2
Oil and grease	mg/l	10
Total suspended solids	mg/l	50
Total coliform bacteria	Most Probable Number/100 ml	400[a]

Source: IFC/WB General EHS Guidelines

4.4.3 National Environment (Noise Standards and Control) Regulations, 2003

Part III Section 8 (1) requires facility operators, to use the best practicable means to ensure that the emission of noise does not exceed the permissible noise levels. The regulations require that persons to be exposed to occupational noise exceeding 85 dBA for eight hours in a day should be provided with requisite hearing protection.

Table 19: Regulatory noise limits

Facility	Noise limits dB (A) (Leq)	
	Day*	Night*
Construction sites	60	50
Mixed residential (with some commercial and entertainment)	55	45
*Time frame: Day 6.00 a.m -10.00 p.m; Night 10.00 p.m. - 6.00 a.m.		

Source: The National Environment (Noise Standards and Control) Regulations, 2003.

Relevance: Both during construction and operation of the water supply facilities, noise generated should not exceed limits prescribed by these regulations.

4.4.4 The National Environment (Wetlands, River Banks and Lakeshores Management) Regulations, 2000

Regulation 12(1) prohibits any person from carrying out an activity in a wetland without a permit issued by the Executive Director of NEMA. Under regulation 34(1), a developer desiring to conduct a project which may have significant impact on a wetland (for example dredging), river bank or lake shore, shall be required to carry out an environmental impact assessment in accordance with sections 20, 21, and 22 of the NES.

In Regulation 17 (1), every landowner, occupier or user who is adjacent or contiguous with a wetland shall have a duty to prevent the degradation or destruction of the wetland and shall maintain the ecological and other functions of the wetland. The tool used under these Regulations to ensure compliance is the permit. The Executive Director of NEMA can only permit activities in a wetland if he or she is satisfied that such activities shall not degrade the wetland in question.

Relevance: Prior to any works at River Nile, NWSC will seek permission from the Executive Director of NEMA, as provided for in these Regulations.

4.4.5 National Environment (Waste Management) Regulations, 1999

These regulations require waste disposal in a way that would not contaminate water, soil, and air or impact public health.

Relevance: These regulations apply to both construction and operation-phase waste which should be managed in a way such as to avoid environmental and public health impact.

4.4.6 Draft National Air Quality Standards, 2006

The draft national air quality standards provide the following regulatory limits (Table 20).

Table 20: Uganda's regulatory air quality standards for selected pollutants

Pollutant	Averaging time for ambient air	Standard for ambient air
Carbon dioxide (CO_2)	8 hour	9.0 ppm
Carbon monoxide (CO)	8 hour	9.0 ppm
Hydrocarbons	24 hour	5 mg m^{-3}
Nitrogen oxides (NO_x)	24 hour 1 year arithmetic mean	0.10 ppm
Smoke	Not to exceed 5 minutes in any one hour	Ringlemann scale No.2 or 40% observed at 6m or more
Soot	24 hour	500 µg Nm^{-3}
Sulphur dioxide (SO_2)	24 hour	0.15 ppm
Sulphur trioxide (SO_3)	24 hour	200 µg Nm^{-3}

Note: ppm = parts per million; "N" in µg/Nm-3 connotes normal atmospheric conditions of pressure and temperature (25oC and 1 atmosphere).

Relevance: These standards will apply particularly during construction of all project components. There should be a justification for applying a less stringent limit value, or in the absence of an acceptable justification, the EHS guidelines (Table 21) will apply.

Table 21: World Health Organisation (WHO) ambient air quality guidelines

	Averaging Period	Guideline value in µg/m^3
Sulphur dioxide (SO2)	24-hour 10 minute	20 500
Nitrogen dioxide (NO2)	1-year 1-hour	40 200
Particulate Matter PM_{10}	1-year 24-hour	20 50
Particulate Matter $PM_{2.5}$	1-year 24-hour	10 25
Ozone	8-hour daily maximum	100

Source: IFC/WB General EHS Guidelines

4.4.7 The Water Supply Regulations, 1999

The Water Supply Regulations, 1999 manage the water supply works including:

a) Permits requirements and procedures for water supply works by authority or connection to land owner (Division 1, clauses 4 to 6);
b) Application, examination and approval of Water supply plan (Division 2, clauses 7 to 11);
c) Cost of works, security deposit, inspection of works and plenty for violation (Division 2, clauses 12 to 18);
d) Metering system and charging rates (Part III, clauses 19 to 21).

4.4.8 National Environment (Audit) Regulations, 2006

Part V, Section 19, Sub-section (1) requires the operator or owner of a facility whose activities are likely to have a significant impact on the environment may, at any time, to carry out a voluntary environmental audit of the facility to determine its compliance with the National Environmental Act, Cap 153, these Regulations and other relevant laws.

Relevance: The project will involve construction and operation of water supply facilities that may indirectly have a negative impact on the environment. Therefore NWSC should conduct Environmental Audits to assess if there are impacts, to what extent and mitigate them.

4.4.9 Uganda National Roads Authority (General) Regulations, 2017

The purpose of these Regulations is to provide for:

- A clear and transparent framework for the use of national roads, road reserves and ferry landing facilities;
- The installation of traffic control devices;
- The carrying out of activities on national roads; including the temporary use of the roads, road reserves and ferry landing facilities for social, economic and political activities;
- The keeping by the Authority of an up-to-date register of usage of road reserves; and

- The requirements and obligations of contractors.

6. Prevention of obstruction: (1) The Authority shall regulate any activity undertaken along a national road, road reserve or ferry landing facility; (2) A person who intends to undertake an activity on a national road, road reserve or ferry landing facility shall obtain a permit from the Authority.

7. Erection of structures and other works on, near, under or above a national road, road reserve or ferry landing facility. (1) A person shall not, except with the written approval of the Authority— (a) erect, construct or lay anything on, near, under or above a national road, road reserve or ferry landing facility.

Relevance: Most of the transmission line will be constructed in the road reserve of the Karuma – Gulu Highway hence NWSC has to make the necessary arrangements with UNRA in order to facilitate the planned activities.

4.5 INSTITUTIONAL FRAMEWORK

4.5.1 National Environmental Management Authority (NEMA)

The National Environmental Act, Cap 153 establishes NEMA as the principal agency responsible for coordination, monitoring and supervision of environmental conservation activities. NEMA is under the Ministry of Water and Environment (MWE) but has a cross-sectoral mandate to oversee the conduct of EIAs through issuance of guidelines, regulations and registration of practitioners. It reviews and approves environmental impact statements in consultation with any relevant lead agencies.

NEMA works with District Environment Officers and local environment committees at local government levels who also undertake inspection, monitoring and enforce compliance on its behalf. In Government ministries, NEMA works with Environmental Liaison Units to ensure incorporation of environmental issues in their activities, policies and programs. NEMA is also responsible for issuing permits including: waste (both hazardous and non-hazardous) storage, disposal and transportation permit; permit to carryout regulated activities in wetlands, riverbanks and lakeshores; licence to emit noise in excess of the permissible noise levels; and permit to use river banks.

Role in the project: NEMA will:

- *Review and approve the ESIA report (ESIS)*
- *Through the Project Districts' Environment Officers, undertake environmental monitoring during project implementation.*
- *Issue relevant permits and licenses as highlighted above.*

4.5.2 National Water and Sewerage Corporation (NWSC)

The National Water and Sewerage Corporation (NWSC) Statute establishes the NWSC as a Water and Sewerage Authority and gives it the mandate to operate and provide water and sewerage services in areas entrusted to it on a sound commercial and viable basis. NWSC is a parastatal that operates and provides water and sewerage services for 111 urban centres across the country, of which Gulu

Municipality is part. Sector reforms in the period 1998-2003 included commercialization and modernization of the NWSC operating in cities and larger towns as well as decentralization and private sector participation in small towns. NWSC also operates small conventional sewage treatment plants in a series of towns.

4.5.3 Directorate of Water Resources Management (DWRM)

The primary goal of the directorate is to promote sustainable development of Uganda's water sector. The directorate is into design and implementation of water quality assessments, monitoring ground and surface water resources, laboratory and field works and ultimately water pollution control. It is also mandated to issue water abstraction permits; river dredging permits, waste (effluent) disposal and discharge permits.

4.5.4 Directorate of Water Development (DWD)

Lead agency responsible for policy guidance, coordination and regulation of all water sector activities including provision of oversight and support services to the local governments and other water supply service providers. DWD has the mandate to promote the provision of clean and safe water to all persons, investigate, control, protect and manage water in Uganda for any use in accordance with the provisions of the Water Statue, 1995.

4.5.5 Directorate of Environmental Affairs (DEA)

The Wetlands Management Department (WMD) within DEA is mandated to manage wetland resources and its goal is to sustain the biophysical and socio economic values of wetlands in Uganda for present and future generations. Wetlands are under a lot of pressure from conversion for industrial development, agriculture, wastewater treatment facilities. WMD has an inventory of the major wetlands in country in the National Wetlands Information System (NWIS). The inventory provides an overview of wetland resource, their values, threats and possible management options.

4.5.6 Ministry of Water and Environment (MWE)

The Ministry of Water and Environment is responsible for policy formulation, setting standards, strategic planning, coordination, quality assurance, provision of technical assistance, and capacity building. The ministry also monitors and evaluates sector development programmes to keep track of their performance, efficiency and effectiveness in service delivery. The ministry has three directorates: Directorate of Water Resources Management (DWRM), Directorate of Water Development (DWD) and the Directorate of Environmental Affairs (DEA).

The mandate of the MWE regarding sanitation and hygiene activities are stipulated in the memorandum of understanding (MoU) that was signed by Ministry of Health, Ministry of Education and Sports and the Ministry of Water and Environment. The role of MWE is limited to development of public sanitary facilities and promotion of good hygiene in small towns and rural growth centres..

4.5.7 Ministry of Gender, Labour & Social Development (MGLSD)

This ministry sets policy direction and monitoring functions related to labour, gender and general social development. Its OHS Department in the ministry is responsible for inspection and mentoring of occupational safety in workplaces and this could be during project construction and operation of the laboratory facilities. It is responsible for work place registration and certification of equipment.

Role in the project: The OHS Department in this Ministry will be responsible for undertaking inspections of construction sites to ensure safe working conditions; issue certification of equipment in compliance with the OHS act and registration of work places.

4.5.8 District Local Administration Structures

The proposed project is within the jurisdiction of Gulu, Omoro, Oyam and Kiryandongo District Local Governments headed by a Local Council V (LC V) Chairman and Chief Administration Officer (CAO) who are the political head and technical head respectively. Various district offices whose functions would be relevant to the project include offices of Natural Resources/Environment, District Health Inspector, District Planner, Community Development Officer, District Director of Health Services, District Water Officer, Town Council and District Engineer. Equally important are village-level local council administration (LC I and LC III). Leaders at these levels of local administration are closer to residents and therefore important in effective community mobilization, sensitization and dispute resolution given that the laboratory is also going to serve cross-border communities.

Role in the project: Local government structures are important for mobilising support for the project as well as monitoring its social-environmental impacts both during construction and operation phases.

4.5.9 Uganda National Roads Authority (UNRA)

Uganda National Roads Authority (UNRA) was established by an Act of Parliament: The Uganda National Authority Act, No. 15 of 2006 and became operational on 1st July 2008. The mandate of UNRA is to develop and maintain national roads network, advise Government on general roads policy and contribute to addressing transport constraints to development.

Role in the project: One of UNRA's responsibilities is the establishment and maintenance road reserves. Given that the water pipelines are in some places located in the road reserve especially on the transmission line along the Karuma – Gulu road, UNRA has to be informed so that any plans with respect to the project area takes into consideration the pipeline.

4.5.10 Ministry of Tourism, Wildlife and Heritage

In this ministry has the Department of Monuments and Museums mandated to protect, promote and present the cultural and natural heritage of Uganda through collection, conservation, study and information dissemination for enjoyment and education.

The department's key functions are:

a) Research about natural and cultural heritage;
b) Conservation and maintenance of important Physical Cultural Resources or Heritage Collections;
c) Provision of professional knowledge and information on the archaeology and palaeontology of Uganda;
d) Publication of research findings in appropriate publications;

e) Exhibition and interpretation of specimens for public study and enjoyment;
f) Monitoring implementation policies and strategies of historical and cultural heritage conservation and development;
g) Development of strategies for community participation in cultural heritage;
h) Promote public awareness about cultural and natural heritage through formal and informal education; and
i) Provide technical guidelines to the private investors.

<u>Role in the project</u>: This Ministry will be responsible for preservation of any chance finds encountered during project implementation.

4.5.11 Ministry of Internal Affairs

Ministry of Internal Affairs facilitates legal and orderly movement of persons to and from Uganda, regulates the residence of immigrants in the country, verifies and processes Uganda citizenship and enforces national and regional immigration laws for the development and security of Uganda.

<u>Role in the project</u>: This Ministry will be responsible for issuing work permits and permit for blasting, importation, storage and transportation of explosives during project implementation.

4.5.12 Ministry of Energy and Mineral Development

Ministry of Energy and Mineral Development (MEMD) is a government ministry to manage utilization of energy and mineral resources for development of Uganda and its people. The ministry is organized into five main departments to carry out its role. These include Departments of Energy Resources (DER), Geological Survey and Mines (DGSM), Petroleum Exploration and Production (DPEP), Petroleum Supplies (PSD), and Support Services. MEMD is mandated to: provide policy guidance in the development and exploitation of the energy and mineral resources; create an enabling environment in order to attract investment in the development, provision and utilization of energy and mineral resources; acquire, process and interpret technical data in order to establish the energy and mineral resource potential of the country; and inspect, regulate, monitor and evaluate activities of private companies in energy and mineral sectors so that the resources are developed, exploited and used on a rational and sustainable basis. Through DGSM, MEMD issues permits for mining (extraction of minerals, opening up of quarries and sand pits); and through PSD, it issues permits for storage of petroleum products.

<u>Role in the project</u>: This Ministry will be responsible for issuing mining permit and permit for storage of petroleum products during project implementation.

Table 22: Institutional coordination for project planning and implementation

Institution	ESIA certificate issuance	Supervision of civil works	Road intervention permits	Mining permit for quarries and storage of petroleum products	Disconnection of electricity	Application of Health and Safety regulations	Coordination with the Institutions and Karuma dam project	Communication Plan with local communities	Chance findings Management	Security and grievences
National Environment Management Authority (NEMA)	x	x								
National Water & Sewerage Corporation (NWSC)		x				x	x	x		
Ministry of Water & Environment (MWE)										
Ministry of Gender, Labour & Social Development (MGLSD)						x				
District Local Administrative Structures		x		x			x	x		
Uganda National Roads Authority (UNRA)			x							
Ministry of Tourism, Wildlife and Heritage									x	
Ministry of Internal Affairs										x
Ministry of Energy and Mineral Development				x	x					
World Bank		x					x			

4.6 PROJECT CLASSIFICATION FOR ESIA PURPOSES

4.6.1 Classification according to Uganda's National Environment Act, Cap 153

The *Third Schedule* of the National Environment Act Cap 153 prescribes projects for which EIA is mandatory and according to Section 1 and Section 12 (b & d) in this Schedule, the project should undertake detailed EIA.

4.6.2 Project Classification according to World Bank

The proposed project is classified as EA Category B. The proposed construction and operation of the water supply facilities will be restricted within the user-communities. Although the transmission main traverses some wetlands, it does so along the edges which were already disturbed the road construction activities and impact arisng from laying of the transmission main can easily be mitigated. On the southern bank of the Victoria Nile, construction of the Karuma HPP was also going on.

4.7 WORLD BANK SAFEGUARD POLICIES

The objective of the World Bank's environmental and social safeguard policies is to prevent and mitigate undue harm to people and their environment during the development process. These policies provide guidelines for bank and borrower staff in the identification, preparation, and implementation of programs and projects. Safeguard policies provide a platform for the participation of stakeholders in project design, and are an important instrument for building ownership among local populations (World Bank, 2006). The project will comply with these Policies by implementing measures that will be described in the ESMP and the government will ensure its application by the staff and contractors. The triggered safeguard policies are presented in the sub-sections below.

4.7.1 OP/BP 4.01 - Environmental Assessment

The World Bank's environmental assessment policy and recommended processing are described in Operational Policy (OP)/Bank Procedure (BP) 4.01: Environmental Assessment (Table 23). Its purpose is to improve decision making, to ensure that all options under consideration are sound and sustainable, and that potentially affected people have been properly consulted. Environmental Assessment (EA) is one of the 10 environmental, social, and legal Safeguard Policies of the World Bank. EA is used in the World Bank to identify, avoid, and mitigate the potential negative environmental impacts associated with Bank lending operations. This policy is considered to be the umbrella policy for the Bank's environmental 'safeguard policies'.

Table 23: WB OP/BP 4.01 Environmental Assessment (April 2013)

Objectives	Operational Principals
To help ensure the environmental and social soundness and sustainability of investment projects.	1. Use a screening process for each proposed project, as early as possible, to determine the appropriate extent and type of environmental assessment (EA) so that appropriate studies are undertaken proportional to potential risks and to direct, and, as relevant, indirect, cumulative, and associated impacts. Use sectorial or regional environmental assessment when appropriate.
	2. Assess potential impacts of the proposed project on physical, biological, socio-economic and physical cultural

Objectives	Operational Principals
	resources, including trans-boundary and global concerns, and potential impacts on human health and safety.
	3. Assess the adequacy of the applicable legal and institutional framework, including applicable international environmental agreements, and confirm that they provide that the cooperating government does not finance project activities that would contravene such international obligations.
	4. Provide for assessment of feasible investment, technical, and siting alternatives, including the "no action" alternative, potential impacts, feasibility of mitigating these impacts, their capital and recurrent costs, their suitability under local conditions, and their institutional, training and monitoring requirements associated with them.
	5. Where applicable to the type of project being supported, normally apply the Pollution Prevention and Abatement Handbook (PPAH). Justify deviations when alternatives to measures set forth in the PPAH are selected.
	6. Prevent and, where not possible to prevent, at least minimize, or compensate for adverse project impacts and enhance positive impacts through environmental management and planning that includes the proposed mitigation measures, monitoring, institutional capacity development and training measures, an implementation schedule, and cost estimates.
	7. Involve stakeholders, including project-affected groups and local nongovernmental organizations, as early as possible, in the preparation process and ensure that their views and concerns are made known to decision makers and taken into account. Continue consultations throughout project implementation as necessary to address EA-related issues that affect them.
	8. Use independent expertise in the preparation of EA where appropriate. Use independent advisory panels during preparation and implementation of projects that are highly risky or contentious or that involve serious and multi-dimensional environmental and/or social concerns.
	9. Provide measures to link the environmental assessment process and findings with studies of economic, financial, institutional, social and technical analyses of a proposed project.
	10. Provide for application of the principles in this Table to subprojects under investment and financial intermediary activities.
	11. Disclose draft EA in a timely manner, before appraisal formally begins, in an accessible place and in a form and language understandable to key stakeholders.

<u>Relevance:</u> The Project triggers this policy because although there is justification for the proposed water supply infrastructure in the project districts, there are also environmental impacts associated with the

construction and operation of these facilities. The proposed project is classified as EA Category B. The proposed project activities will be restricted within the user-communities. Although the transmission main traverses some wetlands, it does so along the edges which were already disturbed the road construction activities and impact arisng from laying of the transmission main can easily be mitigated. OP 4.01 requires an Environmental Assessment (EA) of projects proposed for WB financing to ensure that they are environmentally sound and sustainable, and thus to improve decision making. In this regard, a comprehensive Environmental and Social Impact Assessment has been undertaken by the Proponent to establish a detailed Environmental Management Plan that will provide guidelines for environmental stewardship of the construction and operational phases of the Project.

4.7.2 OP/BP 4.04 - Natural Habitats

This OP seeks to ensure that World Bank-supported infrastructure and other development projects take into account the conservation of biodiversity, as well as the numerous environmental services and products which natural habitats provide to human society. The policy strictly limits the circumstances under which any Bank-supported project can damage natural habitats (land and water areas where most of the native plant and animal species are still present). Specifically, the policy prohibits Bank support for projects which would lead to the significant loss or degradation of any Critical Natural Habitats, whose definition includes those natural habitats which are either:

- Legally protected,
- Officially proposed for protection, or
- Unprotected but of known high conservation value.

Table 24: WB OP/BP 4.04 Natural Habitats (April, 2013)

Objectives	Operational Principals
To promote environmentally sustainable development by supporting the protection, conservation, maintenance, and rehabilitation of natural habitats and their functions.	1. Apply a precautionary approach to natural resource management to ensure opportunities for environmentally sustainable development.
	2. Identify natural habitat issues and special needs for natural habitat conservation, including the degree of threat to identified natural habitats (particularly critical natural habitats), and measures should be put in place for protecting such areas in the context of the country's development strategy.
	3. Projects should be designed to integrate into national and regional development the conservation of natural habitats; maintenance of ecological functions; and rehabilitation of degraded natural habitats.
	4. Projects that, in the Bank's opinion, must not involve the significant conversion or degradation of critical natural habitats.
	5. Projects wherever feasible, should be sited on lands already converted excluding any lands that were converted in anticipation of the project. The

Objectives	Operational Principals
	projects should not involve significant conversion of natural habitats unless there are no feasible alternatives for the project and its siting, and comprehensive analysis demonstrates that overall benefits from the project substantially outweigh the environmental costs. If the environmental assessment indicates that a project would significantly convert or degrade natural habitats, the project should include mitigation measures acceptable to the Bank such as strategic habitat retention and post-development restoration; and establishing and maintaining an ecologically similar protected area. Other forms of mitigation measures are acceptable only when they are technically justified.
	6. For projects with potential adverse impacts on a natural habitat, the borrower's ability to implement the appropriate conservation and mitigation measures will be taken into account. In case of potential institutional capacity problems, the project should include components that develop the capacity of national and local institutions for effective environmental planning and management.
	7. Identify any major natural habitat issues, including identification of important natural habitat sites, the ecological functions they perform, the degree of threat to the sites, priorities for conservation, and associated recurrent-funding and capacity-building needs.
	8. Tthe views, roles, and rights of groups, including local non-governmental organizations and local communities, affected by Bank-financed projects involving natural habitats should be taken into account and such groups of people should be involved in planning, designing, implementing, monitoring, and evaluating of the project.

Relevance: The Project activities have limited potential to trigger this policy as most of the project areas are highly disturbed by agricultural and commercial activities.

4.7.3 OP/BP 4.11 - Physical Cultural Resources

Cultural resources are important as sources of valuable historical and scientific information, as assets for economic and social development, and as integral parts of a people's cultural identity and practices. The loss of such resources is irreversible, but fortunately, it is often avoidable. The objective of OP/BP 4.11 on Physical Cultural Resources is to avoid, or mitigate, adverse impacts on cultural resources from development projects that the World Bank finances.

Table 25: WB OP/BP 4.11 Physical Cultural Resources (April 2013)

Objectives	Operational Principals
To assist in preserving physical cultural resources and avoiding their destruction or damage. PCR includes resources of archaeological, paleontological, historical, architectural, and religious (including graveyards and burial sites), aesthetic, or other cultural significance.	1. Impacts on physical cultural resources should be addressed as an integral part of the environmental assessment (EA) process through screening; developing terms of reference (TORs); collecting baseline data; impact assessment; and formulating and mitigating measures and a management plan.
	2. When the project is likely to have adverse impacts on physical cultural resources, appropriate measures should be identified for avoiding or mitigating these impacts as part of the EA process. These measures may range from full site protection to selective mitigation, including salvage and documentation, in cases where a portion or all of the physical cultural resources may be lost.
	3. As an integral part of the EA process, develop a physical cultural resources management plan that includes measures for avoiding or mitigating any adverse impacts on physical cultural resources, provisions for managing chance finds, any necessary measures for strengthening institutional capacity, and a monitoring system to track the progress of these activities. The physical cultural resources management plan should be consistent with the country's overall policy framework and national legislation and should take into account institutional capabilities with regard to physical cultural resources.
	4. Consult concerned government authorities, relevant non-governmental organizations, relevant experts and local people in documenting the presence and significance of PCR, assessing the nature and extent of potential impacts on these resources, and designing and implementing mitigation plans.
	5. Disclose draft mitigation plans as part of the EIA or equivalent process, in a timely manner, before appraisal formally begins, in an accessible place and in a form and language that are understandable to key stakeholders. Exceptions to such disclosure would be considered when in consultation with the Bank and persons with relevant expertise, determines that disclosure would compromise or jeopardize the safety or integrity of the physical cultural resources involved or would endanger the source of information about the physical cultural resources.

<u>Relevance:</u> The activities of the Project trigger this policy as there are graves at the proposed water treatment plant site (Nora village) and at the proposed Customs Corner reservoir site in Gulu Municipality. The Chance Finds Procedure to provide guidance on handling and management of any PCRs that may be encountered during civil/earth works, is presented in Appendix F.

Photo 11: Graves at Gulu Customs Corner where the water reservoir is planned to be located

4.7.4 OP/BP 4.12 - Involuntary Resettlement

This policy is triggered in situations involving involuntary taking of land and involuntary restrictions of access to legally designated parks and protected areas. The policy aims to avoid involuntary resettlement to the extent feasible, or to minimize and mitigate its adverse social and economic impacts. It promotes participation of displaced people in resettlement planning and implementation, and its key economic objective is to assist displaced persons in their efforts to improve or at least restore their incomes and standards of living after displacement. The policy prescribes compensation and other resettlement measures to achieve its objectives and requires that borrowers prepare adequate resettlement planning instruments prior to Bank appraisal of proposed projects.

Table 26: WB OP/BP 4.12 Involuntary Resettlement (April 2013)

Objectives	Operational Principals
To avoid or minimize involuntary resettlement and, where this is not feasible, to assist displaced persons in improving or at least restoring their livelihoods and standards of living in real terms relative to pre-displacement levels or to levels	1. Assess all viable alternative project designs to avoid, where feasible, or minimize involuntary resettlement
	2. Where it is not feasible to avoid resettlement, resettlement activities should be conceived and executed as sustainable development programs, providing sufficient investment resources to enable the persons displaced by the project to share in project benefits. Displaced persons should be meaningfully consulted and should

Objectives	Operational Principals
prevailing prior to the beginning of project implementation, whichever is higher.	have opportunities to participate in planning and implementing resettlement programs.
	3. Displaced persons should be assisted in their efforts to improve their livelihoods and standards of living or at least to restore them, in real terms, to pre-displacement levels or to levels prevailing prior to the beginning of project implementation, whichever is higher.
	4. Tthe displaced persons should be (i) informed about their options and rights pertaining to resettlement; (ii) consulted on, offered choices among, and provided with technically and economically feasible resettlement alternatives; and (iii) provided prompt and effective compensation at full replacement cost for losses of assets attributable directly to the project.
	5. If the impacts include physical relocation, it should be ensured that the displaced persons are: (i) provided assistance (such as moving allowances) during relocation; and (ii) provided with residential housing, or housing sites, or, as required, agricultural sites for which a combination of productive potential, locational advantages, and other factors is at least equivalent to the advantages of the old site.
	6. Where necessary to achieve the objectives of the policy, the resettlement plan or resettlement policy framework also include measures to ensure that displaced persons are: (i) offered support after displacement, for a transition period, based on a reasonable estimate of the time likely to be needed to restore their livelihood and standards of living; and (ii) provided with development assistance in addition to compensation measures such as land preparation, credit facilities, training, or job opportunities.
	7. Particular attention should be paid to the needs of vulnerable groups among those displaced, especially those below the poverty line, the landless, the elderly, women and children, indigenous peoples, ethnic minorities, or other displaced persons who may not be protected through national land compensation legislation.
	8. Explore all viable alternative project designs to avoid physical displacement of indigenous peoples with traditional land-based modes of production. When it is not feasible to avoid such displacement, preference is given to land-based resettlement strategies for these groups that are compatible with their cultural preferences and are prepared in consultation with them.
	9. Compensation and provision of other assistance required for relocation, should be effected prior to displacement, and preparation and provision of resettlement sites with adequate facilities, where required. In particular, taking of land and related assets may take place only after compensation has been paid and, where applicable, resettlement sites and moving allowances have been provided to the displaced persons.
	10. Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. These strategies may include resettlement on public land, or on private land acquired or purchased for resettlement. Whenever replacement land is offered, resettlers are provided with land for which a combination of productive potential, locational advantages, and other factors is at least equivalent to the advantages of the land taken. If land is not the preferred option of the displaced

Objectives	Operational Principals
	persons, the provision of land would adversely affect the sustainability of a park or protected area, or sufficient land is not available at a reasonable price, non-land-based options built around opportunities for employment or self-employment should be provided in addition to cash compensation for land and other assets lost. The lack of adequate land must be demonstrated and documented to the satisfaction of the Bank.
	11. Payment of cash compensation for lost assets may be appropriate where (a) livelihoods are land-based but the land taken for the project is a small fraction18 of the affected asset and the residual is economically viable; (b) active markets for land, housing, and labor exist, displaced persons use such markets, and there is sufficient supply of land and housing; or (c) livelihoods are not land-based. Cash compensation levels should be sufficient to replace the lost land and other assets at full replacement cost in local markets.
	12. Displaced persons and their communities, and any host ommunities receiving them, should be provided with timely and relevant information, consulted on resettlement options, and offered opportunities to participate in planning, implementing, and monitoring resettlement.
	13. Carry out a census to identify the persons who will be affected by the project, to determine who will be eligible for assistance, and to discourage inflow of people ineligible for assistance. Develop a procedure, satisfactory to the Bank, for establishing the criteria by which displaced persons will be deemed eligible for compensation and other resettlement assistance. The procedure should include provisions for meaningful consultations with affected persons and communities, local authorities, and, as appropriate, non-governmental organizations (NGOs), and it specifies grievance mechanisms.
	14. Persons who encroach on the area after the cut-off date are not entitled to compensation or any other form of resettlement assistance.

Relevance: *The activities of the Project will trigger this policy as the proposed water supply facilities will be located in areas where people were conducting mostly agricultural activities. However, apart from involuntary resettlement with respect to socio-economic activities on land, there will not be resettlement of people from their settlements to other places.*

4.7.5 OP/BP 4.36 – Forests

The Bank's forests policy aims to reduce deforestation, enhance the environmental contribution of forested areas, promote reforestation, reduce poverty, and encourage economic development. Combating deforestation and promoting sustainable forest conservation and management have been high on the international agenda for two decades. However, little has been achieved so far and the world's forests and forest dependent people continue to experience unacceptably high rates of forest loss and degradation. Success in establishing sustainable forest conservation and management practices depends not only on changing the behaviour of all critical stakeholders, but also on a wide range of partnerships to accomplish what no country, government agency, donor, or interest group can do alone.

Table 27: WB OP/BP 4.36 Forests (April 2013)

Objectives	Operational Principals
To realize the potential of forests to reduce poverty in a sustainable manner, integrate forests effectively into sustainable economic development, and protect the vital local and global environmental services and values of forests.	1. Screen as early as possible for potential impacts on forest health and quality and on the rights and welfare of the people who depend on them. As appropriate, evaluate the prospects for new markets and marketing arrangements.
	2. Do not finance projects that would involve significant conversion or degradation of critical forest areas or related critical natural habitats, or that would contravene applicable international environmental agreements.
	3. Do not finance natural forest harvesting or plantation development that would involve any conversion or degradation of critical forest areas or related critical natural habitats.
	4. Support projects that adversely impact non-critical natural forests or related natural habitats only if viable alternatives to the project are not available and only if appropriate conservation and mitigation measures are in place.
	5. Support commercial, industrial-scale forest harvesting only when the operation is certified, under an independent forest certification system, as meeting, or having a time-bound action plan to meet, internationally recognized standards of responsible forest management and use.
	6. Ensure that forest restoration projects maintain or enhance biodiversity and ecosystem functionality and that all plantation projects are environmentally appropriate, socially beneficial and economically viable
	7. Give preference to small-scale community-level management approaches where they best reduce poverty in a sustainable manner
	8. Support commercial harvesting by small-scale landholders, local communities or entities under joint forest management where monitoring with the meaningful participation of local communities demonstrates that these operations achieve a standard of forest management consistent with internationally recognized standards of responsible forest use or that they are adhering to an approved time-bound plan to meet these standards.
	9. Use forest certification systems that require: a) compliance with relevant laws; b) recognition of, and respect for, legal or customary land tenure and use rights as well

Objectives	Operational Principals
	as the rights of Indigenous Peoples and workers; c) measures to enhance sound community relations; d) conservation of biological diversity and ecological functions; e) measures to maintain or enhance environmentally sound multiple benefits from the forest; f) prevention or minimization of environmental impacts; g) effective forest management planning; h) active monitoring and assessment of relevant forest management areas; and i) independent, cost effective, third-party assessment of forest management performance against measurable performance standards defined at the national level and compatible with internationally accepted principles and criteria of sustainable forest management through decision making procedures that are fair, transparent, independent, designed to avoid conflict of interest and involve the meaningful participation of key stakeholders, including the private sector, Indigenous Peoples, and local communities.
	10. Disclose any time-bound action plans in a timely manner, before appraisal formally begins, in an accessible place and in a form and language that are understandable to key stakeholders.

Relevance: The Project activities have limited potential to trigger this policy as only a few planted trees will be affected especially along the water transmission pipeline and natural trees at the proposed water treatment plant site. Most of the project areas are highly disturbed by agricultural and commercial activities.

4.7.6 OP/BP 4.37 – Dam Safety

The safe operation of dams has significant social, economic, and environmental relevance. When the World Bank finances new dams, OP 4.37: Safety on Dams requires that experienced and competent professionals design and supervise construction, and that dam safety measures are adopted and implemented through the project cycle. In addition to new dams, this policy also applies to existing dams where they influence the performance of a project.

Table 28: WB OP/BP 4.37 Safety of Dams (April, 2013)

Objectives	**Operational Principles**
To help ensure that appropriate measures are taken and sufficient resources provided for the safety of the dam, irrespective of its funding sources or construction status.	1. The Bank may finance the following types of projects that do not include a new dam but will rely on the performance of an existing dam or a dam under construction (DUC): power stations or water supply systems that draw directly from a reservoir controlled by an existing dam or a DUC; diversion dams or hydraulic structures downstream from an existing dam or a DUC, where failure of the upstream dam could cause extensive damage to or failure of the new structure; and irrigation or water supply projects that will depend on the storage and operation of an existing dam or a DUC for their supply of water and could not function if the dam failed. Projects in this category also include operations that require increases in the capacity of an existing dam, or changes in the characteristics of the impounded materials, where failure of the existing dam could cause extensive damage to or failure of the Bank-funded facilities.
	2. If such a project, as described in Paragraph 7, involves an existing dam or DUC in the borrower's territory, it is required that one or more independent dam specialists (a) inspect and evaluate the safety status of the existing dam or DUC, its appurtenances, and its performance history; (b) review and evaluate the owner's operation and maintenance procedures; and (c) provide a written report of findings and recommendations for any remedial work or safety-related measures necessary to upgrade the existing dam or DUC to an acceptable standard of safety.
	3. Previous assessments of dam safety or recommendations of improvements needed in the existing dam or DUC may be accepted if evidence is provided that (a) an effective dam safety program is already in operation, and (b) full-level inspections and dam safety assessments of the existing dam or DUC, which are satisfactory to the Bank, were conducted and documented.
	4. When substantial remedial work is needed, (a) the work should be designed and supervised by competent professionals, and (b) the same reports and plans as for a new dam should be prepared and implemented. For high-hazard cases involving significant and complex remedial work, it is also required that a panel of independent experts are employed on the same basis as for a new dam
	5. When the owner of the existing dam or DUC is an entity other than the borrower, the borrower enters into agreements or arrangements providing for the measures set out in paragraphs 8 to 10 to be undertaken by the owner.

<u>Relevance:</u> This policy is not triggered as the Project will not in any way rely on the performance of Karuma HPP. The proposed site for the intake structure is located in the backwater of the Karuma dam which is under construction and the abstraction point of the intake will be close to the river bed and below the minimum reservoir operational level. It is a submerged structure designed to include protective features to pipes, valves and associated electromechanical installations. Failure of the dam will not affect the intake operation given that it is located upstream of the dam and the Nile river environmental flow of 100 m^3/s is more than sufficient to maintain constant raw water flow into the intake wet well of design capacity 0.34 m^3/s. The only impact anticipated from the Karuma HPP is the backwater that would flood the proposed intake area and make construction of the intake and the associated facilities more costly.

4.7.7 OP/BP 7.50 – Projects on International Waterways

This policy recognizes the importance of cooperation and good will of riparians as essential for the efficient utilization and protection of international waterways and attaches great importance to riparian's making appropriate agreements or arrangement for the entire waterway or any part thereof. Projects that trigger this policy include hydroelectric, irrigation, flood control, navigation, drainage, water and sewerage, industrial, and similar projects that involve the use or potential pollution of international waterways. This policy relates to the relations between the riparian states. In the absence of such agreements or arrangements, the Bank requires, as a general rule, that the prospective borrower notifies the other riparian of the project. The policy lays down detailed procedures for the notification requirement, including the role of the Bank in affecting the notification, period of reply and the procedures in case there is an objection by one of the riparian to the project. The policy applies to any river, canal, lake, or similar body of water that forms a boundary between, or any river or body of surface water that flows through, two or more states, whether World Bank members or not. It also includes any tributary or other body of surface water any bay, gulf, strait, or channel bounded by two or more states or, if within one state, recognized as a necessary channel of communication between the open sea and other states and any river flowing into such waters. The policy recognizes prior riparian states agreements/arrangements such as the Nile Basin which the project falls under. The policy also calls for notification of riparian states by parties that proposes to undertake project that affects international waters.

<u>Relevance</u>*: The policy is triggered since water treatment plant and intake are located on the Victoria Nile (River Nile). In accordance with OP/BP 7.50, all riparian states were notified on behalf of Government of Uganda and the Regional Vice President (RVP) cleared the project. However, It is not anticipated that the project will cause appreciable harm to any of the riparian through water deprivation, pollution or otherwise. Neither is it anticipated that the implementation of project activities will adversely change the overall quantity or quality of water flowing to or from any of the riparian of the concerned international waterways (World Bank, 2018).*

4.8 WB - EHS GUIDELINES

The WB Environmental, Health, and Safety (EHS) Guidelines 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. 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.

4.8.1 Water and Sanitation

The EHS Guidelines for Water and Sanitation include information relevant to the operation and maintenance of: potable water treatment and distribution systems; collection of sewage in centralized systems such as piped sewer collection networks or decentralized systems such as septic tanks subsequently serviced by pump trucks; and treatment of collected sewage at centralized facilities.

The Guidelines provide *GIIP* advice relating to the following elements of Water Projects:

Environment Safety

- Drinking water
  - Water withdrawal
  - Water treatment
  - Water distribution

Occupational Health and Safety

- Accidents and injuries
- Chemical exposure
- Hazardous Atmosphere
- Exposure to pathogens and vectors
- Noise

Community Health and Safety

- Drinking water
- Sanitation

Performance Indicators and Industry Benchmarks

- Environment
- Occupational health and safety

<u>Relevance:</u> The WB Environmental, Health, and Safety (EHS) Guidelines (Water and Sanitation, 2007) are relevant to the Project as they provide the latest internationally accepted GIIP for relevant OHS issues. EHS Guideline parameters are required in cases that the country does not have legislation or in cases the requirements are the most stringent. The recommendations contained within the Guidelines have been reviewed during the development of this ESIA and incorporated in to the prescribed management and mitigation measures as appropriate. Drinking water quality standards to be applied are those set out in the EHS Guidelines.

4.8.2 Environmental

<u>Air emissions and ambient air quality:</u> This guideline applies to facilities or projects that generate emissions to air at any stage of the project life-cycle. It complements the industry-specific emissions guidance presented in the Industry Sector Environmental, Health, and Safety (EHS) Guidelines by providing information about common techniques for emissions management that may be applied to a range of industry sectors. This guideline provides an approach to the management of significant sources of emissions, including specific guidance for assessment and monitoring of impacts. It is also intended to provide additional information on approaches to emissions management in projects located in areas of poor air quality, where it may be necessary to establish project-specific emissions standards.

Emissions of air pollutants can occur from a wide variety of activities during the construction, operation, and decommissioning phases of a project. These activities can be categorized based on the spatial characteristic of the source including point sources, fugitive sources, and mobile sources and, further, by process, such as combustion, materials storage, or other industry sector specific processes. Where possible, facilities and projects should avoid, minimize, and control adverse impacts to human health, safety, and the environment from emissions to air. Where this is not possible, the generation and release of emissions of any type should be managed through a combination of:

- Energy use efficiency
- Process modification
- Selection of fuels or other materials, the processing of which may result in less polluting emissions
- Application of emissions control techniques

Table 29: WHO ambient air quality guidelines

Pollutant	Averaging period	Guideline value in µg/m^3
Sulphur dioxide (SO_2)	24-hour	125 (Interim target 1)
		50 (Interim target 2)
		20 (guideline)
	10 minute	500 (guideline)
Nitrogen dioxide (NO_2)	1-year	40 (guideline)
	1-hour	200 (guideline)
Particulate Matter, PM_{10}	1-year	70 (interim target 1)
		50 (interim target 2)
		30 (interim target 3)
		20 (guideline)
	24-hour	150 (interim target 1)
		100 (interim target 2)
		75 (interim target 3)
		50 (guideline)
Particulate Matter, $PM_{2.5}$	1-year	35 (interim target 1)
		25 (interim target 2)
		15 (interim target 3)
		10 (guideline)
	24-hour	75 (interim target 1)

Pollutant	Averaging period	Guideline value in µg/m^3
		50 (interim target 2) 37.5 (interim target 3) 25 (guideline)
Ozone	8-hour daily maximum	160 (interim target 1) 100 (guideline)

Source: World Bank EHS Guidelines, 2007

<u>Relevance:</u> These guidelines are relevant to the project as the activities will lead to emissions of air pollutants. The recommendations contained within the Guidelines have been incorporated in to the prescribed management and mitigation measures as appropriate. The air quality and emissions guidelines will be applied in cases where they are more stringent than the national ones.

4.8.3 Occupational Health and Safety

Employers and supervisors are obliged to implement all reasonable precautions to protect the health and safety of workers. It provides guidance and examples of reasonable precautions to implement in managing principal risks to occupational health and safety. Although the focus is placed on the operational phase of projects, much of the guidance also applies to construction and decommissioning activities. Companies should hire contractors that have the technical capability to manage the occupational health and safety issues of their employees, extending the application of the hazard management activities through formal procurement agreements.

<u>Relevance:</u> The WB Environmental, Health, and Safety (EHS) Guidelines (Water and Sanitation, 2007) are relevant to the Project as they provide the latest internationally accepted GIIP for relevant OHS issues. The recommendations contained within the Guidelines have been reviewed during the development of this ESIA and incorporated in to the prescribed management and mitigation measures as appropriate. Drinking water quality standards to be applied are those set out in the EHS Guidelines.

4.8.4 Community Health and Safety

This complements the guidance provided in the environmental and occupational health and safety sections, specifically addressing some aspects of project activities taking place outside of the traditional project boundaries, but nonetheless related to the project operations, as may be applicable on a project basis. The issues of consideration that may arise at any stage of a project life cycle and can have an impact beyond the life of the project highlighted would be related to any of the following:

- Water quality and availability
- Structural safety of project infrastructure
- Life and fire safety (L&FS)
- Traffic safety
- Transport of hazardous materials
- Disease prevention
- Emergency preparedness and response

Relevance: The health and safety of the communities in the project area is important just like safety and health of workers directly engaged in project activities.These guidelines are therefore very important for guiding the project to ensure that no health and safety issues arise within the project communities. The recommendations contained within the Guidelines have been incorporated in the management and mitigation measures as appropriate.

4.8.5 Construction and Decommissioning

This provides additional, specific guidance on prevention and control of community health and safety impacts that may occur during new project development, at the end of the project life-cycle, or due to expansion or modification of existing project facilities. Cross referencing is made to various other sections of the General EHS Guidelines.

a) Environment

Noise and vibration: During construction and decommissioning activities, noise and vibration may be caused by the operation of pile drivers, earth moving and excavation equipment, concrete mixers, cranes and the transportation of equipment, materials and people. Some recommended noise reduction and control strategies to consider in areas close to community areas include:

- Planning activities in consultation with local communities so that activities with the greatest potential to generate noise are planned during periods of the day that will result in least disturbance
- Using noise control devices, such as temporary noise barriers and deflectors for impact and blasting activities, and exhaust muffling devices for combustion engines.
- Avoiding or minimizing project transportation through community areas

Soil erosion: Soil erosion may be caused by exposure of soil surfaces to rain and wind during site clearing, earth moving, and excavation activities. The mobilization and transport of soil particles may, in turn, result in sedimentation of surface drainage networks, which may result in impacts to the quality of natural water systems and ultimately the biological systems that use these waters.

Air quality: Construction and decommissioning activities may generate emission of fugitive dust caused by a combination of on-site excavation and movement of earth materials, contact of construction machinery with bare soil, and exposure of bare soil and soil piles to wind. A secondary source of emissions may include exhaust from diesel engines of earth moving equipment, as well as from open burning of solid waste on-site.

Solid waste: Non-hazardous solid waste generated at construction and decommissioning sites includes excess fill materials from grading and excavation activities, scrap wood and metals, and small concrete spills. Other non-hazardous solid wastes include office, kitchen, and dormitory wastes when these types of operations are part of construction project activities. Hazardous solid waste includes contaminated soils, which could potentially be encountered on-site due to previous land use activities, or small amounts of machinery maintenance materials, such as oily rags, used oil filters, and used oil, as well as spill cleanup materials from oil and fuel spills.

Hazardous materials: Construction and decommissioning activities may pose the potential for release of petroleum based products, such as lubricants, hydraulic fluids, or fuels during their storage, transfer, or use in equipment. These materials may also be encountered during decommissioning activities in building components or industrial process equipment.

Wastewater discharges: Construction and decommissioning activities may include the generation of sanitary wastewater discharges in varying quantities depending on the number of workers involved. Adequate portable or permanent sanitation facilities serving all workers should be provided at all construction sites.

Contaminated land: Land contamination may be encountered in sites under construction or decommissioning due to known or unknown historical releases of hazardous materials or oil, or due to the presence of abandoned infrastructure formerly used to store or handle these materials, including underground storage tanks. Actions necessary to manage the risk from contaminated land will depend on factors such as the level and location of contamination, the type and risks of the contaminated media, and the intended land use.

b) Occupational health and safety

Over-exertion: Over-exertion, and ergonomic injuries and illnesses, such as repetitive motion, over-exertion, and manual handling, are among the most common causes of injuries in construction and decommissioning sites.

Slips and falls: Slips and falls on the same elevation associated with poor housekeeping, such as excessive waste debris, loose construction materials, liquid spills, and uncontrolled use of electrical cords and ropes on the ground, are also among the most frequent cause of lost time accidents at construction and decommissioning sites.

Work in heights: Falls from elevation associated with working with ladders, scaffolding, and partially built or demolished structures are among the most common cause of fatal or permanent disabling injury at construction or decommissioning sites. If fall hazards exist, a fall protection plan should be in place which includes one or more of the following aspects, depending on the nature of the fall hazard95:

Struck by objects: Construction and demolition activities may pose significant hazards related to the potential fall of materials or tools, as well as ejection of solid particles from abrasive or other types of power tools which can result in injury to the head, eyes, and extremities.

Moving machinery: Vehicle traffic and use of lifting equipment in the movement of machinery and materials on a construction site may pose temporary hazards, such as physical contact, spills, dust, emissions, and noise. Heavy equipment operators have limited fields of view close to their equipment and may not see pedestrians close to the vehicle. Center-articulated vehicles create a significant impact or crush hazard zone on the outboard side ofa turn while moving.

Dust: Dust suppression techniques should be implemented, such as applying water or non-toxic chemicals to minimize dust from vehicle movements and PPE, such as dusk masks, should be used where dust levels are excessive.

Confined spaces and excavations: Examples of confined spaces that may be present in construction or demolition sites include: silos, vats, hoppers, utility vaults, tanks, sewers, pipes, and access shafts. Ditches and trenches may also be considered a confined space when access or egress is limited.

c) Community Health and Safety

General site hazards: Projects should implement risk management strategies to protect the community from physical, chemical, or other hazards associated with sites under construction and decommissioning. Risks may arise from inadvertent or intentional trespassing, including potential contact with hazardous materials, contaminated soils and other environmental media, buildings that are vacant or under construction, or excavations and structures which may pose falling and entrapment hazards.

Disease prevention: Increased incidence of communicable and vector-borne diseases attributable to construction activities represents a potentially serious health threat to project personnel and residents of local communities. Recommendations for the prevention and control of communicable and vector-borne diseases also applicable to construction phase activities are provided.

Traffic safety: Construction activities may result in a significant increase in movement of heavy vehicles for the transport of construction materials and equipment increasing the risk of traffic-related accidents and injuries to workers and local communities. The incidence of road accidents involving project vehicles during construction should be minimized through a combination of education and awareness-raising, and the adoption of procedures described in these guidelines.

Relevance: During decommissioning and maintenance of the project components, same impacts as those anticipated during project construction and operation may arise. Therefore these guidelines are very important and relevant during this phase of the project as highlighted in sub-sections 8.2 to 8.4.

4.9 KfW DEVELOPMENT BANK SUSTAINABLITY GUIDELINES

The priority areas of KfW's promotional activities in developing countries include social development, environmental and climate protection and the conservation of natural resources. Therefore, KfW Development Bank seeks to incorporate climate and/or environmental objectives into the scope of the Financial Corporation measure. With the aim of sustainability and avoiding adverse environmental, social and climate impacts and risks, KfW Development Bank pursues in particular the following principles for its Financial Corporation measures that are financed to:

- Avoid, reduce or limit environmental pollution and environmental damage including climate-damaging emissions and pollution;
- Preserve and protect biodiversity and tropical rainforests and to sustainably manage natural resources;
- Consider probable and foreseeable impacts of climate change including utilising the potential to adapt to climate change. In this context climate change is understood as climate variability and long-term climate change;
- Avoid adverse impacts upon the living conditions of communities, in particular indigenous people and other vulnerable groups, as well as to ensure the rights, living conditions and values of indigenous people;

- Avoid and minimise involuntary resettlement and forced eviction of people and their living space as well as to mitigate adverse social and economic im-pacts through changes in land use by reinstating the previous living conditions of the affected population;
- Ensure and support health protection at work and the occupational health and safety of people working within the framework of a FC measure;
- Condemn forced labour and child labour, ban discrimination in respect of employment as well as occupation and support the freedom of association and the right to collective bargaining;
- Protect and preserve cultural heritage; and
- Support the executing agency in the management and monitoring of possible adverse environmental, social and climate impacts as well as risks within the framework of the implement FC measure.

The project will implement all the above measures and follow these guidelines (https://www.kfw-entwicklungsbank.de/PDF/Download-Center/PDF-Dokumente-Richtlinien/Nachhaltigkeitsrichtlinie_EN.pdf)

4.10 INTERNATIONAL AGREEMENTS

Uganda has signed and/or ratified several international agreements and conventions relating to the environment both at regional and global level such as ones below. However, due to the low environmental sensitivity of the project sites no impact associated with these conventions are anticipated as shown below:

- 1968 African Convention on the Conservation of Nature and Natural Resources:

  Reason: No sensitive natural resources are found at or along the proposed project sites.

- Convention on Wetlands of International Importance Especially as Waterfowl Habitat:

  Reason: No gazetted wetlands are traversed by the project facilities.

- 1987 Montreal Protocol on Substances that Deplete the Ozone Layer

  Reason: No such substances will be used during construction and operation of the project facilities.

- 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora

  Reason: No project facility is located in a protected wildlife area.

- 1992 Convention on Biological Diversity

  Reason: There was no significant biological diversity in the project area.

- The Convention on Migratory Species of Wild Animals (CMS) aimed at conserving species of wild animals that migrate across or outside national boundaries.

  Relevance: This convention is relevant to the Project as implementation could impact on migratory species to only very small extent by constructing a water treatment plant in a portion of their ranging area.

- Convention on the Protection and Use of Trans-boundary Watercourses and International Lakes (1992): The Convention of the Protection and Use of Trans-boundary Watercourses and International Lakes (Water Convention) is intended to strengthen national measures for the protection and ecologically sound management of trans-boundary surface waters and groundwater's. The Convention obliges Parties to prevent, control and reduce water pollution from point and non-point sources. The Convention also includes provisions for monitoring, research and development, consultations, warning and alarm systems, mutual assistance, institutional arrangements, and the exchange and protection of information, as well as public access to information. The Convention obliges Parties to prevent, control and reduce water pollution from point and non-point sources. The Convention also includes provisions for monitoring, research and development, consultations, warning and alarm systems, mutual assistance, institutional arrangements, and the exchange and protection of information, as well as public access to information. Article 3 calls for the application of EIA and other means of assessment for the prevention, control and reduction of transboundary watercourses and international lakes.

The foregoing notwithstanding, the contractor(s) and NWSC will have a contractual obligation to avoid impacts that may violate above conventions, wherever encountered.

4.11 PERMITS AND LICENSES

Permits and licenses that may be required by the project are presented in Table 30.

Table 30: Permits and licenses potentially required by the project

Permit Required	Issuing Authority	Party responsible for acquiring permit/license	Legal Framework
Water Abstraction Permit	DWRM	NWSC & Contractor	Water Act, cap 152
River Dredging Permit	DWRM	Contractor	Rivers Act, cap 357
Waste Discharge permit	DWRM	NWSC & Contractor	Water Act, cap 152
Waste Disposal Permit	NEMA	NWSC & Contractor	National Environment Act Cap 153; National Environment (Waste Management) Regulation
Waste Transportation License	NEMA	Contractor	National Environment Act Cap 153; National Environment (Waste Management) Regulation
Storage of Hazardous/ Non Hazardous Waste	NEMA	Contractor	National Environment Act Cap 153; National Environment (Waste Management) Regulation

Permit Required	Issuing Authority	Party responsible for acquiring permit/license	Legal Framework
* Permit to carry out a Regulated activity in a Wetland, Riverbank, Lakeshore	NEMA	Contractor & NWSC	National Environment Management (Wetland, Riverbank, Lakeshore) Regulation 2000
License to emit noise in excess of permissible noise levels	NEMA	Contractor	National Environment Act Cap 153
Blasting, importation, storage and transportation of explosives	Ministry of Internal Affairs	Contractor	Explosive Act, Cap 298
Mining Permit, Extraction of minerals, opening up of quarries and sand pits	DGSM/ MEMD	Contractor	Mining Act, Cap 148
Permit for Storage of Petroleum Products	PSD/MEMD	Contractor	Petroleum Act, Cap 2003
Work Place Registration	MGLSD	Contractor	OHS Act, 2006
Work Permits	Ministry of Internal Affair	Contractor & Supervising Consultant/ NWSC	Immigrations Act, Cap 66
Certification of statutory equipment	MGLSD, UNBS	Contractor	OHS Act, UNBS Act
Approval of Water Treatment Plant layout plan	MLHUP	NWSC	Physical Planning Act Cap 281
River Bank Use Permit (Waiver for Blasting in the River Bed)	NEMA	NWSC	National Environment Management (Wetland, Riverbank, Lakeshores) Regulations 2000
Permit if the water transmission line is to cross the UNRA road. During construction, NWSC will need UNRA staff to monitor especially traffic and also give alternatives besides	UNRA	NWSC	The Uganda National Roads Authority (General) Regulations 2017

Permit Required	Issuing Authority	Party responsible for acquiring permit/license	Legal Framework
acquiring the permit. The road reserve is 14.5 metres from the centre and other roads is 7 metres from the shoulders especially when the road is approaching the town.			

* No permission is required if activities are confined within the road reserve but if activities will affect the undisturbed parts of the wetlands/swamps then NWSC has to seek permission from NEMA

5 ESIA METHODOLOGY

5.1 INTRODUCTION

This section describes the broad principles of methodology of the ESIA indicating approaches, practices and techniques used for impact identification, quantification, analysis and abatement. Impacts of the project were predicted in relation to environmental and social receptors and natural resources. This was accomplished by comparing prevailing conditions ("pre-project") and "post-project" situations.

The requirement for environmental assessment in Uganda is set out by the National Environment Act (1995) and the Environmental Impact Assessment Regulations (1998). The process was guided by the EIA Guidelines (NEMA, 1997).

The methodology used consisted of a review of Uganda's institutional arrangements, regulations and policies and those of the World Bank and World Health Organisation. Also done were baseline measurements, identification of impact receptors and their relation to project's site; and consultations with various stakeholders. Other activities included data collection & analysis and review of engineering designs.

Impacts of the project were predicted in relation to environmental and social receptors and natural resources. This was accomplished by comparing prevailing conditions ("pre-project") and "post-project" situations.

5.2 ESTABLISHMENT OF ENVIRONMENTAL & SOCIO-ECONOMIC BASELINE CONDITIONS

5.2.1 Physical Environment

Baseline water quality, air quality and noise levels were measured, not only to inform construction contractors about pre-construction conditions existing at proposed sites, but also the first annual environmental audit: subsequent baseline conditions would be those values measured in the first annual full environmental audit. These were determined through the following actions:

Air quality: Baseline air quality was measured using a pair of digital MX6 iBrid™ portable gas meters (Industrial Scientific-Oldham) and a Microdust 880nm digital aerosol monitor (Casella®) (Photo 12). Measurement points or locations (Figure 29) were selected basing on presence of potential receptors.

Ambient noise and vibrations: Baseline noise measurements were undertaken at locations around the proposed storage facility site with potential receptors. Measurement of ambient noise levels was carried out using a precision integrating sound level meter (Photo 13), with an active range of 0-140 decibels (dB) and complying with IEC 651 and ANSI S4 standards. A Casella CEL-621C digital noise logger was set to record for a sample period of ten minutes at each of the selected locations. The assessment procedure involved recording the LA_{MAX} and LA_{MIN} decibel levels. Measurement points were recorded using a GPS receiver and the noise sources together with the ambient environment at each location noted.

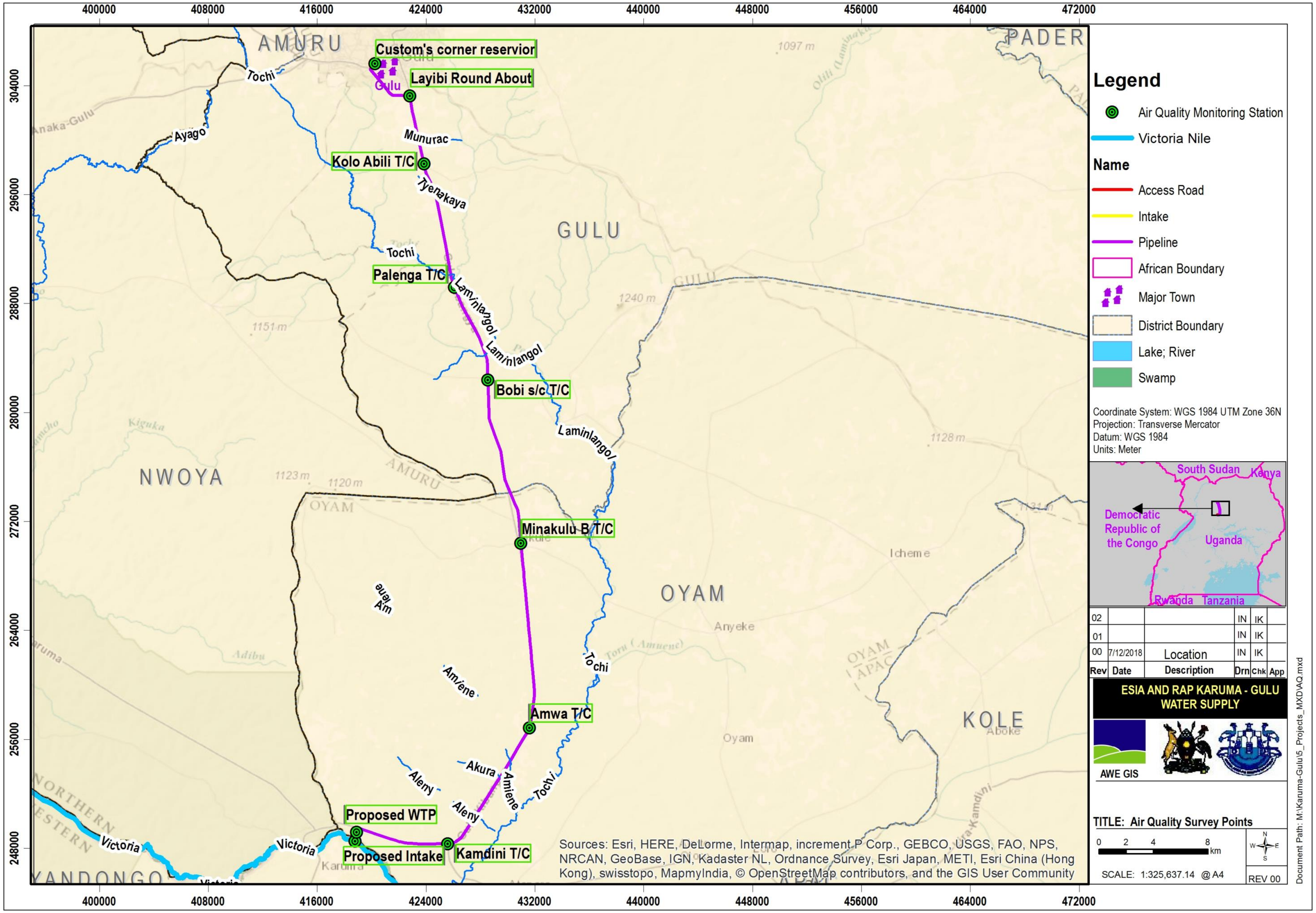


Figure 29 Air quality measurement points

The baseline vibration measurements were taken using a calibrated Nomis SuperMini® Seismograph (Photo 14). The transducer and microphone were pointed towards the vibration source with the seismograph in Monitor mode and stabilized readings were taken after a test run of twenty (20) minutes.

CASELLA Microdust meter

Digital 6-gas MX6 Ibrid meter

Photo 12: Digital CASELLA microdust and 6-gas MX6 iBrid™ meters to be used to measure air quality

Noise measurement will be done with a CASELLA CEL-621C2/K1 Integrating 1/3 Octave Band Sound Level Meter (Class2)

Photo 13: Noise measurement meter

Photo 14: Vibration measurement meter (Nomis SuperMini® Seismograph)

Water quality: Drinking water samples and surface water quality sampling was conducted along the river as well as upstream and downstream of the proposed facilities and at swamps along the Karuma – Gulu Highway as indicated in Figure 30. Samples were stored at 4°C and the following day transported to NWSC laboratory at Bugolobi for biological and physiochemical analysis. In situ measurements were undertaken with a multi-probe water quality meter (HANNA HI 9828). Parameters measured included pH, electrical conductivity, total dissolved solids, temperature, dissolved oxygen, salinity, oxidation-reduction potential, ammonia-nitrogen, nitrate-nitrogen, nitrite-nitrogen, biochemical oxygen demand, turbidity, apparent colour, chemical oxygen demand, total nitrogen, total phosphorus, total suspended solids, fat, oil and grease, and bacteriological quality (Faecal and total coliforms).

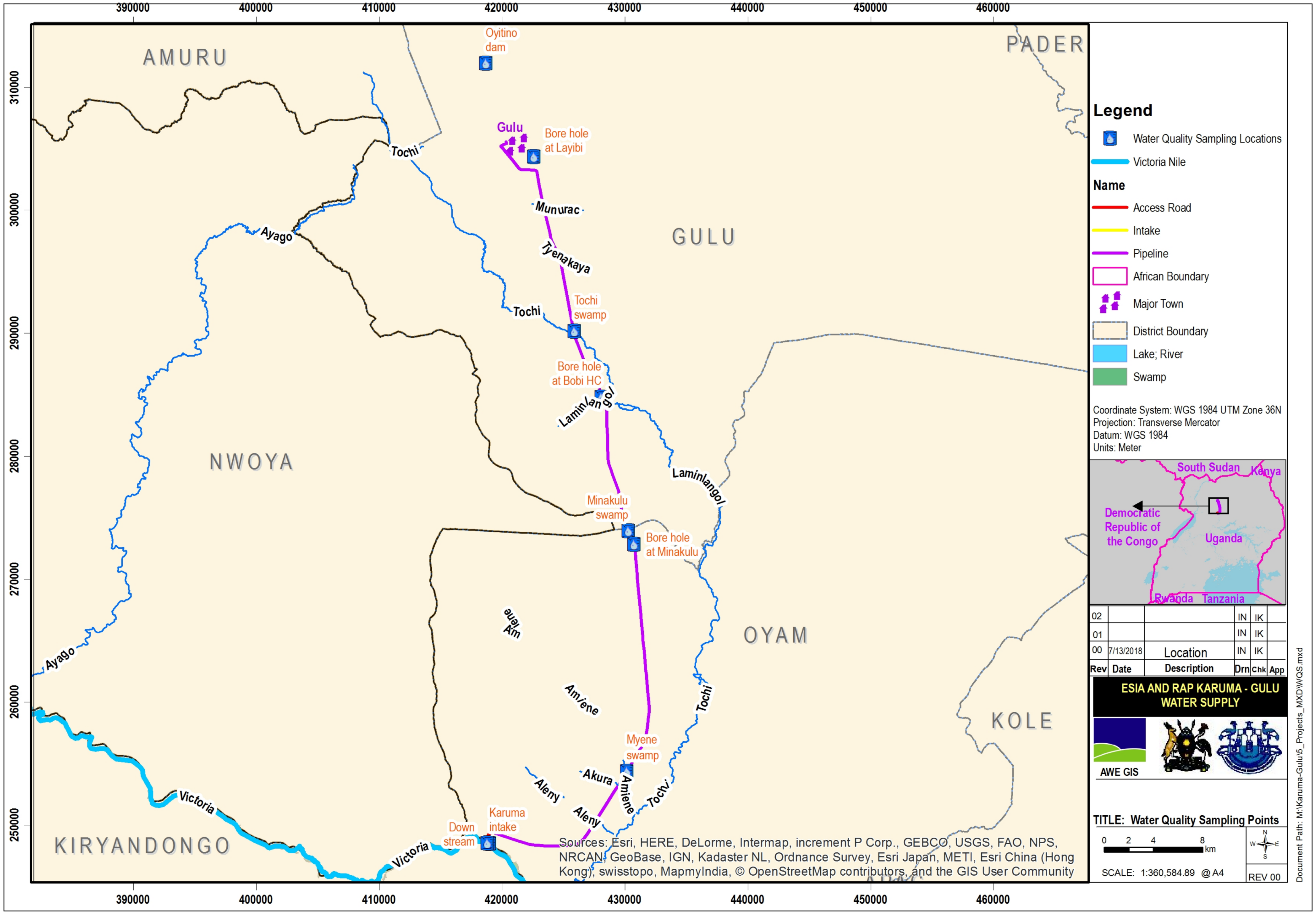


Figure 30 Location of sampling points for water quality measurement

Hydrological assessment: This included review of reports and site visit in order to make in situ observations and assessments. Local conditions were determined and a broad understanding gained of the catchment. The hydrological impact of the proposed Karuma-Gulu Transmission line was assessed and quantified for all phases of the project, from inception to decommissioning. The following aspects were addressed:

i) The proposed project footprint was assessed and its impact on hydrology determined.
ii) Flood peaks and runoff volumes were calculated for the 50- and 100 year recurrence interval storm events.
iii) The project impact on Mean Annual Runoff (MAR) was determined.
iv) Flood lines were determined for the 100 year recurrence interval storm event.

Hydrological modelling of catchment areas: For baseline surface water assessments along the pipeline corridor, the catchments were delineated using ArcHydro tools using the culvert crossings as the catchment outlets. Satellite Imagery from Google earth was used in conjunction with the existing Land cover and soils shape files to assess runoff coefficients 20 catchments were identified totaling roughly to 1042.76 km^2.

For this hydrological Impact Assessment, HEC-HMS was used to compute the peak flow corresponding to design storm for the 2, 5, 10, 25 and 50 year return period. The discharges were computed for each culvert points specified under their respective options.

HECHMS version 4.2.1 designed by the Hydrologic Engineering Centre, U.S. Army Corps of Engineers was adopted for hydrology analysis of culvert peak discharges. HEC-HMS is an event-based rainfall-runoff model largely limited to single-event simulation. For hydrograph simulations, the model applies a number of empirical and physical models such as Clark's, Synder, SCS-Unit hydrograph and the Kinematic wave model to simulate runoff. The runoff volume is computed using the SCS Curve Number method, the runoff coefficient method or using the Green and Ampt loss model.

The HEC-HMS event model for the watersheds uses the following components, meteorological component, rainfall loss component, direct runoff component, river routing component and base flow component. The SCS method for watershed lag developed by Mockus in 1961 was used to estimate the time of concentration.

Determination of flood line: Flood lines, flow velocities and depth have been calculated based on the available STRM Digital Elevation data for the (2, 5, 10, 20, 50 and 100 year RI) design storm events and the flood plain delineated accordingly especially at the culvert and waterway crossings.

The hydraulics of the existing waterways were assessed using the HECRAS hydraulic modelling software. The cross sections through the main waterways were generated at regular intervals. This provided for important factors such as abrupt changes in channel cross section were represented as accurately as possible within the limitations of HECRAS model and the available STRM DEM data. The HECRAS model was used to model the 2,5,10, 50 and 100 year ARI hydraulic characteristics at each of the waterway crossings.

The manning's roughness applied to the model based were on the cover observations from the satellite imagery and. The cross sections were georeferenced in GIS and attributes of cross sections from DEMs to determine the geospatial location of each and to delineate the channel lengths between cross sections appropriately. Inflow hydrographs and peaks from the hydraulic analysis were used as inputs.

5.2.2 Biological Environment

For the surveys, a reconnaissance was conducted, to identify the location and distribution of areas that carried some natural/semi-natural vegetation and that therefore may still hold some importance for biodiversity. In doing this we recognised the fact that human environmentnts also hold levels of biodiversity but these have a continual human footprint/presence and hence will not be of major importance for biodiversity conservation.

General coordinates and landcover description for the areas at which the baseline surveys were conducted are presented in Table 31 while some habitat futures that characterised the areas of natural/semi-natural vegetation cover in which the surveys for the baseline were conducted are illustrated in Table 32.

Table 31: Coordinates of the general areas in which baseline surveys were conducted

Coordinate in UTM (36N)	Project component	Phytosociological description of study sites
0423989E 297619N	Water pipeline from Karuma to Gulu and intermediate tank	*Tectona-Toona* woodlots contiguous with Acacia-Vitex-Sida bishland
0425521E 291714N		*Albizia-Brachiaria-Aframomum* wooded grassland
0425578E 291563N		*Acacia-Erythrina* woodland
425870E 290059N		*Echinochloa-Persicaria-Ipomoea* riverine vegetation
0427115E 287001N		Papyrus swamp
0428378E 284236N		Papyrus swamp
0429272E 277842N		*Phragmites-Leersia* swamp
0429530E 277069N		Seasonally flooded bushed wooded grassland of *Albizia coriaria-Triumfetta rhomboidea contiguous with permanent wetland of Echinochloa pyramidalis-Phoenix reclinata*
0430285E 273964N		*Cyperus-Echinochloa* swamp (Minakulu swamp)
0430950E 271087N		*Cyperus-Leersia-Setaria* swamp at one extreme and the other *Phragmites-Typha* swamp
0431633E 263550N		*Leersia-Cyperus-Bulbostylis* flooded grassland
0431862E 260939N		*Acacia-Mimosa-Miscanthus* swampy woodland (Ngaato swamp)
0431769E 257460N		Degraded *Mimosa-Cyperus* swamp
0430298E 254551N		*Cyperus-Phoenix-Echinochloa* swamp (Nyere swamp)
0427648E 250367N		*Cyperus-Phoenix-Aeschynomene* swamp (Alenyi swamp)
0422486E 248389N		Degraded *Echinochloa-Mimosa-Setaria* swamp
0418965E 248565N	Water abstraction, Access road, water	*Acacia-Panicum-Pennisetum* Lightly wooded bushed grassland of on rocky ground

Coordinate in UTM (36N)	Project component	Phytosociological description of study sites
0418879E 248772N	treatment plant and start of pipeline	*Panicum-Pennisetum* grassland fallow of in quarry
0418963E 248994N		*Panicum-Setaria-Imperata grassland fallow*
0418873E 249127N		*Panicum-Pennisetum* grassland fallow with cassava-Maize garden mosaics
0419050E 249316N		*Panicum-Pennisetum* grassland fallow with cassava-Maize garden mosaics
0419193E 249414N		*Panicum-Pennisetum* grassland fallow with cassava-Maize garden mosaics

Table 32: Location impressions of some of the areas that were surveyed

Photograph	Description
	The general area around 0425521E 291714N which was characterized by *Albizia-Brachiaria-Aframomum* wooded grassland The area was previously used as a murrum borrow pit on which natural vegetation cover has regrown to give a land cover that can be exploited by several groups of animals. The area from which marrum was excavated was never restored leaving a large depression which very likely holds water in the wet season forming a temporal resource for water dependent flora and fauna
	

Photograph	Description
	The local owner of the land at this location has a number of bee hives deployed
 	Opaka Central forest reserve (in the vicinity of 36N 424900E 295148N) planted with *Tectona grandis, Eucalyptus and Pine.* In some sections the undergrowth is quite denseforming suitable habitat for understorey species. Any impacts of the pipeline to the forest reserve will be at the edge next to the road
	A view into Tochi swamp (36 N 425870 290059) that is permanent wetland with papyrus and other swamp vegetation

Photograph	Description
	Uphill in the same area extends into a finer woodland but further removed from the area of direct impact
	Small patch of vegetation in the vicinity of 0423989E 297619N has a *Tectona-Toona* woodlot contiguous with *Acacia-Vitex-Sida* bush-lands pictured here

Photograph	Description
	
	
	The survey area around coordinate 36 N 427115 287001 has areas of seasonal inundation but extends into permanent papyrus swamp
	Bobi swamp (36 N 429272 277842) is an area of papyrus swamp but intergrades into areas without permanent standing water with bushes and surrounding agricultural activities.

Photograph	Description
	
	Papyrus swamp at a number of locations the proposed route will cross through areas of natural papyrus swamp (including Minakulu, Ngaato, Nyeere, Agada, Alek, Myene, Aleny & Tochi) all off which have natural vegetation caver similar to that shown in these two figure
	

Photograph	Description
 	*Acacia-Panicum-Pennisetum* Lightly wooded bushed grassland of on rocky ground at water abstraction point 36N 0418965E 248565N
	Land cover quite converted through stone quarrying activities in the areas around coordinate 36N 0418879E 248772N

Photograph	Description
	

Whereas most of the area to be traversed by the proposed pipeline route is heavily modified by human activities, there are areas that retain some level of importance for biodiversity. The route will marginally cross one protected area Opaka Central Forest reserve which even then is now an area of plantation forestry but with good understorey vegetation in sections.

The surveys for this report were commissioned to capture baseline biodiversity along the route that would be traversed by the proposed pipeline. For the surveys a number of representative taxa were selected and included:

i) Vegetation and flora
ii) Fish
iii) Invertebrates – using butterflies
iv) Amphibians
v) Reptiles
vi) Birds and
vii) Mammals

These taxa are commonly assessed in surveys for completing ESIAs in Uganda and therefore have comparative information that can be found if needed. They are typically easy and quick to survey and their taxonomy is fairly well known.

Surveys were done for species occurrence, relative abundance and habitat suitability for species. In the various checklists that were collected, these were assessed to identify if any species of conservation concern (either endemic, rare or listed on the IUCN or Ugandan list of threatened species and in the case of fish if any were of considerable commercial and/or nutritional value).

An impact assessment was also done for the different taxa for which we collected data. For plants, the surveys focused on the preffered side of road where the transmission pipeline could be installed but for animal taxa because they move around the surveys recorded species observed on both sides of the road if/when observed.

Standard methods were followed for the survey of the different taxa. The details of these are presented in the different subsections.

a) Vegetation, habitats and flora

Study areas: The study areas were those where the proposed water project is anticipated to cause impacts on the biological component. Sites that were studied wholly were around the water abstraction point along river Nile at Karuma, and the proposed water treatment plant, while points were selected along the pipeline route and access road. Study points were identified considering their naturalness, ecological sensitivity and habitat variability. Efforts were made to give greater attention to the points where most disturbances are expected. All sample sites were geo-referenced and characterization was based on the floristic and landscape features observed at the different sites.

Sampling methods: Systematic-random sampling was applied in the study points selected during scoping. Within these points records of features of landscape and environment including vegetation assemblages were made at the specific points. Species of plants recorded were assessed on the DAFOR scale - standing for dominant, abundant, frequent, occasional and rare species. At each study point, quadrats were established randomly according to nature and size of the habitat from which vegetation type, plant species, presence of disturbances and presence of species of conservation interest including invasive species were made in an area of 50×50 m^2. The vegetative communities in the study area were classified basing on Langdale-Brown *et al*. (1964) system. This system recognizes 22 ecosystem types, identified by letters between A to Z. Although the Langdale-Brown (A-Z) system is over 50 years old, it was used in preference to the National Biomass Study 2003 for several reasons as indicated by Van Breugel *et al*. (2011). The A-Z system is based on plant community composition rather than just plant biomass, which was more relevant to the goal of characterizing vegetation identifying plant species and sensitive habitats. Secondly, although much of Uganda's vegetation has been extensively altered over the past two-three decades, the A-Z system can still be considered to epitomize the potential of an area to support an ecosystem type relevant to environmental impacts study (Kalema, *et al*., 2010; Pomeroy, *et al*., 2002). The A-Z system provides 22 vegetative categories opposed to the 13 adopted by the National Biomass System (USAID 2014), this greater level of resolution could necessitate assessment of the potential impacts of water abstraction and distribution systems on ecosystems to greater details. The records generated from each day of field work were used to provide a detailed characterization of vegetation types, generation of species list and illustration of existing forms of disturbances. The species of plants recorded were further analysed into growth forms, ecological type, threat levels according to IUCN (2018) and the National data base of threatened species by WCS (2016). Presence of any form of legal protection by Uganda's acts on conservation of biodiversity by organs such as NFA and WID was also quoted.

Data analysis: The field records were analysed in five different ways:

i) Critical habitats and vegetation in terms of landscape features

According to Begon *et al*. (2006) an Ecosystem is a more or less discrete community of organisms and the abiotic conditions at a site while a habitat is a set of requirements necessary for the survival of an organism. An ecosystem is one of the higher levels of interaction between organisms and their abiotic components and from surveys these are indicated by the plants' community structure in the landscape. Examples of vegetation types include forests, grasslands, bush lands while an ecosystem can also be an individual feature such as a tree providing support to a variety of flora and fauna. Habitat characterization was further done through ascertaining habitat preferences of fauna components to a particular ecosystem. Field observation and use of the Langdale-brown *et al*. (1964) system made the basis for analysis of landscape cover types.

ii) Compilation of Species lists and richness

Compilation of species list for each vegetation type as well as intermediate encounters enabled generation of a general species list for the water project area. This species list was confirmed after identification of all the plants encountered during the surveys as well as identification of specimens collected. Identification of specimens was done from Makerere University herbarium. This list was crucial in a way that it facilitated further analyses including conservation status and invasiveness.

iii) Existing forms of disturbances

Different forms of disturbances at each of the study points were recorded and pictorial illustrations are provided in here. An ecosystem was rated of low conservation value if it was heavily degraded by one disturbance or by a combination of disturbances to none recoverable levels an example here is a built up area in many small towns along Karuma-Gulu road representing totally degraded vegetation.

iv) Species threat levels and invasiveness

The conservation status for each species was obtained from the published most recent IUCN (2018) red data list and the National red list of Uganda's threatened species (WCS 2016). Invasive species considered here included those that are exotic and have threats to native species at both individual and ecosystem levels. Further consideration was made basing on species richness and presence of species that requires special protection from local jurisdictions.

b) Fisheries

Study area: The study area was along the Gulu-Oyam Tochi wetland system. This lies in Gulu and Oyam districts traversing through the sub-counties of Aber, acaba, Ngai, Minakulo and Myene (Oyam district) and Ongako, Bobi, Koro, Layibi Division, Lwakwana and Abok**.**

Table 33: Coordinates (Arc1960, WGS84) of areas where surveys for fish were conducted

Survey area	Coordinates
Tochi swamp	425845˚N 290128˚E
Minakulu swamp	430190˚N 273940˚E
Ogada swamp	431309˚N 266162˚E
Alek swamp	431632˚N 263295˚E
Myene swamp	430257N 254514E
Aleny swamp	427494˚N 250510˚E
Palenga	426033˚N 292106˚E
Bobi Swamp	430849˚N 271165˚E
-no local name found-	427037˚N 286992˚E

Figure 31 Location of swamps along the transmission route where surveys were done

Data collection: Interviews with fishermen, market surveys, onsite seining and on- site analysis were the methods used to collect the data.

i) Interviews with fishermen

Fishermen were targeted during their fish catching hours and here they were interviewed. Analysis and identification was made of the fish they had caught species and questions were directed to the fishermen on the nature of common species caught. Fishermen selling fish on road near the target swamps were also interviewed and here useful information on edible species was obtained.

ii) Market surveys

Markets of Apworocero and Kamdini were surveyed. Here the fish species that were being sold were identified and information was gathered on the most commonly sold/bought fish species, uncommon species and other levels of rarity or commonness.tion was all collected. Market surveys were considered a data collection area since most of the fish species sold there were caught in the swamps of the area.

iii) Active fishing

At suitable locations, siene nets were used to dredge and capture fishes for identification. Scenes of various activities undertaken in the experimental fishing are shown in Photos 15 to 18.

Photo 15: Team of local persons that assisted in the experimental fishing checking in the siene net for captured fish

Photo 16: The fisheries biologist taking note of fish captured

Photo 17: Example habitat in a the wetland habitats in which experiment fishing was conducted

Photo 18: Fish captured in an experimental fishing turn

c) Herptiles

Study area: The study was completed along Karuma - Gulu Highway for the transmission line and along River Nile for water abstraction and water treatment plant. The area was characterised by permanently saturated cyperus swamps (Table 34), wooded grasslands, grassy fallow, gardens and settlements.

Table 34: Survey points at the proposed water treatment plant site and along the transmission line with associated habitat description

Coordinate in UTM (36N)	Phytosociological description of study sites	Project sites	Habitat groupings
0423989E 297619N	Tectona-Toona woodlots contiguous with Acacia-Vitex-Sida bushland	Transmission line	Wood land
0425521E 291714N	Albizia-Brachiaria-Aframomum wooded grassland	Transmission line	Wood land
0425578E 291563N	Acacia-Erythrina woodland	Transmission line	Wood land
425870E 290059N	Echinochloa-Persicaria-Ipomoea riverine vegetation	Transmission line	swamp
0427115E 287001N	Papyrus swamp	Transmission line	Swamp
0428378E 284236N	Papyrus swamp	Transmission line	Swamp
0429272E 277842N	Phragmites-Leersia swamp	Transmission line	Swamp
0429530E 277069N	Seasonally flooded bushed wooded grassland ofAlbiziacoriaria-Triumfettarhomboidea contiguous with permanent wetland of Echinochloa pyramidalis-Phoenix reclinata	Transmission line	Seasonal flooded marsh
0430285E 273964N	Cyperus-Echinochloa swamp (Minakulu swamp)	Transmission line	Swamp

Coordinate in UTM (36N)	Phytosociological description of study sites	Project sites	Habitat groupings
0430950E 271087N	Cyperus-Leersia-Setaria swamp at one extreme and the other Phragmites-Typha swamp	Transmission line	Swamp
0431633E 263550N	Leersia-Cyperus-Bulbostylisflooded grassland	Transmission line	Swamp
0431862E 260939N	Acacia-Mimosa-Miscanthus swampy woodland (Ngaato swamp)	Transmission line	Swamp
0431769E 257460N	Degraded Mimosa-Cyperus swamp	Transmission line	Swamp
0430298E 254551N	Cyperus-Phoenix-Echinochloa swamp (Nyere swamp)	Transmission line	Swamp
0427648E 250367N	Cyperus-Phoenix-Aeschynomeneswamp (Alenyi swamp)	Transmission line	Swamp
0422486E 248389N	Degraded Echinochloa-Mimosa-Setariaswamp	Transmission line	Swamp
0418965E 248565N	Acacia-Panicum-Pennisetum Lightly wooded bushed grassland of on rocky ground	Transmission line	Wood
0418879E 248772N	Panicum-Pennisetum grassland fallow of in quarry	Raw water intake abstraction / water treatment plant	Grass fallow
0418963E 248994N	Panicum-Setaria-Imperata grassland fallow	Raw water intake / water treatment plant	Grass fallow
0418873E 249127N	Panicum-Pennisetum grassland fallow with cassava-Maize garden mosaics	Access road	Grass fallow
0419050E 249316N	Panicum-Pennisetum grassland fallow with cassava-Maize garden mosaics	Access road	Grass fallow
0419193E 249414N	Panicum-Pennisetum grassland fallow with cassava-Maize garden mosaics	Access road	Grass fallow

Source: Primary data

Methods: The common methods available for surveying amphibians are reviewed in Heyer *et al*., (1994). These include visual encounters, egg surveys, call surveys, terrestrial cover boards, dip nets, seines, aquatic funnel traps, and terrestrial pitfall traps. The method to be used is dictated in most cases by the habitat type. Field data was obtained by conducting a survey of amphibians and reptiles along the different sections of the project area. Species observed were counted and recorded; counting was done to give an estimate of each species relative proportions in the project area. The conservation status of the hepertofauna was reported using the IUCN red listing (IUCN 2016) and the National redlist (2016).

i) Visual encounter surveys (VES)

Visual encounter survey method is commonly used to determine the species richness of an area Heyer et al., (1994), to compile a species list and to estimate relative abundances of species within an assemblage. This involved walking through the project area searching and recording species and numbers of amphibians and reptiles. It involved turning logs or stones, inspecting retreats, watching out for surface-active species listening and or recording any amphibians calling.

ii) Audio/acoustic surveys

This is survey based on listening to sound produced by the amphibians. Males of many anuran species vocalize. Sexually mature male frogs and toads call to attract mates and establish territories. Consequently, vocal species can be identified by their distinctive unique calls, and an approximation of their relative abundance can be estimated by the number of calls heard. Several stops were made in the project sites and along transect, to listen, identify and record any frogs or toads heard calling. The reptiles and amphibians were identified using standard reference texts key of which was Schiotz (1999). The IUCN red list was used in the species threat categorization of the amphibians and reptiles.

iii) Local consultations

This is a slightly modified Pooled Local Expert Opinion (PLEO) method on local informants. This method is vital for assessing species presence, density and range estimations and is based on residents with good knowledge on fauna in the area (van der Hoeven *et al*., 2004).

d) Invertebrates

Random surveys for butterflies were carried out in 35 sites along the proposed water pipeline route, access road, water treatment plant and reservoir in areas which appeared to be more pristine. Sampling was done from 9:00 am till 5:00 pm which is the peak time for butterfly activity using both visual identification and hand held aerial sweep nets for those specimens which could not be readily identified in the field. Collected specimens were placed in an envelope and stored for further identification using a field guide by Larsen (1996). The observed butterflies were categorized in five categories on the basis of their abundance in a given sample location. VC - very common - (> 100 sightings), C - common - (50–100 sightings), NR - not rare - (15–50 sightings), R - rare - (2–15 sightings), VR - very rare (1–2 sightings) (Tiple *et al.* 2006). All voucher specimens collected during the present research were deposited at Makerere University Zoology Museum.

e) Invertebrates

Birds were surveyed for in habitats in areas identified to present the best opportunity for survival of biodiversity. Because the proposed pipeline is within 30 m buffer of the road the survyes were meant to look just in the areas. However because butterflies, birds and mammals move around, they can cover more distance thnan 30 m in a single bout of activity. The method that we used aimed at collecting a total species list at every survey location. The surveys were started between 7:00 - 8:00 am and we spent 30 minutes at each survey location each survey day before driving to the next. All species seen or heard were recorded at any distance within the survey area.

f) Mammals

Mammals as a group are a very diverse taxonomic group of animals that range in size from very small ones (shrews and bats weighing about 3-4 gm) to large ones that weigh up to several tons. Some mammals are active during the day and if medium or large sized can be observed, inventoried or their ecology studied. Most small sized mammals are however quite cryptic and/or nocturnal in habit that observation approaches are not good enough for studies of these.

The foregoing therefore means that different approaches are required to document the presence as well as study the ecology of mammals.

To understand the patterns of occurrence of mammals in the different areas surveyed, the methods used included:

i) Trapping with Sherman traps – In places where traps could be deployed without the risk of losing them to local people, we used Sherman traps to capture small mammals and therefore gain a quick insight about which small mammals occurred in the different survey areas. Traps were left in place for 2 nights and moved to other survey areas. In addition weused the nature of the habitats to compile a list of potential species on small mammals that could be in the areas surveyed.
ii) Spoor tracking - Spoor tracking is considered to be the world's oldest science, enabling detailed sampling of mammalian species without the need for trapping or direct observation. Spoors were recorded and documented during general fieldwork.
iii) Scats and pellets – mammal sats were oportunisticaly searched for to provide information on species occurrence.
iv) Roadkill Direct Observation: All mammals observed dead on the roads were examined, geo-referenced and catalogued.

5.2.3 Social Environment

The social assessment sought to identify any changes in socio-economic activities within project affected areas. It sought to identify socially disadvantaged groups such as women, elderly people, terminally ill and those at risk and described their social and cultural characteristics. Field surveys, including consultations and focus group discussions were utilized in the assessment.

In order to get the current situation of the project area as well as ensure and adequately assess the social economic information and impacts resulting from the development of the Karuma-Gulu Water Supply Project, the following methods were employed:

- Ugandan Government development documents, guiding reports and policies;
- Secondary data collection at local districts and national levels;
- Key informant interviews;
- Participant observations;
- Case study reviews and;
- Focus group discussions; and
- Use of checklists.

Participant observation and photographic records: During field surveys, information obtained through household surveys, interviews and focus group meetings was verified through direct observation by the study team. Observation was specifically aimed at assessing physical assets of people in affected areas, living conditions, settlement patterns, and capacity to diversify income, and social and economic networks. Where possible, observations were backed up by photographic records.

Stakeholder identification and consultation: The consultations involved meeting with various stakeholders including relevant Government agencies, Local Government Leaders, leaders of sub-counties/divisions to be affected by the project, project affected communities and the developer. Stakeholder consultation aimed at:

- Generating good understanding of the project;
- Understanding local expectations of the project;
- Characterizing potential environmental, socio-economic impacts;
- Developing effective mitigation measures; and
- Enabling project-affected households to suggest desired amicable resolution of land take issues.

Stakeholder engagement comprised consultations with Nwoya, Omoro, Oyam and Gulu District Local Government Officials, Layibi Koro, Bobi Minakuku, Myena, Kamdini Town Officials and the community members living within the project area. Notifications at the district and Sub-county levels were made through the CAO and LCIIIs, respectively, while the meetings at the community level were made through Local Council I (LC I) chairpersons. To disclose the project and obtain views of communities, meetings were held on 3rd - 9th June 2018 at the respective villages. For District Local Government, the team met the district technical official on 17th- 23rd May, 2018 at the respective district offices.

Focus Group Discussions (FGD): Subsequently, group discussions were conducted as a follow-up to the content analysis and individual interactions in interviews. FGDs were conducted at the community level mainly with people within the project affected area. Participants in these discussions included local population, women's groups, local leaders and elders and district officials. Attitudes towards social benefits, risks involved during construction and operation, resettlement, compensation and land takes were also discussed.

Photo 19: AWE consultant holding a consultative meeting with the stakeholders in Gulu District

Photo 20: Consultations with Gulu District officials

Photo 21: Consultations with the project area communities

Photo 22: Focus group discussions with the women along the project area

5.3 CULTURAL HERITAGE

The study involved a desktop study of the history of the area as well as a study of the customs and history of the Acholi and Lango people who inhabit in the project area. Lastly fieldwork in the project area from the water in- take location at Nora village on the northern Bank of the Nile river at Karuma ,then at the location of the water treatment plant in Nora village and along transmission route following the Karuma – Gulu Highway up to the Customs corner water reservoir in Gulu Municipality .The fieldwork investigated the presence of cultural resources like historic buildings, cultural sites, sacred traditional religion sites and the presence of archaeological resources.

5.4 CONSULTATION AND PROJECT DISCLOSURE

Relevant and adequate project information was provided to stakeholders to enable them to understand project risks, impacts and opportunities. Stakeholder consultation aimed at:

- Generating understanding of the project
- Understanding local expectations of the project
- Characterising potential environmental, socio-economic impacts
- Garnering consensus on mitigation options

The following techniques were used:

- Face-to-face or telephone interviews
- Data and literature review
- Email consultation correspondences

- Meetings of communities were mobilised through the Local Council I and III Chairpersons of the project villages and Sub-counties, respectively.

5.5 REVIEW OF POLICY, REGULATIONS, INSTITUTIONAL FRAMEWORK & INTERNATIONAL GUIDELINES

This was done to determine if the proposed project was in line with national policies and met environmental laws and regulations, to achieve this, the following actions were undertaken:

i) Review of national environmental laws, policies and institutional framework.

ii) Review of World Bank Group (IDA is one of the 5 World Bank Group member organizations) guidelines on environment.

5.6 IMPACT IDENTIFICATION AND ANALYSIS

5.6.1 Impact Description

Describing a potential impact involved an appraisal of its characteristics, together with the attributes of the receiving environment. Relevant impact characteristics included whether the impact is:

- Adverse or beneficial;
- Direct or indirect;
- Short, medium, or long-term in duration; and permanent or temporary;
- Affecting a local, regional or global scale; including trans-boundary; and
- Cumulative (such an impact results from the aggregated effect of more than one project occurring at the same time, or the aggregated effect of sequential projects. A cumulative impact is "the impact on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions").

Each of these characteristics is addressed for each impact. Consideration of the above gives a sense of the relative **intensity** of the impact. The **sensitivity** of the receiving environment was determined by specialists based on the baseline data collected during the study.

5.6.2 Impact Evaluation

Each impact is evaluated using the criteria listed in Table 35. To provide a relative illustration of impact severity, it is useful to assign numerical or relative descriptors to the impact intensity and receptor sensitivity for each potential impact. Each is assigned a numerical descriptor of 1, 2, 3, or 4, equivalent to very low, low, medium or high. The severity of impact was then indicated by the product of the two numerical descriptors, with severity being described as negligible, minor, moderate or major, as illustrated in Table 37. This is a qualitative method designed to provide a broad ranking of the different impacts of a project. Illustrations of the types of impact that were assigned the different grades of severity are given in Table 39.

Table 35: Classification of impact evaluation

	Classification	Description
1	Extent:	Evaluation of the area of occurrence/influence by the impact on the subject environment; whether the impact will occur on site, in a limited area (within 2 km radius of the site); locally (within 5 km radius of the site); regionally (district wide, nationally or internationally).
2	Persistence/Duration:	Evaluation of the duration of impact on the subject environment, whether the impact was temporary (<1 year); short term (1 – 5 years); medium term (5 – 10 years); long term (>10); or permanent.
3	Social Context / Sensitivity or Potential for Stakeholder Conflict:	Assessment of the impacts for sensitive receptors in terms of ecological, social sensitivity and such things as rare and endangered species, unusual and vulnerable environments, architecture, social or cultural setting, major potential for stakeholder conflicts. The sensitivity classification is shown below: ***High sensitivity:*** Entire community displacement, destruction of world heritage and important cultural sites, large scale stakeholder conflict, etc. ***Medium sensitivity:*** Displacement of some households, moderate level of stakeholder concern ***Low sensitivity:*** No displacements, no potential for stakeholder conflict.
4	Regulatory and Legal Compliance:	Evaluation of the impact against Local and International legislative requirements. ***High:*** Prohibition terms for specific activities/emissions. Major breach of regulatory requirements resulting in potential prosecution or significant project approval delays. ***Medium:*** Potential breach of specific regulatory consent limits resulting in non-compliance. ***Low:*** No breach of specific regulatory consent limits anticipated.
5	Overall Impact rating (Severity):	Using a combination of the above criteria, the overall severity of the impact was assigned a rating Severe, Substantial, Moderate, Minor and negligible. Refer to Table 21 for broad categories of impact for each rating. **Note:** These are just guidelines that will constitute professional judgement required in each individual case.

5.6.3 Intensity of Impact

The scale of intensity is defined on the basis of ecological-toxicological studies and expert judgment and is presented in Table 36.

Table 36: Intensity scale gradation for environmental impacts

Scale of Impact Intensity	Criterion	Score
Very low	Environmental changes are within the existing limits of natural variations	1
Low	Environmental changes exceed the existing limits of natural variations. Natural environment is completely self-recoverable.	2
Medium	Environmental changes exceed the existing limits of natural variations and results in damage to the separate environmental components. Natural environment is remains self-recoverable.	3
High	Environmental changes result in significant disturbance to particular environmental components and ecosystems. Certain environmental components lose self-recovering ability.	4

5.6.4 Impact Significance

The textural description of the descriptors ranging from "Very low" to "High" is presented in Table 37. Impact significance is determined from an impact significance matrix (Table 38) which compares severity of the impact with probability of its occurrence. Impact significance criteria are as follows:

Table 37: Criteria for rating impact intensity and likelihood

Criteria	Rating scales
Intensity (the expected magnitude or size of the impact)	**Very Low-** where the impact affects the environment in such a way that natural, and /or cultural and social functions and processes are negligibly affected and valued, important, sensitive or vulnerable systems or communities are negligibly affected.
	Low- where the impact affects the environment in such a way that natural, and/or cultural and social functions and processes are minimally affected and valued, important, sensitive or vulnerable systems or communities are minimally affected. No obvious changes prevail on the natural, and / or cultural/ social functions/ process as a result of project implementation.
	Medium - where the affected environment is altered but natural, and/or cultural and social functions and processes continue albeit in a modified way, and valued, important, sensitive or vulnerable systems or communities are moderately affected.
	High - where natural and/or cultural or social functions and processes are altered to the extent that they will temporarily or permanently cease, and valued, important, sensitive or vulnerable systems or communities are substantially affected. The changes to the natural and/or cultural / social- economic processes and functions are drastic and commonly irreversible.
	None – where the impact will not materialize

Criteria	Rating scales
Probability (The likelihood of the impact occurring)	**Low** – where the possibility of the Impact materializing is very low (<20%)
	Medium – where there is a good possibility (30%-60% chance) that the impact will occur.
	High– where it is most likely (60% -100% chance) that the impact will occur.

Table 38: Determination of impact severity

		Sensitivity of receptor			
		Very low	**Low**	**Medium**	**High**
		1	**2**	**3**	**4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

- ***Major:*** These denote that the impact is unacceptable and further mitigation measures must be implemented to reduce the significance. More details are provided in Table 39.
- ***Moderate:*** Impacts in this region are considered tolerable but efforts must be made to reduce the impact to levels that are as low as reasonably practical. Shaded orange in the impact significance matrix.
- ***Minor:*** Impacts in this region are considered acceptable. Shaded blue.
- ***Negligible:*** Impacts in this region are almost not felt. Shaded green.

Table 39: Impact significance assessment criteria and rating scale

Impact Rating	Impact Description
Major	▪ Highly noticeable, irreparable effect upon the environment ▪ Significant, widespread and permanent loss of resource ▪ Major contribution to a known global environmental problem with demonstrable effects ▪ Causing mortality to individuals of a species classified as globally or regionally endangered ▪ Major expedience of water/air quality and noise guidelines representing threat to human health in long and short term ▪ Causing widespread nuisance both on and off site
	▪ Noticeable effects on the environment, reversible over the long term

Impact Rating	Impact Description
Moderate	▪ Localised degradation of resources restricting potential for further usage ▪ Sub-lethal effects upon a globally or regionally endangered species with no effect on reproductive fitness and/or resulting in disruption/disturbance to normal behaviour returning to normal in the medium term ▪ Elevated contribution to global air pollution problem partly due to preventable releases ▪ Frequent breaches of water/air quality and noise guidelines ▪ Causing localised nuisance both on and off site
Minor	▪ Noticeable effects on the environment, but returning naturally to original state in the medium term ▪ Slight local degradation of resources but not jeopardising further usage ▪ Disruption/disturbance to normal behaviour of a globally or regionally endangered species returning to normal in the short term ▪ Small contribution to global air problem through unavoidable releases ▪ Elevation in ambient water/air pollutant levels greater than 50% of guidelines ▪ Infrequent localised nuisance
Negligible	▪ No noticeable or limited local effect upon the environment, rapidly returning to original state by natural action ▪ Unlikely to affect resources to noticeable degree ▪ No noticeable effects on globally or regionally endangered species ▪ No significant contribution to global air pollution problem ▪ Minor elevation in ambient water/air pollutant levels well below guidelines ▪ No reported nuisance effects

5.7 CUMULATIVE IMPACTS

Cumulative effects manifest when socio-environmental conditions are already or will be affected by past or reasonably probable future development or activities. The ESIA identified current, past and probable future similar activities that may compound socio-environmental conditions in the project area.

5.8 MITIGATION OF ENVIRONMENTAL IMPACTS

Mitigation measures are designed in order to avoid, reduce, mitigate, or compensate for adverse environmental and social impacts and inform the Environmental and Social Management Plan (ESMP).

6 ENVIRONMENTAL AND SOCIO-ECONOMIC BASELINE

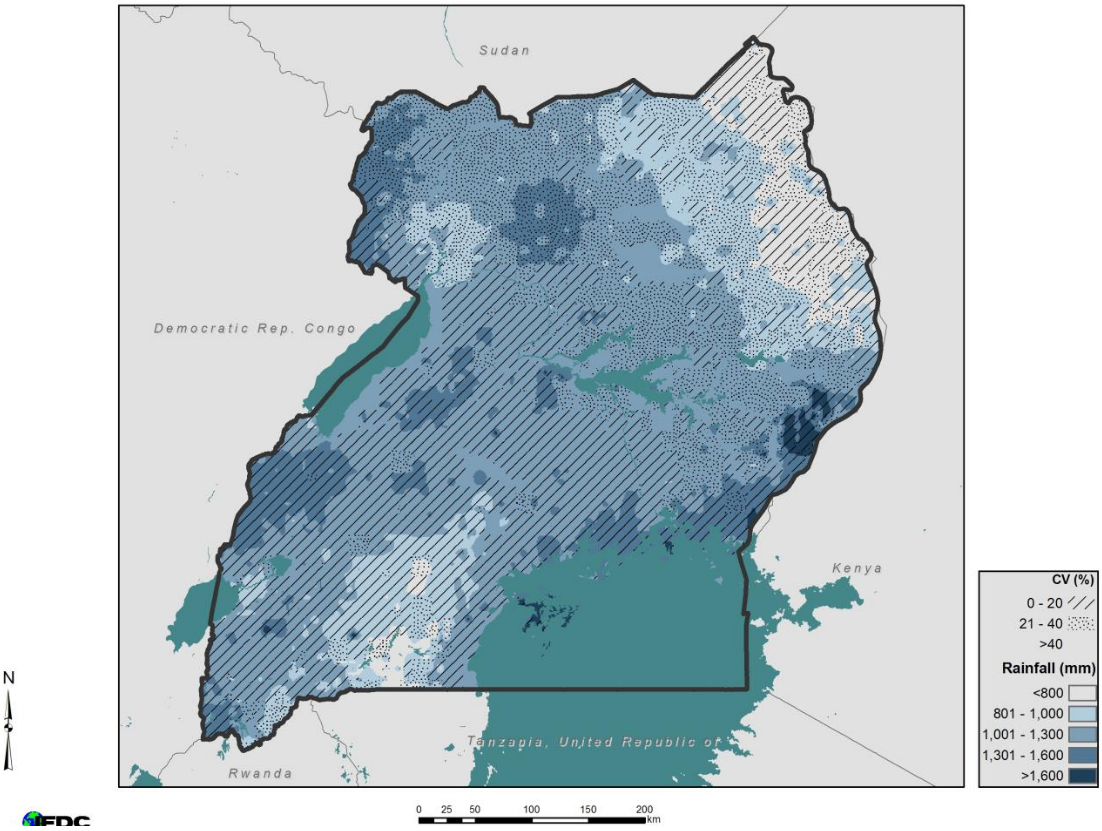
6.1 INTRODUCTION

This section describes environmental and social baseline conditions of the area in which the proposed water supply project is to be located and in which impacts may be experienced. The service areas for the project are well within the boundaries of Gulu, Omoro, Oyam and Kiryandongo districts.

6.2 PHYSICAL ENVIRONMENT PROFILE

6.2.1 Climate

The type of climate experienced in region consists of dry and wet seasons. The average total rainfall received is 1500 mm per annum with the monthly average rainfall varying between 1.4 mm in January and 230 mm in August. Normally the wet season extends from April to November with the highest peaks during May, August and October, while the dry season begins in November and extends up to March. The average maximum temperature is 50°C and the minimum being 18°C. Relative humidity is high during the wet season and low in the dry season. The distribution of rainfall in Uganda and project area is shown in Figure 32.



Source: IFDC (www.amitsa.org)

Figure 32 Distribution of annual rainfall in Uganda

From Figure 32, the monthly distribution of the Mean monthly Precipitation (MAP), occasional rains occur between April and October, while the period from November to March is often very dry. Average annual rainfall received is 1500 mm. Mean monthly rainfall ranges from 14 mm in January to 230 mm in August. The project construction phase should be carried out in the dry season to minimise transportation of sediments and pollutants/ contaminants into water courses and over land.

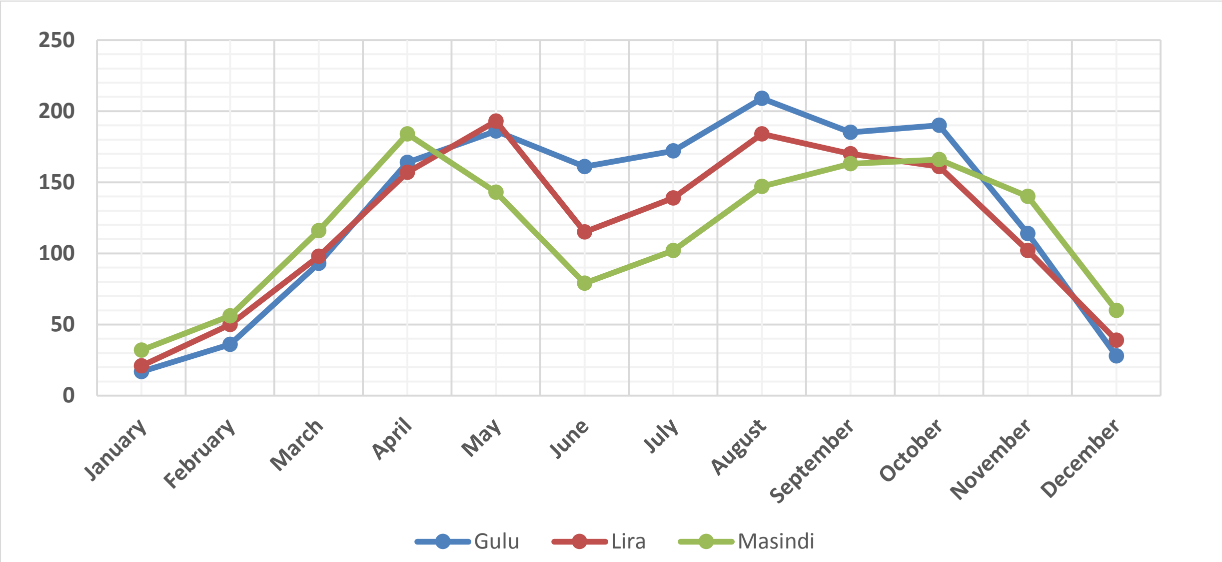


Figure 33 Mean annual rainfall for Gulu, Lira and Masindi

Micro-climate of the area is hot and humid with average relative humidity of 60%, mean maximum temperature of 29°C, mean minimum temperature of 22°C and wind speeds of 8 kph.

Table 40: Other Meteorological parameters for Lira

Month	Min Temp (°C)	Max Temp (°C)	Humidity (%)	Wind (km/day)	Sun (Hours)	Rad (MJ/m²/day)	ETo (mm/day)
Lira							
January	16.5	32.0	53	268	4.8	15.9	5.39
February	17.1	32.2	54	268	6.7	19.5	5.85
March	17.6	31.2	61	268	4.6	16.6	5.12
April	17.7	29.3	73	251	5.6	17.9	4.43
May	17.5	28.0	78	233	5.7	17.3	3.93
June	17.0	27.5	77	199	5.9	17.1	3.76
July	16.6	26.5	78	199	4.9	15.8	3.49

Month	Min Temp (°C)	Max Temp (°C)	Humidity (%)	Wind (km/day)	Sun (Hours)	Rad (MJ/m²/day)	ETo (mm/day)
August	16.6	26.7	79	199	5.4	17.1	3.67
September	16.6	28.0	76	216	6.4	19.3	4.21
October	16.7	28.7	74	233	7.0	19.9	4.48
November	16.5	29.6	68	233	7.6	20.2	4.81
December	16.2	30.3	61	251	8.0	20.2	5.19
Average	16.9	29.2	69	235	6.1	18.1	4.53
Gulu							
January	16.0	33.1	56	268	8.5	21.5	6.02
February	16.7	33.2	57	251	8.3	22.0	6.04
March	17.3	32.2	63	251	7.7	21.6	5.71
April	17.3	30.1	72	190	7.1	20.1	4.66
May	17.0	28.7	80	173	7.7	20.1	4.17
June	16.6	28.1	78	156	7.8	19.6	4.01
July	16.0	27.2	80	156	6.3	17.8	3.63
August	16.0	27.7	80	173	6.8	19.3	3.94
September	16.0	28.7	77	190	7.7	21.3	4.45
October	16.0	29.7	74	190	7.8	21.2	4.61
November	16.0	30.6	69	233	7.8	20.5	4.92
December	15.6	31.1	63	251	8.2	20.7	5.25
Average	16.4	30.0	71	207	7.6	20.5	4.78

6.2.2 Water Resources and Hydrology

The river network in and around the project area forms part of the bigger Nile Basin network. The River flows in North - South direction in its upper reaches and then join the Koyga Nile which flows in East - West direction after Karuma falls. The major ones are those flowing into the Nile, which include rivers: Tochi, Aswa, Pece, Odek, Akoyo, Unyama, Abera, Lagude, Larwodo, Chome, Laminonyut, Abwoch, Ocaga, and many other small streams. The hydrology of the project area is indicated in Figure 34.

The catchment area up to the proposed intake is 346,000 km^2 of which the catchment area up to Jinja, located downstream of Lake Victoria is 264,160 km^2. The geographic coordinates of the dam site is 1°29’45” N, 32°49’45” E and the river bed level is 1019 m.

The base flow in River Nile at Karuma site is generally dominated by the outflows from Lake Victoria and the releases from the Lake Victoria are made as per the Agreed Curve (Based on an Agreement between Uganda and Egypt (1949 and 1953), depending on Lake Victoria Levels.

The flows at Karuma intake depend mainly on the Lake Victoria outflows at Jinja, contribution of intermediate catchment between Jinja and Lake Kyoga, outflows from Lake Kyoga and contribution of the catchment between Lake Kyoga and the proposed intake site. The Lake Victoria outflows arrive at the Lake Kyoga nearly unmodified, since minor tributaries join the river up to Lake Kyoga.

Various studies have indicated that under normal dry condition, Lake Kyoga outflows at Masindi Port downstream of Lake Kyoga are slightly less than the outflows from Lake Victoria and the loss of river flows are 20 – 50 m^3/s, depending on Lake Level. However, during wet periods, Lake Kyoga catchment adds water to the river flow and increase in river flow is 50 – 70 m^3/s dependent on Lake Kyoga Level. The intermediate catchment area between Masindi Port and the project site is about 7,700 km^2. From various studies, it has been concluded that flow contribution from this area during dry periods is small and can be neglected. Hence the catchment area between Masindi Port and the proposed project site does not contribute much to the flows of River Nile.

Regarding groundwater, geotechnical investigations conducted in the project area (Appendix I) using boreholes (BHs) indicated groundwater table level from the existing ground level as provided in Table 41.

Table 41: Depths of water table in boreholes

No	BH Label	Water Table (m) from Existing Ground Level
1	BH1 - Karuma Intake	1.2
2	BH2 - Karuma Intake	1.0
3	BH1 - Access Road to Karuma Intake	Not encountered
4	BH2 - Access Road to Karuma Intake	"
5	Clear Water Tank (Reservoir Pumping Station) location - BH	2.0
6	Filter Wash Water/ Mineralisation/Chlorination dry chamber	3.5
7	Buffer Filter wash water	4.0
8	Filtration	0.8
9	Coagulation / flocculation	1.0
10	Karuma Reservoir	Not encountered
11	Kamdini tank reservoir - BH	"
12	Minakulu tank reservoir - BH	"
13	Bobi pump station - BH	"
14	Bobi reservoir - BH	"
15	Koro Abili reservoir - BH	"

No	BH Label	Water Table (m) from Existing Ground Level
16	New Customs Corner Tank - BH1	"
17	New Customs Corner Tank - BH2	"

Source: Fitchner, 2018

In the event that foundations are to be constructed below the ground water table for particular locations, the allowable bearing capacity to be considered in the design should be a half of the obtained allowable bearing capacity (See Appendix I); thus catering for the effect of the high water table. For foundations likely to be constructed at depths below the ground water level in some cases, rapid hardening cement is recommended to be used for achievement of early strength of concrete for those particular locations.

a) Vegetation

The land use land cover data was procured from NFA (National Forest Authority) Kampala, Uganda. NFA has carried out Land use \ land cover classification using Landsat data of the year 2014.The land use/cover within the catchment areas is predominantly subsistence farmland (76%), open grasslands (6.4%) and closed grassland (5.7%).

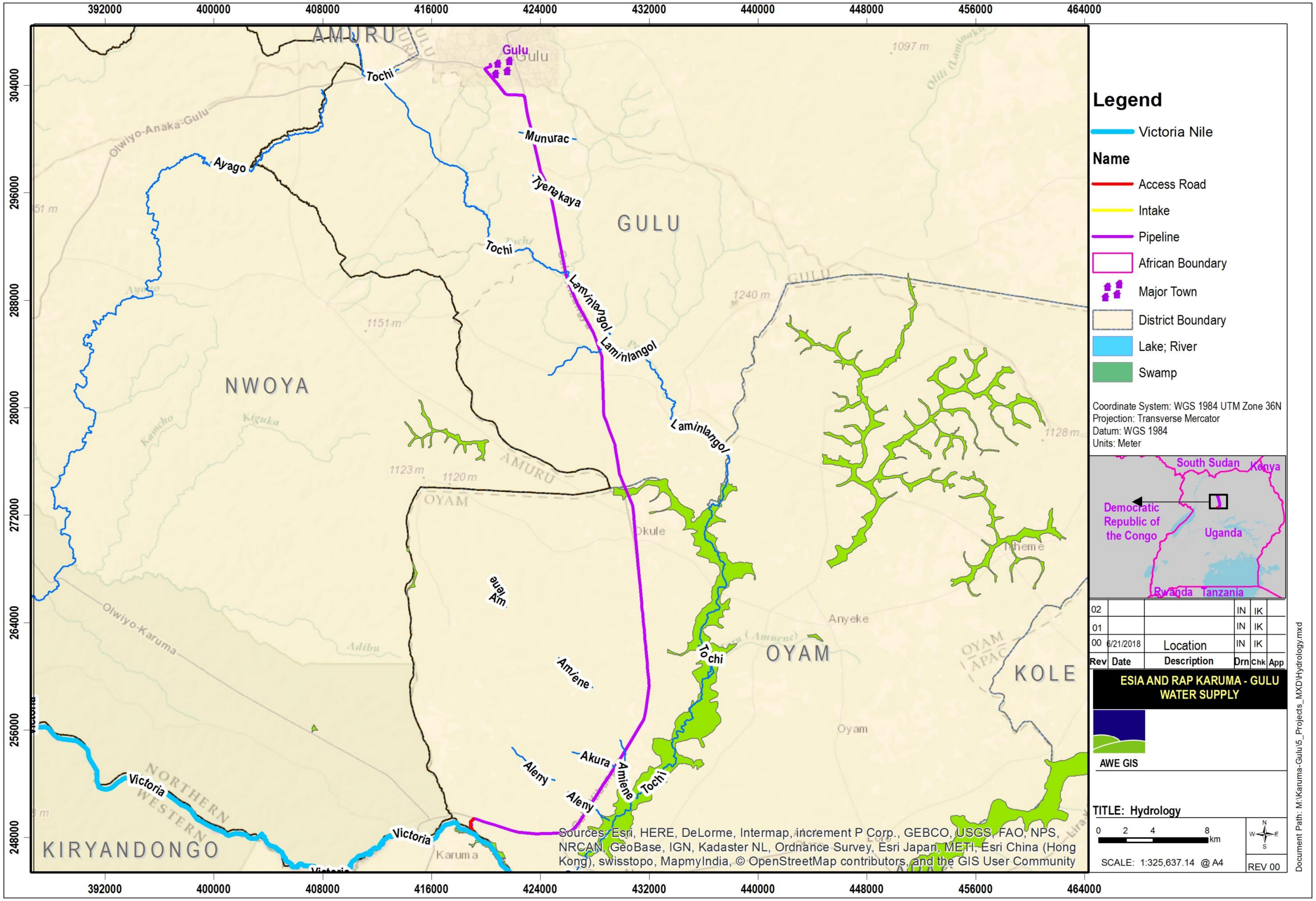


Figure 34 Hydrology of the project area

Table 42: Land cover within the catchment areas

Land cover	Area	Percentage
Annual Commercial Cropland	0.1	0.01
Closed Bushland	0.4	0.0
Closed Grassland	57.2	5.7
Dense Natural Forest	0.2	0.0
Dense Woodland	0.0	0.0
Moderate Natural Forest	16.1	1.6
Moderate Woodland	0.2	0.0
Open Bushland	33.4	3.3
Open Grassland	64.2	6.4
Plantation Forest	4.1	0.4
Settlement	29.0	2.9
Sparse Natural Forest	16.8	1.7
Sparse Woodland	0.0	0.0
Subsistence Cropland	770.5	76.2
Water Body	0.0	0.0
Wetland	18.9	1.9
	1011.2	**100.0**

The baseline catchment characteristics that affect the time of concentration are illustrated in Table 43. It is not anticipated that the proposed infrastructure will affect the nature of the sub-catchments and alter the rainfall- runoff response along the transmission line corridor but for only construction period.

Photo 23: Papyrus and swampy sections along the pipeline corridor

Photo 24: Water ways and small streams emerging from the swamps through culvert

Photo 25: Water ponds in some sections

Photo 26: Extent of Water Level fluctuation in some waterlogged areas

Photo 27: Circular culverts

Photo 28: Box Culverts

Table 43: Catchment characteristics at the identified major swamps along the transmission line

Name	Area	Basin Slope (%)	Longest Flow Path (m)	Longest Flow Path (ft)	Composite CN	Maximum Potential Retention S	Time of Centration Tc (h)	Lag (h)
GK2	1.2	2.5	1,681.2	5,515.8	71.5	4.0	16.8	10.1
GK3	2.5	2.7	2,470.1	8,103.8	68.2	4.7	24.3	14.6
GK4	2.9	2.8	2,870.1	9,416.1	70.3	4.2	25.4	15.2
GK5	4.5	2.5	3,231.8	10,602.9	69.7	4.3	29.5	17.7
GK6	3.0	1.7	3,115.6	10,221.7	67.7	4.8	37.0	22.2
GK8	1.0	1.8	1,518.8	4,983.0	67.0	4.9	20.4	12.3
GK9	4.6	2.7	3,255.6	10,680.9	70.8	4.1	28.1	16.9
GK10	509.8	2.7	43,420.6	142,454.4	67.2	4.9	246.2	147.7

Name	Area	Basin Slope (%)	Longest Flow Path (m)	Longest Flow Path (ft)	Composite CN	Maximum Potential Retention S	Time of Centration Tc (h)	Lag (h)
GK11	216.7	2.6	30,092.1	98,726.0	67.9	4.7	181.6	109.0
GK12	5.4	2.4	4,262.9	13,985.6	64.6	5.5	43.0	25.8
GK13	12.3	2.4	7,265.5	23,836.8	66.6	5.0	63.1	37.9
GK13_2	16.0	2.4	7,488.6	24,568.7	66.6	5.0	64.7	38.8
GK14	9.5	2.0	5,123.6	16,809.4	70.9	4.1	46.4	27.8
GK15	2.6	2.2	2,500.4	8,203.3	70.9	4.1	25.0	15.0
GK16	188.0	2.4	29,907.8	98,121.5	70.3	4.2	177.0	106.2
GK17	5.5	2.1	4,855.6	15,930.3	72.9	3.7	41.2	24.7
GK18	5.2	1.7	4,478.0	14,691.5	74.4	3.4	40.9	24.5
GK19	22.3	2.2	9,573.2	31,407.7	70.9	4.1	72.9	43.7
GK20	9.4	2.2	6,082.7	19,956.2	69.6	4.4	52.9	31.8
GK10_2	509.8	2.7	43,420.6	142,454.4	67.2	4.9	247.1	148.2
GK10_2	20.3	2.6	7,401.5	24,282.8	69.6	4.4	57.2	34.3
GK7	286.6	2.7	36,212.8	118,806.9	68.1	4.7	207.8	124.7

Design rainfall intensities were derived from extreme rainfall peaks obtained from fitting annual maxima's on probability distributions (Log Normal and Log-Pearson Type III). The best fitting distribution was chosen after testing the Goodness of fit.

Table 44: Peak design rainfall for different probabilities of exceedance for project area

Percent Chance Exceedance	Log Pearson Distribution		Log Normal Distribution
	Computed Curve	Expected Probability	Computed Curve
0.2	171.9	266.2	107.7
0.5	135.2	183.1	94.9
1.0	112.1	139.9	85.5
2.0	92.3	107.8	76.3
5.0	70.5	76.8	64.4
10.0	56.7	59.6	55.3
20.0	44.6	45.7	46.0

50.0	30.4	30.4	32.4
80.0	22.7	22.4	22.8
90.0	20.1	19.7	19.0
95.0	18.5	18.0	16.3
99.0	16.3	15.7	12.3

b) Intensity-duration-frequency

Where rational method is to be used for peak flow rate, rainfall intensity in mm per hour must be determined from an event with duration equivalent to the time of concentration. Rainfall intensity Frequency duration IDF were derived for each catchment based on the peak rainfall values for different recurrence periods. Probable maximum Precipitation (PMP) rainfall estimates were used to calculate design hydrographs for 10 yr, 25 yr, 50 yr, 100yr and 200yr recurrence intervals events.

c) Peak flow rates and volumes

Hydrological analysis of the peak flows was done in HECHMS for catchment area at Culverts and bridges, Assessment of the possibilities of modification of project area hydrology (Infiltration, evaporation e.g. at quarries and burrow pits).The results show that there is substantial amount of runoff generated with increase in catchment area and high recurrence intervals. The catchments have relatively lower peak discharges due to long lag time and attenuation effects of the swamps (Tables 45 and 46). The peak discharges reveal a flood risk and backwater effects due to obstruction of flow by construction activities or pipeline infrastructure during operation. However it was evident that there are downstream crossings and the pipeline will be constructed on pillars thus less impact.

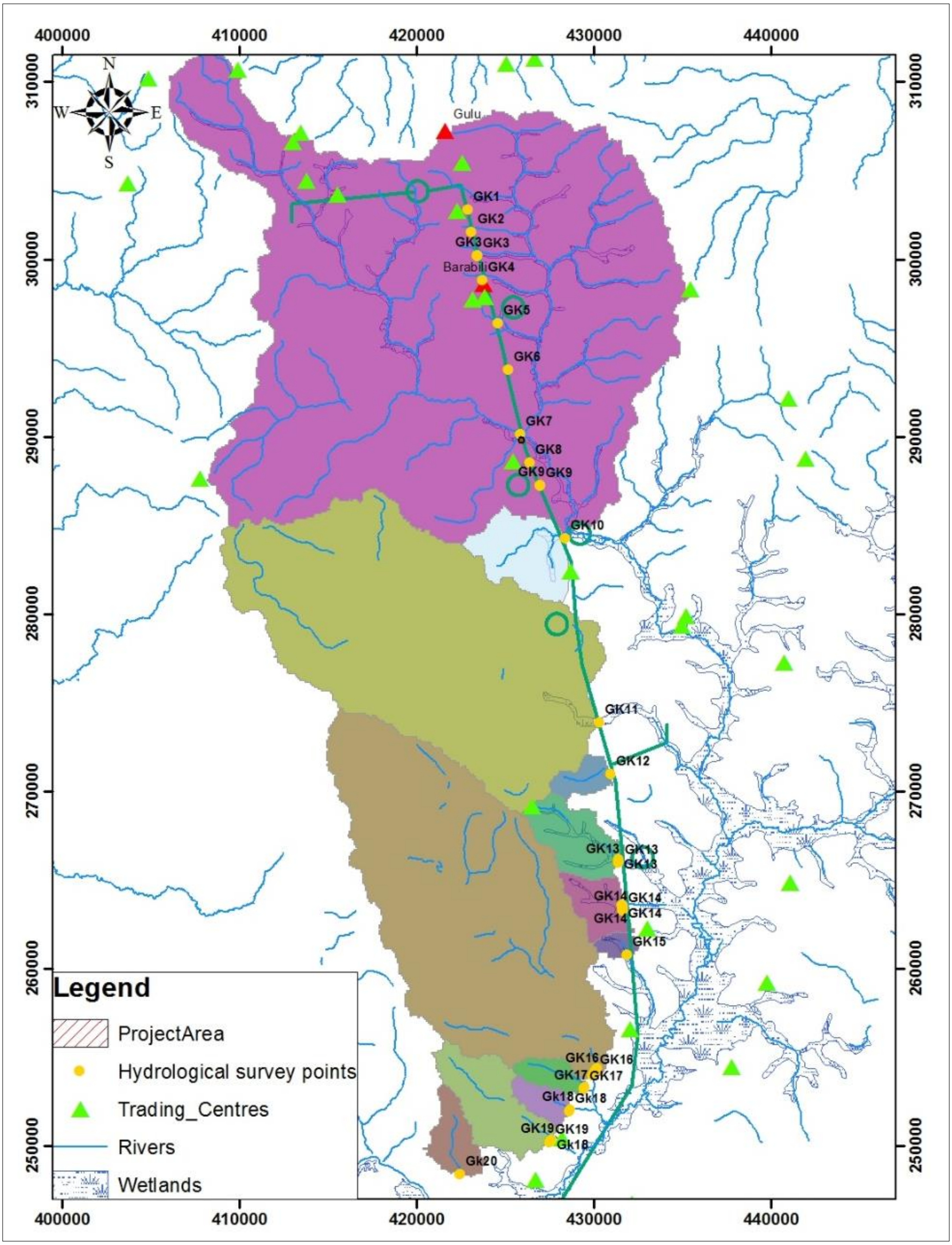


Figure 35 Delineation of catchment with outlets at culverts

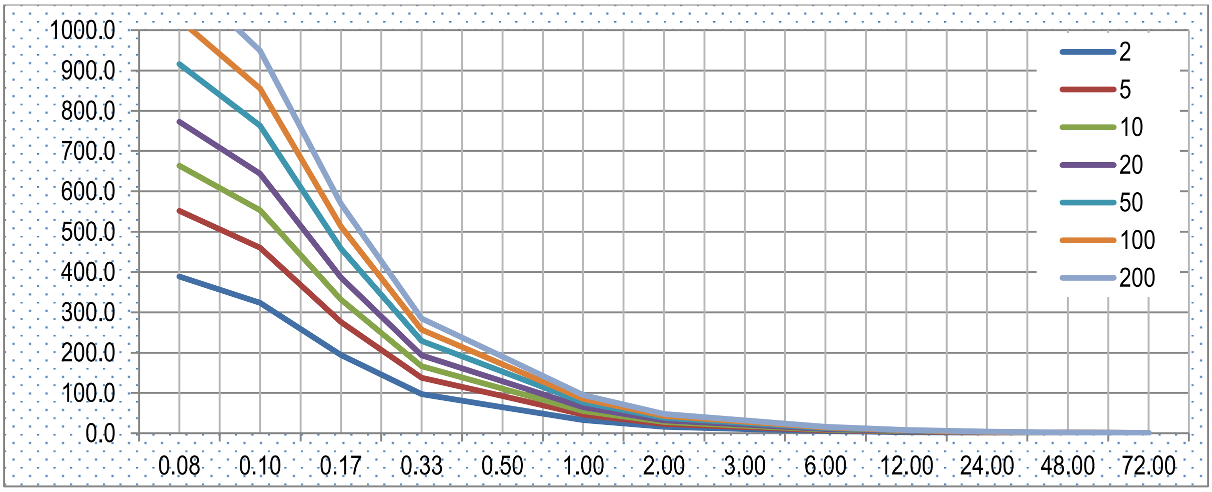


Figure 36 Rainfall intensity frequency duration curves for project area

Table 45: Peak flow rates (m^3/s) at swamp sections along Karuma – Gulu transmission Line

Name	5yr	10yr	20yr	50yr	100yr	200yr	500yr
GK2	0.020	0.2	0.3	0.4	0.5	0.7	0.8
GK3	0.018	0.2	0.32	0.5	0.7	0.9	1.1
GK4	0.038	0.3	0.4	0.7	0.9	1.1	1.4
GK5	0.041	0.4	0.6	0.9	1.1	1.4	1.9
GK6	0.014	0.2	0.3	0.4	0.6	0.7	0.9
GK7	0.3	3.2	4.9	7.7	10.1	12.7	16.6
GK8	0.006	0.08	0.12	0.21	0.3	0.4	0.5
GK9	0.1	0.4	0.7	1.0	1.3	1.6	2.1
GK10	0.32	4.3	6.9	10.9	14.3	18.2	23.9
GK11	0.2	2.7	4.2	6.6	8.6	10.9	14.2
GK12	0.006	0.16	0.31	0.5	0.7	0.9	1.2
GK13	0.021	0.4	0.6	1	1.3	1.6	2.2
GK13_2	0.03	0.5	0.8	1.2	1.6	2.1	2.7
GK14	0.1	0.6	0.9	1.3	1.7	2.1	2.7
GK15	0.035	0.3	0.4	0.6	0.8	1.0	1.3
GK16	0.4	3.0	4.5	6.8	8.8	11.0	14.1
GK17	0.1	0.5	0.7	1.0	1.2	1.5	1.9
GK18		0.5	0.7	1.0	1.3	1.6	2.0
GK19	0.1	0.9	1.4	2.0	2.6	3.2	4.2

Name	5yr	10yr	20yr	50yr	100yr	200yr	500yr
GK20	0.1	0.5	0.7	1.1	1.4	1.7	2.3
GK10_2	0.1	0.9	1.4	2.2	2.8	3.5	4.5

Table 46: Peak flow volumes (1000 m^3) at swamp sections along Karuma – Gulu transmission line

Name	5yr	10yr	20yr	50yr	100yr	200yr	500yr
GK2		10.8	16.1	24	30.7	38	48.6
GK3	1.50	16.7	26	40.5	53.0	66.9	87.2
GK4	2.9	23.5	35.6	53.8	69.4	86.5	111.4
GK5	4.0	34.5	52.7	80.3	104.0	130.1	168.1
GK6	1.5	18.9	29.8	46.6	61.2	77.5	101.4
GK7	166.1	1,888.4	2,958.1	4,602.8	6,033.6	7,615.8	9,935.5
GK8	0.4	6.1	9.7	15.4	20.3	25.8	33.9
GK9	5.2	39.0	58.6	88	113.2	140.8	180.8
GK10	222.7	3,053.0	4,860.0	7,662.2	10,113.8	12,835.4	16,839.9
GK11	118.6	1401.1	2202.4	3436.8	4511.9	5701.7	7447.6
GK12	0.8	24.4	41.1	67.6	91.2	117.7	157.2
GK13	4.4	69.6	112.1	178.3	236.5	301.2	396.7
GK13_2	5.7	90.5	145.8	231.9	307.6	391.8	516.1
GK14	10.9	81.3	121.9	182.9	235.1	292.2	375
GK15	3.0	22.2	33.4	50.1	64.3	80	102.6
GK16	190.2	1525.1	2307	3486.7	4499.5	5609.6	7223.9
GK17	9.3	55.7	81.4	119.4	151.6	186.5	236.8
GK18	11.3	59.4	85.2	123	154.8	189.1	238.3
GK19	25.7	190.8	286.2	429.3	551.8	685.8	880.2
GK20	8.1	71.5	109.4	166.8	216.2	270.6	349.9
GK10_2	17.5	154.5	236.2	360.1	467.0	584.4	755.6

d) Hydraulic analysis at swamps

The flood hydrographs for the hydraulic structures were used as inflows to HECRAS model to simulate the flood plain redistributions of flows upstream of the study area. The flow area and top width for cross-sections in swamps sections likely to be transversed by the transmission line are indicated in (Appendix B, Table 10). The water depth does not exceed 2 m which is typical for most swamps.

6.2.3 Tectonics and Seismology

The site is located on a fairly stable geological unit. However, numerous faults exist within the country and tremors due to earthquakes do occur. The site area is located within the shield area, but only approximately 50 – 100 km from the western rift and about 70 km south of the Aswa Fault Zone. It is therefore susceptible to the potential effect of major tectonic features of regional scale. The site is in the main, located in Zone 2 of the Seismic Zoning of Uganda, implying a moderate/ medium risk (Figure 38). Appropriate design seismic acceleration values consistent with Contract Technical Specifications and Uganda Seismic Code US319:2003 were adopted during foundation design due to the high likelihood of earthquake occurrence in the area.

6.2.4 Geology and Geomorphology

The major rock types that form the geology are from the remains of the low surfaces and scarps related to rift sediments of the western rift valley.. Often the focus in these areas is the Inselbergs and hot springs. Limited geological reconnaissance investigations were carried out in some parts of the district and some minerals were found to occur in some areas. Among these minerals are; kynite found to occur in the pennatic vein rock areas of Attiak trading centre (town boarder), magnetite, a source of iron ore is found in Alero at patiri hill and the surrounding rock. More minerals were observed in rock of Keyo hill a few miles north east of Patitri hill. Chalcopyrite copper mineral occurred in small quantity in granite gneisses at Lawiyadul area 2 km north of Gulu town. Gold is said to have been traced in Atiak –Bibia up to the Sudan boarder (here detailed geological investigation is needed). Clay suitable for good quality roofing tiles and building bricks is found to occur in almost all parts of the district. Stone quarrying in several rocks has also been identified and are said to be of good quality for building and construction industries. The major rock types that form the geology of the project area are from the remains of the low surfaces and scarps related to rift sediments of the western rift valley.

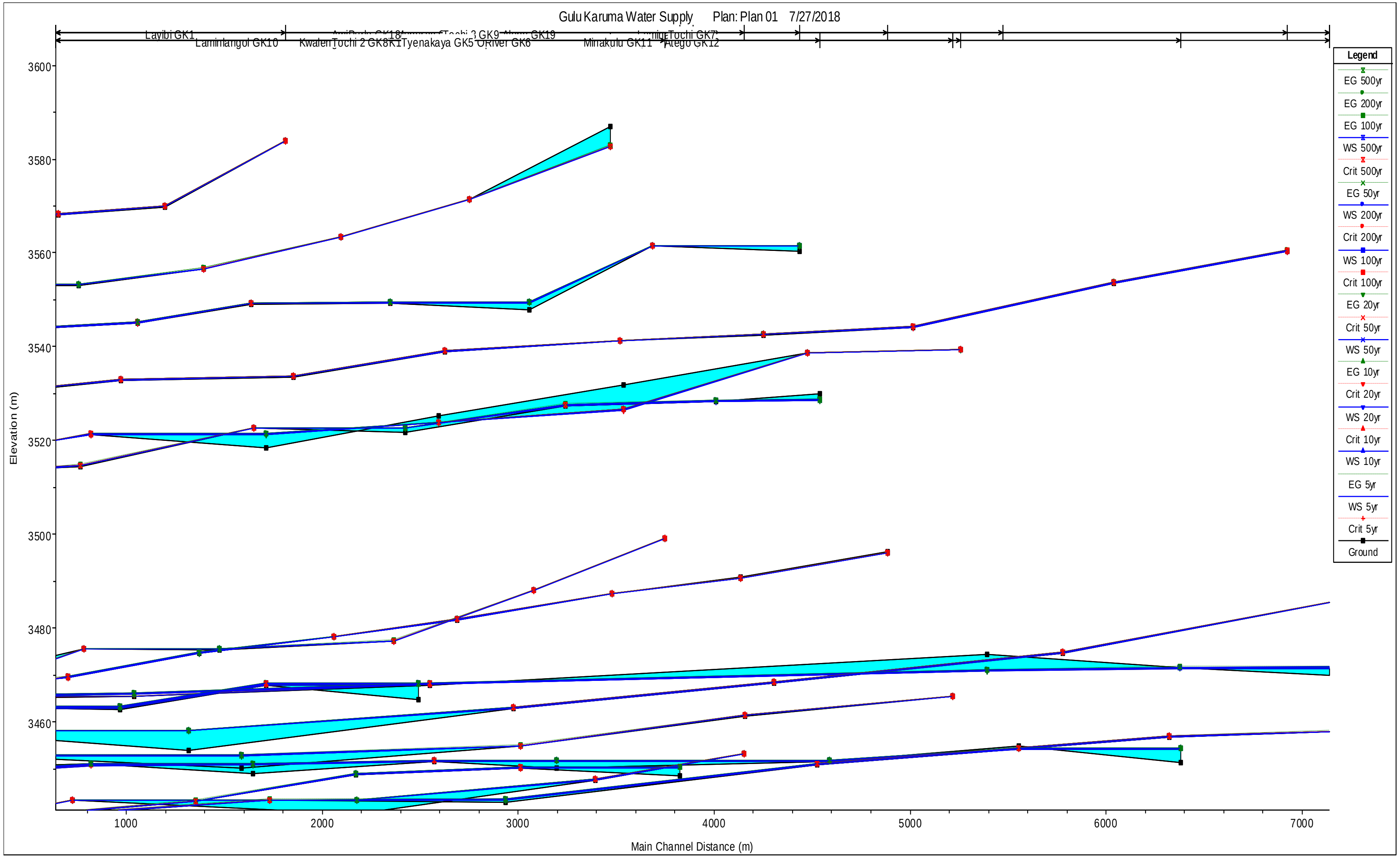
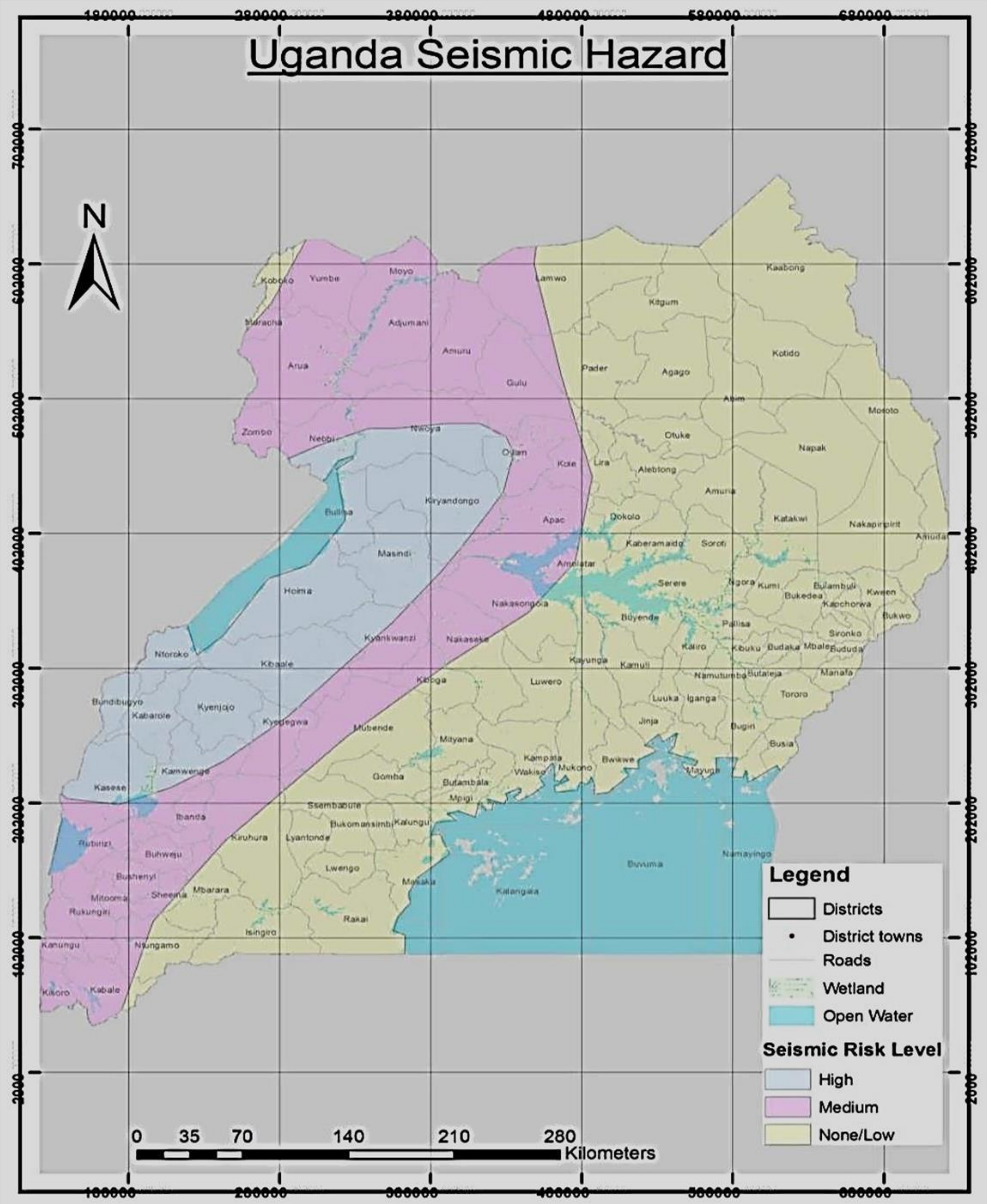


Figure 37 Water surface profiles along swamp sections



Source: Geotech Solutions, 2017

Figure 38 Seismic hazard zonation map of Uganda: Office of the Prime minister

Broadly the geological set up of Karuma Intake and Water treatment sites Project area can be subdivided into two categories: overburden and bedrock (Fitchner, 2018). Broadly the geological set up of Karuma Intake and Water treatment sites can be subdivided into two categories, that is, overburden and bedrock. The water treatment site was found to be filled with riprap from the Nile River during the time of preparation for Karuma dam construction works; to depths ranging from 3.0m – 5.0m in some cases. Based on visual inspection, the in-situ soils strata at the intake site were generally granite rocks from a depth of 4.5m. The strata from the intake and water treatment sites were to a large extent; non-cohesive. The strata from the boreholes at towns en-route from Karuma to Gulu; and from the hand auger locations and trial pits were of varied composition.

6.2.5 Soils

According to Langlands (1974) classifications, the soil consists of ferruginous soil. In some areas, the soils have a high percentage of sandy soils and therefore susceptible to erosion while in others they are heavily textured ranging from clay loam to clay. Due to its sandy nature, the soil has low water retention capacity and high rate of water infiltration. The soils are usually deep with little differentiation into clearly defined zones and possess fine granular structure, others moulded into large, weak coherent clods that are very porous. The districts are endowed with vast fertile soils which can support quite a number of both cash/food crops including bananas and coffee. The soils in the project area are mainly ferrosols and are characterized with a reddish colour. The soils are moderately productive in terms of agriculture. Such soils are also susceptible to runoff and logging. Within the catchment areas the soils are predominantly Shallow brown sandy loams over rock or laterite and Black and grey clays often calcareous. More than 64 % of study area is under Petric Plinthosols followed by Gleysols (2%) and Acric Ferralsols (34%).

Petric Plinthosols (Acric): Shallow reddish brown or grey sandy loams and loams over laterites, often formed from basement complex granites and gneisses or from lake deposits derived from basement complex granites and gneisses. Examples are soils in the Buruli Catena mapping units. This soil is Vulnerable to erosion.

Acric Ferralsols: Shallow reddish brown or dark brown or black sandy loams or laterites, formed from basement complex gneisses and granites. Examples are soils in the Anaka Complex mapping units. This soil is Vulnerable to erosion.

Gleysols: Dark brown or grey sandy loams and sandy clay loams often calcareous of river alluvium. Examples are soils in the Undifferentiated Alluvium mapping units. This soil is not Vulnerable to erosion.

Chemical tests on soil samples retrieved from the boreholes yielded pH values ranging from 6.45 to 6.64 (Fitchner, 2018). The hand auger soil samples posted pH values ranging from 6.45 to 6.78. All the samples obtained had negligible quantities of chlorides and sulphates that may not have any adverse effect on the construction materials likely to be used (Fitchner, 2018). The strata at the proposed sites are within acceptable limits of alkalinity. Therefore no special cement is required to be used during the construction of the foundations. In all cases therefore, readily available Portland cement, 42.5N is recommended for use for the construction works owing to its ability to ensure the achievement of good early strength for concrete. Water proof cement may also be used as necessary.

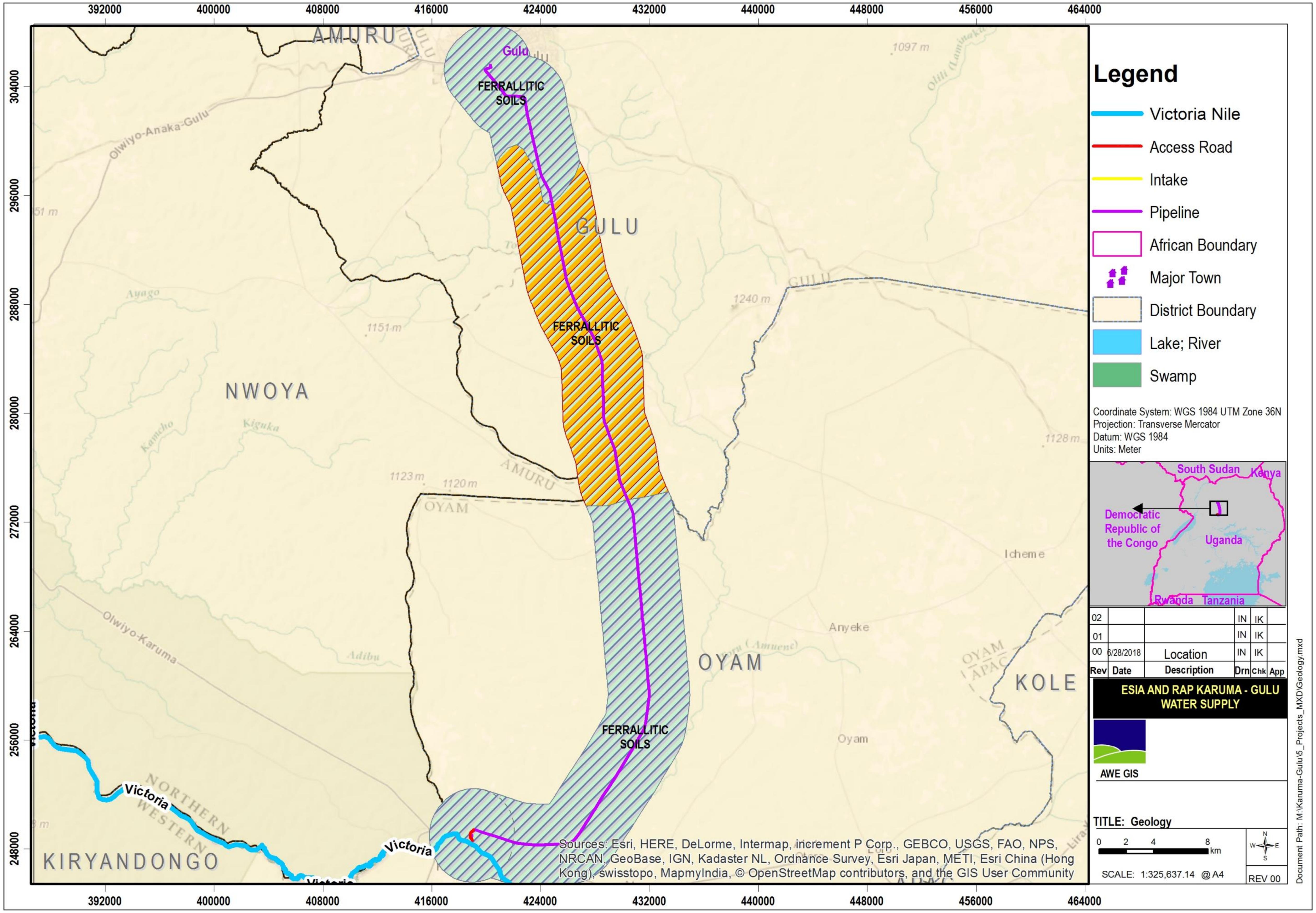


Figure 39 Soils of the project area

6.2.6 Air Quality

Uganda currently has no comprehensive database about national air quality. However, motor vehicles are major emission sources for several air pollutants, including nitrogen oxides (NO_X), carbon monoxide (CO), particulate matter (PM), and hydrocarbons (HCs) (WHO, 2005).

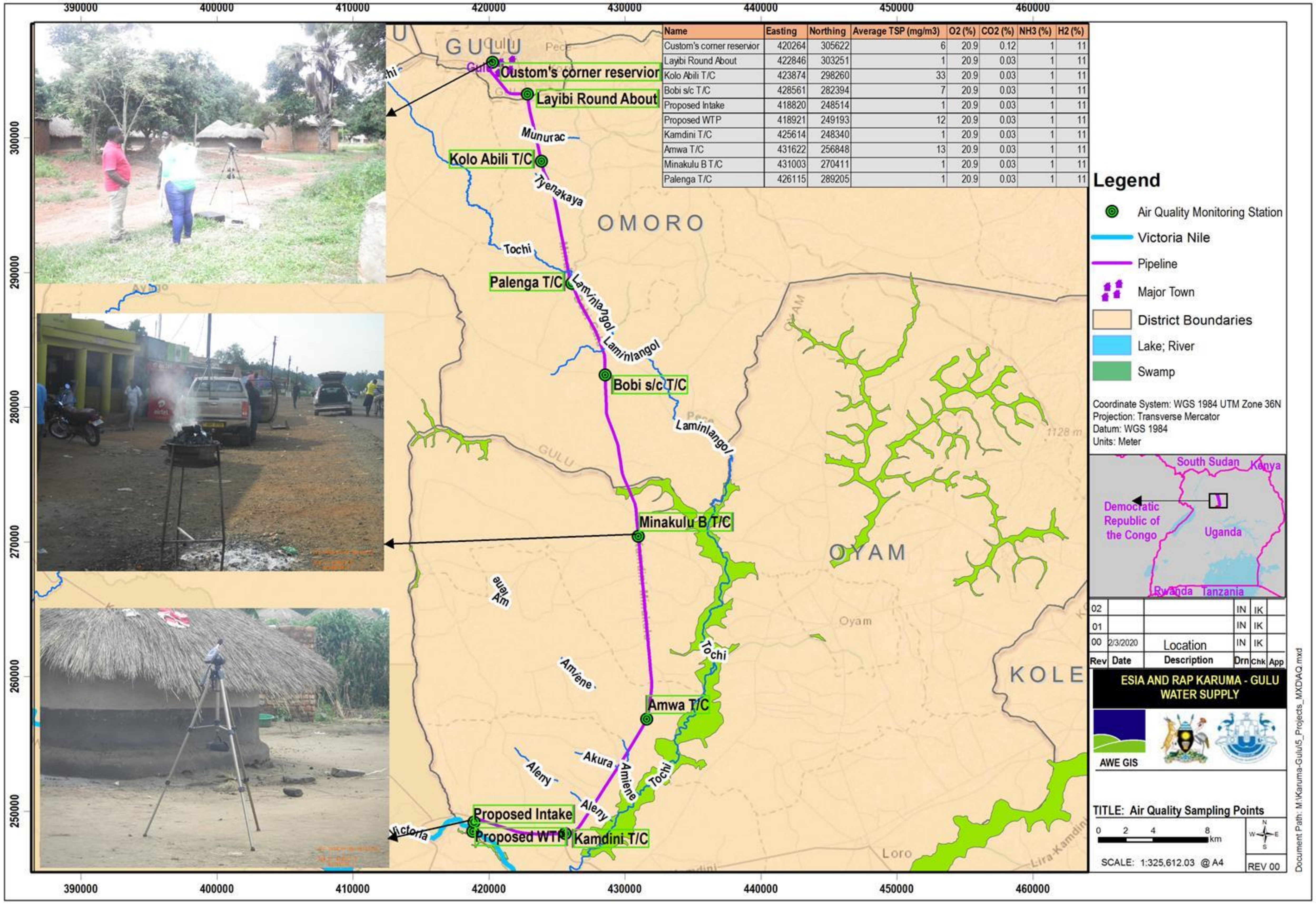
Measurements at all points surveyed did not encounter any detectable levels of SO_2, VOCs, NOx, CO, Cl_2 and/or ClO_2. Levels of other air quality parameters quantified are presented in Table 47 and Figure 40. Compared to existing proposed national standards, measured TSP levels and other detectable gas level measurement results indicate a clean air environment existing in all towns/trading centres where air quality measurements were made. Increased traffic due to pipeline construction vehicles along the unpaved roads branching onto and off the highway may locally increase air pollutant quantities, particularly Total Suspended Particulates (TSP).

Table 47: Air quality at the proposed project sites

Location	Average TSP (mg/m^3)	O_2 (%)	CO_2 (%)	NH_3 (ppm)	H_2 (ppm)	Notes
420264 E, 305622 N **Custom's Corner (Reservoir)**	6	20.9	0.12	1.0	11	Very little vehicular and foot traffic activity
422846 E, 303251 N **Layibi Roundabout**	1	20.9	0.03	1.0	11	Very heavy vehicular traffic
423874 E, 298260 N **Kolo Abili**	33	20.9	0.03	1.0	11	Highway traffic and an active Trading centre
426115 E, 289205 N **Palenga**	7	20.9	0.03	1.0	11	Highway traffic and mild trading centre activity
428561 E, 282394 N **Bobi Trading Centre**	1	20.9	0.03	1.0	11	Traffic police stop; slow highway traffic speeds
431003 E, 270411 N **Minakulu B**	12	20.9	0.03	1.0	11	Smoke from charcoal; stove in vicinity of test site; and highway traffic
431622 E, 256848 N **Amwa**	1	20.9	0.03	1.0	11	Highway traffic
425614 E, 248340 N **Kamdini**	13	20.9	0.03	1.0	11	Very heavy vehicular traffic and junction to Lira; busy activity at trading centre
418921 E, 249195 N **Proposed Water Treatment Site**	1	20.9	0.03	1.0	11	Homestead with 13 huts Livestock at measurement site. (goats, poultry)

418820 E, 248514 N **Intake**	1	20.9	0.03	1.0	11	Victoria Nile running in vicinity of measurement site; heavy vegetation at test site

During project implementation especially the construction phase, measures will be put in place to ensure that the air quality in the working areas is not polluted with gaseous emissions and particulates. More details are presented in the impact assessment section 7.



Name	Easting	Northing	Average TSP (mg/m3)	O2 (%)	CO2 (%)	NH3 (%)	H2 (%)
Custom's corner reservior	420264	305622	6	20.9	0.12	1	11
Layibi Round About	422846	303251	1	20.9	0.03	1	11
Kolo Abili T/C	423874	298260	33	20.9	0.03	1	11
Bobi s/c T/C	428561	282394	7	20.9	0.03	1	11
Proposed Intake	418820	248514	1	20.9	0.03	1	11
Proposed WTP	418921	249193	12	20.9	0.03	1	11
Kamdini T/C	425614	248340	1	20.9	0.03	1	11
Amwa T/C	431622	256848	13	20.9	0.03	1	11
Minakulu B T/C	431003	270411	1	20.9	0.03	1	11
Palenga T/C	426115	289205	1	20.9	0.03	1	11

Figure 40 Air quality at selected project sites

6.2.7 Noise

The major sources of noise in urban centres of Uganda include humans and transportation activities. Results of noise measurements are provided in Table 48 and Figure 41 which show the state of compliance with day time regulatory limits of 55 dBA respectively corresponding to land use zoning of "Mixed Residential (with some commercial and entertainment " as per First Schedule (Maximum permissible noise levels) Part 1 in National Environment (Noise Standards and Control) Regulations, 2003.

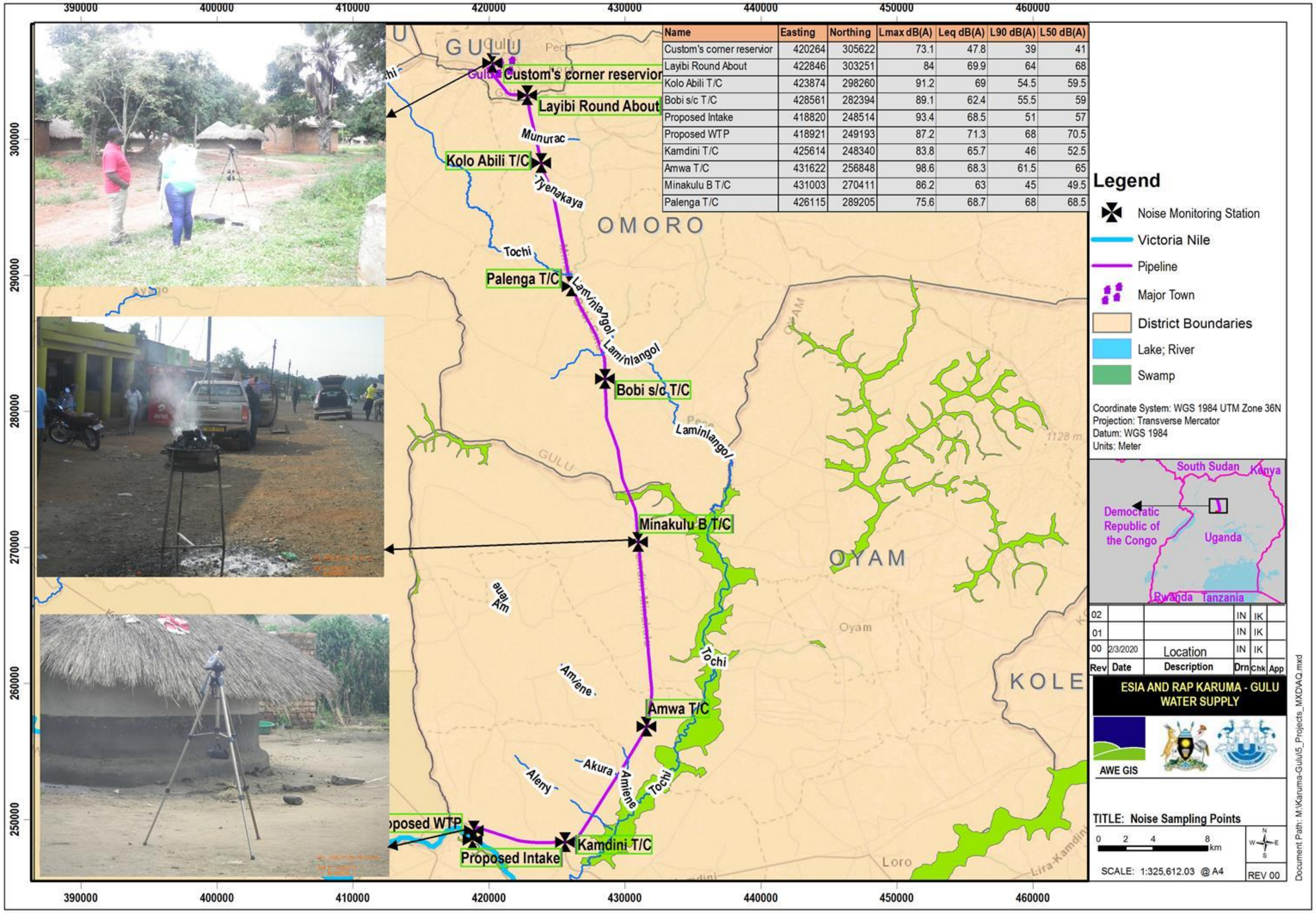
Table 48: Noise levels measured at the proposed project ccomponent sites

Location	**Sound Pressure dB(A)**				**Notes**
	L_{max}	L_{eq}	L_{90}	L_{50}	
420264 E, 305622 N **Custom's Corner (Reservoir)**	73.1	47.8	39.0	41.0	Very little vehicular and foot traffic; homestead latrine in the vicinity
422846 E, 303251 N **Layibi Roundabout**	84.0	**69.9**	64.0	68.0	Very heavy vehicular traffic and noise from trading centre near the roundabout
423874 E, 298260 N **Kolo Abili**	91.2	**69.0**	54.5	59.5	Highway traffic and active trading centre
426115 E, 289205 N **Palenga**	89.1	**62.4**	55.5	59.0	Highway traffic and mild trading centre activity
428561 E, 282394 N **Bobi Trading Centre**	93.4	**68.5**	51.0	57.0	Traffic police stop; slow highway traffic speeds; Sub-county headquarters near test site
431003 E, 270411 N **Minakulu B**	87.2	**71.3**	68.0	70.5	Highway traffic
431622 E, 256848 N **Amwa**	83.8	**65.7**	46.0	52.5	Highway traffic and little activity at test area
425614 E, 248340 N **Kamdini**	98.6	**68.3**	61.5	65.0	Very heavy vehicular traffic and junction to Lira; and noise from Busy activity at trading centre
418921 E, 249195 N **Proposed Water Treatment Site**	86.2	**63.0**	45.0	49.5	Homestead with 13 huts and livestock at test site (goats and poultry)
418820 E, 248514 N **Intake**	75.6	**68.7**	68.0	68.5	Noise from Victoria Nile running at test site

** Based on landuse Category D (Residential + Industry or small scale production + commerce) for which daytime and night limits are 60 and 50 dBA, respectively according to The National Environment (Noise Standards and Control) Regulations 2003.*

Inference from measurements:

i) The daytime noise levels L_{Aeq} values varied from 47.8 to 71.3 dB(A), dependant on prevailing highway traffic and roadside human activities.
ii) Highway traffic noise is best compared using L_{A10} weighting and averaging methods. However, NEMA currently does not have officially published L_{A10} noise standards but it does have an LAeq standard for "Mixed Residential (with some commercial and entertainment) for daytime. The value attached to this limit/standard is 55 dB(A).



Name	Easting	Northing	Lmax dB(A)	Leq dB(A)	L90 dB(A)	L50 dB(A)
Custom's corner reservior	420264	305622	73.1	47.8	39	41
Layibi Round About	422846	303251	84	69.9	64	68
Kolo Abili T/C	423874	298260	91.2	69	54.5	59.5
Bobi s/c T/C	428561	282394	89.1	62.4	55.5	59
Proposed Intake	418820	248514	93.4	68.5	51	57
Proposed WTP	418921	249193	87.2	71.3	68	70.5
Kamdini T/C	425614	248340	83.8	65.7	46	52.5
Amwa T/C	431622	256848	98.6	68.3	61.5	65
Minakulu B T/C	431003	270411	86.2	63	45	49.5
Palenga T/C	426115	289205	75.6	68.7	68	68.5

Figure 41 Noise levels measured at the proposed project ccomponent sites

iii) The roadside measured noise L_{Aeq} values were observed to exceed 55 dB(A) in all towns along the highway except at the Custom's Corner for the proposed reservoir site at 47.8 dB(A). This is due to the site being in a residential area.
iv) Besides highway traffic as a source, observed noise measured in all these locations was contributed by activity in nearby entertainment centres in the towns, motorcycle commuter transport and roadside markets.
v) These measurements therefore indicate that during the construction phase, noise contribution by the pipeline construction traffic will not significantly increase the existing noise levels based on the human activities already routinely happening in these towns except at the proposed reservoir site.

6.2.8 Vibrations

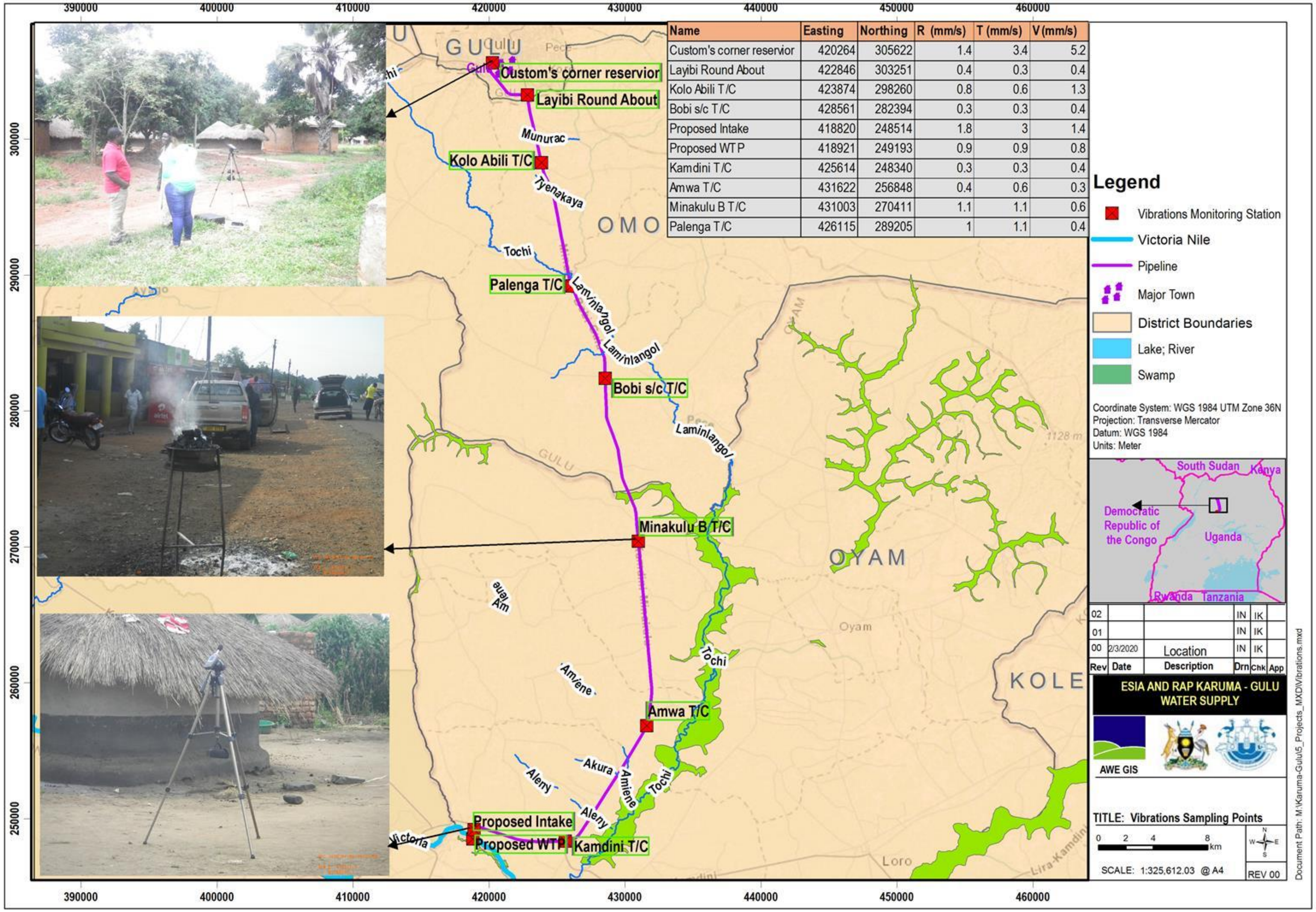
The resultsof the seismic testing for the selected points along the route is shown in Table 49. From measurement data in Table 49, baseline vibration levels ranged between 0.3-1.4 mm/s. which according to BS 5228-2:2009 might be just perceptible in residential environments. The elevated vibration level at Bobi Trading Centre is as a result of heavy and slow trailer traffic observed during the measurement of vibrations at that point..

Table 49: Vibration levels at selected sites along the pipeline route

Location	Vibration Readings				Microphone (Air Reading) SPL (dB)
		Axis			
		R	T	V	
420264 E, 305622 N	Peak (mm/s)	1.4	3.4	5.2	101.0
Custom's Corner (Reservoir)	Frequency (Hz)	8.6	11.5	11.5	4.2
422846 E, 303251 N	Peak (mm/s)	0.4	0.3	0.4	108.4
Layibi Roundabout	Frequency (Hz)	68.3	0.0	93.1	11.8
423874 E, 298260 N	Peak (mm/s)	0.8	0.6	1.3	106.0
Kolo Abili	Frequency (Hz)	20.9	146	20.1	6.4
426115 E, 289205 N	Peak (mm/s)	0.3	0.3	0.4	109.2
Palenga	Frequency (Hz)	0.1	0.0	3.7	10.8
428561 E, 282394 N	Peak (mm/s)	1.8	3.0	1.4	114.4
Bobi Trading Centre	Frequency (Hz)	113	0.0	341	146
431003 E, 270411 N	Peak (mm/s)	0.9	0.9	0.8	105.5
Minakulu B	Frequency (Hz)	0.1	146	35.3	9.8
431622 E, 256848 N	Peak (mm/s)	0.3	0.3	0.4	112.0
Amwa	Frequency (Hz)	0.0	0.0	6.4	8.5

Location	Vibration Readings				Microphone (Air Reading) SPL (dB)
		Axis			
		R	T	V	
425614 E, 248340 N	Peak (mm/s)	0.4	0.6	0.3	113.5
Kamdini	Frequency (Hz)	0.1	0.0	0.0	1.2
418921 E, 249195 N	Peak (mm/s)	1.1	1.1	0.6	109.5
Proposed Water Treatment Site	Frequency (Hz)	204	204	113	2.2
418820 E, 248514 N	Peak (mm/s)	1.0	1.1	0.4	114.0
Intake	Frequency (Hz)	0.1	0.0	0.4	3.2

The national standards for maximum permissible vibrations are yet to be promulgated and therefore baseline levels cannot be authoritatively interpreted in Uganda’s regulatory context. However, these levels will be useful for monitoring ground vibrations during project construction to determine any impacts due onsite activities.



Name	Easting	Northing	R (mm/s)	T (mm/s)	V (mm/s)
Custom's corner reservior	420264	305622	1.4	3.4	5.2
Layibi Round About	422846	303251	0.4	0.3	0.4
Kolo Abili T/C	423874	298260	0.8	0.6	1.3
Bobi s/c T/C	428561	282394	0.3	0.3	0.4
Proposed Intake	418820	248514	1.8	3	1.4
Proposed WTP	418921	249193	0.9	0.9	0.8
Kamdini T/C	425614	248340	0.3	0.3	0.4
Amwa T/C	431622	256848	0.4	0.6	0.3
Minakulu B T/C	431003	270411	1.1	1.1	0.6
Palenga T/C	426115	289205	1	1.1	0.4

Figure 42 Vibration levels at selected sites along the pipeline route

To put above baseline vibration values in context, use is made of BSI British Standards (BS 5228-2:2009): Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration. In this Standard, peak particle velocity (PPV) in millimeters per second (mm/s) is the simplest indicator of both perceptibility and the risk of damage to structures. BS 7385-1 and BS 7385-2 provide guidance on measurement, evaluation of effects on buildings, and damage levels, and are based upon use of the PPV. The vibration dose value (VDV) is recommended in BS 6472 as the appropriate measure to evaluate human exposure to vibration in buildings in residential and other uses. The likelihood of adverse comment occurring from building occupants is used to evaluate the likely severity of effect. The effects that can be caused by various levels of vibration are presented in Table 50.

Table 50: Levels of vibration and their effects

Vibration PPV (mm/s)	Effect
0.14	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.
0.3	Vibration might be just perceptible in residential environments.
1.0	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.
10	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

6.2.9 Topography

The relief consists of complex low landscape with relatively uniform topography marked by few sharp contrasts like Oroko and Ajulu hills to the north, Ayamo, Awere and Omoro hills in the east (Figure 43). Generally, the altitude ranges between 1000 - 1200 m above sea level. The low landscape will make it easier for pipeline laying and hence minimise the cut-and-fill during construction activities.

6.3 BIO-PHYSICAL PROFILE

The proposed route for the Water pipeline from Karuma to Gulu traverses largely human impacted and/or modified landscapes in which the land cover is mostly dominated by settlement and cultivation. Because of such a scenario most of the area to be traversed by the proposed project is considered of low biodiversity value.

6.3.1 Vegetation, Habitats and Flora

Karuma-Gulu water project traverses Savannah vegetation of various phytosociological characteristics. For example the area around the water intake along river Nile is in lightly wooded bushed grassland of *Acacia polyacantha, Panicum maximum and Pennisetum polystachion* on a rocky ground. The pipeline from the intake to the water treatment plant traverses through bushed grasslands of *Panicum maximum* and *Pennisetum polystachion* grassland fallows and a stone quarry area, while the treatment plant and the access road traverse areas of *Panicum-Pennisetum* grassland fallows with cassava-maize garden mosaics. The pipeline route from Karuma to Gulu traverses various plant communities outstanding among them are wetlands with various phytosociological characteristics. Most of the habitats the project is anticipated to traverse are already transformed; however, there are wetlands some of which are still natural while others are degraded. Irrespective of the degradation levels, wetlands are vital ecosystems for both amphibious and aquatic organisms they have to be given due protection from vandalism. Photos 29 - 42 give a pictorial illustration of the state of vegetation at various sites of the project area from

Karuma-Gulu. At some point the pipeline route passes through a Forest reserve (Photo 42) however there will be no big impact here if the pipe is passed in the road reserve besides the vegetation here is not natural.

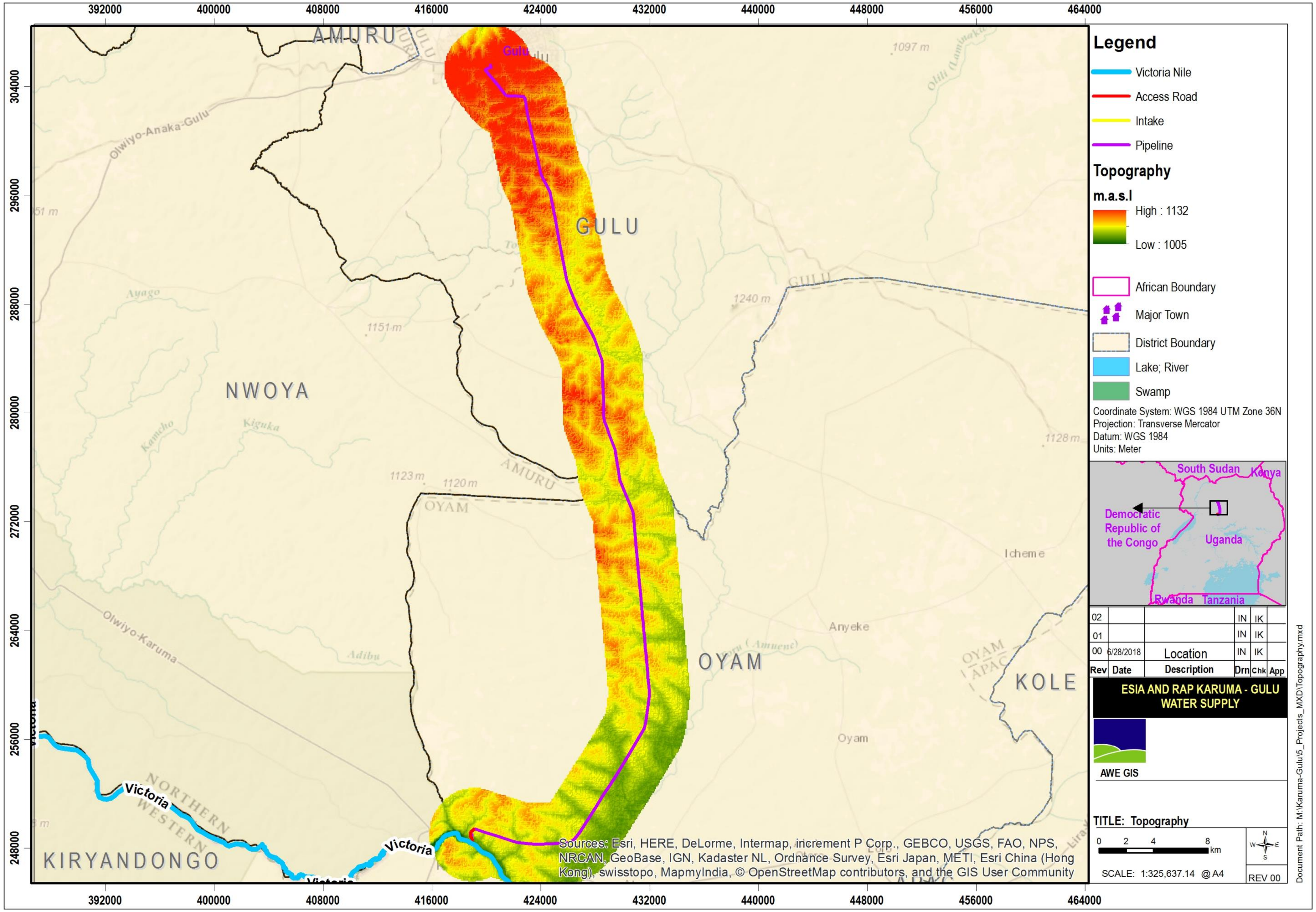


Figure 43 Topography of the project area

Photo 29: Plantation of Pinus pinus along the road at 36N 424900E 295148N

Photo 30: Brick making I a degraded swamp along the road at 36N 422486E 248389N

Photo 31: Cultivation at wetland fringes at 36N 430285E 273964N

Photo 32: Heaps of stones in a quarry through which the pipeline from abstraction point pass at 36N 418965E 248565N

Photo 33: *Acacia-Panicum-Pennisetum* Lightly wooded bushed grassland of on rocky ground at water abstraction point 36N 0418965E 248565N

Photo 34: *Panicum-Pennisetum* grassland fallow of in quarry 36N 0418879E 248772N

Photo 35: *Panicum-Setaria-Imperata* grassland fallow near 36N 0418963E 248994N

Photo 36: *Panicum-Pennisetum* grassland fallow near 36N 0419193E 249414N

Photo 37: *Albizia-Brachiaria-Aframomum* wooded grassland near 36N 0425521E 291714N

Photo 38: *Acacia-Erythrina* wooded grassland *Acacia-Erythrina* woodland near 36N 0425578E 291563N

Photo 39: *Cyperus-Phoenix-Echinochloa* swamp (Nyere swamp) near 36N 0430298E 254551N

Photo 40: Acacia-Vitex-Sida bush land near 36N 0423989E 297619N

Photo 41: *Leersia-Cyperus-Bulbostylis* seasonally flooded grassland near 36N 0431633E 263550N

Photo 42: *Tectona grandis* Opaka NFA forest reserve at 36N 424900E 295148N

The proposed project site traverses through an area with 173 species of plants belonging to 45 families. Majority of these were in form of herbs with a percentage composition of 34.1, followed by trees and grasses with 20.1 and 19.1, respectively. In general, the project component sites have very little woody biomass which would take long to be replaced compared to the easily replaceable non woody biomass. The high species richness of the area is as a result of habitat diversity and degradation of some of the habitats for example wetlands and bushed grasslands such that many are now fallows which are characteristic of high species diversity. The names, families and assessment on the DAFOR scale of the plant species encountered are given in Appendix D. Only six plant species *Cyperus papyrus, Leersia hexandra, Echinochloa pyramidalis, Setaria sphacelata, Cynodon dactylon* and *Acacia polyacantha* which is the only woody species were overall dominant in the project area.

At the intake site, only one tree species *Acacia polyacantha* was the dominant tree, other small trees and shrubs are sporadic in *Panicum maximum* and *Pennisetum polystachion* dominated fallows. These two grasses are characteristic of fallow lands a justification of already existing degradation from stone quarrying activities at the site. The pipeline route from the abstraction point to the water treatment plant has small and few bushes scattered in rock excavations, on rocks, roads and heaps of stones. At both sites, the species richness was generally very low due the intensive disturbance from stone works.

However, the project area has species of socio-economic importance. Some of these species provide high valued timber, poles for electricity transmission and roofing materials for houses as well as fruit trees and food crops. Trees with high valued timber and poles were *Khaya anthotheca, Markhamia lutea, Maesopsis eminii, Milicia excelsa, Eucalyptus* sp and *Griveria robusta*. Fruit trees were *Mangifera indica, Persea americana* and *Psidium guajava*. Many of the food crops in gardens and dominant crops were *Manihot esculenta, Musa sp* and *Zea mays*.

Species Threat levels and National legal protection: There were two tree species that fall under the IUCN list of threatened species *Khaya anthotheca* and *Milicia excelsa* which are vulnerable (VU) and Near Threatened (NT) respectively worldwide (IUCN 2018). From the national red list data for threatened species of Uganda *Khaya anthotheca* and *Milicia excelsa* are both Endangered (EN). According to WCS (2016) these species were assessed as such due to increasing reduction in their geographical distribution and consequently their numbers as a result of environmental degradation. This implies that the species and their immediate habitats require protection from any form of destructive disturbances. It is also worth noting that *Markhamia lutea*, *Maesopsis eminii* and *Milicia excelsa* are listed by the National Forestry and Tree planting Act 2003 scheduled VI because of their economic importance and threats from human activities. Photo 43 gives a pictorial illustration of some of the threatened species.

Milicia excelsa woodlot (Neat threatened, NT by IUCN, Endangered, EN by WCS and protected by NFA act 2003) Located at 36N 424999E 294543N

Markhamia lutea (protected by NFA act 2003) located at 36N 423972E 297577N

Khaya anthotheca woodlot (Vulnerable, VU by IUCN, Endangered, EN by WCS) located at 36N 429530E 277069N

Individual of *Maesopsis eminii* (protected by NFA act 2003) at 36N 421095E 248802N

Photo 43: Some of the trees of conservation importance

Invasive (noxious) plant species: Several invasive species of plants were encountered along the project area. *Mimosa pigra, Senna spectabilis, Imperata cylindrica* and *Ricinus communis* were frequently encountered along. The pictorial illustration of some of these species is provided in the Photo 43. Disturbances of some magnitude are anticipated during and after construction therefore these species require careful management and monitoring.

6.3.2 Fisheries

In 1991 it was estimated that 2546 species of fish populated the world belonging to 969 genera, 254 families, and 40 orders. Around 80% of fish population around the globe was represented by the Indian fishes. Depending upon the habitats and characteristics there are a variety of fish around the world existing as fresh water, tropical, marine, cold water and aquarium fishes. In Uganda, there are fresh water fishes; fishes that are found in the water bodies such as lakes and rivers in which the salinity is less than 0.05% comprising a total diversity of at least 500 species (NARO, 2013). The most common species are *Lates niloticus, Oreochromis niloticus, Clarias gariepinus, Rastriniobola argentia* and *Protopterus* spp.

Fish were captured in the experimental fishing but also a survey of local fishers' catches was made to compile the checklists of fish in the different survey areas. Some of the fish species are of commercial value as they are captured and sold in the market while others are captured for domestic consumption. Some of the fish captured in the experimental fishing are shown in Photo 44.

At least 20 species were recorded some of which are only identified to genus level. A summary of the fish capture results for the project area is presented in Tables 51 and 52. The species richness varied from as few as 4 species for the most species poor area to as many as 12 species for areas that were richer in species captured. However, because the wetlands we surveyd are a series in an interconnected system, it is likely that the various species may be as widely occurring as the wetland system that is to be traversed by the project.

1) Petrocephalus castoma; 2) Labeo victorianus; 3) Schilbe mystus; 4) Synodonti afro fischeri; 5) Synodontis species 2; 6) Poecilia reticulata and 7) Petrocephalus castoma

Photo 44: Examples of fish species captured in the experimental fishing

Table 51: Fish diversity recorded in the project area

Overall list of species	The most widely occurring species	Species recorded in only a few locations	The edible species
Alestes baremoze	*Clarias gariepinus*	*Alestes baremoze*	*Alestes baremoze*
Bagrus docmak	*Haplochromis* sp 1	*Bagrus docmak*	*Bagrus docmak*
Clarias gariepinus	*Haplochromis* sp 2	*Lates niloticus*	*Clarias gariepinus*
Haplochromis sp. 1	*Haplochromis* sp *3*	*Mormyrus caschives*	*Labeo victorianus*
Haplochromis sp. 2	*Haplochromis* sp 4		*Lates niloticus*
Haplochromis sp. 3	*Haplochromis* sp 5		*Mormyrus kanume*
Haplochromis sp. 4	*Labeo victorianus*		*Oreochromis niloticus*
Haplochromis sp.5	*Mormyrus kanume*		*Orochromis leucosticus*
Labeo victorianus	*Oreochromis niloticus*		*Oreochromis esculentus*
Lates niloticus	*Orochromis leucosticus*		*Protopterus aethiopicus*
Mormyrus kanume	*Oreochromis esculentus*		*Synodontis afrofisheri*
Mormyrus caschives	*Poecilia reticulata*		*Tilapia zilli*
Oreochromis niloticus	*Protopterus aethiopicus*		
Orochromis leucosticus	*Synodontis afrofisheri*		
Oreochromis esculentus			
Protopterus aethiopicus			
Poecilia reticulata			
Synodontis afrofisheri			
Synodontis sp			
Tilapia zilli			

Table 52: Fish species recorded in the different survey areas

Species	**Tochi Swamp 425845N 290128E**	**Palenga 426033N 292106E**	**Minakulu swamp 430190N 273940E**	**Bobi swamp 430849N 271165E**	**Ogada swamp 431309N 266162E**	**Alek swamp 431632N 263295E**	**Myene swamp 430257N 254514E**
Alestes baremoze	√		√		√		√
Bagrus docmack	√						√
Clarias gariepinus	√	√	√	√	√	√	√

Species	**Tochi Swamp 425845N 290128E**	**Palenga 426033N 292106E**	**Minakulu swamp 430190N 273940E**	**Bobi swamp 430849N 271165E**	**Ogada swamp 431309N 266162E**	**Alek swamp 431632N 263295E**	**Myene swamp 430257N 254514E**
Haplochromis spp	√	√	√		√	√	√
Labeo victorianus			√		√		√
Lates niloticus			√		√	√	
Mormyrus kanume.	√	√	√		√		√
Oreochromis niloticus		√	√		√	√	√
Poecilia reticulata	√	√	√	√	√	√	
Protopterus aethiopicus	√	√	√	√			√
Synodontis spp	√	√	√	√	√		√
Oreochromis leucosticus		√	√		√	√	
Oreochromis esculentus						√	
Tilapia zilli		√	√		√	√	√

The conservation status of the species of fish found is presented in Table 53. Two species (*Labeo victorianus* and *Oreochromis esculentus*) are listed as critically endangered. The wetland habitats are important range areas for these species and therefore loss of habitat is a key contributing factor to their endangerement as is the case for several other taxa.

Table 53: Conservation status of some of the fishes recorded

Species	**IUCN Conservation status**
Alestes baremoze	LC
Clarias gariepinus	LC
Labeo victorianus	CR
Mormyrus kanume	LC
Oreochromis niloticus	NE
Oreochromis esculentus	CR
Poecilia reticulata	NE
Bagrus docmak	LC
Lates niloticus	LC
Mormyrus caschives	LC

Species	IUCN Conservation status
Oreochromis leucosticus	LC
Protopterus aethiopicus	LC
Synodontis afrofisheri	LC

Key: CR- Critically endangered, NE - Not evaluated, LC - Least Concern, VU – Vulnerable

Labeo victorianus was evaluated by FishBase team RMCA & Geelhand, (2016) as critically endangered (CR) owing to declining populations. Most of the species range is mapped by these authors as being in Uganda but with smaller ranges into Burundi, Kenya, Rwanda and Tanzania. The species is reported by these authors to have population in at least one protected area – but from the map they present, it may have populations in Lake Mburo National Park and Serengeti National Park, Elesewhere in its range the map suggest its occurrence to be wider in the water course system through Uganda. They highlight a number of threats to the survival of this species including Natural system modifications due to Dams & water management/ use.

Oreochromis esculentus- the other critically endangered species recorded in the project area was assessed by Twongo *et al* (2006) due to declining population. The species has a considerable extent of occurrence in East Africa (Kenya, Uganda & Tanzania). The key threats for the species that these authors identified were:

i) Biological resource use -fishing and haeevesting aquatic resources
ii) Invasive and other problematic species, genes and diseases
iii) Invasive non-native/alien species/diseases
iv) Pollution from domestic and urban waste water as well as Agricultural and forestry effluents.

For both these species, the wetlands in which they were recorded are perhaps extra-limital to their range. *Labeo victorianus* is described as potamodrometic (Rutaisire & Booth 2005) that migrates upstream to spawn. It may very well be that the populations we sampled represent such spawnings that would eventually move back into the River Nile. This observation would make the wetlands of major importance for the breeding of this species and likely also *Oreochromis esculentus* too. It would therefore be valuable if the water flow though the wetlands was not obstructed by the project.

6.3.3 Herptiles

Herptiles, like many other groups of organisms, are facing worldwide population declines, range contractions, and species extinctions. The single most important cause of amphibian declines globally is habitat degradation, largely as a result of human activities (Blaustein *et al.,* 1998). It is imperative that conservation action such as this study be taken to reverse this trend and maintain herpetilian diversity.

Given their sensitivity to habitat alteration and pollution, amphibians may serve as indicators of overall environmental health. Many species of amphibians provide both indirect and direct benefits to humans. Amphibians are bio indictors of an altered ecosystem and are very sensitive environmental monitors; and significant declines could indicate deterioration in the quality of the environment. This role as indicators can be based on the assumption that the adverse effects of environmental degradation will be reflected in reduction of diversity (Magurran, 1988). Amphibians unlike people breathe at least partly through their skin making them much sensitive to environmental disturbance (IUCN/SSC, 2003).

They have also been used in assays to determine the effect of water–borne pollutants. Most frog species have both aquatic and terrestrial life stages that signify changes in both types of environment. The tadpoles, the eggs and embryos of frogs in wetlands are very sensitive indicators of any adverse changes in the water chemistry (Channing, 2001).

Ecologically, amphibians are important; they are mostly predators, acting as primary and secondary carnivores. Their prey consists mostly of insects, some of which are pests to crops or disease vectors. They are also inter-linked in food chains, often acting as food for other vertebrates, such as, birds and snakes.

Overall 113 amphibians were recorded representing 23 species from eight families (Table 54); while 163 reptiles were recorded representing 31 species from 12 families (Table 55). Amphibians were mostly recorded from sites close to water with fewer species being recorded away from water. Amphibian diversity was generally low compared to that of reptiles Table 56), the highest being recorded in the permanently flooded swamps. These swamps provide the adequate ecological requirements need by most amphibians. Amphibian relative abundance was dominated by *Ptychadena mascareniensis* 16% followed by *Amietophrynus maculatus* and *Hyperolius viridiflavus* (Photo 45 (c) and (d)) with 11% and 8% respectively); *P mascareniensis* and *Hyperolius viridiflavus* are from Family Hyperolidea which represented the most species (Table 54). Family Hyperolidae was represented by the most species, this large family of small to medium-sized, brightly colored frogs contains more than 250 species in 19 genera with seventeen genera being native to sub-Saharan Africa (Shiotz, 1999).

All identified amphibian species belong to Order Anura. According to Channing (2001), order Anura has the most surviving species with about 4,000 members worldwide. It consists of several families of frogs and toads of which eight were recorded for this study. Family Ranidae constitute the highest number of species followed closely by Bufonidae and Hyperolidae. The richness of these families is attributable to the agility of members which enable them escape and cross the matrices of disturbed landscape.

Reptilian species were recorded from all the sampled points, but most were in locations that were drier without standing water such as grasslands and woodlands. A few species recorded in the swampy / marshy areas such as *Phylothamnus angolensis* are quite versatile on habitat occupancy. Some species such as *Agama agama* and *Naja melanoleuca* were recorded from most sites. Diversity was generally high in all sampled habitats, much as the drier areas were represented by the highest number of species; diversity was highest in permanently flooded swamps (Table 55). *Agama agama* was the most abundant 22% followed by *Philothamnus semivariegatus* and *Trachylepis maculirabris* at 15% and 12% respectively (Table 55).

Table 54: Amphibian species in habitats along the Karuma-Gulu water transmission with their threat status

Family	Species	English Name	Conservation status	National Threat Status
Arthroleptidae	*Leptopelis* sp	Tree frog		
	Phrynobatrachus mababiensis	Mababe puddle toad	LC	
	Phrynobatrychus natalensis	Natal puddle toad	LC	
Bufonidae	*Amietophrynus gutturalis*	Guttural Toad	LC	
	Amietophrynus maculatus	Flat-backed Toad	LC	
	Amietophrynus regularis	Common African toad	LC	
	Amietophrynus vittatus	Lake Victoria Toad	LC	
Dicroglossidae	*Hoplobatrachus occipitalis*	Crowned bull frog	LC	
Hyperolidae	*Hyperolius acuticeps*	Sharp nosed reed frog	DD	
	Hyperolius cinnamomeoventris	Cinnamon bellied	LC	
	Hyperolius kivuensis	Kivu reed frog	LC	
	Hyperolius sp	Reed frog		
	Hyperolius viridiflavus	common reed frog	LC	DD
	Kassina snegalensis	Senegal kassina	LC	
	Afrixalus quadrivitatus	Four-Lined Spiny	LC	DD
Pipidae	*xenopus laevis*	African Clawed Frog	LC	
Ptychadenidae	*Ptychadena anchietae*	Anchieta's ridged frog	LC	
	Ptychadena mascareniesis/ hylaea	Mascarene Grass Frog	LC	DD
	Ptychadena oxyrhynchus	Sharp nosed ridged	LC	
	Ptychadena porosissima	Grass land ridged frog	LC	
Pyxicephalidae	*Amietia angolensis*	Angola river frog	LC	DD
Ranidae	*Amnirana galamensis*	Glam white lippe frog	DD	

Table 55: Reptile species in habitats along the Karuma-Gulu water transmission with their threat status

Family	Scientific name	English name	Conservation status	National Threat Status
Agamidae	*Agama agama*	Orange headed agama	LC	
Chamaeleonidae	*Chamaeleo bitaeniatus*	Side stripped chameleon	LC	
	Chamaeleo gracilis	Gracefull chameleon	LC	
Gekkonidae	*Hemidactylus brookii*	Brooks'gecko	LC	
	Hemidactylus mabouia	Tropical house gecko	LC	
Scincidae	*Trachylepis maculirabris*	Speckle-Lipped skink	LC	
	Trachylepis	Rainbow skink	NE	VU
	Trachylepis striata	Striped skink	LC	
	Trachylepis variabilis	Variable skink	LC	
Varanidae	*Varanus niloticus*	Nile monitor lizard	LC	
Boidae	*Python sebae*	East African rock python	LC	
Colubridae	*Crotaphopeltis degeni*	Yellow flanked snake	LC	
	Crotaphopeltis hotamboeia	White lipped snake	LC	
	Hapsidophrys lineata	Black linned green snake	NE	DD

Family	Scientific name	English name	Conservation status	National Threat Status
	Lamprophis olivaceus	Olive house sanke	LC	
	Natriciteres olivacea	Olive marsh snake	LC	DD
	Philothamnus angolensis	Angola green snake	LC	
	Philothamnus bequaerti	Bequaerti's green snake	LC	DD
	Philothamnus	Slender green snake	LC	
	Philothamnus	Spotted bush snake	LC	
	Psammophis sibilans	Hissing Sand-snake	LC	
	Psamophis mosambicus	Olive sand snake	LC	
Elapidae	*Dendroaspis polylepis*	Black mamba	LC	
	Elapsoidea laticincta	Sudanese Garter-snake	LC	DD
	Naja melanoleuca	Water cobra	LC	
Lamprophiidae	*Prosymna sp*	Speckled Shovel-snout	LC	
Pelomedusidae	*Pelomedusa subrufa*	Marsh terrapin	LC	
	Pelusios williamsi	Williams' hinged terrapin	LC	
Typhlopidae	*Typhlops lineolatus*	Lineolate blind snake	LC	
Viperidae	*Bitis arietans*	Puff adder	LC	
	Bitis nascornis	Rhinoceros viper	LC	

Table 56: Shanon diversity indices for the two herpetile taxa for the generalized habitats in the study area

General habitat	Amphibians	Reptiles
Wooded grasslands	0.89	1.73
Seasonally flooded marsh	1.73	2.02
Permanently flooded swamp	2.98	2.66
Grassland	1.95	2.13

Reptiles were dominated by *Trachylepis maculirabris*, *Varanus niloticus* and *Naja melanoleuca,* the former two species are from Order Sauria. These are mostly lizards with well developed limbs making them more agile hence covering and colonizing more ground compared to their limbless cousins in the Order Serpentes (Cogger, 2000). Species from Order Sauria are also very adaptive with some preferring being comensal (*Agama agama* and *Trachylepis striata*) while others occupy various habitat strata (Gerlach, 2005).

(a) Hoplobatrachus occipitalis

(b) Kassina senegalensis

(c) Amietophrynus maculatus

(d) Hyperolius viridiflavus

Photo 45: Some amphibian species recorded in the major swamps along the project area

A fair amount of survey work has been conducted in Uganda on herpetiles; however these have been concenbtrated in some protected areas or in the Albertive Rift area (see for example https://albertinerift.wcs.org/wildlife/biodiversity). For such areas, the biodiversity is now fairly well known, but places away from these remain gray areas in terms of biodi ersity information. Surveys conducted such as for this report in the project area, are valuable for generating additional information on species for better understanding of their occurrence. All such information would have been used for conducting the National Threat status evaluations by WCS (2016) for Ugandan taxa. Assessment such as that by IUCN and even WCS (2016) will work on the strength of available and accessible information – it is not straight forward therefore how to interprete the relevance of new data from areas that have not been surveyed before, on the conclusions about threat category of a species already evaluated.

Conservation status: Some of the herpetile species recorded have not been evaluated and some are listed as data deficient by IUCN (2016) – Table 56, those that have been evaluated are of least concern due to the fact that they are known to occur widely and are not known to be under going any population decline or threatening decline in their habitat quality IUCN (2016). It should be noted that most of the ecological aspects of most herpetilian species in Uganda are poorly known. Several species are also listed as data deficient owing to their unknown ecology. Table 56 and 57 that list the species which were recorded, also show their threat status at the Global level (IUCN) and at the country level (National Threat). For emphasis, at the global level most of the species recorded in the project area are listed as of Least Concern (LC) and some as Data Deficient. At the national level only four of all species for both amphibians and also reptiles that were recorded in the project area were evaluated by WCS (2016) and all are also listed as Data Deficient.This phrase refers to those species for which insufficient data was available at the time of evaluation (IUCN or National Threat levels) to draw conclusions. One species of reptiles – the Rainbow skink was evaluated by WCS (2016) as Vulnerable.

The Side stripped Chameleon, Graceful Chameleon and East African rock python although not listed as endangered on the Global and National lists, the three are on Appendix II of CITES Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled. It also includes so-called "look-alike species", i.e. species whose specimens in trade look like those of species listed for conservation. International trade in specimens of Appendix-II species may be authorized by the granting of an export permit or re-export certificate. No import permit is necessary for these species under CITES (although a permit is needed in some countries that have taken stricter measures than CITES requires).

There is no information available to suggest that in Uganda there is any trade in any of the three listed species.

AmphibiaWeb (2020) lists 62 species for Uganda of which two (*Arthroleptides dutoiti* and Leptopelis karissimbensis) are endangered species, critically endangered and vulnerable, respectively. The first of these species arcording to these authors, is only found in Kunya Uganda border areas around Mt Elgon. The latter species on the other hand is mapped by AmphibiaWeb (2020) to occur in Murchison Falls National Park in Uganda and in North Eastern DRC. Given the range of occurrence, it may not be unreasonable to expect that this species may occur in the project area. The individuals that were record in the project area although only identified to the genus level, did not match the description of *Leptopelis karissimbensis*. The other two species of *Leptopelis* reported for Uganda by AmphibianWeb (2020) are listed as of least concern (LC).

6.3.4 Invertebrates

Butterflies populate the entire land area of the earth except for the Polar Regions and the most arid deserts (Larsen, 1991). Apart from their diurnal activity, they are amongst the most colourful and conspicuous of the invertebrate taxon, which has prompted more research on their activity and taxonomy (Plumptre *et al*. 2003). Butterflies are considered important flagships for insect conservation (New *et al*., 1995) and are important ecological indicators as they signal the presence/abundance of other species, or signal chemical/physical changes in the environment through changes in their own presence or abundance (Simberloff,1998).

Many butterfly species migrate over long distances as many as 3,000 miles which enables pollination across long distances (Ghazanfar *et al*., 2016). In Uganda, about 1245 butterfly species have been recorded from a variety of habitats and it is thus feasible to evaluate the butterfly fauna of the region as well as deriving reasonably accurate comparisons of sites and subsequently identify conservation requirements (Kasangaki *et al*., 2012). The present study aims to collect baseline data for butterfly diversity in a proposed water treatment plant, water reservoir and a water pipeline route from Karuma to Gulu.

A total of 36 butterfly species belonging to 23 genera and five families (Hesperiidae, Lycaenidae, Nymphalidae, Papilionidae and Pieridae) were recorded in this survey (Table 57). All species recorded were of least concern conservation status. Nymphalidae was the most diverse family with 16 species (44.4%) followed by Pieridae with 9 species (25.0%). Only four species each of the families Lycaenidae and Hesperiidae were recorded while Papilionidae had the least number of species recorded (n=3, 8.3%). The family Nymphalidae is the largest family of butterflies while Papilionidae has few species.

Table 57: Habitat prefertence of the butterfly species recorded

Butterfly grouping	Common name	Ecological Type	Status
Hesperiidae			
Eretis lugens	Savanna Elf	W	UC
Eretis herewardi	-	f	R
Lepella lepeletier	Lepeletier's sylph	f	VR
Metisella midas	Golden Sylph	W	VR
Lycaenidae			
Azanus natalensis	Natal Babul Blue	W	C
Leptotes pirithous	Common Zebra Blue	W	C
Ypthima asterope	Common Three-Ring	W	C
Zizeeria knysna	African Grass Blue	W	UC
Nymphalidae			
Acraea encedon	Common Acraea	O	UC
Acraea eponina	Orange Acraea	W	C
Bicyclus angulosus	Startled Bush Brown	O	UC
Bicyclus campinus	Chirinda Bush Brown	f	C
Bicyclus safitza	Common Bush Brown	W	C
Bicyclus vulgaris	Vulgar Bush Brown	W	C
Danaus chrysippus	African Queen	M	C
Hamanumida	Guineafowl	W	UC
Junonia chorimene	Golden Pansy	O	UC
Junonia oenone	Dark Blue Pansy	W	C
Junonia terea	Soldier Commodore	W	C
Melanitis leda	Common Evening Brown	W	UC
Neptis saclava	Small Spotted Sailor	W	R
Neptis serena	River Sailor	W	C
Vanessa cardui	Painted Lady	M	VR
Ypthimomorpha	Swamp Ringlet	f	R
Papilionidae			
Graphium leonidas	Veined Swordtail	M	VR
Papilio demodocus	Citrus Swallowtail	M	UC
Papilio nireus	Narrow G-banded Swallowtail	f	VR
Pieridae			
Belenois creano	African Caper	M	VR
Captosilia florella	African Emigrant	M	VR

Butterfly grouping	Common name	Ecological Type	Status
Dixeia charina	African Small White	O	VR
Eronia leda	Autumn Leaf Vagrant	W	VR
Eurema hapale	Marsh Grass Yellow	S	C
Eurema hecabe	Common Grass Yellow	M	C
Eurema regularis	Regular Grass Yellow	W	C
Mylothris rubricosta	Eastern Swamp Dotted Border	S	C
Nepheronia	Blue Vagrant	f	R

***Key:** W Widespread species; O – Open habitat species; M – Migratory species; f – Forest edge/ woodland species; and S – Swamp/ wetland species*

Junonia terea

Mylothris rubicosta

Leptotes pirithous

Photo 46: Three of the commonest butterfly species in the project area

The occurrence status was decided on number of encounters of the species in the study sites: Very Rare (VR) – 1 to 2 sightings; Rare (R) – 3 to 4 sightings; Uncommon (UC) – 5 to 10 sightings; Common (C) – 11 to 16 sightings in study sites. From this classification, Nymphalidae had the highest number of common species followed by Pieridae (Table 42) though this classification might have been subjective as the sites were surveyed for short periods of time some of the survey days were very wet which could have affected butterfly activity.

6.3.5 Birds

Occurrence, composition and habitat use by birds can be and has been used to examine change in the habitat without instruments. This is because; studying the presence and behavior of birds can inform us about changing ecosystems. Any living organism that is used in such a manner to measure environmental conditions is called an indicator species. As with other native organisms, birds help maintain sustainable population levels of their prey and predator species and, after death, provide food for scavengers and decomposers. Many birds are important in plant reproduction through their services as pollinators or seed dispersers.

A total of 71 species of birds were recorded for the project area. The full list is presented in Appendix D. The individual survey area results showed generally low species richness and very different species assemblages. Only a few of the species were recorded in more than a few survey areas. It is howeververy likely that more of the species recordd will be widely occurring ieven in areas where we didn't record them at this oint in time. This is because biodiversity patterns have a temporal signature and therefore different species could be recorded in an area on different survey occasions.

Three species (Table 58) listed in the "Bird Atlas of Uganda" as of conservation concern are shown. Although listed by Carswell (2005) in the Atlas as of conservation concern, these species have a relatively wide occurrence in Uganda. No evidence was found of nesting for any of these species, which would make the areas a critical habitat for their reproduction.

Table 58: Species of birds of conservation interest recorded in the project area

Atlas Number	Species	Threat
28	Purple Heron *Ardea purpurea*	R-NT
95	African Marsh Harrier *Circus ranivorus*	R-NT
539	Spot-flanked Barbert *Tricholaema lachrymosa*	R-RR

Key: R-NT – Regional near threatened, R-RR – species of regional responsibility having a considerable extent of their range in Uganda (See Carswell *et al* 2005)

The list includes 5 species of raptors for which a good population would be a good indicator of healthy populations of their prey.

Table 59: Species of raptors recorded in the project area

Atlas Number	Species	Threat
95	African Marsh Harrier *Circus ranivorus*	R-NT
96	African Harrier-Hawk Polyboroides typus	
129	Lizard Buzzard K*aupifalco monogrammicus*	
138	Black Kite *Milvus migrans*	
147	Grey Kestrel Falco ardosiaceus	

6.3.6 Mammals

A lot of the landscape traversed by the proposed waterline project is considerably human impacted and converted through agriculture, settlement, extractive use and others, the prospects for survival of large mammals has been reduced considerably. In the areas of wetland however extensive areas of near natural vegetation survive and will continue to provide refuge for species that can survive in human impacted habitats.

Most the area surveyed showed no potential for ranging and conservation of large mammals. Large mammal species will usually avoid areas of human habitation, or will be vagrant in such areas where they will likely be killed for meat as soon as they are seen.

The survey area with the green highlight (Table 60) in the general abstraction and piping area to the water treatment plant was the only location where many signs of large mammals were recorded. The majority of these as spoor prints of the species (Photo 47).

The species that were recorded in the different locations that were surveyed are listed in Table 62. For most of the survey areas we recorded only the occurrence of small mammals and also the potential for occurrence of small sized carnivores (genets and Mongooses). Overall we recorded 28 species with the rodent species being more widely occurring than the othe taxa.

The survey area highlighted green in Table 60 with the most species of large mammals is much closer to Bugungu Wildlife reserve and Murchison Fall National park and it should not be suprising that these species extend their ranging into this survey area. This particular survey area has a prominent human foor print as members of the local community are present every day excavating and breaking rocks for sale. This means therefore that the general area is only utilisied by the mammals at night.

Hippopotamus print

Striped Jackal print

Baboob Print

Duiker Print

Photo 47: Example foot prints of mammals recorded in the general areabewteen water abstraction and water treatment plant area

A summary of the species richness by order of the species recororded in the project area is provided in Table 61. There were overall more rodent species than any of the other orders, and for three orders we only recorded one species in each.

Hippos (VU) and Leopard (NT) are the only mammals species recorded in the project area, that are listed by IUCN as threatened. WCS (2016) on the other hand lists the Leopard as Vulnerable (VU) and Hippos asvulnerable (VU) like the glodal listing. However, the part of the project area where they were recorded is not considered as a critical part of their range and or habitat since they never reach the proposed water intake site.

Table 60: Mammal species occurrence recorded in the different survey areas

Order	Species	0423989E 297619N	0425521E 291714N	424900E 295148N	425870E 290059N	0427115E 287001N	0427136E 286970N	0429530E 277069N	0430285E 273964N	0418965E 248565N	0418879E 248772N
Artiodactyla	*Bush Duiker*			p							
	Common Bush Duiker									p	p
	Hippopotamus									p	
	Reed buck			p							
Carnivora	*African Civet*									p	
	Genet		p								
	Large grey Mongoose	p	p							p	
	Leopard									p	
	Marsh Mongoose				p					p	
	Serval									p	
	Side Stripped Jackal									p	
	Slender Mongoose	p	p						p		p
Chiroptera	*Lavia fron*							p			
	Nycteris thebaica								p		
Insectivora	*Crocidura olivieri*			p		p					
Lagomorpha	*Grass Hare*					p					
Primates	*Olive Baboon*									p	
Rodentia	*Aethomys hindei*	p	p		p	p	p				
	Alexander's tree squirrel	p		p							
	Dasymys incomtus		p		p	p	p				
	Lemniscomys striatus	p	p		p	p	p				
	Lophuromys flavopunctatus	p	p		p	p	p				
	Lophuromys sikapusi	p	p		p	p	p				
	Mastomys natalensis	p	p	p	p	p	p				
	Mus mintoides	p	p	p	p	p	p				
	Oenomys hypoxanthus	p			p	p	p				
	Praomys jacksoni	p									
	Striped ground Squirel	p								p	


SA1
A
Lira - Gulu Rd


SA2


SA3
Lira - Gulu Rd


SA4
Lira - Gulu Rd


SA5
Lira - Gulu Rd


SA5
SA6
Lira - Gulu Rd


SA7


Minakulu Swamp
SA8

Table 61: Distribution of mammal species recorded by order

Order	Number of species
Artiodactyla	4
Carnivora	8
Chiroptera	2
Insectivora	1
Lagomorpha	1
Primates	1
Rodentia	11
Grand Total	**28**

6.4 SOCIO-ECONOMIC AND LAND USE ACTIVITIES

6.4.1 Administrative Structure

The proposed project traverses Gulu, Omoro, Oyam and Kiryandongo districts (Figure 44). Gulu District is located in Northern Uganda between longitudes 30-32° East and latitudes 02-4° North. It is bordered by Amuru District in the West, Lamwo District in the North East, Pader District in the East, Lira District in the South East, Oyam District in the South and Nwoya District in the South West.

Omoro District is a newly created district in Northern Uganda in the Acholi region curved out of Gulu District. It is bordered by Gulu District to the north, Pader District to the east, Oyam District to the south and Nwoya District to the west. The district headquarters are located in Palenga, which is about 24 kilometres (15 mi), by road, south of Gulu. It is approximately 311 kilometres (193 mi), by road, north of Kampala. The District is located at GPS coordinates: 020° 32'N 320 22'E and is composed of 2 counties namely; Tochi and Omoro where the proposed project site is situated.

Oyam district is a district in the Northern Region of Uganda. Like most Ugandan districts, it is named after its 'chief town', Oyam, where the district headquarters are located. the District is bordered by Gulu District to the north, Lira District to the northeast, Apac District to the east and south, Kiryandongo District to the southwest and Nwoya District to the west. The administrative headquarters of the district at Oyam, are located 73 km by road, west of Lira, the largest city in the sub-region. Oyam District with total land area of 2.207 sq km was established by the Ugandan Parliament in 2006. Prior to that, Oyam District was part of Apac District. Together with Lira District, Amolatar District, Apac District and Dokolo District, Oyam District is part of the larger Langi sub-region, home to an estimated 2.7 million Langi. The district is a predominantly rural district.

6.4.2 Ethnicity and Religion

According to the Gulu District State of Environment report, 2005, the largest ethnic group in Gulu district are the Acholis (Indigenous of the district) comprising 94%, followed by the Langi 4% , the Madi 1% and the others 1% of the total population in the district.

Almost all religious denominations are represented in Gulu District. The dominant religions are; the Catholics (78%), Abglicans (17%), Pentecostals (2%), Muslims (1%), Seventh Day Adventists (0.2%) and others (0.7%). People who describe themselves as none religious/traditionalist form a percentage of 0.6 (*Source: UBOS, 2013*).

The predominant ethnic group in Oyam District is the Langi ethnic group. They are considered to be part of the Nilo-Hamites (also known as semi-Hamitic) group which includes the Teso, Kumam, Jie and Karamojong tribes. The Langi, in contrast of their fellows, have adopted the simpler Nilotic tongue. It is believed that their move from further North into the present habitat took place between the years 1800-1890 approximately. Other ethnic groups present in district are Acholi, Alur, Chope, Palwo and Lugbar.

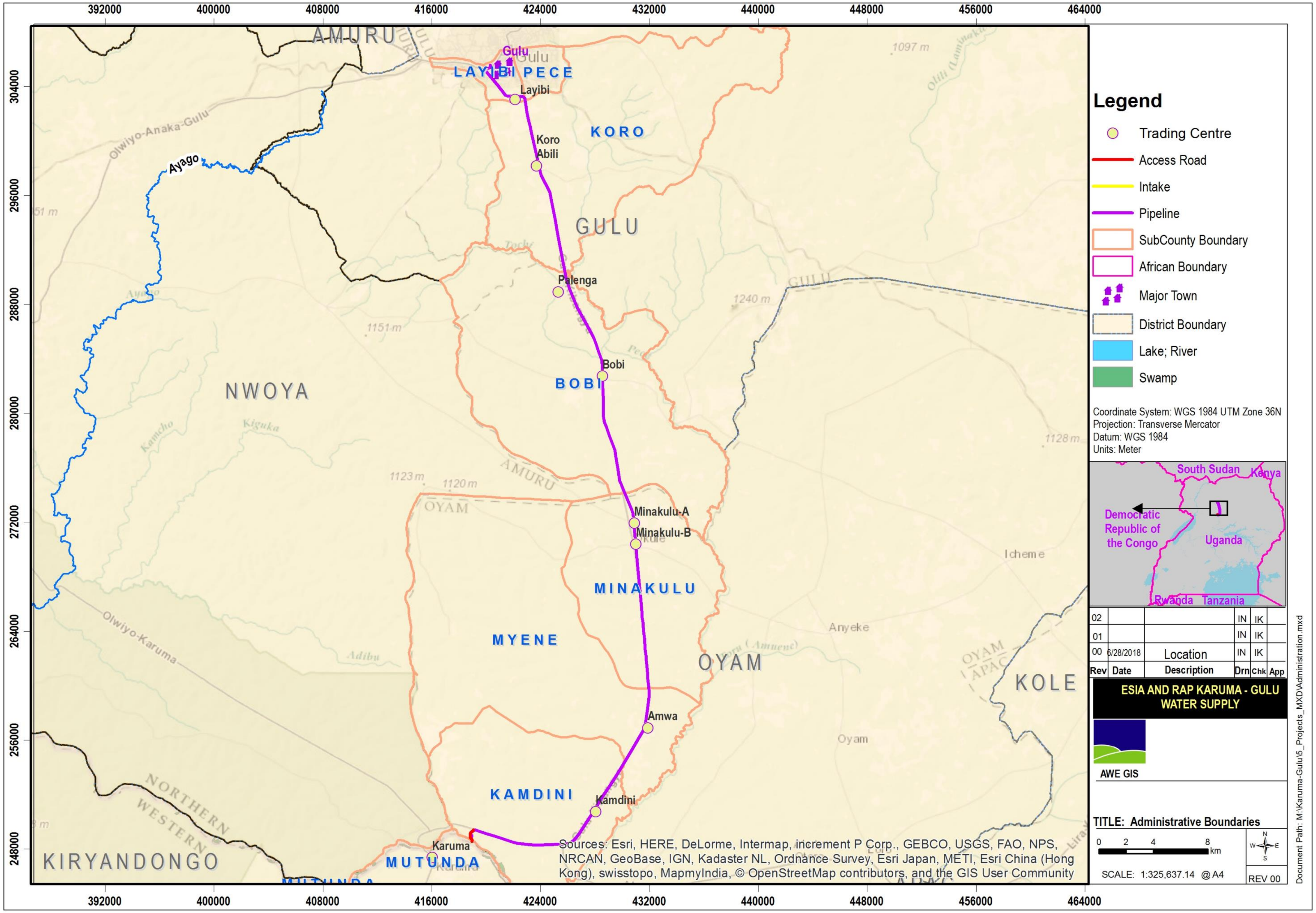


Figure 44 Administrative boundaries of the project area

6.4.3 Employment

The major economic activity carried out in the District is agriculture. In the rural areas, most of the men and women are involved in agriculture while in urban areas; most men are involved in professional associate work while most of the women are social service workers. Majority of the population are agricultural workers (63.4 %), dominated by females (52.4 %) both in rural areas and urban areas. Generally they are very few female managers and professionals both in urban and rural areas. On the whole managers are few compared to the rest of the occupations.

However, within the Municipality, crop production accounts for almost 95% employment of the population. Arable land is very fertile and makes up 87.4% of the total land area. Traditional cash crops grown are cotton and tobacco. However, due to decreasing prices and limited access to markets, these have declined rapidly in the last 25 years. Production of other cash crops like rice, groundnuts, simsim and millet has however increased over the recent years. Major food crops are maize, rice, finger millet, sorghum, sweet-potatoes, cassava, groundnuts, simsim, beans, peas and sunflower. Livestock provides the key source of school fees, security of family welfare and source of protein for most families in Gulu Municipality. In addition, ox-ploughing is a vital part of crop production. Some people are employed in the small fisheries activities on some small rivers, streams and swamps such as Aswa, Torchi, Unyama, etc. however, the larger quantities of fish are supplied from sources outside the district such as Lake Kyoga, Lake Albert and as far as Lake Victoria. Sand mining is also being practiced in the municipality especially upstream of the proposed additional water source of Oyitino. It is a source of living for some young and middle aged males.

Omoro: Agriculture is the major economic activity in the district, employing about 95% of the work force. The people around the borrow pit derive their livelihood from agriculture. Agriculture is a source of food for the population, subsistence income for most families and provides direct employment to a big fraction of the district population. People are involved in growing of crops like coffee, cassava, simsim, groundnuts among others while animals are also reared like cows, goats and birds like chicken and turkey.

6.4.4 Land Tenure and Use

In Gulu District, the most common system of land ownership is the customary land holding (58.1%), followed the leasehold land tenure system with a proportion of 4.2%. This is due to the tradition of the people of the area. The most common system of land ownership in Omoro district is customary land holding (86.9 %), 6.1 percent under Free hold, 6.2 percent under Lease hold and 0.8 percent under other tenure systems. The land for the proposed borrow pit is under customary tenure which has been leased out by the local owners to CICO for extraction of gravel marrum.

In Oyam district, Otwal Sub-county had the highest number of households owning cattle (43.3%) and Oyam Town Council had the least proportion of households owning cattle (31.6%). Still Otwal Sub County had the highest proportion of households owning goats (63.0%) while Ngai Sub County had the least households owning goats at (46.3%). The highest proportion of households owning pigs was in Ngai and the lowest was in Loro Sub-county (6.1%). For the chicken rearing, Oyam TC had the highest proportions of households (89%) followed by Iceme Sub County (79.9%) and the least chicken rearing Sub County was Otwal was 64%. The most dominant crops in Oyam District are beans and cassava which registered 86% and 78% of the total households, respectively. Minakulu Sub County had the highest number of households growing Beans at 100% followed by Iceme with 86.9% of the households engaged in Beans growing. The least households growing beans were recorded in Otwal Sub County with 80%. Minakulu

Sub County has the highest number of households growing Cassava (96%) while Iceme recorded the least (70.6%). The land use and vegetation cover in the project corridor is presented in Figures 45 and 46.

6.4.5 Population and Demographic Characteristics

The population distribution in project districts is presented in Table 62 and the distribution by sub-counties in each district presented in Figure 47. From the tables it can be seen that a large proportion of the population in all the three districts is below the age 40 years.

Table 62: Total population by age group and sex in Gulu, Omoro and Oyam Districts

Age group (years)	Male	Female	Total
Gulu District			
0 – 9	43,397	40,761	84,158
10 – 19	35,832	37,879	73,711
20 – 39	39,093	42,753	81,846
40 – 59	12,254	13,823	26,077
60 and above	3,995	5,826	9,821
Total	**134,571**	**141,042**	**275,613**
Omoro District			
0 – 9	28,351	26,571	54,922
10 – 19	22,761	21,630	44,391
20 – 39	17,473	20,657	38,130
40 – 59	7,492	8,880	16,917
60 and above	2,760	4,157	6,917
Total	**78,837**	**81,895**	**160,732**
Oyam District			
0 – 9	67,980	64,604	132,584
10 – 19	51,636	52,524	104,160
20 – 39	42,956	49,933	92,889
40 – 59	17,268	20,005	37,273
60 and above	7,281	9,457	16,738
Total	**187,121**	**196,523**	**383,644**

Source: UBOS, 2017

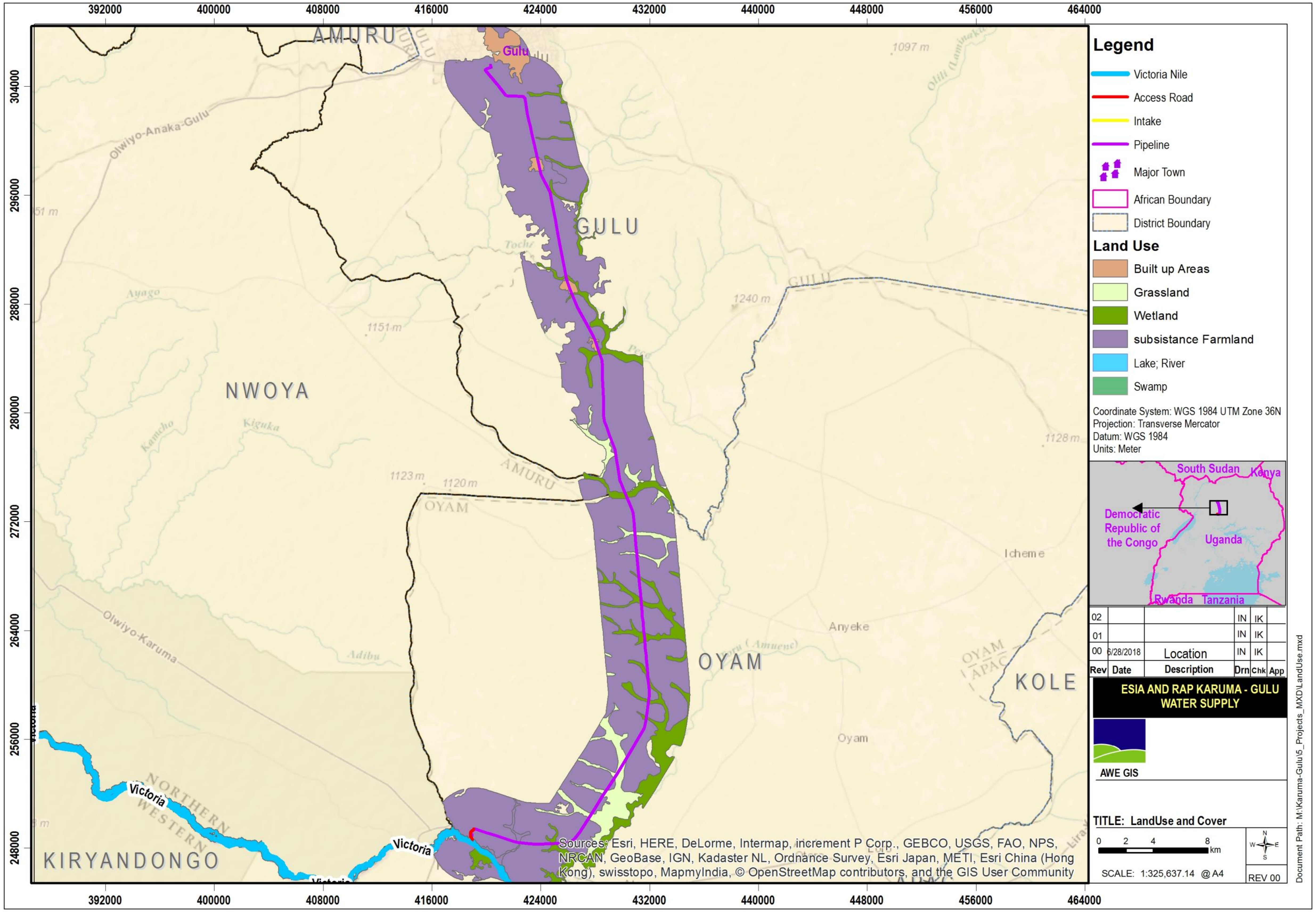


Figure 45 Landuse in the project area

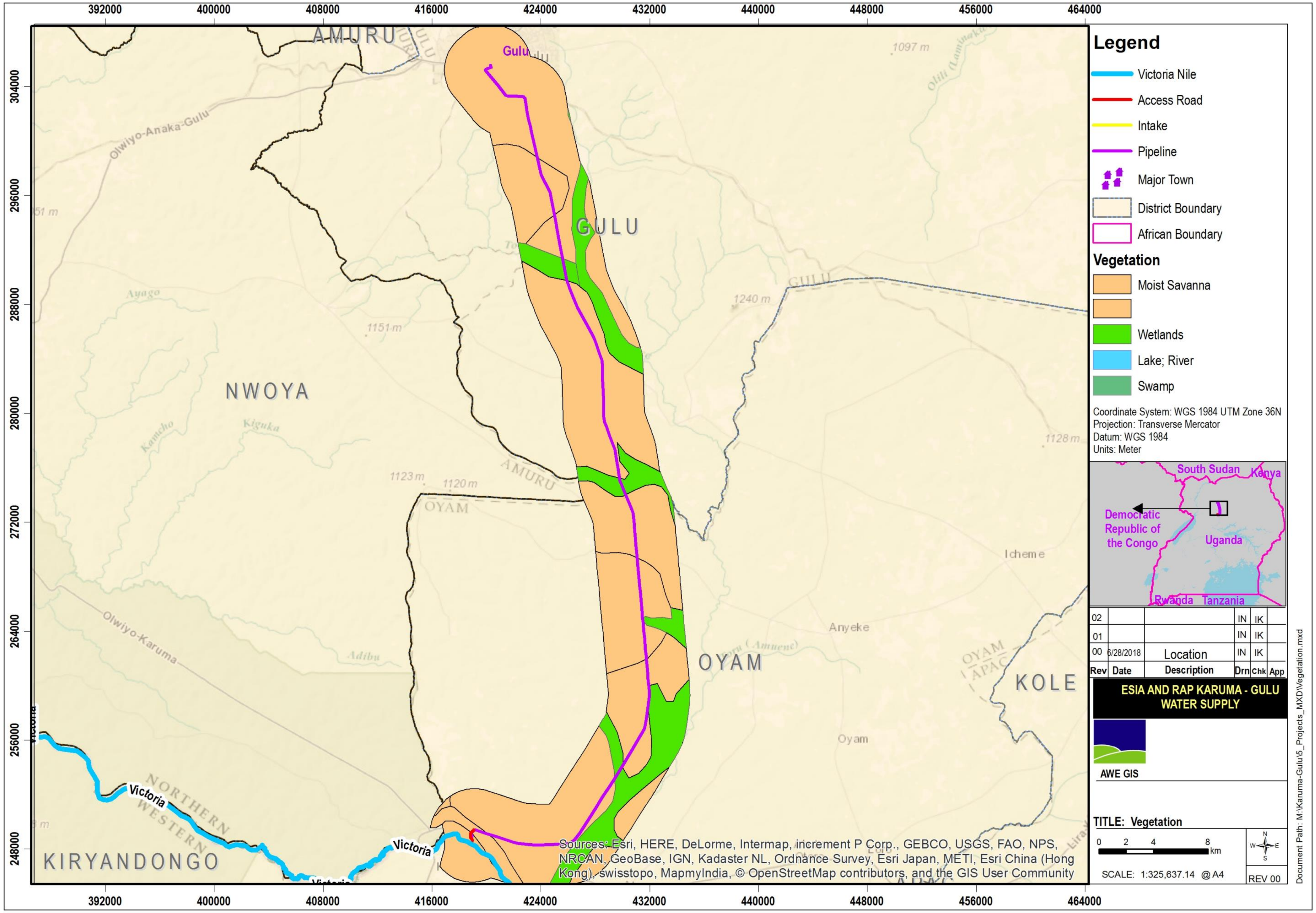


Figure 46 Vegetation cover of the project area

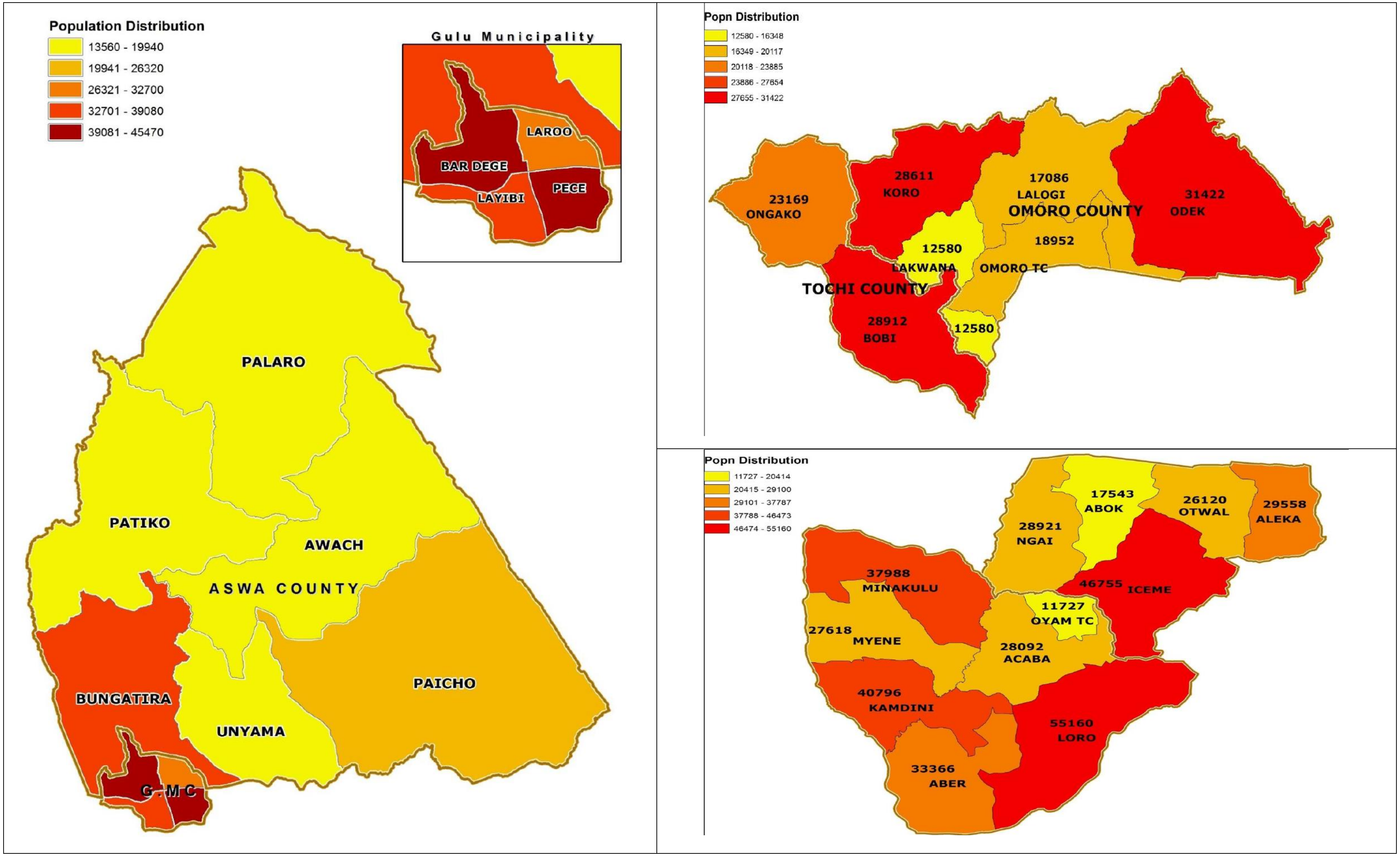


Figure 47 Population distribution by sub-county in the project districts

6.4.6 Level of Education and Literacy

Gulu district is blessed with many educational facilities like nursery schools, primary schools and secondary schools. However, the facilities are being constrained because of the influx of displaced pupils from the neighbouring district schools (GMC DP 2015). The number of primary schools, secondary schools and other educational institutions are indicated in Table 63. Gulu District has a total of 129 government owned schools and 27 privately owned schools. The District has one Public University called Gulu University located at Laroo Division, Gulu municipality.

Table 63: Number of pre-primary schools in the district per sub-county

County	Sub-county	Primary		Secondary		Tertiary	
		Government	Private	Government	Private	Government	Private
Aswa	Awach	8	2	2	0	0	0
	Bungatira	10	1	1	1	0	0
	Paicho	12	2	1	0	0	1
	Patiko	8	2	1	0	0	0
	Unyama	7	1	2	0	2	0
Omoro	Bobi	13	1	1	1	1	1
	Koro	11	1	1	1	1	1
	Lakwana	7	1	1	1	0	1
	Lalogi	12	1	1	0	0	1
	Odek	15	0	1	0	0	1
	Ongako	9	1	1	2	0	2
TOTAL		**112**	**13**	**13**	**6**	**4**	**8**

Source: DDP 2011/12 -Education Sector, 2011/12

To date, Oyam district has 109 primary schools, 9 secondary schools, 1 tertiary institution and 4 vocational schools. Over 97% of the educational institutions in the District are government aided. The percentage distribution of the youth population aged 18 – 30 years who are not going to school and not working in the project districts is indicated in Figure 47.

6.5 SOCIO-ECONOMIC PROFILE OF PROJECT AFFECTED PERONS

This socio-economic survey is premised on the households and businesses, especially the PAPs along the corridor of the project site with a view to determining their socio-economic conditions, and how the project stands to impact them.

The objectives of the socio-economic survey were to:

- Establish the social profile of the affected population out along the line route;
- Inform the affected population about the proposed civil works;
- Announce the cut-off date for capturing those affected by the proposed project who are along the zone of impact;
- Obtain feedback from the affected population about the proposed NWSC transmission and distribution line;
- Record/update the base line situation of all affected people;
- Identify the affected households and individuals;
- Identify vulnerable individuals or groups; and
- Record all assets and impacts in areas traversed by the line route.

A total of 347 project affected persons (PAPs), 274 PAPs by the transmission line and 73 PAPs by the distribution system will be affected from the community including those identified in the areas/zones traversed by the transmission and distribution lines from Karuma Town Bedmont, Ayuda, Gwara to Akurudiya in Gulu District and includes 16 villages. The PAPs referred to as the respondents here are person/ /workshops whose businesses, kiosks working space and principal places of residence are going to be directly affected by the construction of the proposed project.

6.5.1 Demographic Information

a) Average size of the affected households

According to the United Nations Data Booklet (2017) a household is defined as a group of persons who make common provision of food, shelter and other essentials for living and is a fundamental socio-economic unit in human societies. According to census data, the Karuma- Gulu Water Supply Project implementation will directly affect 631 households with a total of approximately 4417 household members. Results from Gulu municipality and surrounding sub-counties in the project affected areas show the highest mean household size being 9 and above people (38.4%) followed by 7-8 (30.3%), and 5-6 people (20.9%).

Table 64: Average number of people living within the household

Average number of people	Percentage
1-2 people	4.2
3-4 people	6.3
5-6 people	20.9
7-8 people	30.3
9 and above	38.3
Total	**100**

Source: Primary data

This socio-economic survey is premised on the households and businesses, especially the PAPs along the corridor of the proposed project site with a view to determining their socio-economic conditions, and how the project stands to impact them.

b) Gender distribution of household heads

Field census survey results in the project area also established that there were more male respondents (74.5%) among affected households in comparison to females respondents (25.5%). From field observations most of these female headed households are characterised by extreme poverty and bear the burden of looking after children despite their meagre incomes. Regarding marital status, majority of the PAPs were married (78.5%) this is mainly due to reason that men tend to marry at an early age so that they are availed with labour for subsistence agriculture by the women and the children they bear.

Table 65: Marital status in project area

Gender (%)	Single	Married	Divorced	Widowed	Total
Male	3.4	69.2	0.7	1.2	74.5
Female	1.3	9.3	1.4	13.5	25.5
Total	**4.7**	**78.5**	**2.1**	**14.7**	**100**

Source: Primary data

c) Age-group

In planning for involuntary resettlement, consideration should be made for different age groups in a project affected area to align it with policy and plans for involuntary displacement. Dependencies in the households play a big role in mitigating impacts of displacement. In the entire project affected area, the largest numbers of project affected household heads were male (74.5%) compared to females (25.5%). A sizeable portion of household heads for both male and female (16.26 %) are within the age bracket of 56 years and above. RAP implementation will need to cater for PAPs in this age group as they might be potentially vulnerable.

Table 66: Age group of respondents

Gender	15-25	26-35	36-45	46-55	56 and above	Total
Male (%)	9.2	16.5	26.8	12	10	74.5
Female (%)	0.6	2.1	7.2	9.4	6.2	25.5
Total	**9.8**	**18.6**	**34**	**21.4**	**16.2**	**100**

Source: Primary data

6.5.2 Land Tenure and Ownership

Within the project area, the predominant land tenure system identified was: customary (71.8%) and leasehold were mainly mentioned by PAPs. This land is used communally and parcels of land are given out to community members by clan head knowns as Rwodis. Customary land tenure was predominant in rural areas while leasehold was common around Gulu Municipality and the suburbs. However, some owned titles deeds and documentation proving ownership. Other land tenures included public land (2.2%) private mailo 11.3% and freehold 14.6%.

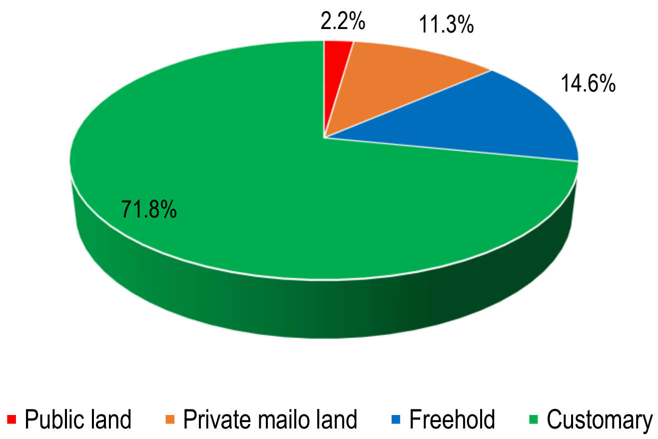


Figure 48 Land tenure systems by proportion in project area

Field survey results pertaining to property ownership in relation to land, revealed a significant proportion of men (74.5%) were found to own land compared to the women (25.5%) in the project-affected areas. The men comprised of (46.9%) land owners and (13.2%) female land owners as shown in Table 67. Important to note that in most rural settings women have limited rights to land, except through outright purchases given the patrilineal lineage and cultural beliefs that sideline women and deny them the right to own property. Analysis of method of acquisition shows that more men (52.5%) acquired land through inheritance than the women (14.9%).

Table 67: Land ownership by gender

Gender	Landowner	Tenant kibanja	Co-owner	Licensee	Total
Male (%)	46.9	25.4	1.6	0.6	74.5
Female (%)	13.2	9.6	1.2	1.5	25.5
Total (%)	**60.1**	**35**	**2.8**	**2.1**	**100**

Source: Primary data

Table 68: Methods of acquisition of land ownership by gender

Gender	Bought	Inherited	Renting	Total
Male (%)	20.4	52.5	1.6	74.5
Female (%)	8.9	14.9	1.7	25.5
Total (%)	**29.3**	**67.4**	**3.3**	**100**

Source: Primary data

6.5.3 Livelihoods

a) Occupations

According to the World Development Report on Agriculture for Development (World Bank, 2007), agriculture is critical if countries are to achieve the poverty targets set forth by the millennium Development Goals within the agreed timeframe. Although the contribution of agriculture to total GDP has been declining over the years, the sector has continued to dominate the Ugandan economy. It contributed approximately 22.9 percent of the total gross domestic product in 2011 at current prices.

This is consistent with the project affected area for Karuma- Gulu WSP which thrives mainly private agriculture (69.3%) as the main source of livelihood for household heads within the surveyed project affected villages is mainly followed by private informal retail trading (7.5%) (Table 69). Further analysis showed that 12.4% were mainly engaged in private formal service (6.4%) and government service (5.3%). The typically grown crops were maize, cassava, beans and Sweet potatoes which also serve as the main source of agricultural trade within and outside the district to the neighboring districts and across the border in Southern Sudan.

Table 69: Occupations of project-affected household heads

Main occupation	Percentage
Private formal/service	6.4
Private informal retail	7.5
Private Agriculture	69.3
Public Government	5.3
Carpenter	2.5
Mason	3.4
Brick making	1.1
Transport	4.5

Source: Primary data

b) Levels of income

Census findings how that the majority of those affected by the proposed project are farmers. Agriculture being the main source of income for households along Karuma- Gulu project area. When further probed for average monthly income majority of respondents (25%) revealed making UGX 100,001-200,000 from their respective occupations. Only a few made over UGX 1,500,000 in a month.

Table 70: Average monthly income levels of PAPs

Average monthly income	Valid percentage
Below 100000	19.0
100001-200000	25.0
200001-300000	13.0
300001-400000	7.0
400001-500000	10.0
500001-1000000	13.0
1000001-1500000	9.0
Over 1500000	4.0

Source: Primary data

c) Spending Patterns

From interviews, affected households along Karuma- Gulu project area majority of the PAPs spent their incomes mainly on healthcare, food, transport, school fees.

Table 71: Spending patterns among affected households

Spending Patterns	Rank*
School fees	1
Healthcare/medical expenses	2
Food	3
Clothing	5
Transport	6
Dependants	7
Rent	8
Airtime	4

** Rank 1= Item most spent on; 10= item least spent income on*

Source: Primary data

6.5.4 Ethnicity and Religion

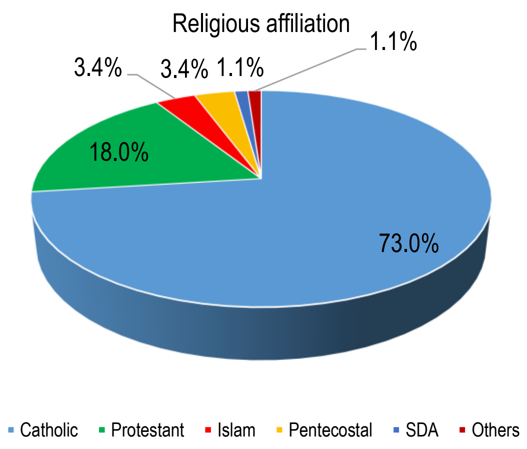
Ethnic composition of PAPs in the project area was homogenous (Table 72) indicates that most people are Acholi (96.8%) and Alur (2.2%) and Langi (1.0%).

Table 72: Tribal affiliation in the project affected area

Tribe	Percentage
Acholi	96.8
Alur	2.2
Langi	1.0
Total	100.0

Source: Primary data

In the project affected villages along Karuma- Gulu and the surrounding sub-counties, the biggest number of PAPs in households surveyed were predominantly Christians with Catholics making up the largest percentage at (73%) followed by Protestants (18%) , Islam and Pentecost's (3.4%) and Seventh Day Adventists(1.1%) and others (1.1%).



Source: Primary data

Figure 49 Religion among PAPs.

6.5.5 Health and Sanitation

Prevalent diseases reported by PAPs were malaria (76.6%), highly terminal diseases such as Hepatitis B HIV AIDS and other venereal diseases (4.1%) and respiratory infections such as cough, asthma and flu cough (7.2%) as indicated in Table 73. Malaria and respiratory infections were mainly common among children, while the terminal diseases and other conditions such as hypertension were common among the old. The district health official also indicated the high prevalence of Hepatitis B within the communities and the district at large. A preventive healthcare strategy will have to be developed for during implementation to help mitigate spread of communicable and sexually transmitted diseases. All PAPs were had knowledge about HIV/ AIDS.

Table 73: Most common diseases reported in the affected household

Most common diseases	Percentage
Malaria	76.6
Venereal disease	14.1
Mental illness	1.1
Respiratory diseases	8.2

Source: Primary data

Malaria is the commonest disease and 89.4% of the surveyed households spend various amounts on treating it throughout the year.

According to the Ministry of Health the recommended maximum distance to the nearest health facility is 5 km. From the census data a large proportion of respondents walk less than 5 km to the nearest health facility79.4%) while only (17%) go between 5 and 10 km to get health care (Table 74).

Table 74: Annual expenditure on most common diseases

Disease	Annual expenditure on most common diseases (UGX)				
	Below 10,000	**11,000 – 20,000**	**20,000 – 30,000**	**Above 30,000**	**Total**
Malaria	20	11.3	24.1	34	89.4
Respiratory diseases	0.6	2.4	0	3.6	6.6
Venereal diseases	0	0	0	4	4
Total	**20**	**13.7**	**24.1**	**41.6**	**100**

Source: Primary data

Census results on the mode of transport in the project affected area also indicated that most respondents when travelling to the health centres or clinics, walked to the health centres (while others use “boda boda” transport especially in cases of emergencies. During the focus group discussion and interviews with some key stakeholders, they reported that a significant majority of people use “boda bodas” as the fastest and easier way to access health services in the area given the breakdown of public transport in the area (Table 75).

Table 75: Distance to health facilities

	Less than 5 km	**5-10 km**	**10 km or more**	**Total**
District Hospital (%)	8.5	4.0	0.0	12.5
Health Centre IV (%)	2.0	0.3	0.0	2.3
Health Centre III (%)	41.4	7.0	2.4	50.8
Health Centre II (%)	24.3	5.7	1.2	31.2
Health Centre I (%)	2.1	0	0.0	2.1
Private Clinic (%)	1.1	0	0.0	1.1
Total (%)	**79.4**	**17**	**3.6**	**100**

Source: Primary data

Table 76: Means of travelling to the health centres

	Walk	**Bicycle**	**Boda boda**	**Car**	**Total**
District Hospital (%)	3.5	1.2	4.6	1.2	10.5
Health Centre IV (%)	1.2		1.2		2.4
Health Centre III (%)	26.7	2.1	20	3.5	52.3
Health Centre II (%)	11.5	3.8	16	1.3	32.6
Health Centre I (%)	1.1				1.1
Private Clinic (%)				1.1	1.1
Total (%)	**44**	**7.1**	**41.8**	**7.1**	**100**

Source: Primary data

6.5.6 Sources of Water

In the entire project affected areas, within the project affected households, the commonest sources of water for domestic use include communal borehole (36.3%) protected spring (34.2%) followed by unprotected spring (9.1%) and piped water (9.1%) as indicated in Table 77) . Very few respondents reported using the river (1.2%). The respondents that used piped water from NWSC were mainly found within the urban and peri-urban centres. Distance to the nearest water source fell within nationally recommended radius. A majority (50.5%) and 30.5% of PAPs reported being were within 100-500m and 100m of the nearest water source (Table 78).

Table 77: Type of water source

Source of water	Percentage
Communal borehole	36.3
Protected spring	34.2
Unprotected spring	9.1
River	1.2
Piped water in house	9.1
Open stand pipes	10.1

Source: Primary data

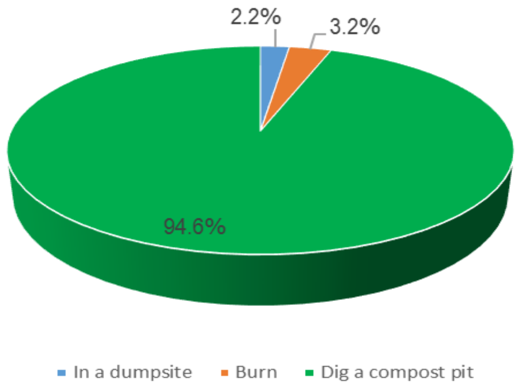
Table 78: Distance to nearest water source

Water source		100 m	100 - 500 m	1 - 1.5 km	Over 5 km	Total
Community borehole	%	12.3	18	3.7	2.3	36.3
Protected spring	%	9.3	18.7	6.2		34.2
Unprotected spring	%	1.5	5.8	1.8		9.1
River	%	0	0.6	0.6		1.2
Piped water in house	%	5	3.6	0.5		9.1
Open stand pipes	%	3.2	3.8	3.1		10.1
Total	**%**	**31.3**	**50.5**	**15.9**	**2.3**	**100**

Source: Primary data

6.5.7 Waste Management

On management of waste, domestic refuse was mainly disposed of in a compost pit (94.6%), burning of the refuse (3.2%) and dump sites (2.2%) away from the homesteads.



Source: Primary data

Figure 50 Method of disposing refuse

In relation to disposal of human waste, most respondents used pit latrines (79.5%). However, some respondents revealed having toilets (18.1%). There were also some areas where community latrines (2.4%) were used such as market areas, trading centers, primary schools and churches within the project area.

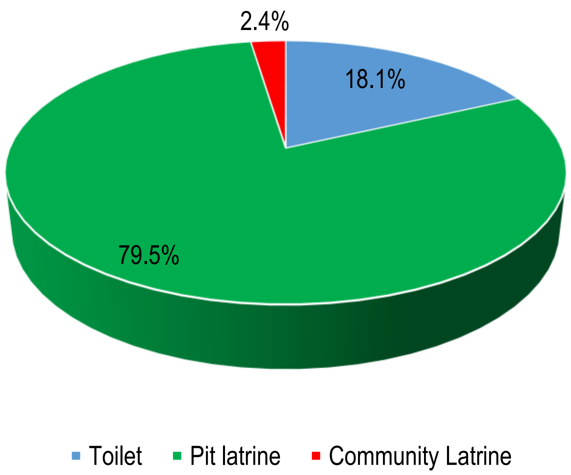
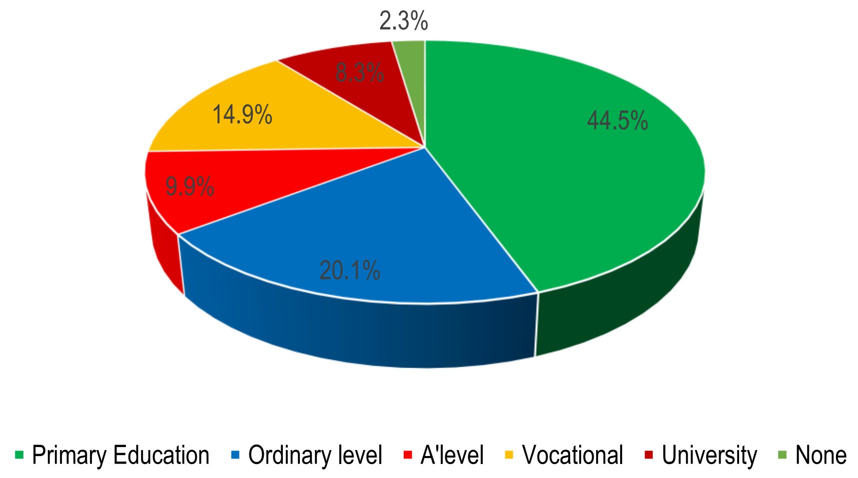


Figure 51 Disposal of human waste

6.5.8 Level of Education

Education is a major socio-economic aspect which influences nearly every aspect of human life and socio-economic development. Census results of education level of PAPs reveal that the majority of respondents had attained primary education (44.5%) and only (2.3%) had never attained any formal education. This means that the vast majority of the PAPs can provide unskilled labour to the project if it is available. At the stage of implementation, it is important to take into consideration those with low levels of literacy in the project area as it can affect not only the compensation process and communication strategy need to be targeted to address this minority group as well.



Source: Primary data

Figure 52 Education levels of house hold heads

6.5.9 Energy Sources

In the project affected areas of Karuma- Gulu primary data reveals that there is limited access to grid electricity and households relied mainly on biomass as a source of energy with fuel wood(59.2%) and charcoal (34%) used as the main source of cooking energy and Kerosene (72.2%) was used as the main source of lighting in the surveyed households followed by use of solar (13.4 %) lighting although some households were connected to grid electricity in the trading centres (7.5%); there were also other (2.2%) sources such as battery powered torches and gas (1.7 %) for some households. Fuel sources in affected household in project area are shown in Table 79.

Table 79: Sources of energy

Source	Percentage Usage
Lighting	
Firewood	1.6
Gas	1.7
Charcoal	1.4
Solar	13.4
Kerosene	72.2
Electricity	7.5
Other	2.2
Cooking	
Firewood	59.2
Gas	4.5
Charcoal	34.0
Solar	1.1
Electricity	1.1

Source: Primary data

6.5.10 Vulnerability among PAPs

Vulnerable groups, according to the World Bank definition, are people who by virtue of gender, ethnicity, age, physical or mental disability, economic disadvantage, or social status may be more adversely affected by resettlement than others and who may be limited in their ability to claim or take advantage of resettlement assistance and related development benefits. For this RAP, vulnerable people were identified following the criteria below:

- Widows
- Child headed
- Disabled or seriously sick people
- Elderly
- Households whose heads are female and who live with limited resources.

Examples of vulnerable PAP identified during the census survey are indicated in Photo.

Photo 48: Some of the vulnerable project affected persons

6.6 CULTURAL HERITAGE AND ARCHEOLOGICAL RESOURCES

a) Cultural heritage

The project area was like the rest of Uganda first inhabited by the hunter gatherer people. These people had been in the area since the Stone Age period. From 1000 B.C other communities entered the area the Sudanic speaking people related to the Madi were the first to arrive in the area. They were followed by the Luo Nilotic people who entered Uganda from the present day South Sudan.

The Luo moved into Uganda as a single community up to Pumbugu near Pakwach town on river Nile .At this point the Luo community split into three groups. One group crossed river Nile to the western side of the river and became the Alur tribe. A smaller group moved south into Bunyoro and overthrew the Chwezi dynasty establishing the dynasty of Bito rulers. Another group under the leadership of Labongo moved eastwards into the project area and formed the Acholi people after absorbing the earlier Sudanic communities they encountered in the area. The Acholi people were organized into chiefdoms ranging in various sizes. The biggest chiefdom was that of the Payera Chiefdom which provides the Paramount Chief of the Acholi people.

The Luo also mixed with the highland nilotes (Eteker) who were moving westwards north of Lake Kyoga to form the Lango people who live in Oyam District where the proposed water intake is located. The project is therefore located in the land of the Lango and Acholi people.

There is one cultural site in the vicinity of the project area. This is the Nora Te Kwaro cultural site near the site of the proposed water intake on the northern side of the River Nile at Karuma.

Photo 49: Mr. Moses Oyepa, the LC1 Chairman of Nora Village at the Nora Tekwaro Cultural site

This location is marked by a tree in a thicket where the local residents pray to the local spirits for protection from problems and sickness .This location will not be affected by the project infrastructure as it is 262 m from the water in take point. The coordinates of this cultural site are 36N 0418905, UTM 0248875.

However this site was disturbed by the construction of the road to the Karuma HPP and the local leadership is engaged in negotiations with the Chinese Contractor who is building the Karuma dam to pay for the relocation of the cultural site from the area.

b) Archaeological resources

Surface transects walks in the Nora village and in gardens along the pipeline route from Karuma to Gulu were conducted. Ancient pot shards were observed at two locations: a) 36N 0418994, UTM 0249128 at the proposed location of the water treatment plant at Karuma and at b) 36N 0431619, UTM 0256867 at Amwa area. The Roulette decorated potshards indicated that human village communities have existed in the project area since the late iron age period.(around 1000 A.D) This is corroborated by the oral history of the people in the region.

Photo 50: Pot Shards observed in Nora village

Photo 51: Close view of the roulette decorated pot shards

c) Cultural property at household level

The Cultural properties at house hold level found in the project area during the survey were graves in the homesteads .One such homestead was encountered at Nora village at 36N0418920, UTM 0249183 belonging to Mr. Omara Francis the Defence secretary Nora village at the proposed location of the Water treatment plant. This Lango homestead has four ordinary graves. The graves are marked by a stone in the courtyard.

In Gulu Municipality at Customs corner, six graves were observed at the location planned for the new water reservoir. The coordinates of the location are 36N 0420349, UTM 0305503. The graves were found to exist at the water in- take and at the final destination of the water reservoir in Gulu. There were no grave on the route from Karuma to Gulu as the pipeline route is located in the UNRA road reserve where the population does not carry out activities. Graves can be relocated to enable development projects. The relocation rates are determined by the District boards. In this case where the project facilities are placed in the same location as the graves and homesteads, these will have to be relocated according to the Resettlement Action Program of the Project in accordance with the Gulu and Oyam district compensation rates.

Photo 52: Defense Secretary and his wife of Nora village standing on top of one of the graves in at their homestead

Photo 53: Graves at Gulu customs corner where the water reservoir is planned to be located

7 STAKEHOLDER ENGAGEMENT - CONSULTATIONS

The objectives of consultations during the ESIA study were to share Project information with key stakeholders, to obtain baseline information, and to allow stakeholders the opportunity to make comments and express their views on the proposed Project's impacts and mitigation measures being proposed to address these impacts. It will be important to share the Project benefits and adverse impacts, as well as the proposed enhancement and mitigation measures. Information to be disclosed will include details of the purpose, nature, location and duration of Project activities. The aim of these consultations was to identify any environmental and social impacts that could occur from the ESIA and take note of the concerns and views of all the stakeholders so that appropriate mitigation measures are incorporated before the project commences. In this context, meetings were held with relevant Nwoya, Oyam, Omoro and Gulu District Local Administration, Koro, Bobi, Minakulu, Myena, Kamdini and Layibi Sub-Counties and with the local communities.

Consultation meetings were held with Nwoya, Oyam, Omoro and Gulu District Local Administration, Koro, Bobi, Minakulu, Myena, Kamdini and Layibi Sub-Counties and with the local communities within the project area. These were conducted by the ESIA Team. Stakeholder engagement constituted an important part of the ESIA process, in light of the Project's commitment to adhering to national requirements, as well as a best practice approach to public consultation, that is, an approach that encourages open and transparent dialogue, with as broad a range of stakeholder groups as possible. A number of pertinent issues were raised from the meetings held with the different stakeholders. Some of the major issues raised during meetings with the project affected communities were employment, compensation issues and Corporate Social Responsibilities . A summary of the key findings from the consultation process are presented in Table 81 and 82 while a detailed transcription of the meetings is provided in Appendix A.

Table 80: Stakeholders engaged during consultations

Date	Place/ Insitution	Communities/ Government Officials
19th April 2018	UNRA – Nakawa Offices	▪ Senior Environmental Officer - UNRA ▪ Environmental Specialist - UNRA ▪ Highway Engineer – UNRA ▪ Environmental Engineer – NWSC ▪ AWE Team
04th June 2018	UWA - Headquarters	▪ Deputy Director Planning ▪ Manager EIA/OM ▪ EIA Officer ▪ EIA/OM Intern ▪ AWE Team
06th June 2018	DWRM - Entebbe	▪ Ag. Assistant Commissioner ▪ AC Water Use Planning ▪ 2 Senior Water Officers ▪ Ag. Senior Water Officer (PC) ▪ Ag. Senior Water Officer (ESIA)

Date	Place/ Insitution	Communities/ Government Officials
		▪ Ag. Principal Water Officer (RR) ▪ Water Officer ▪ Hydrogeologist Trainee ▪ AWE Team
02nd July 2018	UEGCL - Kamwokya	▪ Manager Health, Safety, Environment and Social Development ▪ Strategy and Business Development Officer ▪ Two Project Officers ▪ AWE Team
17th May 2018	Gulu District Local Government	
	Nwoya District Local Government	
23rd May 2018	Oyam District Local Government	
4th June 2018	Bobi Sub-County, Omoro District Local Government	Pato and Kalamomia villages
5th June 2018	Koro Sub-county, Omoro District Local Government	Kal, Pida, Lajwatek villages
	Bobi Sub-county, Omoro District Local Government	Kuluotit Along and Onekdyel villages
6th June 2018	Bobi Sub-county, Omoro District Local Government	Idop, Obalwat villages
	Minakulu Sub-county, Oyam District Local Government	Akaoidebe, Obapo, AJaliopo, Adel, Aromo, Nyango, Minakulu TC and Ngu-cuti villages
7th June 2018	Minakulu Sub-county. Oyam District Local Government	Opati A, Kagera, Agugu-arac, Arak East and West, Alati, Bobi, Lango Opati B villages
	Myena Sub-county, Oyam District Local Government	Abang Ipiny, Abang Imalo, Akaoidebe TC, waring Amukugungu, Abako villages
8th June 2018	Kamdini Sub-county, Oyam District Local Government	Arukolong, Barolimo, Bororboro,Pukica, Pida, Alyec, Abanya A villages
9th June 2018	Gulu District Local Government	Techo and Go down villages
25th July 2018	Bobi Sub-county, Omoro District Local Government	Gudu Odyak villages

Table 81: Summary of key issues raised from consultations with all stakeholders on differents aspects

Subject	View
On water	The community advised NWSC to develop transmission and distribution lines concurrently where possible in order for the people to be able to get water from the project.
Employment	There was a concern on whether local communities will be involved and employed during construction of the proposed facilities. The contractor should consider employing local people from the project areas. *Mitigation measures provided under sub-section 8.2.2*
Air pollution impacts	Air pollution impacts, such from construction activities and quarry sites should be prevented. *Mitigation measures provided under sub-section 8.3.5*
Noise and vibrations from project construction	Issues and criteria associated with damage to property and how they would be compensated should be addressed during project implementation. Baseline information should include record of state of structures to avoid future claims of structural damage (cracking) yet were not caused by the project. *Grievance mechanism has been provided in sub-section 9.2 and RAP study is being conducted for properties within the project corridor*
Stakeholder engagement and awareness creation	There should be continuous and effective communication with stakeholders at all stages of the proposed development. For instance affected persons should be provided with project timelines to enable them plan to vacate affected areas in adequate time. Information about the project should be availed to local people in native languages for effective disclosure, engagement and meaningful feedback.
On Royalties	Nwoya as a district requested for a royalty as the district that will be housing the water treatment plant. *This has been taken into consideration under sub-section 8.2.5*
On the technical design	Final technical designs need to be shared to the District and the input from the district should be considered

Table 82: Key issues from institutional stakeholders

Institution	Issue(s) raised/ Suggestion(s) made	Remark(s)	Status
Uganda National Roads Authority (UNRA)	i) NWSC need to apply for a permit if the water transmission line is to cross the UNRA road. During construction NWSC will need UNRA staff to monitor especially traffic and also give alternatives besides acquiring the permit. The road reserve is 14.5 metres from the centre and other roads is 7 metres from the shoulders especially when the road is approaching the town.	The permits and licenses required to facilitate implementation of the project have been indicated in Table 30 under Sub-section 4.11.	Approval for road crossing has been issued to NWSC
	ii) In order to quire right of way, NWSC need to find out if UNRA acquired the land and paid off the PAPs, because not all where UNRA roads pass land is acquired fully.	RAP study is being carried out and after identification of project affected people in the road reserves, consultations will be held with UNRA	RAP for the project was completed. Preparations are underway to ensure payment is done in time
	iii) NWSC should work with UNRA because there are plans to upgrade or rehabilitate the Kamudini – Lira road so there is need to match the schedules of the two planned activities.		NWSC is in close touch with the UNRA team. Relationship between the two projects is to be harmonised to avoid challenges in future
	iv) NWSC should make a request for access to the road reserve from UNRA and also refer to the regulations/ guidelines for use of the road reserves.	This requirement has been included in the institutional requirements with reference to UNRA (Sub-section 4.5.9)	NWSC has made application to UNRA for using road reserves, payment notification has also been issued to NWSC to pay for the lease to use the road reserve
	v) UNRA has a Green Right of Way (GROW) program of planting trees along the road reserve. This should be taken into consideration when planning the route of the transmission line along the Karuma – Gulu Highway.	Discussion were held with the design consultant and NWSC to take this into consideration	The GROW program has not yet been implemented for the Karuma-Gulu route, collaboration with UNRA has kick-started for partnership when the exercise begins late 2020
Uganda Wildlife Authority (UWA)	i) Proposed Project layout: It was noted that if the water transmission line from Karuma to Gulu is outside the Murchison Falls National Park (MFNP)		There is no usage of the Murchison falls national park

Institution	Issue(s) raised/ Suggestion(s) made	Remark(s)	Status
	and therefore no impacts to MNFP. However the water supply line may encroach on the MFNP if passed along the Karuma Bridge. It was suggested that to supply Karuma town, one option was to take the pipe along the Karuma HPP dam to avoid the park as much as possible.		
	ii) Murchison Falls National Park: In case there is need to pass the water supply line through the MNFP land, the following would be required: ▪ Waste management plan for material waste, food waste and human waste ▪ Follow park regulations ▪ Apply for park entry/ pewrmission to work within the park ▪ Open and reinstate pipe trenches as soon as possible. No trenches should be left open overnight ▪ Restoration plans especially for tress and vegetation and these should be indigenous species ▪ Activity schedule indicating time to spend in the MNFP area	The permits and licenses required to facilitate implementation of the project have been indicated in Table 30 under Sub-section 4.11.	There is no usage of the Murchison Falls National Park
Directorate of Water Resources Management (DWRM)	i) With improved supply of water, consideration should also be given to provision of sanitation facilities	Recommendation was made as a mitigation measure for the wastewater generated as a consequence of improved water supply (Sub-sections: 8.3.1, 8.3.2 and 8.3.3).	Proper sanitation facilities are to be provided before the works start
	ii) NWSC should adopt the 2013 water supply design manual set for 20 -25 years of which 5 years are for planning and 20 years of		The design engineer adopted the 2013 water supply design manual

Institution	Issue(s) raised/ Suggestion(s) made	Remark(s)	Status
	implementation according the design manual for water supply projects.		
	iii) The water balance study should be taken into consideration the Karuma HPP being a water user not a consumer during the ESIA development.	The water resources assessment was conducted as part of this study and took into consideration the impacts that may arise from the Karuma HPP (Appendix B)	Consideration for the HPP was done
	iv) The Water Resources Assessment study should take into consideration Karuma HPP and other adjacent water users to ensure that they would not be affected. Although water abstraction is expected to be minimal, a water resources assessment report should be provided.		Consideration for the HPP was done
	v) How far is the waste treatment plant from the water treatment plant and on which side of the river (Victoria Nile)? Where is the location of the discharge point and how far is the discharge point from the abstraction point?	The water treatment is a complex plant comprising of all necessary unit processes and sludge treatment facilities (sludge drying bed). All these will be located within the demarcated area for the water treatment plant which about 1.2km from the riverbank.	No waste water treatment plant shall be constructed at Karuma
	vi) Was the water source protection component considered under this project?	The Water source protection is outside the scope of this assignment but usually the client engages a separate consultant to do the plans just like it has been handled with other projects.	Water source protection plans for the project have been finalised by the consultant (Fitchner)
	vii) How is the sludge generated during operation of the water treatment plant going to be handled?	NWSC will work with the concerned authorities to identify the most suitable way of disposing it off. If classified as hazardous, the option is to transport to Luweero Industries where there is an approved hazardous waste handling facility otherwise it could be disposed at a sanitary or municipal landfill. Mitigation	Land for sludge disposal shall be secured

Institution	Issue(s) raised/ Suggestion(s) made	Remark(s)	Status
		mesures have been provided under sub-section 8.3.3.	
	viii) As ESIA consultants, has the Karuma HPP study been taken into consideration so that the abstraction point is not within the back water curve region?	Yes, and for the same reason, it was agreed to extend the intake point 550 m further upstream of the Karuma HPP dam.	Adopted
	ix) Taking into consideration UNRA's future plans about the expansion for the northern economic corridor, the consultant should engage UNRA about the metres between the road and the pipeline to save NWSC from future compensations	Consulations were held with UNRA (Appendix A)	Adopted
	x) Why should the pipeline cross the main road at 3 points and the railway yet their other options like the bridges and culverts which cannot impair the structural integrity of the infrastructure?	Trenchless drilling is being proposed. Mitigation measures have been provided in Sub-section 8.3.9	To be adopted
Uganda Electricity Generation Company Limited (UEGCL)	i) Inquiring about the extent to which extent was land acquired for the Karuma Hydro Power Project (Karuma HPP) to avoid double compensation; UEGCL responded that the Resettlement Action Plan for the Karuma HPP was conducted by the Ministry of Energy and Mineral Development. It would therefore be good to directly consult with the Ministry. Any assistance in this regard will be availed to you.	During the RAP study, which is still on-going, land already acquired by the Ministry of Energy was identified.	Completed
	ii) Requested the Design Consultant/ NWSC to share the technical designs with UEGCL so that they review all the scenarios for more comments or suggestions.	Request will be made to NWSC to share the documents	Adopted
	iii) It was pointed out that the Karuma HPP is about to be commissioned towards the end of 2018 and advised that construction of the intake should be	This was already communicated to the consultant by the client, NWSC	Mitigation measures adopted

Institution	Issue(s) raised/ Suggestion(s) made	Remark(s)	Status
	done as soon as possible before the area is flooded.		
	iv) AWE (ESIA Consultant) inquired whether an Environmental Flow Study was conducted for the Karuma HPP and if yes, can it be shared for use for this study. In response: Yes, the agency did the study and it will be availed. Although the EF study determined an environmental flow of 50 m^3/s, DWRM made a recommendation of maintaining an environmental flow of 100 m^3/s to cater for other water uses being planned along River Nile.	Environmental Flow Report was shared and included (see Appendix H)	Adopted
	v) As one of the mitigation measure to sustain the water resource, a catchment management plan is recommended and should be developed.	Development of a catchment management plan is a study on its own and given the expanse of the Victoria Nile catchment, it was not part of the scope of this study. However, NWSC develops water source protection plans for sources from which it abstracts its raw water.	Source protection plans for the project have been developed
	vi) Issue of where the waste to be generated during construction will be deposited was also raised.	NWSC and the Contractor will work with the respective district to identify the most appropriate sites for disposal of such waste. Mitigation measures provided in Sub-sections 8.3.1, 8.3.2 and 8.3.3	To be adopted

Coordination with institutions: The government through National Water & Sewerage Corporation and Ministry of Water & Environment will provide to the Bank official letters from each institution related to the project to inform about the project, ensure communication and agreement in the project and engagement of their staff in the combined supervision to reduce impact to people and environment.

a) Consultative meeting with UNRA Officials at UNRA Offices at Nakawa on 19th April 2018

b) Consultative meeting with DWRM Officials at Entebbe Offices on 06th June 2018

c) Consultative and sensitisation meetings with communities in the project area

d) Consultative and sensitisation meetings with communities in the project area

e) Consultative and sensitisation meetings with communities in the project area

Photo 54: Some of the photographs of consultative meetings held in the project districts

8 POTENTIAL ENVIRONMENTAL AND SOCIAL IMPACTS

8.1 INTRODUCTION

This section provides a evaluation of the environmental and social impacts and the corresponding mitigation strategies of the project. To sustain the water supply in Gulu it is anticipated to draw water from the Victoria Nile near Karuma and transport it along the road Karuma-Gulu to Gulu town. It is currently planned to supply 6 towns along the route of this transmission main, namely Karuma, Kamdini, Minakulu, Bobi, Palenga and Koro Abili. This will improve access to safe and sustainable water supply not only to Gulu Municipality but also to towns/ communities enroute. Although water supply exists in the towns of Kamdini, Minakulu, Palenga and Koro Abili, the additional supply from NWSC will further boost the service level and reliable supply. This will translate in improvements in health, economic and social welfare of the community.

However, in addition to the many possible beneficial impacts, adverse impacts may arise from these improvements. In this chapter, prediction and analysis of possible positive and negative impacts of construction and operation of the water supply and sanitation project is presented, with main focus on the proposed new raw intake and water treatment plant in Karuma; water transmission line from Karuma to Gulu Customs Corner; and distribution systems within the 6 towns, that is, Karuma, Kamdini, Minakulu, Bobi, Palenga and Koro Abili.

8.2 POSITIVE IMPACTS

The development and operation of the proposed project will have substantial positive environmental and social impacts. The following are the positive impacts anticipated to arise from the construction and operation activities of the project:

8.2.1 Income to Material/ Equipment Suppliers and Contractors

Both construction and operation of the project will require supply of various materials and/ or equipment. For example, construction will require cement, aggregates, sand, etc some of which can be sourced locally. Some equipment and materials, for example, pumps, required for the project will be sourced nationally and internationally to ensure that the desired quality is achieved. Local suppliers of materials and equipment who get involved in the project will benefit financially. The project affected communities would benefit mostly during the construction phase.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	√
Water Transmission and distribution systems	√	√

Enhancement measure*:* Earth materials needed for construction, for example, murram, aggregate (stones and sand) are obtained from quarry operations. These should be largely obtained from the project affected districts. However, conscious or unwitting purchase of these materials from unlicensed operations indirectly promotes environmental degradation at illegal quarry sites and can cause medium-to long-term negative impacts. It will therefore be a contractual obligation for contractors to procure construction materials from quarries legitimately licensed the project District Local Governments and duly approved by NEMA.

8.2.2 Employment

Construction will avail both skilled and unskilled job opportunities for residents, especially youths. The project will employ about 1000 workers, 3% of which will be foreigners and 97% Ugandan nationals. Skilled labour will include artisans such as plumbers, carpenters, masons while unskilled labour will include trench excavation. The sub-counties in the project area have youths aged between 18 and 30 years who are not in school and not working but yound and energetic. Therefore this age group should be considered for employment especially during construction. Indirect job opprotunities during construction will arise from provision of services to the contractor and his employees.

Employee Category	Project components to be attached	Percentage (%) of total expected	Number of people
Foreigners		3%	30
Consultants key staff	Genral supervision; civil works and ESHS	1%	10
Contractor's key staff	General supervision; civil works and ESHS	2%	20
Local workers		97%	970
Consultant's non-key staff	Genral supervision; civil works and ESHS	0.5%	5
Contractor's non key staff	Genral supervision; civil works and ESHS	5%	50
Casual laborers	Water intake	4%	40
	Water treatment plant	11%	110
	Water transmission line	50%	500
	Reservoirs	8.5%	85
	Distribution systems in the small towns	18%	180
Total		100%	1,000

During the operation phase, long-term technical and non-technical job opportunities for professionals, casual labourers, etc. will be available to operate and maintain the water works. New towns are being considered for supply and this will necessitate new staff to manage water supply in these towns. Water supply will boost the economy, for example, hotels, restraunts, etc. in the project area and this will indirectly avail more job opportunities.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	√
Water Transmission and distribution systems	√	√

Enhancement measure*:* Wherever feasible, local people should be considered for job opportunities commensurate with their level of skills. Adequate occupational health and safety standards should be provided to ensure the work environment is conducive.

Construction phase

i) NWSC shall ensure that all personnel to be involved in implementation of this ESMP are adequately qualified. A training programme for the NWSC staff to implement the ESMP shall be facilitated by the project to ensure that staff have the appropriate skills.
ii) Unskilled labour will be recruited exclusively from local community, and semi-skilled labour will be recruited preferentially from such communities, provided that they have the requisite qualification, competence and desired experience;
iii) Contractors will be encouraged to pay a "living wage" to all workers and to ensure that workers have contracts;
iv) A training programme for artisans (builders, carpenters, plumbers) in the project area could be facilitated by the project to ensure skills transfer during the construction period; and
v) Contractor will develop and implement Labour Influx Management Plan, Workers Camp Management Plan and Code of Conduct. An example of the code of conduct for contractors and sub-contractors is provided in Appendix G. Camp site selection shall involve several factors, including; the size and conditions of the site and availability of resources; the safety, security and protection it offers and cultural and social considerations. Choosing a site shall involve consideration of access, coexistence with surrounding communities, topography, trees and vegetation, the potential impact on the environment, environmental causes of disease and other public health issues.

Operation phase

i) NWSC will consider local people for the unskilled labour requirements and where the required skills are available locally, the local people will be given first priority commensurate to their level of training;
ii) Gender equity will be one of the guiding principles in recruitment of employees; and
iii) Occupational health and safety of workers will be adequately taken into consideration.

8.2.3 Infrastructure Improvement

With improved water supply, development of infrastructure like hotels, restraunts, etc will be triggered. Water supply will induce development, stimulate investment and employment and helps improve marginal investment opportunities.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant		√
Water Transmission and distribution systems		√

Enhancement measure*:* The extent to which development becomes a positive or negative impact will be determined by the effectiveness of the planning framework. Such induced developments should be of a type that is desirable and sustainable and for this to happen, all future developments must be undertaken within the framework of proactive government policy and strict planning and environmental enforcement by the responsible Local Government.

8.2.4 Improved Health and Economic Status of Households and Communities

The provision of an adequate, safe water supply has positive impacts on the health of users by greatly reducing the incidence of communicable enteric and infectious related diseases, which, in many instances occur in communities due to lack of adequate potable water supply. Both potable water supplies as well as safe disposal of human excreta are needed to break the chain of transmission of diseases.

Livestock and poultry keeping: Improved water supply would lead to an increase in poultry and livestock keeping in homesteads. A permanent water source near or on the farm will permit an increase in cattle and improve the production of milk and beef. Those farmers who previously felt water to be a crucial constraint preventing them from keeping such livestock as grade cows and pigs, poultry like chicken or expanding their activities in this regard, may find it feasible to do so.

Small scale gardens: The provision of piped potable water supply may indirectly have positive beneficial impact on the irrigation of small scale gardens if there is excess water available and it can be used for irrigation of small scale garden plots near each household or tap. For example, rain water harvesting can now be reserved partly for irrigation. This will have positive beneficial *impacts* on increasing agricultural productivity and perhaps also improving nutrition status of households.

Small scale industries: The ample availability of piped potable water supply may lead to improvements in the small scale industrial development and increased production.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant		√
Water Transmission and distribution systems		√

Enhancement measures:

i) Users will be educated on the proper use, regular cleaning and effective maintenance of both the household and public facilities. The communities will be sensitised about proper disposal of wastewater generated as a result of improved water supply and how to use water sparingly with minimal or no wastage.
ii) Water tariffs should be set taking into consideration the different levels of users (Table 83) and users should also be educated to avoid wasteful use of the resources.

Table 83: Water tarrif structure as per July 2018

Type of consumer	Charges (UGX/ m^3)	Cost per jerrycan
Public standpipe	1,060	25
Domestic	3,400	80
Institutional/ Government	3,441	81
Industrial/ Commercial: ▪ Below 500 m^3 per month ▪ 500 – 1500 m^3 per month ▪ Over 1500 m^3 per month	 4,220 4,220 3,373	 99 99 79

Source: NWSC website

8.2.5 Revenues for Government

The implementation of the project will increase revenue and taxes for both the central and local government authorities through indirect taxes resulting from the construction project such as value added taxes (VAT), income tax, etc paid to Uganda Revenue Authority; and royalties paid to the project districts.

8.3 NEGATIVE ENVIRONMENTAL IMPACTS

8.3.1 Degradation of Soils

Deterioration of soil quality would arise from erosion where the top and productive soil layer is washed away or from leaching of minerals from the stockpiled soil during rains. In addition, compaction activities would affect soil texture, its transmissivity and ability to hold moisture. Incidents and activities having potential effect on soil quality are anticipated to occur during the site preparation where strips of vegetation are cleared and soils heaped or stored. Soils excavated may be stored at the project sites hence exposure to agents of erosion such as wind and storm water. Poor disposal or management of the wastewater generated will lead to land/soil pollution and related drainage problems.

Also construction equipment engaged in activities might cause contaminations of soil due to leakage of fuels and lubricants from equipment. The fuel and lubricating oils required during both construction and operation of the project have the potential to contaminate soil if they leak or are spilled during handling or use.

These impacts are negative and the stakeholders likely to be affected are nearby community, land and aquatic fauna and flora. Its extent will be mainly local limited within site boundary and communities in its immediate vicinity. The project components that may contribute to these impacts are presented below.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	√
Water Transmission and distribution systems	√	

Impact significance: The in-situ soils strata at the intake site were generally granite rocks from a depth of 4.5 m (Appendix I) and the strata from the intake and water treatment sites were to a large extent; non-cohesive. The strata from the boreholes at towns en-route from Karuma to Gulu; and from the hand auger locations and trial pits were of varied composition. In other project areas, the soils are moderately productive in terms of agriculture and are also susceptible to runoff and logging. Even though there are earthworks (for example grading, levelling and compaction), the terrain around the proposed sites, especially along the water transmission and distribution lines is flat making the area less suscptable to runoff but water logging would be a problem. The rock nature of the geology at the intake reduces the amount of top soil that may be affected.

Therefore, the ***intensity*** of the impacts is ***medium*** and ***sensitivity*** of the receptor is rated ***medium*** given the flat nature of the area and its closeness to ecosystems like the Victoria Nile and water transmission line crosses several swamps/ wetlands. Impact significance is ***moderate***.

		Sensitivity of receptor			
		Very low 1	Low 2	Medium 3	High 4
Intensity of impact	Very low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies – construction phase

i) A waste management plan will be developed prior to start of construction activities.

ii) Topsoil and subsoil removed from the site during site preparation will be stored properly (away from runoff and possible contaminants) for reuse elsewhere or for backfilling and reinstatement. Topsoil will be protected through separation from subsoil and storage in a manner that, as far as possible, retains the soil structure and minimises the risk of topsoil loss. For the water pipelines, the trenches will be subsequently backfilled with subsoil, followed by topsoil as soon as possible. In order to prevent loss of fertility and degradation of the seed bank within stored topsoil (where present), the topsoil will be stored for as short a time as possible, allowing for engineering constraints.

iii) Contractor will avoid use of old equipment and damaged equipment that is most likely to have oil leakages thus contaminate the soils and the Contractor will ensure that equipment is properly maintained and fully functional to avoid leakages that may contaminate soils.

iv) During reinstatement, the trench back-fill material will be compacted to a level similar to the original surrounding soils to avoid subsidence as a consequence of rain water channelling.

v) Recreation of a stable landform that mirrors the pre-disturbed condition (e.g. contours, shape, level of compaction, etc.) as this will minimise the risk of preferential erosion and therefore facilitate natural revegetation.

vi) Upon completion of subsoil and topsoil reinstatement, disturbed areas will be inspected jointly by the construction contractor and NWSC personnel for stability, relief, topographic diversity, acceptable surface water drainage capabilities, and compaction.

vii) All waste generated during site preparation and construction will be transported to an authorized disposal area. The contractor will seek guidance from the respective District Local Government of the respective project areas on the final disposal point.

viii) Waste shall not be taken out of the Site without a Waste Manifest.

ix) A Spill kit will be maintained onsite to clean-up any accidental spills.

x) Retention ditch will be provided such that runoff from the project site does not go directly into the Victoria Nile. It will only be released after quality assessment to ensure that it meets the national discharge standards.

Mitigation strategies – operation phase

i) Cut-off drain will be provided around the waterworks to avoid intrusion of storm water and stormwater within the water works will be guided away from chemical storage areas using cut-off drains around them.

ii) Staff operating the plant will be trained/ sensitised on proper management of screenings, sludge, etc., to avoid soil contamination.

iii) Periodic tests will be done to assure the quality of effluent and treated sludge meets the national effluent discharge standards (see sub-section 4.4.2).

Adoption of the above mitigation measures will reduce impact intensity to “very low” resulting in a residual impact of minor significance.

8.3.2 Pollution of Water Resources

During construction activities, the principal potential contaminants associated with the construction activities include: sediments, fuels and lubricating oils; domestic wastes; welding wastes; paints and solvents; and hydro-testing chemicals if used (for example, biocides, oxygen scavengers and corrosion inhibitors), etc.

With a work-force of about 1000 employees, the contribution of wastewater and waste will be significant. Large populations of workers generate increased amounts of waste, for which no sufficient local waste management capacities may exist, which would likely lead to improper disposal practices. Project-related activities, along with workers’ camps, and a lack of appropriate wastewater discharges may pollute nearby water resources, for example, Victoria Nile. Major health risks can occur if latrine pits spill over into local streams that are used for drinking water by the host community.

Oils and greases contain hydrocarbons and/or heavy metals such as lead, chromium and cadmium, which are known drinking water pollutants. Increased water runoff and erosion from various work sites could potentially result in siltation of water courses, that is, the Victoria Nile and several swamps along the Karuma – Gulu Highway.

Dredging activities during construction of the intake would also lead to contamination of the Victoria Nile waters. The inlet area in front of the intake structure has trapezoid foot print of about 800 m^2 that will be stabilized and covered by a layer of rough gravel, diameter 100 to 600 mm, thickness => 0.50 m with remove of any cohesive soil.

During construction, there may also be need to stockpile assorted materials on site. There is a potential pollution risk if construction materials are not stored or handled responsibly such as to lead to stockpiles wash away.

The sewage/ excreta produced by the construction personnel have a high potential of contaminating water resources if not properly handled. Transportation of pollutants with runoff would affect the water quality hence the communities/ livestock depending on it. General wastes may have the same effect if not handled properly.

During the operation phase, the treated effluent from the press filter and sludge conditioning basins will be discharge in to the Victoria Nile and if this is not well treated, there is a potential to pollute the Nile water.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	√
Water Transmission and distribution systems	√	

Impact significance: The likelihood of the impact occurring is high. The duration of the impact will generally be short-term during construction but long-term during operation. The extent of the impact will be local for the water pipelines but regional for pollutants arising from the operation of the water treatment plant given that River Nile traverses a number of regions and countries.

a) Construction phase

The ***intensity*** of the impact is assessed as ***low*** given the short term duration of construction activities and the dilution impact made by the greater River Nile In addition, NWSC will procure an experienced contractor for the construction activities. The ***sensitivity*** of the receptor is ***high*** given the number of users who depend on the River Nile as a source of livelihood. This results in a ***moderate*** impact significance.

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor

	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies

i) All construction equipment will be kept in good operating condition to avoid oil or fuel leakages that might contaminate water resources. Poorly maintained machinery will not be allowed to operate on site. All routine maintenance of construction machinery and vehicles shall be carried out in a designated workshop / maintenance area with concrete hard standing surface and drainage to an oil interceptor.

ii) Workers' camp and associated facilities will be connected to septic tank or other wastewater systems which are appropriate and of sufficient capacity for the number of workers and local conditions. The facilities for this purpose will be inspected regularly to ensure proper functioning. Camp site selection shall involve several factors, including; the size and conditions of the site and availability of resources; the safety, security and protection it offers and cultural and social considerations. Choosing a site shall involve consideration of access, coexistence with surrounding communities, topography, trees and vegetation, the potential impact on the environment, environmental causes of disease and other public health issues. The Contractor shall conduct the necessary environmental and social assessments according to national and World Bank Environment and Social Safeguards Policies and acquire approvals from NEMA and the supervising engineer prior to establishment of new camp sites.

iii) Stockpile areas for materials such as sand, gravel, stone, laterite, lime and topsoil, as well as overburden dumps will be located away from water courses and will be surrounded by perimeter or cut-off drains with sediment and other pollutant traps located at drain exits. Cut-off drains will be maintained throughout the subsequent operation phase;

iv) All hazardous wastes including material soiled with hazardous wastes and empty containers of hazardous materials shall be stored in a designated area on site for regular removal and disposal by a registered contractor in accordance with the National Environment (Waste Management) Regulations, 1999. All other wastes generated during site preparation and construction will be transported by the contractor or a company that has been specifically contracted to an authorized disposal area.

v) Fuel handling and oil spill measures will be implemented to prevent, control and address spill or leaks. Fuel storage and dispensing on site shall not be allowed. Fuel and oil handling will be assigned to trained personnel and procedures for fuel storage, operation of mobile fuel tankers and refuelling areas will be well defined. Impermeable sheets, spill mats, and drip trays will also be provided in the appropriate areas to curb fuel and oil leakage to the ground. This will be done at designated places at the contractor's camp and in accordance with relevant standards set by the Energy Regulation Board and Uganda Bureau of Standards.

vi) Construction activities will largely be carried out during the dry season to avoid sediment transport to the nearby land, water courses and roads;

vii) Any cleaning and hydrotest water which could cause contamination of surface (or ground) waters will be tested and treated as necessary prior to discharge, including debris and sediment removal.

viii) NWSC will ensure the contractor complies with its environmental management policies, ESIA recommendations and national regulations.

ix) In open waters, especially during construction of the intake, plastic curtains will beused to contain and confine resuspension of bottom silt to minimize turbidity in surrounding and downstream areas, using longer support spans and restricting construction to dry weather where possible.

b) Operation phase

The ***intensity*** of the impact is assessed as ***low*** given the waste from operations of the plant will be pre-treated before disposal to the environment and the operator NWSC has a vast experience in managing such waste streams. The discharge of effluent containing relatively high levels of chlorine, especially, when calcium hypochlorite is used as an oxidant or disinfectant, can affect aquatic life in the Victoria Nile. The ***sensitivity*** of the receptor is ***low*** given the dilution effect of the River Nile. This results in a ***minor*** impact significance.

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		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies

i) Monthly quality tests for effluent and receiving water resources (the Victoria Nile) will be done to ensure that the quality of effluent meets the national discharge standards or requirements.

ii) Vehicles and machinery/ equipment will be maintained, repaired and refuelled at an offsite garage/workshop.

Adoption of the above mitigation measures will reduce impact intensity to "Very low" level resulting in a residual impact of minor significance.

8.3.3 Improper Management of Waste

During construction, waste will be generated, including vegetation stripped from site, soil excavated from foundation sites, packaging waste (cement bags, paper, polythene sheets, and wood pallets), metal scrap, wire cuttings, wooden planks, polyethene sheets, PET water bottles, empty paint and solvent containers and waste oil from construction equipment or vehicles. Some of the waste materials such as paints, cement, adhesives and cleaning solvents contain hazardous substances, while some including metal cuttings and plastic containers are not biodegradable and can have long-term and cumulative effects on the environment. Other wastes which will be generated by non-construction activities because of the presence of the workers, for example, during construction there will be about 1000 workers all contributing to wastes like food debris, contaminated water from washing, exreta, wastewater, cleaning equipment, tools and vehicles. Inappropriate disposal of waste or spoil could have medium or long-term environmental and public health impact. Improper managing of these wastes could result in:

- Littering, health and safety risks associated with uncontrolled public access to disposal sites;
- Impairment of local air quality and increased health risks due to open burning of wastes; and
- Contamination of soil, air, surface water (in this case the Victoria Nile located adjacent to the Water Treatment Plant site) and impact on public health when hazardous waste is improperly disposed of.

Operation of the water treatment plant (WTP) will generate relatively large quantities of sludge that provoke negative impact on all media (soil, groundwater, surface water, etc.).

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	√
Water Transmission and distribution systems	√	

a) Construction phase

Impact significance: The ***sensitivity*** of receptors is assessed as ***'high'*** given that some sites for the proposed intake and the WTP are located close to the bank of River Nile while the water transmission line traverses a number of swamps, some of which are used for fishing. The impact intensity is assigned ***'low'*** rating resulting in a ***moderate*** impact significance.

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies-Construction phase

i) The Contractor will be required to prepare a Waste Management Plan that will ensure that:

- The wastes are properly segregated and separated to encourage recycling of some useful waste materials, that is, some excavated material can be used as backfills.
- Solid waste storage bins and/or skips are provided at contractor's sites and at the construction sites and ensure they are collected or emptied in time. Depending on the rate of accumulation, waste collection is made at least once in 24 hours and done in such a way to minimize nuisance of smell and dust during collection.
- Hazardous wastes such as paints, cement, adhesives are managed through a third party contractor certified by NEMA.

ii) The contractor and NWSC Area Management will work hand in hand the respective Local governments to facilitate sound waste handling and disposal from the site. All wastes must be taken to the approved dumpsites.

iii) Proof of delivery and safe disposal of waste will be provided and records maintained at all times.

iv) The contractor will provide his own facilities (e.g. mobile toilets) which should be adequate at construction sites.

v) Workers' camp and associated facilities will be connected to septic tank or other wastewater systems which are appropriate and of sufficient capacity for the number of workers and local conditions. The facilities for this purpose will be inspected regularly to ensure proper functioning.

Adoption of the above mitigation measures will reduce impact intensity to "very low" resulting in a residual impact of minor significance.

b) Operation phase

Impact significance: The ***sensitivity*** of receptors is assessed as ***low*** given that the water treatment and supply facilities will be enclosed off and waste managed like in other NWSC areas. The impact intensity is assigned ***low*** rating resulting in a ***minor*** impact significance.

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies

i) NWSC will ensure adequate operation and management of the facilities to avoid improper management of waste;

ii) NWSC together with the respective District Local Governments at the growth centres will ensure that the solid waste is collected by a firm licensed by NEMA and that the collected waste is disposed of at dumpsite or landfill approved by NEMA; and

iii) Adequate bins will be provided to prevent access by vermin at the WTP.

Adoption of the above mitigation measures will reduce impact intensity to "very low" resulting in a residual impact of minor significance.

8.3.4 Disturbance or Destruction of Archaeological / Cultural Heritage

There are currently no known archaeological sites within the immediate vicinity of the proposed project area. However, some of the areas, for example, the proposed reservoir site at Custom's Corner, within contain other community assets such as grave yards (see sub-section 6.6).

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	
Water Transmission and distribution systems	√	

Significance of impact: Owing to the importance of and sentiments attached to burial sites, the ***sensitivity*** of the receptors is considered to be ***'high'***. The impact ***intensity*** is considered to be ***high*** given that the grave yard at the proposed reservoir site will be affected and there will be need to relocate the graves resulting in a ***major*** impact significance.

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies:

i) A 'chance find' procedure (Appendix F) will guide actions to be taken in the event that suspected archaeological artefacts or paleontological items are encountered and they should be handed over to Ministry of trade and industry- Department of Museums and Monuments.

ii) Construction works will be designed to ensure no damage to any cultural sites or medicinal plants that may be encountered. Where such sites cannot be avoided, culturally appropriate measures will be agreed and implemented prior to the construction activities.

iii) Compensation of the affected sites will be undertaken before construction activities commence in accordance with World Bank and KFW requirements.

The above measures will reduce the impact intensity to 'very low' and the resulting impact severity is minor.

8.3.5 Introduction of Invasive Species

The introduction of invasive species, for example on vehicle tyres, in the imported construction materials such as murram, could degrade habitats and crops since invasive species such as Lantana Camara can spread quickly. Several invasive species of plants were encountered along the project area and these included *Mimosa pigra, Senna spectabilis, Imperata cylindrica* and *Ricinus communis.* These were mainly at the peripheral of swamps along the Karuma – Gulu Highway. This impact could mainly occur during the construction phase.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	
Water Transmission and distribution systems	√	

Significance of impact: Invasive species can affect the species diversity of the project area especially at the proposed site for the water treatment plant and intake given their location in the vicinity of Victoria Nile ecosystem making the ***sensitivity*** of the receptor site to be ***medium***. A '***medium***' ***intensity*** of impact is expected since the number of vehicles for the construction phase is expected to be relatively high and ferrying materials from various locations. This thus results in a ***moderate*** impact significance.

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies:

i) Vehicles and equipment entering and leaving the project area will be inspected and cleaned to remove invasive species.

ii) When invasive species are encountered, they will be removed and destroyed, for example, by burning.

Application of the above mitigation measures will reduce the impact intensity to 'very low' resulting in a minor severity.

8.3.6 Deterioration of Landscape and Visual Quality

Sourcing earth materials which are used for construction works such as murram and gravel can pose considerable visual and socio-environmental impact if quarry pits are not properly managed or restored. Water impounded in derelict borrow pits forms a breeding ground for mosquitoes or other disease vectors, posing health risks to local communities which is a negative but reversible impact. In addition, there will be change in the land use at the proposed water treatment plant and intake sites hence a change in the visual quality.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	√
Water Transmission and distribution systems	√	√

Significance of impact: The potential impact receptors are assigned a ***medium sensitivity***, given that a similar project, Karuma HPP is already being implemented in the same project locality. Since the scale of the activities is short term and limited in extent, the ***intensity*** of impact is considered to be **'low'**. The impact significance is assessed as ***moderate***.

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies – construction phase:

Murram, gravel, sand and any subsoil required will be obtained by contractor in accordance with the following contractual requirements:

i) Murram and subsoil will be obtained preferentially from a licensed source and in accordance with any terms of the license. "Licensed" means approved by NEMA or the respective Project District Local Governments. The contractor will provide a copy of the license to NWSC before the beginning of works at the murram/subsoil extraction location.
ii) If no suitable licensed source of murram/subsoil is available in the area and the contractor plans to obtain the material from a private landowner, then the contractor will:

- Provide NWSC with a copy of the written agreement between the contractor and the owner of the murram/subsoil source in advance of the beginning of works at the location. The identity of the landowner will be certified by a certificate of ownership or a paper signed by the LC1 Chairperson and/ or Head of Clan;
- Engage and consult any households and/or communities in close proximity to the identified murram/topsoil source and provide evidence of these consultations to NWSC;
- Ensure adequate compensation on mutually agreed terms is made to people who are either physically or economically displaced by the activities of the contractor. The contractor will provide documentation of the compensation terms (minutes of consultation meetings, signed agreements with affected persons, compensation receipts etc.) to NWSC;
- Assess health and safety risks linked to murram/subsoil extraction and transport, and implement appropriate mitigation measures. The risk assessment will be provided to NWSC ahead of the beginning of works; and

- Provide a restoration plan for review, and ensure that the actions of the restoration plan are implemented to the satisfaction of concerned authorities. Sign-off from the relevant authorities will be required and copies of the sign-off will be provided to NWSC.

iii) Surface water run-off will be controlled during earthworks. Surface water features down-slope of the earthworks will be identified, and the necessary berms and drainage channels will be installed to ensure that run-off does not collect or pond in excavated areas or quarries.
iv) Restoration of borrow pits to as close to pre-project conditions as possible will be done immediately after use in cases where they are specifically opened up for this project. Native vegetation must be used for re-seeding the excavated site.
v) The contractor will exercise prompt and effective response to environmental and social issues raised by supervision engineer.
vi) There will be close monitoring of impact on natural resources with enforcement of contract or legislative options.

The above will be captured in a murram/ subsoil extraction plan, which will be provided by the contractor prior to the start of works. Following approval of the plan, NWSC will monitor the contractor's extraction sites and operations throughout the project.

Mitigation strategies – operation phase: The sorroundings of the water treatment plant and intake will be planted with native trees to reduce on the visual blight in the area.

The above measures will reduce the impact intensity to 'very low' and the resulting impact significance to minor.

8.3.7 Loss and Degradation of Natural Habitats

Most of the habitats the project is anticipated to traverse are already transformed. However, there are wetlands some of which are still natural while others are degraded (sub-section 6.3.1). Irrespective of the degradation levels, wetlands are vital ecosystems for both amphibious and aquatic organisms they have to be given due protection from vandalism. Some of the wetlands are used for fishing activities as indicated under sub-section 6.3.2. Fish species *Labeo victorianus* and *Oreochromis esculentus* are critically endangered species identified in Minakulu, Ogada, Myene and Alek swamps along the Karuma – Gulu Highway. There were two tree species along the transmission line project area that fall under the IUCN list of threatened species *Khaya anthotheca* and *Milicia excelsa* which are vulnerable (VU) and Near Threatened (NT) respectively worldwide (IUCN 2018).

Given the transmission pipeline will be mainly laid in the road reserve, there will be minimal vegetation clearance and encroachment on wetlands/ swamps during construction activities especially during excavation of land. This is expected to cause minimal disturbance since almost all natural vegetation were converted into farm land. Loss of a few trees may occur along all the routes during pipeline construction especially in Opaka Central Forest Reserve. Most of the proposed pipeline route passes through mixed patches of post cultivated areas, woodlots, and agricultural gardens.

The standard construction procedure to for pedestals (pipe supports) in wetlands (swamps) is as follows

i) Based on the Engineers route and alignment, the Contractor undertakes a confirmatory survey to set out the actual pipeline route.
ii) Once this has been approved by the Engineer, the Contractor pinpoints (identifies) the exact locations for the pedestals.
iii) These locations are excavated and filled with hardcore until settlement ceases.
iv) Formwork (in the shape of a square or rectangle) is placed above the hardcore.
v) Depending on the degree of upward seepage, a moderately dry or wet lean concrete mix is placed above the hardcore and within the confines of the hardcore and left to set for about a day. This acts as the blinding for the base steel reinforcement.
vi) Once approved by the Engineer – reinforcement works for the pedestal base and column are undertaken until the pedestal is ready to receive the pipe.

Note: Two (2) pipe supports (pedestals) are normally adopted for a 6-metre length of a pipe because the risk of bending is at the ends of the pipe.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	
Water Transmission and distribution systems	√	

Impact significance: Impact ***intensity*** is considered ***medium*** since the pipeline will mainly be laid in the road reserve although there are swamps with critically endangered and vulnerable fish species, the road will not encroach on a alrge expanse of the swamps. The trees are also located away from the road reserve. Moreover where natural vegetation exists along the proposed pipeline route, it exists in a post cultivated form except at some swamps. The ***sensitivity*** of the receptor is rated ***medium*** given that most of the areas traversed by the project were already disturbed with human activities resulting in a ***moderate*** impact significance.

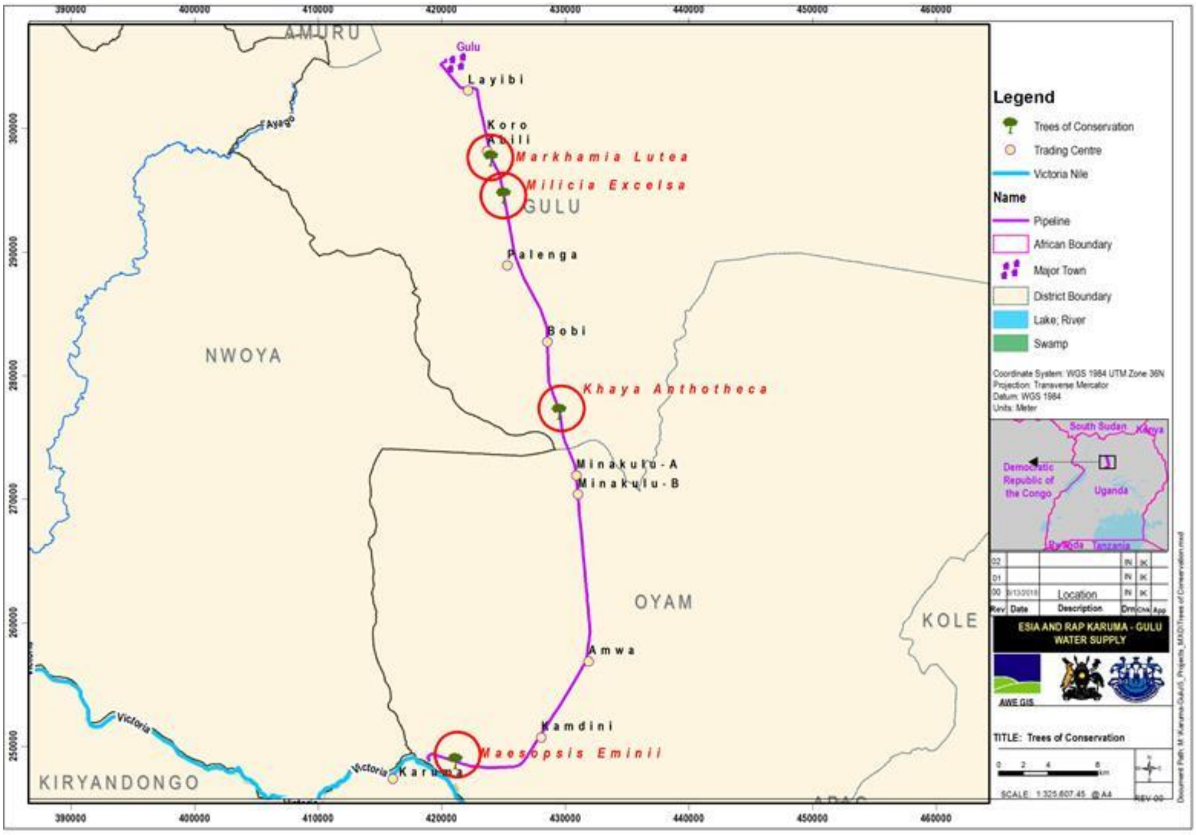

Figure 53 Location of trees that are vulnerable and near-threatened

Wetland	Eastings	Northings	Distance (m)	Number of pedestals assuming 6m-spacing
Start	423104.549	301610.603	111	18
End	423128.718	301502.266		
Start	423729.113	298876.979	145	24
End	423761.312	298735.629		
Start	424592.068	296439.965	156	26
End	424663.977	296301.47		
Start	424805.079	295682.95	77	13
End	424819.145	295607.723		
Start	425145.931	293820.949	147	25
End	425172.679	293676.802		
Start	425835.006	290131.96	183	30
End	425869.12	289951.715		
Start	425869.114	289951.714	177	29
End	425902.646	289777.568		
Start	425903.14	289777.678	124	21
End	425934.556	289657.539		
Start	426350.556	288593.853	143	24
End	426403.327	288461.246		
Start	426927.556	287326.482	265	44
End	427055.964	287094.851		
Start	428331.595	284348.089	178	30

Wetland	Eastings	Northings	Distance (m)	Number of pedestals assuming 6m-spacing
	428334.936	284349.143		
	428337.755	284350.168		
	428391.993	284180.458		
End	428398.86	284182.057		
Start	429258.161	277831.256	47	8
End	429274.516	277786.787		
Start	430244.557	274016.175	588	98
End	430474.956	273474.659		
Start	430923.244	271252.665	386	64
End	430958.196	270868.309		
Start	431068.066	269649.715	277	46
End	431092.938	269373.719		
Start	431220.327	267963.899	172	29
End	431235.757	267793.087		
Start	431379.76	266209.265	386	64
End	431414.839	265824.484		
Start	431609.128	263688.877	922	154
End	431692.891	262771.09		
Start	431844.709	261109.818	572	95
End	431896.795	260539.877		
Start	431905.137	258599.958	57	10
End	431912.466	258655.98		
Start	431761.838	257507.555	307	51
End	431720.264	257203.474		
Start	430063.833	254175.826	469	78
End	430303.68	254578.822		
Start	429412.792	253139.645	294	49
End	429574.866	253385.248		
Start	428593.908	251862.046	204	34
End	428703.54	252034.177		
Start	427659.134	250398.156	334	56
End	427479.336	250116.821		
Start	418898.427	248875.974	153	26
	419087.324	249435.752		
	422427.122	248399.394		
End	422579.06	248380.643		
Total distance			**6874**	**1146**

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies

i) Construction activities should be restricted only to the areas that must be disturbed to avoid unnecessary disturbance. Destruction of trees in Opaka Central Forest reserve along the Karuma – Gulu Highway will be avoided as much as possible.

ii) All project workers should be sensitized to minimize damage to vegetation and flora and strictly prohibited from fishing activities within Minakulu, Ogada, Myene and Alek swamps.

iii) Close monitoring and supervision of the construction operations to ensure compliance and avoid causing further damage to undesignated project areas.

iv) Where tree cutting is inevitable, replacement planting should be done wherever feasible. No trees of protected species *(Milicia excelsa woodlot at 36N 424999E 294543N and Khaya anthotheca woodlot at 36N 429530E 277069N*) will be cut. Any trees specie to be cut will need to be replaced in public lands in the project area. The project will implement a restoration program that can be implemented in the wetlands, rivers, riparian areas. Liason with UNRA shall also me made such that any tree restoration along the transmission line sections that shall be located in the road reserve is done jointly with UNRA.

v) The use of cut wood as fuel will be prohibited in the camp. Instead, all camps will use propane or electricity for cooking.

Ensure the waterflow direction is not obstructed when pipeline is installed especially in the areas where the critically endangered fish species were recorded *(in Minakulu, Ogada, Myene and Alek swamps).* This will ensure that their movement routes are not destroyed and if they are potamodrometic that they can continue ttheir movements towards the main river. This will be done by planning for working in waters to protect fish eggs, spawning adults, organisms upon which they feed by maintaining an undisturbed vegetation buffer zone and preventing soil compaction in such areas.

Spawning season of *Labeo victorianus* is synchronized with rainfall seasons and *Oreochromis esculentus spawns throughout the year but the* probability of spawning is triggered by the rains, with the time of maximum spawning activity coinciding with the wettest months of the year. Minakulu, Ogada, Myene and Alek swamps are located in the Northern region of Uganda and according to the National Meteorological Authority; The average amount of annual precipitation in Northern Uganda is 999.9 mm (39.37 in) a lot of rain (rainy season) falls in the months: April, May, June, July, August, September and October in the Districts; Gulu and Oyam. On average, **Augus**t is the wettest month and January is the driest month. In order to protect the spawning period of *Labeo victorianus* and *Oreochromis esculentus* species of fish; the contractor shall ensure that there are no active works

crossing Minakulu, Ogada, Myene and Alek swamps in the month of August during the construction period.
NWSC shall ensure that the dimensions of the undisturbed vegetation buffer zone are maintained to avoid destruction of the fish habitat and a fish monitoring exercise prior, during and post pipeline construction to ascertain that their breeding patterns and migration routes are not interfered with shall be undertaken.

8.3.8 Risk of Seismic Activity

The site is located on a fairly stable geological unit. However, numerous faults exist within the country and tremors due to earthquakes do occur. The site area is located within the shield area, but only approximately 50 – 100 km from the western rift and about 70 km south of the Aswa Fault Zone. It is therefore susceptible to the potential effect of major tectonic features of regional scale. The site is in the main, located in Zone 2 of the Seismic Zoning of Uganda, implying a moderate/ medium risk (Figure 38).

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	√
Water Transmission and distribution systems	√	√

Impact significance: The intensity of the impact will be ***medium*** given the location of the project area. The sensisity of the receptors is rated ***medium***. Therefore significance is predicted to be ***moderate***.

		Sensitivity of receptor			
		Very low **1**	**Low** **2**	**Medium** **3**	**High** **4**
Intensity of impact	**Very low** **1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low **2**	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium **3**	3 Minor	6 Moderate	9 Moderate	12 Major
	High **4**	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies:

i) The structures should be designed to exhibit some amount of ductility to tolerate dynamic loads generated from seismic activity. Reinforced concrete structures are recommended for such purposes. Pre-stressed concrete structures are also useful, but do not perform as well as reinforced concrete under earthquake conditions.

ii) Appropriate design codes have been followed to reduce risks of damage to health and property.

Implementation of the above mitigation strategies will reduce the impact intensity to low hence a moderate impact significance.

8.3.9 Impacts of Karuma HPP

The impacts from the dam would mainly arise from failure or break of the dam, sediment transport and backwater curve after commission and during operation of the dam. However, failure of the dam would to a large extent affect the downstream part. The powerhouse intake and tailrace gates have been designed in such away that in case of complete break of the dam and the water levels drop below the minimum of 1028 m, the intake gates are shut automatically. Regarding sediment transport, this was found found to minimal at the Karuma area (See sub-section 2.4) and measures have been put in place at the proposed project intake that would minimise impacts from sediments. However, commissioning of the Karuma HPP before construction of the intake would its construction more difficult and costly. This would create a reservoir and backwater flow which would mean working in deeper water during construction activities.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	√
Water Transmission and distribution systems	√	√

Impact significance: The likelihood of this impact occurring is high if commissioning of the Karuma HPP is done before construction of the intake. Impact intensity is ***low*** since intervention measures have been inbuilt inn the HPP and the qualified contractor with experience to construct in deep waters would be hired. Sensitivity of receptors is ***medium*** because temporatry shut down of water supply would affect a number of activities. Therefore significance is ***moderate***.

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies:

i) Where possible, NWSC should ensure that construction works of the intake are completed before commissioning of the Karuma HPP.
ii) Measures will be instituted at the intake to ensure that when the water levels approach the minimum of 1028 m, the pumps switch themselves off automatically.

8.4 NEGATIVE SOCIAL IMPACTS

8.4.1 Risk of Traffic Accidents

The water transmission pipeline and some distribution lines will have to be laid across existing roads (Figure 37). The transmission line will cross the existing road at three points. The trenches created for the pipe crossing can lead to accidents if proper signage is not put in place. Vehicles and trucks transporting construction materials to the site may result in risk of traffic-related accidents, especially when the safe speed limits are not adhered to. Most of the water transmission pipeline will be laid within the road reserves that traverse several public and private facilities with a significant number of school going children and traders along the Karuma – Gulu Highway (Figure 54). In addition to materials, delivery of supplies for construction workers and the transportation of workers can also lead to an increase in traffic and rise in accidents. The rise in traffic would also be an additional burden on the transportation infrastructure.

Figure 54 Access road to the proposed water treatment plant site and water intake adjoining the Karuma – Gulu Highway

Construction traffic accidents would be a significant social impact and likely to affect children, women, disabled, elderly people and livestock. The duration of the risk will be short-term occurring only during the construction phase. Although some effects of the accidents (e.g. minor injuries) may be reversible, some, for example, loss of human life are irreversible.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	
Water Transmission and distribution systems	√	

Impact significance: The receptor sensitivity is ***high*** given that there are a number of pedestrians and commercial activities along the roads while the intensity is ***medium*** given the temporary nature of the construction activities, however, some of the impacts like loss of life or damage to body may be irreversible. The impact significance is thus assessed to be ***major***.

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies

i) The contractor will prepare and implement a traffic management plan to be approved by supervision engineer.

ii) Contractor will adopt best transport safety practices (Journey Management Plans (JMPs)) with the goal of preventing traffic accidents and minimizing injuries suffered by project personnel and the public by: employing safe traffic control measures, including road signs and flagmen/traffic guides to warn of dangerous conditions and children crossings; and setting speed limits on all access roads in the project area and towns/ trading centres will be 40km/h for light vehicles and 30km/h for heavy vehicles; and not more than 80 km/h on the Karuma – Gulu Highway. Through the JMPs, optimum routes from material storage areas to the construction sites will be identified to avoid sensitive receptors such as schools and hospitals. Key elements of the JMP include:

- Strict speed control;
- Advance sensitization of communities;
- Defensive driving training;
- Use of vehicle tracking systems (VTS);
- Identification of sensitive areas where reduced speed limits will be imposed (e.g. near schools, communities)

- Procedures for transport of fuels and chemicals like equipping vehicles with fire extinguishers and fire fighting equipment;
- Training of all staff on site in EHS techniques.
- No work will be undertaken unless the required personal protective equipment (PPE) has been provided and is being worn;
- Timing of vehicle movements;
- Respect for other road users, particularly pedestrians and cyclists (vehicles will stop and allow their safe passage);

iii) The Contractor shall provide dedicated site entrances and exits for personnel, which shall be manned 24 hours per day, 7 days per week including holidays.

iv) Some roads in Gulu Municipality were recently surfaced and other are being surface under the Uganda Support to Municipality Infrastructure Development (USMID) Project. NWSC should contact Gulu Municipality early enough and request for service ducts to be installed at points where water mains will cross roads to avoid cutting through roads that have just been upgraded.

v) The Contractor will have a community liaison Officer (CLO) to get feedback/complaints from communities regarding activities of the project and issues the communities think are not being done in a proper manner. The CLO would also be responsible for informing project-affected communities of the timing and duration of the construction activities across access roads and any uncertainties or potential for change.

vi) All workers, including sub-contractors and casual labour, will undergo an environmental, health and safety induction before commencing work on site. This will include a full briefing on site safety and rules.

vii) Restrictions on hours of driving (including night time restrictions where sensitive receptors may be affected) and timing of vehicle movements will be emphasized to avoid busy periods in urban areas, particularly the start and end of school and the working day.

viii) No drivers or personnel under the influence of alcohol or any drug abuse will be allowed onsite.

ix) The water treatment plant and intake sites will be fenced and signalization put in place with security personnel to stop unauthorised people from accessing the site.

x) The contractor will hire drivers trained in defensive driving and all drivers will be trained in road and safety.

xi) Strict adherence to safety measures and procedures are required to minimise (or eliminate) risks of accidents or hazardous developments occurring and ensure healthy and safe conditions for all persons working on the site and the project-affected communities. To ensure occupational health and safety on construction sites, the Contractor shall be obliged to comply with all applicable Ugandan construction Health and Safety Standards as required by the Occupational Safety and Health Act of 2006. These include provisions of the Factories Act, Labour Unions Act and Workman's Compensation Act.

xii) Materials will be preferentially sourced locally to minimize transport distances.

Adoption of the above mitigation measures will reduce impact intensity to "very low" resulting in a residual impact of minor significance.

8.4.2 Unsustainable Use of Resources

Use of natural resources has impacts including depletion of non-renewable resources (in the case of fuels, murram, sand, etc) or depletion of renewable resources if used at an unsustainable rate (which may be the case in the case of water). This is one of the projects that will require extraction of murram and abstraction of water from the River Nile. The increased demand and use of resources will have a cumulative effect on the resources. To ensure that the project water needs are balanced with those of the existing or potential users, a water abstraction permit will be sought from DWRM.

In addition, with a workforce of about 1000 people, there will be increased demands on the ecosystem and natural resources. The presence of construction workers and service providers can generate additional demand for the provision of public services, such as water, electricity, medical services, transport, education and social services. This is particularly the case when the influx of workers is not accommodated by additional or separate supply systems. A significant increase in demand for goods and services due to labor influx may lead to local price hikes and/or crowding out of community consumers.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	√
Water Transmission and distribution systems	√	

Impact significance: The concept of sustainable resource use means that use of the resources today should take into consideration the needs of future generations. Depletion of non-renewable resources is negative and irreversible while depletion of renewable resources may be short to long-term but reversible. The amount of murram, sand and gravel that will be required is small given the project size. Impact receptors are assigned a '***medium***' **sensitivity**. Considering that temporal scale of project activities is short-term and of limited spatial extent, the impact **intensity** is considered to be ***'low'*** resulting into moderate impact significance.

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies – Construction Phase

i) Through inductions and tool box meetings, the contractor will ensure that staff and contractors are conversant with resource conservation practices in all project activities. Conservation awareness will focus on water use efficiency and general day-to-day measures such as turning engines and air conditioning units off when machinery and offices or dwelling quarters are not in use.

ii) The Contractor will acquire water abstraction permits with conditions to guide the amount of water to be abstracted as stipulated in the Water Supply Regulations (1999). Water abstraction will comply with rates allowed by the DWRM permit that will be obtained.

iii) Earth materials will be sourced from a NEMA-approved source in a manner that reduces environmental and social impacts. Murram will be sourced in accordance with a NWSC approved murram/ subsoil extraction plan, which will be provided by the contractor prior to the start of works.

iv) Any new borrow pits established by the project and would not be used later, shall be restored to as close to pre-project conditions as possible immediately after use. Native vegetation must be used for re-seeding the excavated site.

v) The Contractor and NWSC will acquire water abstraction permits with conditions to guide the amount of water to be abstracted as stipulated in the Water Supply Regulations (1999).

vi) The contractor's Worker Code will include clauses of conduct on water and electricity consumption.

Mitigation strategies - operation phase

i) Catchment management plans are being developed with the aim of conserving and allowing recharge of water resources.

ii) Water conservation measures will be encouraged: saving water is an efficient way of reducing the overuse of ground water resources. It does not only decrease the amount of the water withdrawn, but may also reduce the threat of pollution.

iii) NWSC should adhere to the stipulated limits in the water abstraction permit obtained from DWRM throughout the project life.

Adoption of the above mitigation measures will reduce impact intensity to "very low" resulting in a residual impact of minor significance.

8.4.3 Damage to Existing Public Infrastructure

The non-hard surface roads in the communities around the proposed project area are reportedly difficult to travel in some places during the rainy season. The water transmission pipeline and some distribution lines will have to be laid across existing roads). The transmission line will cross the existing road at three points and railway at one point, that is:

- At the southern start near the water treatment plant to reach its intended alignment along the right edge of the road reserve from Karuma towards Gulu (sub-section 8.3.8);
- Near the Petrol Station crossing Sira Dongo Road, Gulu Municipality;
- Near the existing Customs Corner Tank crossing Arua-Gulu Road; and
- At the railway crossing in Gulu along Sira Dongo Road.

The damage to existing public roads could be due to considerable volume of construction traffic using the existing roads and passage of heavy construction equipment such as excavators, graders and murram trucks which may exacerbate erosion of the road surface.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	
Water Transmission and distribution systems	√	

Significance of impact: Since the duration of the impacts is short- term the ***intensity*** of the impacts is considered to be '***medium***'. The receptor ***sensitivity*** is considered to be '***high***' in terms of deterioration given the vulnerability of such roads and access routes for the communities to and around the proposed project area and given the some of the roads in Gulu Municipality and the Karuma – Gulu Highway have just been resurfaced. The impact significance is therefore ***major***.

Photo 55: State of one of the community roads after a heavy rain

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies:

i) Trucks ferrying materials will be loaded commensurate with the recommended axle load for a given road to avoid or minimize damage.
ii) Locally sourced materials will be used, whenever possible, to minimize travel distances and expanse of road damaged.

iii) Special permission will have to be sought from Uganda National Roads Authority (UNRA) and Gulu District Local Government before activities at road crossing are carried out. A typical drawing for a road / highway crossing is presented in drawing WS_CD_9_4_02 in Appendix J. Similarly permission from Uganda Railways Authority will be sought for the railway crossing at Sira Dongo Road.
iv) The trenchless technology will be used at the road and railway crossing to avoid damaging them.

These project-specific mitigation measures will reduce the intensity of impacts at the project level to a 'very low', resulting in a minor impact severity.

8.4.4 Social Misdemour of Workers

Workers have adverse impacts on the project communities such as increased demand and competition for local social and health services, as well as for goods and services, which can lead to price hikes and crowding out of local consumers, increased demands on the ecosystem and natural resources, social conflicts within and between communities, increased risk of spread of communicable diseases, and increased rates of illicit behavior and crime. While most workers may originate from the local community where they have families, there might be others from distant places and working away from their families, for example about 200 workers will be foreigners and of the remaining 800 workers, not all of them will originate from the project area.

The influx of people may bring communicable diseases to the project area, including sexually transmitted diseases (STDs), or the incoming workers may be exposed to diseases to which they have low resistance. This can result in an additional burden on local health resources. Workers with health concerns relating to substance abuse, mental issues or STDs may not wish to visit the project's medical facility and instead go anonymously to local medical providers, thereby placing further stress on local resources. Local health and rescue facilities may also be overwhelmed and/or ill-equipped to address the industrial accidents that can occur in a large construction site. With some disposable income to spend, this might induce illicit sexual relationships, with attendant risk for spread of HIV/AIDS. Irresponsible sexual relationships in project communities can break families and heighten risk of contracting HIV/AIDS. Illicit sexual relationships can be short-term but have long-term and irreversible effects if HIV were contracted.

Conflicts may arise between the local community and the construction workers, which may be related to religious, cultural or ethnic differences, or based on competition for local resources. Tensions may also arise between different groups within the labour force, and pre-existing conflicts in the local community may be exacerbated. Ethnic and regional conflicts may be aggravated if workers from one group are moving into the territory of the other. Given the number of incoming workers out the 1000 workers anticipated and their engagement with the host community, the composition of the local community, and with it the community dynamics, may change significantly. Pre-existing social conflict may intensify as a result of such changes.

The influx of workers and service providers into communities may increase the rate of crimes and/or a perception of insecurity by the local community. Such illicit behavior or crimes can include theft, physical assaults, substance abuse, prostitution and human trafficking. Local law enforcement may not be sufficiently equipped to deal with the temporary increase in local population.

Such adverse impacts are usually amplified by local-level low capacity to manage and absorb the incoming labour force, and specifically when civil works are carried out in, or near, vulnerable communities and in other high-risk situations.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	
Water Transmission and distribution systems	√	

Impact significance: Duration of the impact will be short-term or long-term depending on whether HIV/AIDS is contracted and the extent of the impact will be local or national depending on origin of construction workers. The likelihood of the impact occurring is low if contractor adequately sensitise workers about responsible and safe behaviour. The ***intensity*** of the impact is ***medium*** given the size of the workforce and that similar construction activities like Karuma HPP, the Gulu Water Supply and Sanitation Project and USMID project are already taking place in the area but in the towns enroute it may slightly differ but the duration is small. ***Sensitivity*** of the receptor is rated ***high*** given that HIV/AIDS, if contracted, is a long-term effect. Therefore significance of the impact is ***major***.

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies – construction phase

i) The contractor will be required to develop a Labor Influx Management Plan and/or a Workers' Camp Management Plan. These will include sanctions for workers involved in criminal activities.
ii) As a contractual obligation, contractors shall be required to have an HIV/AIDS policy and a framework (responsible staff, action plan, etc.) to implement during project execution.
iii) All construction workers shall be orientated and sensitized about responsible sexual behaviour in project communities.
iv) The contractors will develop and follow a code of conduct. The information regarding Worker Code of Conduct will be provided in local language(s). An example is provided in Appendix G
v) The contractor will reduce labor influx by tapping into the local workforce. Depending on the size and the skill level of the local workforce, a share of the workers required for the project may be recruited locally. The local labour if trained could be employed afterwards for the operation and maintenance of the new infrastructure. The recruitment criteria should be transparent and fair to local communities to avoid conflicts.

vi) The contractor will conduct cultural sensitization training for workers regarding engagement with local community.
vii) The contractor will endeavour to provide entertainment and events for workers within camp to reduce incentives for mixing with local community.
viii) Workers will be encouraged to get vaccinated against common and locally prevalent diseases;
ix) The contractor, where need arises, will engage an HIV service provider to be available on-site who should conduct campaigns on STDs among the workers and local community; educate workers and the community about the transmission of diseases; and implement HIV/AIDS education program and provision of condoms.

8.4.5 Gender-based Violence

Construction workers are predominantly younger people. Those who are away from home on the construction job are typically separated from their family and act outside their normal sphere of social control. This can lead to inappropriate and criminal behavior, such as sexual harassment of women and girls, exploitative sexual relations, and illicit sexual relations with minors from the local community. A large influx of male labour may also lead to an increase in exploitative sexual relationships and human trafficking whereby women and girls are forced into sex work. This may be execarbated in the rural areas where the presence of law enforcement is often low; the risk of sexual harassment for local women is likely higher, in particular for younger women and girls, but also boys.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	
Water Transmission and distribution systems	√	

Impact significance: Duration of the impact will be short-term or long-term depending on the nature of violence inflicted. The likelihood of the impact occurring is low if contractor adequately sensitise workers about responsible and safe behaviour. The ***intensity*** of the impact is ***medium*** given the size of the workforce and that similar construction activities like Karuma HPP, the Gulu Water Supply and Sanitation Project and USMID project are already taking place in the area. However, in the towns enroute, the impact may slightly differ but the duration is small. ***Sensitivity*** of the receptor is rated ***high*** regardless the nature of violence some of which may not be bodily harm but may leave the affected person pyscologically tortured. Therefore significance of the impact is ***major***.

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major

	High **4**	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies

i) The contractor will conduct mandatory and repeated training and awareness raising for the workforce about refraining from unacceptable conduct toward local community members, specifically women;
ii) Workers will be informed about national laws and funder's policies that make sexual harassment and gender-based violence a punishable offence which is prosecuted;
iii) Worker Code of Conduct will be part of the employment contract, and including sanctions for non-compliance (for example, termination);
iv) The contractor, where a case arises, will cooperate with law enforcement agencies in investigating complaints about gender-based violence.

8.4.6 Child Labour and School Dropout

Increased opportunities for the host community to sell goods and services to the incoming workers can lead to child labour to produce and deliver these goods and services, which in turn can lead to enhanced school dropout.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	
Water Transmission and distribution systems	√	

Impact significance: Duration of the impact will be short-term but can result in long-term impacts for school drop depending on the days children are not in school. The likelihood of the impact occurring is low given that there are similar project and commercial activities with no or minimal involvement of children. The ***intensity*** of the impact is ***low*** given the size of the workforce and that similar construction activities like Karuma HPP, the Gulu Water Supply and Sanitation Project and USMID project are already taking place in the area. ***Sensitivity*** of the receptor is rated ***high*** given that the impacts would affect the child's future. Therefore significance of the impact is ***major***.

		Sensitivity of receptor			
		Very low **1**	**Low** **2**	**Medium** **3**	**High** **4**
Intensity of impact	**Very low** **1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low **2**	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium **3**	3 Minor	6 Moderate	9 Moderate	12 Major
	High **4**	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies

i) The contractor and NWSC will ensure that children and minors are not employed directly or indirectly on the project.

The contractor will communicate the hiring criteria, minimum age and applicable laws (for example, Children Act, Cap 59) in his ESMP.

8.4.7 Permanent Land-take

Construction of the water treatment plant and associated facilities, water transmission and distribution system will to certain extents involve taking of land permanently from the original owners. In addition, affected people will loose not only access to land but also property on the land.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	
Water Transmission and distribution systems	√	

Impact significance: The likelihood of this impact occurring is high because land will be lost to the different project components, for example, the water treatment pland and reservoirs. Impact intensity is ***low*** since most of the said land is not under intensive agricultural activities and the water pipelines will mainly lie in the road reserve. Sensitivity of receptors is ***medium*** because apart from graves that will be relocated, most of it was not under intensive agricultural use. Therefore significance is ***moderate***.

		Sensitivity of receptor			
		Very low 1	Low 2	Medium 3	High 4
Intensity of impact	Very low 1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies:

i) NWSC will ensure that the project-affected persons identified through the Resettlement Action Plan study of the project are compensated for the land and property on it in time and fairly.

ii) Land will be acquired in accordance with the Resettlement Action Plan developed for the project based on Uganda's Land Access and Compensation Procedure and World Bank's Safeguard requirements (OP/BP 4.12), which requires amongst others:

- Sensitization of community members whose property will be affected.
- Completion of a full inventory of privately registered and/cultivated, grazed or other uses of the property that will be taken for the project as well as structures and graves within the road reserves.
- Compensation to be paid in line with mandated rates agreed in consultation with the respective Project District Officials' before commencement of construction activities.
- Ensuring that the Chief Government Valuer approves the valuation rates.

Adoption of the above mitigation strategies will lower the impact intensity to "very low" rate resulting in a *minor* significance.

8.4.8 Occupational Health and Safety (OHS) Risks

Construction traffic, excavation machinery, rock blasting, working in water and trenches may pose accident risk to workers either when equipment is operated by inexperienced workers or when in a poor mechanical condition or falls into the trenches/ deep waters. Inadequate OHS risks or problems could also result from insufficient medical capability at the construction site; or neglect of safety equipment, precautions and procedures.

During operation and maintenance of the water treatment and supply facilities, occupational health and safety problems will arise. Workers at the facilities might experience negative health impacts, particularly during operation of deep water treatment units like clarifiers, filters and poor operation of the chemical equipment like chlorine gas or calcium hypochlorite powder. Fatal falls, suffocation and injury while working in confined places. Other causes of OHS problem include but not limited to:

- Lifting of heavy and sharp objects;
- Poor transportation of materials for maintenance;
- Improper storage as well as handling and use of dangerous substances/ chemicals;

- Inadequate lighting and ventilation in workplaces;
- Lack of adequate training (or neglect of safety precautions/ guidelines) in use of equipment and tools;
- Misuse of equipment and materials for functions they are not designed;
- Lack of safety signage in specific areas;
- Electrical hazard;
- Eye hazards such as splashes;
- Lack of adequate PPE; and
- Biological hazards (vermin, mosquitos, pathogens, etc.).

Figure 55 Proposed location of the intake at the northern bank of the Victoria Nile

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	√
Water Transmission and distribution systems	√	√

Impact significance: Accidents could cause considerable ecological damage, financial loss and harm to human life. While largely reversible, some impacts such as loss of human life and body injury are irreversible. The receptor ***sensitivity*** is considered ***medium*** given that although such impacts may be irreversible once they occur; the workers have done similar work and have knowledge on how to avoid such incidences. The impact ***intensity*** is considered to be ***high*** even if NWSC procures a qualified contractor who is aware of OHS measures but workers do not follow OHS requirements and NWSC will be incharge of operating the facilities for which it has vast experience. Nevertheless, this gives rise to an impact of ***major*** significance.

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies

i) A qualified Health and Safety Officer will be recruited by the Contractor to oversee OHS matters on a daily basis.

ii) All construction workers will be oriented on safe work practices and guidelines and ensure that they adhere to them.

iii) Appropriate signage will be used to warn staff and/ or visitors that are not involved in construction and operation activities in dangerous places.

iv) Regular drills will be constantly followed on various possible incidences. This will test the response of the involved stakeholders. Such drills will keep them alert and they will become more responsive in case of incidences.

v) Training will be conducted on how to prevent and manage incidences. This should involve proper handling of electricity, water etc. and sensitization on various modes of escape, conduct and responsibility during such incidences. All must fully be aware and mentally prepared for potential emergency.

vi) Personnel will only undertake tasks for which they are trained/ qualified. A formal 'permit to work' system will be in place and strict instructions will be given for operators of equipment.

vii) Strict instructions will be given to drivers of heavy equipment and operators of equipment/ machinery. Ensure electrical safety at fabrication workshops by putting in place secure electrical connections and providing adequate insulation. All temporary electrical installations in use on site such as generators and welding sets should be adequately and effectively earthed at all times during operation.

viii) Supervision of works will be done regularly (daily during construction and weekly during operation) to ensure that safety conditions are met while any deviation from safety regulations is immediately reclaimed following the best practices regarding safety at work.

ix) Clear communication line will be ensured between workers and operators/ drivers of heavy equipment.

x) Evacuation procedures to handle emergency situations will be developed. A van should be dedicated to this purpose during and throughout construction activities.

xi) Adequate OHS personnel protective gear will be provided to the employees. The guide below should be useful:

Hearing (Over 80 Decibels for 8 hours a day requires hearing protection)

- Ear Muffs: One size fits all, comfortable, less ear infection risk
- Ear Plugs: Small, lightweight, can get dirty and cause infection

Face/Eye (Working with any chemical or using any mechanical equipment)

- Face Shield: Protect face from splashing and particles
- Safety Glasses: Protection from solids (cutting, sanding, grinding)
- Safety Goggles: Protects eyes from splashing

Hand (Use correct gloves for the job)

- Chemical Gloves: (Nitrile, Latex, PVC)
- Gloves for other use: special gloves for cutting, burning, abrasions/ blisters

Body

- Overalls: Can protect against dust, vapours, splashes

Foot Protection

- If electrical hazard present ensure boots offer protection
- Safety Toe/Steel Toe Boots: Always worn when potential for falling hazards exists
- Water/Chemical Resistant Boots: Use in a spill situation
- Non-slip boots for working on wet/slippery floors.

Working in water

- Water rescue apparel
- Water proof cardboard element
- Life jackets

xii) Strict adherence to safety measures and procedures are required to minimise (or eliminate) risks of accidents or hazardous developments occurring and ensure healthy and safe conditions for all persons working on the site. To ensure occupational health and safety on construction sites, the Contractor shall be obliged to comply with all applicable Ugandan construction Health and Safety Standards as required by the Occupational Safety and Health Act of 2006. These include provisions of the Factories Act, Labour Unions Act and Workman's Compensation Act.

xiii) First aid box will be available at all active construction sites and at accessible locations at the water treatment plant during the operation phase.

xiv) An Accident Log will be maintained onsite to register all injuries and to investigate their causes during both the construction and operation phases of the project.

xv) Emergency resources (e.g., fire extinguishers, stocked First Aid kits, Emergency Contacts, Doctor on Call, etc.) will be maintained at all active construction sites and at the water treatment facilities during operation.

xvi) The Contractor shall ensure that all areas requiring access including platforms, under platforms, underpasses, excavations, etc. have enough illumination.

xvii) Excavations and rock blasting activities will be undertaken under strict guidance to avoid chances of collapse and injury, respectively.

xviii) The manufacturer's instructions and Material Safety Data Sheets (MSDS) shall be followed for the storage of all chemicals used in water treatment. Storage must conform to compatibility restrictions.

xix) All construction workers will be oriented on safe work practices and guidelines especially regarding work in confined spaces and it will be ensured that they adhere to them.

xx) The Contractor shall provide a signal man, barricades and safety sign boards around the excavations.

xxi) Routine maintenance (removal of garbage, removal of screenings and grit, slashing around the embankments, repair of damages to the fence, etc.).

xxii) Regular fumigation of the WTP will be undertaken to kill disease vectors such as mosquitoes.

xxiii) The PPEs shall be provided at no cost to workforce and shall be replaced once in three months. Any damaged/lost PPEs shall be replaced with no cost to workforce. Visitors/officials to work sites are to be provided with PPEs (hard hats and safety shoes) and shall be briefed ongoing operations on that specific time and related safety requirement at work site including safe distances to keep during the site visit.

xxiv) Work force shall be subjected only to standard work shifts/hours. Overtime allowances, if applicable/warranted shall be paid with ceiling limits. Working beyond such ceiling limits shall be discouraged, even if, so desired workforce or contractor

Adoption of the above mitigation measures will reduce impact intensity to “very low” resulting in a residual impact of minor significance.

8.5 CUMMULATIVE NEGATIVE IMPACTS

Cumulative effects manifest when socio-environmental conditions are already or will be affected by past or on-going infrastructure development projects or activities. In the case of the Karuma - Gulu Water Supply Project, there is Karuma HPP already on-going at Karuma, USMID project and the Gulu Water Supply and Sanitation Project in Gulu Municipality. The cumulative impacts that would arise from all these projects include air and noise pollution, increased traffic within the municipality and Karuma – Gulu Highway.

8.5.1 Disruption to Traffic Flow and Communication Routes

The installation of transmission line along the Karuma – Gulu Highway and other crossing points as highlighted under sub-section 8.3.3 will result in additional considerable and unavoidable delays to traffic flows especially along the Karuma – Gulu Highway. At the present time, and until the contractor has developed a detailed programme of work, the exact timing and duration of delays, the overall impact upon the community is difficult to assess. The impact upon vehicular movement will generally be confined to increased journey time and the costs associated with delays, which in the majority of cases will only be of minor inconvenience. Effective traffic management will be key in determining the severity of impacts. In addition, laying of water pipes will result in the temporary loss of access as work progresses past individual property entrances.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	
Water Transmission and distribution systems	√	

Impact significance: Duration of the impact will generally be short-term and the extent of the impact will be local. The ***intensity*** of the impact is ***low*** given that the road network in the municipality is well planned and has interconnections in most parts of the project area. ***Sensitivity*** of the receptor is rated ***low***. Therefore significance of the impact is ***minor***.

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies

i) The trenchless technology will be used at major crossings like roads to avoid disruption of traffic flow.
ii) Appropriate signage will be used and impacted owners will be informed ahead of disruption.
iii) Disruptions to public access shall be identified in the Contractor's Traffic Management Plan, under which suitable notice of intending delays and closures are given to all concerned parties and approved prior to commencing work. All road closures shall be separately notified and agreed with the Municipality administration.
iv) Where access to or from an individual property is closed for a period of 2 hours or more, the owner shall be informed at least 24 hours in advance.
v) Vehicular access to and from hospitals, police stations, and other public institutions shall be maintained through the use of steel road plates over open trenches. Pedestrian access to schools, health facilities, and other premises frequently accessed by the public will be maintained with the use of walking boards.

vi) The laying of pipelines, backfilling and temporary reinstatement shall follow trench excavation as quickly as possible and trenches will not be left open for extended periods.

8.5.2 Air Pollution

The most significant issues that could potentially impact on air quality and climate during construction are combustion gas emissions and nuisance dust. During the construction phase there will be an increase in road traffic associated with material and equipment haulage. The principal sources of combustion gases are the exhausts of vehicles and construction equipment. The potential impacts are nuisance to people in the area, coverage of crops (possibly leading to reduced yields) and deposition on natural vegetation and fauna who feed on the vegetaion.

This impact will occur mainly during the construction phase. Due to the temporary nature of construction, dust emissions are not anticipated to have a long-term impact on local air quality. Dust nuisance will decline as stripped areas of land re-vegetate. Ambient air quality measurements (Table 47) indicate that the environment around the project area is currently devoid of sources of high noise and air pollution.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	
Water Transmission and distribution systems	√	

Impact significance: The manageability of the impact is high since typical impacts are well understood in conventional infrastructure construction industry and the ability to adapt to the impact is high because construction activities have been going on in the project area especially at the Karuma HPP. Due to the intermittent and short-term nature of the activities, the ***intensity*** of impact is assessed as ***low*** and ***sensitivity*** of the receptors as ***low***. The impact significance is therefore ***minor***.

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies:

i) Construction work will be undertaken by an experienced and duly registered contractor with a verifiable sense of environmental awareness and responsibility;

ii) Travel speeds of construction vehicles along the road especially at trading/ business centres will be controlled and should not exceed 50 km/h on the highway and 40 km/h off the highway;

iii) Trucks will be covered during haulage of construction materials to reduce on spillage of materials and wherever dust suppression is necessary, water will be sprayed over dusty areas;

iv) Workers will be provided with PPE and the use of PPE shall be enforced;

v) All surfaced roads shall be subject to road cleaning and un-surfaced roads to dust suppression, the methodology and frequency of which shall be included in the Contractor's Traffic Management Plan;

vi) Stockpiles of friable material will be grassed in order to prevent wind erosion;

vii) A maintenance programme for equipment and vehicles will be implemented, to ensure air emissions like particulates, SO_2 and NO_2 are minimised.

Adoption of the above mitigation measures will reduce impact intensity to "very low" resulting in a residual impact of minor significance.

8.5.3 Generation of Noise and Vibrations

Generation of noise will mainly occur during the construction phase. This is a cumulative impact because activities from ongoing projects like Karuma HPP are producing some levels of noise arising from constructionactivities and workers. The use of heavy equipment including bulldozers, graders and dump trucks during site preparation and transportation of materials will generate noise and vibrations. The proposed site of the intake and water treatment is partly rock and will involve blasting of rock.

Operation of heavy equipment, drilling and any blasting activities on sites may contribute to increase in the noise level of the area. Certain amount of ground vibration is anticipated due to blasting and fly rocks that may fall on the vicinity of fields nearby the project site area.

Traffic associated with the construction activities will be routed via the Karuma – Gulu Highway with some minor roads used for access to the construction sites and some new access roads will be created. The levels of noise generated will depend on the type and condition of equipment employed by the contractor; and the number of employees at a particular site, in addition to the time of the day during which construction activities are taking place. However, the noise levels at most of the proposed project areas are relatively higher than the level of 55 dBA required by the standards for mixed residential and commercial areas (See Table 49).

Table 84: Institutions close to the transmission line route and reservoirs

Institute	
Bobi Health Centre III (N428086.2, E284815.65)	St Thomas O.T.T Primary School (N428498.25, E280335.42)
Bobi Sub-county (N428512.54, E282704.61)	Ministry of Energy Offices (N421542.49, E248677.74)
Koro Abili C.O.U Primary School (N423536.66, E299479.75)	St. Peter Paul Catholic Church (N428598.34, E280554.22)
MTN Mast (N423534.44, E299676.99)	St. Joseph Catholic Church (N429801.34, E276378.46)

Minakulu Primary School (N430713.94, E272720.91)	Jeroline School (N425855.36, E289522.13)
St Baptist Church (N422771.5, E303450.33)	Adel Primary School (N431255.18, E270057.49)
St Thomas More Primary School- Minakulu (N423038.87, E302369.94)	

From measurement data in Table 49, baseline vibration levels ranged between 0.3-1.4 mm/s. which according to BS 5228-2:2009 might be just perceptible in residential environments. Depending on equipment used and soil characteristics, ground vibration levels from compaction can span a wide range from 0.4 mm/s PPV to a maximum of 11.0 mm/s PPV. There is often expectation that the softer soils would produce higher amplitude vibrations but this is not always the case. Also contrary to expectation, there is usually no significant correlation between weight of compaction equipment and resulting ground vibration level. For instance in one case a heavy 33 tonne static roller induced a low ground vibration level of only 0.7 mm/s PPV.

	Project phase when impact will occur	
Project Component (↓)	Construction	Operation
Water intake and treatment plant	√	√
Water Transmission and distribution systems	√	

Impact significance: Given that most of the proposed project site is located in relatively noisy areas. The receptor ***sensitivity*** is considered to be '***low***'. The ***intensity*** of impact is assessed as ***low*** resulting into a ***minor*** impact significance.

		Sensitivity of receptor			
		Very low 1	**Low 2**	**Medium 3**	**High 4**
Intensity of impact	**Very low 1**	1 Negligible	2 Minor	3 Minor	4 Minor
	Low 2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium 3	3 Minor	6 Moderate	9 Moderate	12 Major
	High 4	4 Minor	8 Moderate	12 Major	16 Major

Mitigation strategies:

i) Contractor will be careful when selecting the working equipment to avoid use of old equipment or damaged equipment with high level of noise emissions that would have a negative impact on the environment. Contractor will ensure that equipment is properly maintained and fully functional. Servicing of all construction vehicles and machinery will be done regularly and during routine servicing operations, the effectiveness of silencing equipment (e.g. exhaust silencers) will be checked and if found defective will be replaced.

ii) The Contractor shall develop a Blasting Management Plan in case there are any blasting activities to be done during construction.

iii) Construction workers will be made aware of the permissible noise levels at the workplace and surrounding environment, and be advised to limit verbal noise or other forms of noise. For example, metallic objects or tools can be passed on to a colleague rather than dropping or throwing them with loud bangs. Construction truck drivers will be required to switch off vehicle engines while offloading materials. According to National Environment (Noise Standards and Control) Regulations, 2003; noise levels at construction sites should not exceed 60 dBA and 50 dBA during the day and night, respectively.

iv) All generators and heavy duty equipment will be insulated or placed in enclosures to minimize disrupting ambient noise levels. Pumps, generators and other mobile equipment will be sited as far as practicable from housing and other noise sensitive locations. Regular maintenance, monitoring and, where necessary, the use of silencing equipment will be employed with the aim of reducing noise emissions.

v) The contractor will submit detailed information on the noise levels which will be generated by the specific methods and equipment proposed and the actions that will be taken to minimise the noise impact. Equipment shall be operated within their specifications and capacity (for example, avoid overloading machines).

vi) During periods of inactivity, equipment will be switched off whenever possible. Where appropriate, residents living in the vicinity of where construction activities are taking place will be kept informed of the contractor's proposed working schedule (through implementation of the Community Liaison Management Plan) and will be advised on the times and duration of any abnormally noisy activity likely to cause concern.

vii) Project vehicles will have a restricted speed limit of 40 km/h through settlements and trading centres to minimise noise.

viii) No construction activities will take place at night for sites where the closest residence and institutions (for example schools, hospitals) is within less than 150 m from the project site, the operations on site shall be restricted to the hours 6.00 -22.00

ix) Construction activities in the identified sensitive areas as indicated in Table 84 shall be scheduled during weekends, stockpiling supplies and materials shall also be done during noncritical times to minimize transport noise. The maximum allowed noise level should be 45dBA for night and 55dBA for evening and day. Measurement of noise level should be performed before the start up with the working activities and during work peaks (of particular importance when project activities take place in the immediate vicinity of the primary school). Restriction or suspension of pipe laying activities during critical times (such as school exam or test times) shall be abided to.

x) The noise due to blasting operation lasts for a very short period. Primary blasting shall be carried out with adequate preventive measures to control the noise to the permissible limits. Consideration for the nearest habitation shall be at a distance of 500 m from the site boundary. Before blasting is undertaken all the relevant permissions shall be obtained from the Ministry of Internal Affairs Uganda.

xi) Sequential timer blast machine or other approved methods shall be used for primary blasting and there shall be no secondary blasting. The boulders shall be broken using a hydraulic rock breaker. Proper maintenance of the noise generating parts of the machines shall be undertaken. Air silencers of suitable type that can modulate the noise of the engines of machinery can shall also be put in use and maintained effectively.

xii) Ear muffs shall be given to all the workers operating or working close to any machine and full PPE for any persons participating in blasting activities. Periodical monitoring of noise levels and blast vibrations will be practiced and the contract shall ensure that the necessary noise/vibration meters for taking measurements are available.

xiii) The contractor shall also use control measures like wet drilling to avoiding blasting during high wind speed and development of green belt within the safety barrier of the specific project site and shall ensure that there is no impact of blasting activity in the surrounding area.

9 ENVIRONMENTAL AND SOCIAL MANAGEMENT & MONITORING PLAN (ESMP)

The environmental and social mitigation & monitoring plans for the proposed project are presented in Tables 85 and 86. The ESMP identifies the potential environmental and social aspects that should be managed and monitored and identifies parties responsible for monitoring actions, associated costs, indicators and training or capacity building needs and reporting. Various aspects of the ESMP are detailed in sections below

9.1 INSTITUTIONAL ARRANGEMENTS

9.1.1 Institutional Structure and Responsibilities

During the construction phase, the parties involved with the ESMP include: the client NWSC with ultimate responsibility for Environmental & Social performance on the project; the Supervising Engineer (with an Environment and Social Specialist on their team) responsible for monitoring and supervising the implementation of the ESMP and contract requirements by the contractor(s); and the the Contractor (with an Environmental Specialist, Social Development Specialist and Health & Safety Specialist) who has responsibility for implementing the ESMP. NWSC will ensure that both the Supervising Engineer and Contractor are doing their jobs effectively and that the ESMP is delivering the necessary environmental and social protection measures.

Therefore, the institutional responsibility of ensuring that this ESMP is implemented will rest with NWSC having a key role of reviewing consultants' reports for compliance with the ESMP, among others. The Project Manager shall have the ultimate responsibility for implementation of ESMP and will therefore ensure that resources are duly provided. Other roles will be:

- Monitoring implementation of mitigation actions by contractors
- Coordinating training and capacity building where planned

NWSC should ensure that all its personnel to be involved in implementation of this ESMP are adequately qualified and will be appointed based on their qualification and suitability for respective roles.Training for the NWSC staff in implementation of the ESMP has been provided for in the ESMP . Supervising Engineer is required to have an Environmental & Social Management Specialist by contractual obligation. The Contractor's Environmental Specialist, Social Development Specialist and Health & Safety Specialist will ensure that the provisions in this ESMP are implemented within the sites under their supervision and to collect and transmit relevant information to the Supervising Engineer.

The construction works will be tendered out as two separate procurements. One for the IDA funded scope of works and another for the KFW funded scope of works. The works may be awarded to two separate contractors or one contractor. In both scenarios, sub-contractors will be required by a condition of their sub-contract with the main contractor to actively manage environmental and social issues associated with their subcontract works and comply fully with all the applicable statutory regulations and the main contractor's environmental and social management plans. The Resident Engineer in consultation with NWSC shall review the main Contractor's ESMP and approve it prior to commencement and implementation of the works. (***Note: sub-contractors shall not develop their own ESMP but shall follow and abide by the main contractor's ESMP***).

The Municipal & District Environmental Officers (DEOs) in the project districts, that is, Gulu, Omoro, Oyam and Kiryandongo, are responsible for overseeing environmental protection on behalf of NEMA. The DEOs within the respective project districts will have monitoring roles during execution of this ESMP in their respective project areas. Usually, these officials lack adequate facilitation so the project will need to provide auxiliary financial assistance for them to have effective participation in this project.

The contractor will be required to prepare ESMPs setting out the measures that they will take to implement the ESIA ESMP during the construction. This requirement also applies to NWSC during the operation phase of the project in their respective areas of operation.

9.1.2 Monitoring and Reporting Arrangements

Monitoring will verify if predicted impacts have actually occurred and check that mitigation actions recommended in the ESIA are implemented and their effectiveness. Monitoring will also identify any unforeseen impacts that might arise from project implementation.

Who monitors and how: Monitoring will be undertaken by NWSC and Environmental Officers from the project districts who represent NEMA at local administrative level. Monitoring by NEMA in this case can be considered "third party monitoring" but this is its regulatory mandate according to Sections 6 and 7 of the National Environment Act (Cap 135).

Another government agency that may undertake "third party monitoring" is the Occupational Health & Safety Department in Ministry of Gender, Labour & Social Development (MGLSD). This unit has authority to inspect any facility for compliance with national requirements on safety in workplaces. The project shall make no funding to MGLSD since this is provided for in its annual budget.

Monitoring will be done through site inspection, review of site records (Accident Log, issuance of PPE, waste records, trainings and inductions, permits and approvals, etc.), review of grievances logged by stakeholders and *ad hoc* discussions with potentially affected persons (construction workers, residents near the project facilities). At each monitoring, a discussion with chairpersons of environment committees of the areas' local councils (LC) could provide insight into views and grievances communities have about the project since they regularly interact with their community members.

Frequency: Monitoring will be undertaken continuously on a daily basis over the construction period.

Audits: Audits will be necessary both during construction and project operation. While construction audits will aim to verify compliance to impact mitigation requirements, post-construction audits are a regulatory requirement within 12 months and not more than 36 months after completion of construction, according to national EIA Regulations, 1998 Section 31(2).

Since construction duration is estimated to be 1½ years, this ESMP has included a budget for **1½ year's** construction audit and a separate provision so that from year 2 to year 5 full environmental audits are done as per Uganda requirements.

Both construction and post-construction audits can be conducted internally (by NWSC) or by a consultant hired by NWSC. If undertaken by a hired consultant, a budget has been proposed for both in this ESMP.

Reporting: Concise monthly monitoring reports should be compiled by the Contractor. The report will highlight the different activities undertaken to manage environmental and social aspects of the project in line with contract specifications, laws, standards, policies, and plans of Uganda and World Bank Safeguard policies. The report will be discussed during the monthly progress meetings. The Supervising Engineer guided by the Environmental and Social Specialist will approve the Contractor's monthly environmental and social monitoring report that will then be transmitted to NWSC for final approval. NWSC's Environmental Management and Social Specialist will also independently monitor the implementation of the ESMP and/or verify the accuracy and content of the Contractor's monitoring report and then report to the client. The report will also be shared with The World Bank, KFW and other relevant stakeholders. Strictly it will be the contractor's compliance with the contract requirements (whether BOQ items or items considered part of other BOQ items) that will enable the Resident Engineer or Supervising Engineer to approve payment.

Construction and post construction phase auditing should culminate in reports that NWSC shall share with World Bank/ KFW, NEMA or other interested stakeholders. Note that while NWSC is under no obligation to disclose construction phase audits, annual post-construction audits must be submitted to NEMA as a regulatory requirement as per Section 31(2) of National EIA Regulations, 1998.

Stakeholder Engagement Plan/Communication Strategy: Given the project's geographical scope, NWSC will develop an engagement plan and communication strategy; and recruit or assign a Communications Specialist to manage their implementation throughout the project cycle.

9.2 GRIEVANCE REDRESS MECHANISM

This section describes avenues for affected persons to lodge a complaint or express a grievance against the project, its staff or contractors during project implementation. It also describes the procedures, roles and responsibilities for addressing grievances and resolving disputes. Every aggrieved person shall be able to trigger this mechanism to quickly resolve their complaints.

The objectives of the grievance process are:

i) Ensure that appropriate and mutually acceptable corrective actions are identified and implemented to address complaints;

ii) Verify that complaints are satisfied with outcomes of corrective actions;

iii) Avoid the need to resort to judicial proceedings.

The grievance mechanism at each project facility will be fed from three main sources:

- Community residents and the respective local leaders;
- Supervising engineer or contractor; and
- Monitoring team who will forward issues/concerns identified in the field.

Steps of the grievance process are described below. A flow chart outlining the main actions and decision points is shown in Figure 56.

Step 1: Receipt of complaint

A verbal or written complaint from a complainant will be received by the Supervising Engineer or Project Office and recorded in a complaints log s(he) keeps on site. The log will indicate grievances, date lodged, action taken to address complaint or reasons the grievance was not acted on; information provided to complainant and date the grievance was closed. Grievances should be lodged at any time, either directly to the Supervising Engineer/ Project Office or through the Local Council Chairperson. The process for lodging a complaint is outlined below:

i) Project Office (Project Engineer, two (2) Sociologists or Community Lialison Officers and one support staff) receives complaint(s) from complainant and records it in log (in English).

ii) Project Office reads the recorded complaint translating it into local language for the complainant to confirm correct detail of complaint has been documented.

iii) Complainant signs the log to confirm grievance was accurately recorded.

Step 2: Determination of corrective action

If in his/her view, a grievance can be solved at this stage, the Project Office will determine a corrective action in consultation with the aggrieved person. Remedial action(s) and timeframe within which they must be accomplished has been described and the party responsible for implementing them will be recorded in the complaint log.

Grievances will be resolved and status reported back to complainants within 5 days. If more time is required this will be communicated clearly and in advance to the aggrieved person. For cases that are not resolved within the stipulated time, detailed investigations will be undertaken and results discussed not more than 1 month from lodging a grievance.

Step 3: Meeting with the complainant

The proposed corrective action and the timeframe in which it is to be implemented will be discussed with the complainant within 5 days of receipt of the grievance. Consent to proceed with the corrective action will be sought from the complainant and witnessed by the respective village local council chairperson (LC Chairman).

Step 4: Implementation of corrective action

Agreed corrective action will be undertaken by the project or its contractor within the agreed timeframe. The date of the completed action will be recorded in the log against the complainant's grievance.

Step 5: Verification of corrective action

To verify satisfaction, the aggrieved person will be asked to return if not satisfied with the corrective action.

Step 6: Action by NWSC and project contractors

If the Project Office cannot solve the grievance, he will refer it to NWSC (and contractor) through the Supervising Engineer. It is believed all possible grievances can be solved at this level. In case, they are not adequately solved to the satisfaction of the complainant, the case could then be referred to the Courts of Law.

The grievance process to be followed is depicted in Figure 56.

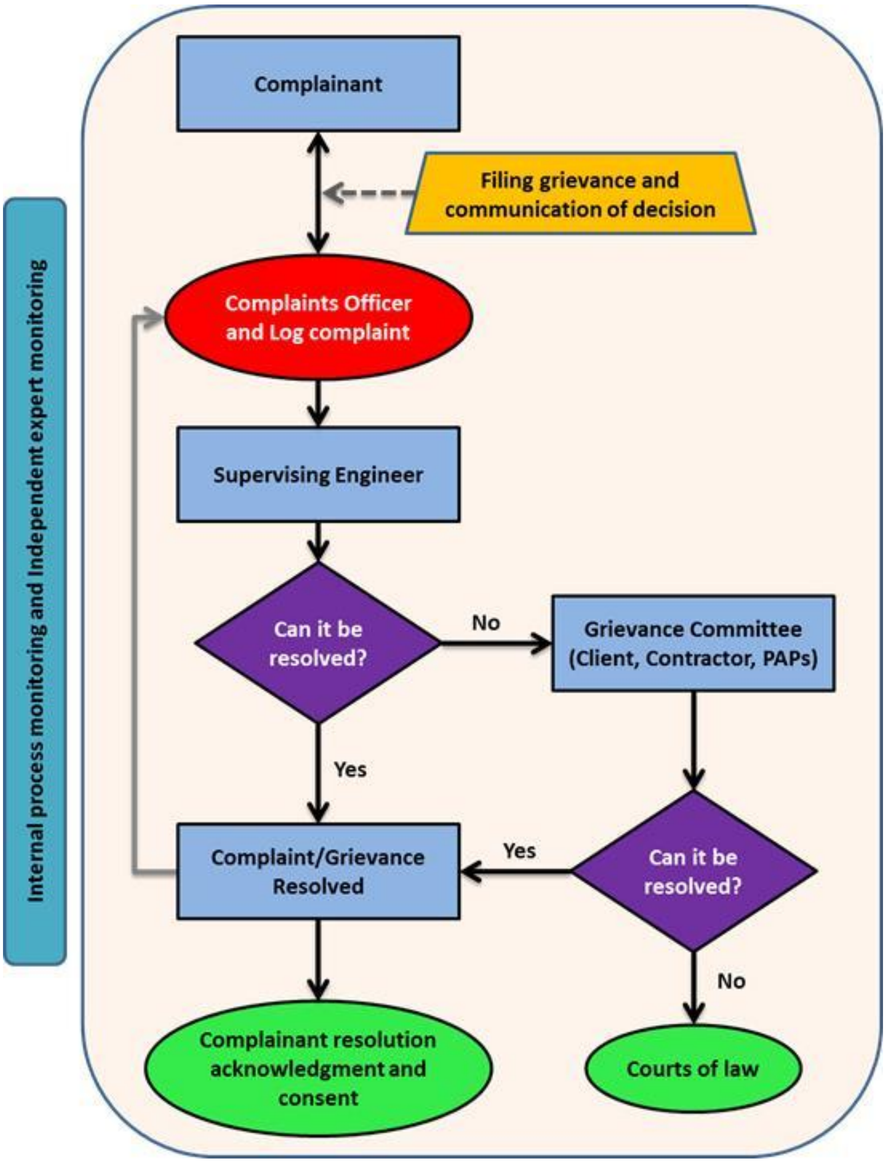

Figure 56 Mechanism for grievance management

Table 85: Environmental and social mitigation plan

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
POSITIVE IMPACTS				
Construction and Operation phase	8.2.1 Income to material/ equipment suppliers and contractors	a) Project will promote local procurement where technically or commercially reasonable and feasible.	Contractor	Embedded in contractor's fees
		b) For earth materials, procurement will be made from legitimate sources to avoid encouraging environmental degradation	Contractor	
	8.2.2 Employment	a) NWSC shall ensure that all personnel to be involved in implementation of this ESMP are adequately qualified. A training programme for the NWSC staff to implement the ESMP shall be facilitated by the project to ensure that staff have the approriiate skills.	NWSC	25,000,000
		b) Unskilled labour will be recruited exclusively from local community, and semi-skilled labour will be recruited preferentially from such communities, provided that they have the requisite qualification, competence and desired experience.	Contractor	
		c) Contractors will be encouraged to pay a "living wage" to all workers.	Contractor	
		d) A training programme for artisans (builders, carpenters, plumbers) in the project area could be facilitated by the project to ensure skills transfer during the construction period.	NWSC/ Contractor	10,000,000
		e) Contractor will develop and implement Labour Influx Management Plan, Workers Camp Management Plan and Code of Conduct. An example of the code of conduct for contractors and sub-contractors is provided in Appendix G.	Contractor	11,100,000
	8.2.3 Infrastructure improvement	The extent to which development becomes a positive or negative impact will be determined by the effectiveness of the planning framework. Such induced developments should be of a type that is desirable and sustainable and for this to happen, all future developments must be undertaken within the framework of proactive government policy and strict planning and environmental enforcement by the responsible Local Government.	Developer	
	8.2.4 Improved Health and Economic Status of Households and Communities	a) Users will be educated on the proper use, regular cleaning and effective maintenance of both the household and public facilities. The communities will be sensitised about proper disposal of wastewater generated as a result of improved water supply and how to use water sparingly with minimal or no wastage	NWSC/ District Local Governments of Project Area	20,000,000
		b) Water tariffs will be set taking into consideration the different levels of users. The users should also be educated to avoid wasteful use of the resources	NWSC/ District Local Governments of Project Area	Within NWSC jurisdiction
NEGATIVE ENVIRONMENTAL IMPACTS				
Construction phase	8.3.1 Degradation of Soils	a) A waste management plan will be developed prior to start of construction activities.	Contractor	11,100,000
		b) Topsoil and subsoil removed from the site during site preparation will be stored properly (away from runoff and possible contaminants) for reuse elsewhere or for backfilling and reinstatement. Topsoil will be protected through separation from subsoil and storage in a manner that, as far as possible, retains the soil structure and minimises the risk of topsoil loss. For the water pipelines, the trenches will be subsequently backfilled with subsoil, followed by topsoil as soon as possible. In order to prevent loss of fertility and degradation of the seed bank within stored topsoil (where present), the topsoil will be stored for as short a time as possible, allowing for engineering constraints.	Contractor	Within contractor's bid budget
		c) Contractor will avoid use of old equipment and damaged equipment that is most likely to have oil leakages thus contaminate the soils and the Contractor will ensure that equipment is properly maintained and fully functional to avoid leakages that may contaminate soils.	Contractor	Within contractor's bid budget
		d) During reinstatement, the trench back-fill material will be compacted to a level similar to the original surrounding soils to avoid subsidence as a consequence of rain water channelling.	Contractor	Within contractor's bid budget
		e) Recreation of a stable landform that mirrors the pre-disturbed condition (e.g. contours, shape, level of compaction, etc.) as this will minimise the risk of preferential erosion and therefore facilitate natural revegetation.	Contractor during construction phase	Within contractor's bid budget
		f) Upon completion of subsoil and topsoil reinstatement, disturbed areas will be inspected jointly by the construction contractor and NWSC personnel for stability, relief, topographic diversity, acceptable surface water drainage capabilities, and compaction.		NWSC Supervisory budget
		g) All waste generated during site preparation and construction will be transported to an authorized disposal area. The contractor will seek guidance from the respective District Local Governments in project area on the final disposal point.	Contractor	To be included in the contractor's bid
		h) Waste shall not be taken out of the Site without a Waste Manifest.	Contractor	

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
		i) A Spill kit will be maintained onsite to clean-up any accidental spills.	Contractor	50,000,000
		j) Retention ditch will be provided such that runoff from the project site does not go directly into the Victoria Nile. It will only be released after quality assessment to ensure that it meets the national discharge standards.	Contractor	3,000,000
Operation phase		a) Cut-off drain will be provided around the waterworks to avoid intrusion of storm water and stormwater within the water works will be guided away from chemical storage areas using cut-off drains around them.	NWSC	7,000,000
		b) Staff operating the plant will be trained/ sensitised on proper management of waste associated with the operation of the water treatment plant to avoid soil contamination.	NWSC	20,000,000
		c) Periodic tests will be done to assure the quality of effluent from filter press or sludge conditioning basins and treated sludge meets the national effluent discharge standards (see sub-section 3.4.2), to avoid partially sludge from reaching the soils.	NWSC	24,000,000
Construction phase	8.3.2 Pollution of water resources	a) All construction equipment will be kept in good operating condition to avoid oil or fuel leakages that might contaminate water resources	Contractor	
		b) Workers' camp and associated facilities will be connected to septic tank or other wastewater systems which are appropriate and of sufficient capacity for the number of workers and local conditions. The facilities for this purpose will be inspected regularly to ensure proper functioning. Camp site selection shall involve several factors, including; the size and conditions of the site and availability of resources; the safety, security and protection it offers and cultural and social considerations. Choosing a site shall involve consideration of access, coexistence with surrounding communities, topography, trees and vegetation, the potential impact on the environment, environmental causes of disease and other public health issues. The Contractor shall conduct the necessary environmental and social assessments according to national and World Bank Environment and Social Safeguards Policies and acquire approvals from NEMA and supervising engineer prior to establishment of new camp sites.		25,000,000
		c) Stockpile areas for materials such as sand, gravel, stone, laterite, lime and topsoil, as well as overburden dumps will be located away from water courses in order not to affect fish spawning and guard against ecosystem destruction. The working areas will be surrounded by perimeter or cut-off drains with sediment and other pollutant traps located at drain exits. Cut-off drains will be maintained throughout the subsequent operation phase	Contractor	-
		d) All hazardous wastes including material soiled with hazardous wastes and empty containers of hazardous materials shall be stored in a designated area on site for regular removal and disposal by a registered contractor in accordance with the National Environment (Waste Management) Regulations, 1999. All other wastes generated during site preparation and construction will be transported by the contractor or a company that has been specifically contracted to an authorized disposal area.	Contractor	15,000,000
		e) Fuel handling and oil spill measures will be implemented to prevent, control and address spill or leaks. Fuel storage and dispensing on site shall not be allowed. Fuel and oil handling will be assigned to trained personnel and procedures for fuel storage, operation of mobile fuel tankers and refuelling areas will be well defined. Impermeable sheets, spill mats, and drip trays will also be provided in the appropriate areas to curb fuel and oil leakage to the ground. This will be done at designated places at the contractor's camp and in accordance with relevant standards set by the Energy Regulation Board and Uganda Bureau of Standards.	Contractor	10,000,000
		f) Construction activities will largely be carried out during the dry season to avoid sediment transport to the nearby land, water courses and roads	Contractor	-
		g) Any cleaning and hydrotest water which could cause contamination of surface (or ground) waters will be tested and treated as necessary prior to discharge, including debris and sediment removal.	Contractor	5,000,000
		h) NWSC will ensure the contractor complies with its environmental management policies, ESIA recommendations and national regulations	NWSC	-
		i) In open waters, especially during construction of the intake, plastic curtains will be used to contain and confine resuspension of bottom silt to minimize turbidity in surrounding and downstream areas, using longer support spans and restricting construction to dry weather where possible.	Contractor	Within Contractor's bid budget
		j) The contractor shall ensure that appropriate monitoring of the water quality is done during the construction phase to prevent contamination of the Nile water when construction activities are being undertaken (both upstream and downstream the intake should be monitored and monthly reports produced)	Contractor	Within Contractor's bid budget

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
Operation phase		a) NWSC will ensure that there is no discharge of effluent from the onsite sanitation facilities. All septic tanks shall be emptied oftenly by licencsed emptiers. Disposal shall be made at the appropriate NWSC waste water treatment plants located in Gulu. Daily/monthly quality tests shall also be undertaken to monitor the changes in the quality of raw water abstracted from the Nile overtime.	NWSC	Part of NWSC's operation's budget
		b) NWSC shall ensure that it adheres to the specific conditions issued by the Directorate of Water Resources Management (DWRM) to ensure that the integrity of the water quality is maintained in line with the water abstraction permit issued to NWSC. For example, prevention of damage to the water source, ensuring that no activities on the land where the water is used results in accumulation of any substances that may render water less fit for use, efficiently using the water and making annual payment for use of the water.		
		c) Vehicles and machinery/ equipment will be maintained, repaired and refuelled at an offsite garage/workshop.	NWSC	Part of NWSC's operation's budget
Construction phase	8.3.3 Improper management of waste	a) The Contractor will be required to prepare a Waste Management Plan.	Contractor	15,000,000
		b) The contractor and NWSC Area Management will work hand in hand with the respective Local governments to facilitate sound waste handling and disposal from the site. All wastes must be taken to the approved dumpsites.	Contractor	100,000,000
		c) Proof of delivery and safe disposal of waste will be provided and records maintained at all times.		-
		d) The contractor will provide his own facilities (e.g. mobile toilets) which should be adequate at construction sites.	Contractor	6,000,000
		e) Workers' camp and associated facilities will be connected to septic tank or other wastewater systems which are appropriate and of sufficient capacity for the number of workers and local conditions. The facilities for this purpose will be inspected regularly to ensure proper functioning. Camp site selection shall involve several factors, including; the size and conditions of the site and availability of resources; the safety, security and protection it offers and cultural and social considerations. Choosing a site shall involve consideration of access, coexistence with surrounding communities, topography, trees and vegetation, the potential impact on the environment, environmental causes of disease and other public health issues.		Covered in 8.3.1
Operation phase		a) Adequate operation and management of the facilities will ensured to avoid improper management of waste and solid waste is collected by a firm licensed by NEMA and that the collected waste is disposed of at dumpsite or landfill approved by NEMA	NWSC	10,000,000
		b) NWSC together with the respective District Local Governments at the growth centres will ensure that the solid waste is collected by a firm licensed by NEMA and that the collected waste is disposed of at dumpsite or landfill approved by NEMA	NWSC	
		c) Adequate bins will be provided to prevent access by vermin at the WTP	NWSC	5,000,000
Construction phase	8.3.4 Disturbance or Destruction of Archaeological / Cultural Heritage	a) A 'chance find' procedure will be put in place to determine actions to be taken in the event that suspected archaeological artefacts or paleontological items are encountered and they should be handed over to Ministry of trade and industry- Department of Museums and Monuments.	Contractor	2,000,000
		b) Construction works will be designed to ensure no damage to any cultural sites or medicinal plants that may be encountered. Where such sites cannot be avoided, culturally appropriate measures will be agreed and implemented prior to the construction activities.		
		c) Compensation of the affected sites, especially the affected grave yards, will be undertaken before construction activities commence in accordance with World Bank and KFW requirements.	NWSC	To be determined in the RAP
Construction phase	8.3.5 Introduction of invasive species	a) Vehicles and equipment entering and leaving the project area will be inspected and cleaned to remove invasive species.	Contractor	-
		b) When invasive species are encountered, they will be removed and destroyed, for example, by burning.	Contractor	-
Construction phase	8.3.6 Deterioration of landscape and visual quality	a) Murram and subsoil will be obtained preferentially from a licensed source and in accordance with any terms of the license. "Licensed" means approved by NEMA or the respective Project District Local Governments. The contractor will provide a copy of the license to NWSC before the beginning of works at the murram/subsoil extraction location.	Contractor	Contractor's bid budget
		b) If no suitable licensed source of murram/subsoil is available in the area and the contractor plans to obtain the material from a private landowner, then the contractor will:	Contractor	

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
		▪ Provide NWSC with a copy of the written agreement between the contractor and the owner of the murram/subsoil source in advance of the beginning of works at the location. The identity of the landowner will be certified by a certificate of ownership or a paper signed by the LC1 Chairperson and/ or Head of Clan; ▪ Engage and consult any households and/or communities in close proximity to the identified murram/topsoil source and provide evidence of these consultations to NWSC; ▪ Ensure adequate compensation on mutually agreed terms is made to people who are either physically or economically displaced by the activities of the contractor. The contractor will provide documentation of the compensation terms (minutes of consultation meetings, signed agreements with affected persons, compensation receipts etc.) to NWSC; ▪ Assess health and safety risks linked to murram/subsoil extraction and transport, and implement appropriate mitigation measures. The risk assessment will be provided to NWSC ahead of the beginning of works; and ▪ Provide a restoration plan for review, and ensure that the actions of the restoration plan are implemented to the satisfaction of concerned authorities. Sign-off from the relevant authorities will be required and copies of the sign-off will be provided to NWSC.		
		c) Surface water run-off will be controlled during earthworks. Surface water features down-slope of the earthworks will be identified, and the necessary berms and drainage channels will be installed to ensure that run-off does not collect or pond in excavated areas or quarries.	Contractor	
		d) Restoration of borrow pits to as close to pre-project conditions as possible will be done immediately after use in cases where they are specifically opened up for this project. Native vegetation must be used for re-seeding the excavated site.	Contractor	
		e) The contractor will exercise prompt and effective response to environmental and social issues raised by supervision engineer.	Contractor	
		f) There will be close monitoring of impact on natural resources with enforcement of contract or legislative options.	DLGs/ NWSC	10,000,000
Construction phase	8.3.7 Loss and degradation of natural habitats	a) Construction activities should be restricted only to the areas that must be disturbed to avoid unnecessary disturbance. Destruction of trees in Opaka Central Forest reserve along the Karuma – Gulu Highway will be avoided as much as possible	Contractor	-
		b) All project workers should be sensitized to minimize damage to vegetation and flora	Contractor	Duty of EHS specialist hired by contractor
		c) Close monitoring and supervision of the construction operations to ensure compliance and avoid causing further damage to undesignated project areas	NWSC/ DWD	
		d) Where tree cutting is inevitable, replacement planting should be done wherever feasible. No trees of protected species *(Milicia excelsa woodlot at 36N 424999E 294543N and Khaya anthotheca woodlot at 36N 429530E 277069N)* will be cut. Any trees specie to be cut will need to be replaced in public lands in the projec area. The project will implement a restoration program that can be implemented in the wetlands, rivers, riparian areas. Liason with UNRA shall also me made such that any tree restoration along the transmission line sections that shall be located in the road reserve is done jointly with UNRA.	Contractor/ NWSC	
		e) The use of cut wood as fuel will be prohibited in the camp. Instead, all camps will use propane or electricity for cooking.	Contractor	-
		f) Critically endangered fish include Labeo victorianus and Oreochromis esculentus in Minakulu, Ogada, Myene and Alek swamps. The contractor shall ensure that the fish habitat is not destructed while undertaking works in wetland areas (especially in Minakulu, Ogada, Myene and Alek swamps where critically fish endangered species were found) by planning for working in waters to protect fish eggs, spawning adults, organisms upon which they feed by maintaining an undisturbed vegetation buffer zone and preventing soil compaction in such areas. Construction in these sections of the pipeline shall not be carried out in the month of August since it is the wettest season and fish spawning takes place during the high rains that occur in August of every year. g) The contractor should ensure that the waterflow direction is not obstructed when the pipeline is installed to ensure that fish movement routes are not destroyed, and if these fish species are potamodrometic that they can continue their movements towards the main river. NWSC shall ensure that the dimensions of the undisturbed vegetation buffer zone are maintained to avoid destruction of the fish habitat and a fish monitoring exercise prior, during and post pipeline construction to ascertain that their breeding patterns and migration routes are not interfered with shall be undertaken.	Contractor	-

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
Pre-construction phase	8.3.8 Risk of seismic activity	a) The structures should be designed to exhibit some amount of ductility to tolerate dynamic loads generated from seismic activity. Reinforced concrete structures are recommended for such purposes. Pre-stressed concrete structures are also useful, but do not perform as well as reinforced concrete under earthquake conditions.	NWSC	Part of the Design Consultant's work
		b) Appropriate design codes have been followed to reduce risks of damage to health and property	NWSC	
Pre-construction phase	8.3.9 Impacts of Karuma HPP	a) Where possible, NWSC should ensure that construction works of the intake are completed before commissioning of the Karuma HPP; and not a contractor with experience of working in deep waters will be hired.	NWSC	-
		b) Measures will be instituted at the intake to ensure that when the water levels approach the minimum of 1028 m, the pumps switch themselves off automatically	NWSC	-
NEGATIVE SOCIO-ECONOMIC IMPACTS				
Construction and operation phase	8.4.1 Risk of traffic accidents	a) The contractor will prepare and implement a traffic management plan to be approved by supervision engineer	Contractor	11,100,000
		b) Contractor will adopt best transport safety practices (Journey Management Plans (JMPs)) with the goal of preventing traffic accidents and minimizing injuries suffered by project personnel and the public by: employing safe traffic control measures, including road signs and flagmen/traffic guides to warn of dangerous conditions and children crossings; and setting speed limits on all access roads in the project area and towns/ trading centres will be 40km/h for light vehicles and 30km/h for heavy vehicles; and not more than 80 km/h on the Karuma – Gulu Highway.	Contractor	-
		c) The Contractor shall provide dedicated site entrances and exits for personnel, which shall be manned 24 hours per day, 7 days per week including holidays.		-
		d) Some roads in Gulu Municipality were recently surfaced and others are being surface under the Uganda Support to Municipality Infrastructure Development (USMID) Project. NWSC should contact Gulu Municipality early enough and request for service ducts to be installed at points where water mains will cross roads to avoid cutting through roads that have just been upgraded.	NWSC	-
		e) The Contractor will have a community liaison Officer (CLO) to get feedback/complaints from communities regarding activities of the project and issues the communities think are not being done in a proper manner. The CLO would also be responsible for informing project-affected communities of the timing and duration of the construction activities across access roads and any uncertainties or potential for change.	Contractor	-
		f) All workers, including sub-contractors and casual labourers, will undergo an environmental, health and safety induction before commencing work on site. This will include a full briefing on site safety and rules.	Contractor	Duty of the EHS specialist hired by contractor
		g) Restrictions on hours of driving (including night time restrictions where sensitive receptors may be affected) and timing of vehicle movements will be emphasized to avoid busy periods in urban areas, particularly the start and end of school and the working day.	Contractor	-
		h) No drivers or personnel under the influence of alcohol or any drug abuse will be allowed onsite	Contractor	-
		i) The water treatment plant and intake sites will be fenced and signalization put in place with security personnel to stop unauthorised people from accessing the site.	Contractor	50,000,000
		j) The contractor will hire drivers trained in defensive driving and all drivers will be trained in road and safety	Contractor	-
		k) Strict adherence to safety measures and procedures are required to minimise (or eliminate) risks of accidents or hazardous developments occurring and ensure healthy and safe conditions for all persons working on the site and the project-affected communities. To ensure occupational health and safety on construction sites, the Contractor shall be obliged to comply with all applicable Ugandan construction Health and Safety Standards as required by the Occupational Safety and Health Act of 2006. These include provisions of the Factories Act, Labour Unions Act and Workman's Compensation Act.	Contractor	-
		l) Materials will be preferentially sourced locally to minimize transport distances.	Contractor	Part of contractor's bid budget
Construction phase	8.4.2 Unsustainable use of resources	a) Through inductions and tool box meetings, the contractor will ensure that staff and contractors are conversant with resource conservation practices in all project activities. Conservation awareness will focus on water use efficiency and general day-to-day measures such as turning engines and air conditioning units off when machinery and offices or dwelling quarters are not in use.	Contractor NWSC	-

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
			DWD	
		b) The Contractor will acquire water abstraction permits with conditions to guide the amount of water to be abstracted as stipulated in the Water Supply Regulations (1999). Water abstraction will comply with rates allowed by the DWRM permit that will be obtained.	Contractor NWSC/MWE	5,000,000
		c) Earth materials will be sourced from a NEMA-approved source in a manner that reduces environmental and social impacts. Murram will be sourced in accordance with a NWSC approved murram/ subsoil extraction plan, which will be provided by the contractor prior to the start of works.	Contractor	-
		d) Any new borrow pits established by the project and would not be used later, shall be restored to as close to pre-project conditions as possible immediately after use. Native vegetation must be used for re-seeding the excavated site.		To be determined by contractor
		e) The contractor's Worker Code will include clauses of conduct on water and electricity consumption		-
Operation phase		a) Catchment management plans are being developed with the aim of conserving and allowing recharge of water resources.	NWSC	
		b) Water conservation measures will be encouraged: saving water is an efficient way of reducing the overuse of ground water resources. It is not only decreases the amount of the water withdrawn, but may also reduce the threat of pollution	NWSC	
		c) NWSC should adhere to the stipulated limits in the water abstraction permit obtained from DWRM.	NWSC	-
Construction phase	8.4.3 Damage to Existing Public Infrastructure	a) Trucks ferrying materials will be loaded commensurate with the recommended axle load for a given road to avoid or minimize damage.	Contractor	
		b) Locally sourced materials will be used, whenever possible, to minimize travel distances and expanse of road damaged.		
		c) Special permission will have to be sought from Uganda National Roads Authority (UNRA) and Gulu District Local Government before activities at road crossing are carried out. A typical drawing for a road / highway crossing is presented in drawing WS_CD_9_4_02 in Appendix J. Similarly permission from Uganda Railways Authority will be sought for the railway crossing at Sira Dongo Road.	NWSC	
		d) The trenchless technology will be used at the road and railway crossing to avoid damaging them.	Contractor/ NWSC	Within the contractor's bid budget
Construction phase	8.4.4 Social Misdemour by Workers	a) The contractor will be required to develop a Labor Influx Management Plan and/or a Workers' Camp Management Plan. These will include sanctions for workers involved in criminal activities.		Covered under 8.2.2
		b) As a contractual obligation, contractors shall be required to have an HIV/AIDS policy and a framework (responsible staff, action plan, etc.) to implement during project execution.	Contractor	-
		c) All construction workers shall be oriented and sensitized about responsible sexual behaviour in project communities.	Contractor	
		d) The contractors will develop and follow a code of conduct. The information regarding Worker Code of Conduct will be provided in local language(s).		Already covered
		e) The contractors will develop and follow a code of conduct. An example is provided in Appendix G		Already covered
		f) The contractor will conduct cultural sensitization training for workers regarding engagement with local community.		
		g) The contractor will endeavour to provide entertainment and events for workers within camp to reduce incentives for mixing with local community.		5,000,000
		h) Workers will be encouraged to get vaccinated against common and locally prevalent diseases		20,000,000
		i) The contractor, where need arises, will engage an HIV service provider to be available on-site who should conduct campaigns on STDs among the workers and local community; educate workers and the community about the transmission of diseases; and implement HIV/AIDS education program and provision of condoms.		25,000,000
Construction phase	8.4.5 Gender-based violence	a) The contractor will conduct mandatory and repeated training and awareness raising for the workforce about refraining from unacceptable conduct toward local community members, specifically women		

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
		b) Workers will be informed about national laws and funder's policies that make sexual harassment and gender-based violence a punishable offence which is prosecuted		Duty of Contractor's Social safeguard specialist
		c) Worker Code of Conduct will be part of the employment contract, and including sanctions for non-compliance (for example, termination)		Already covered
		d) The contractor, where a case arises, will cooperate with law enforcement agencies in investigating complaints about gender-based violence		10,000,000
Construction phase	8.4.6 Child labour and school dropout	a) The contractor and NWSC will ensure that children and minors are not employed directly or indirectly on the project		-
		b) The contractor will communicate the hiring criteria, minimum age and applicable laws (for example, Children Act, Cap 59) in his ESMP		-
Pre-construction phase	8.4.7 Permanent land take	a) NWSC will ensure that the project-affected persons identified through the Resettlement Action Plan study of the project are compensated for the land and property on it in time and fairly.		Amounted to be determined in the RAP
		b) Land will be acquired in accordance with Uganda's Land Access and Compensation Procedure taking into consideration the Development Partner's requirements. Amongst others, this requires: sensitisation of community members whose property will be affected; Completion of a full inventory of privately registered and/or cultivated and grazed or other uses of the land that will be taken for the project as well as structures and graves along the access road; compensation to be paid in line with mandated rates agreed in consultation with District officials before commencement of construction activities; and ensuring that the Chief Government Valuer approves the valuation rates.	NWSC/MWE	
Construction and operation phase	8.4.8 Occupational health safety (OHS) Risks	a) A qualified Health and Safety Officer will be recruited by the Contractor to oversee OHS matters on a daily basis.	Contractor	
		b) All construction workers will be oriented on safe work practices and guidelines and ensure that they adhere to them all the time.	Contractor's EHS Specialist	
		c) Appropriate signage will be used to warn staff and/ or visitors that are not involved in construction and operation activities in dangerous places	Contractor	5,000,000
		d) Regular drills will be constantly followed on various possible incidences. This will test the response of the involved stakeholders. Such drills will keep them alert and they will become more responsive in case of incidences.	Contractor	-
		e) Training will be conducted on how to prevent and manage incidences. This should involve proper handling of electricity, water etc. and sensitization on various modes of escape, conduct and responsibility during such incidences. All must fully be aware and mentally prepared for potential emergency	Contractor's EHS Specialist	-
		f) Personnel will only undertake tasks for which they are trained/ qualified. A formal 'permit to work' system will be in place and strict instructions will be given for operators of equipment.	Contractor during construction; NWSC during operation	-
		g) Strict instructions will be given to drivers of heavy equipment and operators of equipment/ machinery. Ensure electrical safety at fabrication workshops by putting in place secure electrical connections and providing adequate insulation. All temporary electrical installations in use on site such as generators and welding sets should be adequately and effectively earthed at all times during operation	Contractor	-
		h) Supervision of works will be done regularly to ensure that safety conditions are met while any deviation from safety regulations is immediately reclaimed following the best practices regarding safety at work equipment.	NWSC & Supervision Consultant	
		i) Clear communication line shall be ensured between workers and drivers of heavy equipment.	Contractor	-
		j) Evacuation procedures to handle emergency situations will be developed	Contractor's EHS Specialist	
		k) Adequate OHS personnel protective gear will be provided to the employees.	Contractor/ NWSC	100,000,000
		l) Strict adherence to safety measures and procedures are required to minimise (or eliminate) risks of accidents or hazardous developments occurring and ensure healthy and safe conditions for all persons working on the site. To ensure occupational health and safety on construction sites, the Contractor shall be obliged to comply with all applicable Ugandan construction Health and Safety Standards as required by the Occupational Safety and Health Act of 2006. These include provisions of the Factories Act, Labour Unions Act and Workman's Compensation Act.	Contractor	-

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
		m) First aid boxes will be available at all active construction sites and at accessible locations at the water treatment plant during the operation phase.		3,000,000
		n) An Accident log will be maintained onsite to register all injuries and to investigate their causes during both the construction and operation phases of the project.	NWSC	-
		o) Emergency resources (e.g., fire extinguishers, stocked First Aid kits, Emergency Contacts, Doctor on Call, etc.) will be maintained at all active construction sites and at the water treatment facilities during operation.	NWSC	10,000,000
		p) The Contractor shall ensure that all areas requiring access including platforms, under platforms, underpasses, excavations, etc. have enough illumination.	Contractor and NWSC	-
		q) Excavations and rock blasting activities will be undertaken under strict guidance to avoid chances of collapse and injury, respectively.	Contractor	-
		r) The manufacturer's instructions and Material Safety Data Sheets (MSDS) shall be followed for the storage of all chemicals used in water treatment. Storage must conform to compatibility restrictions.	NWSC	-
		s) All construction workers will be oriented on safe work practices and guidelines especially regarding work in confined spaces and it will be ensured that they adhere to them.		-
		t) The Contractor shall provide a signal man, barricades and safety sign boards around the excavations.		-
		u) Routine maintenance will be carried out at sites (removal of garbage, removal of screenings and grit, slashing around the embankments, repair of damages to the fence, etc.).		5,000,000
		v) Regular fumigation of the WTP and contractor's/ workers' camp will be undertaken to kill disease vectors such as mosquitoes	Contractor/ NWSC	3,000,000
		vii) All workers shall be provided with PPE during work. The PPEs shall be provided at no cost to workforce and shall be replaced once in three months. Any damaged/lost PPEs shall be replaced with no cost to workforce. Visitors/officials to work sites are to be provided with PPEs (hard hats and safety shoes) and shall be briefed ongoing operations on that specific time and related safety requirement at work site including safe distances to keep during the site visit.	Contractor	15,000,000
		viii) Work force shall be subjected only to standard work shifts/hours. Overtime allowances, if applicable/warranted shall be paid with ceiling limits. Working beyond such ceiling limits shall be discouraged, even if, so desired workforce or contractor	Contractor	-
NEGATIVE CUMULATIVE IMPACTS				
Construction phase	8.5.1 Disruption of traffic and communication routes	a) The trenchless technology will be used at major crossings like roads to avoid disruption of traffic flow.		-
		b) Appropriate signage will be used and impacted owners will be informed ahead of disruption	Contractor/ NWSC	Already covered
		c) Disruptions to public access shall be identified in the Contractor's Traffic Management Plan, under which suitable notice of intending delays and closures are given to all concerned parties and approved prior to commencing work. All road closures shall be separately notified and agreed with the Local gov't administration.	Contractor/ NWSC	-
		d) Where access to or from an individual property is closed for a period of 2 hours or more, the owner shall be informed at least 24 hours in advance.	Contractor/ NWSC	-
		e) Vehicular access to and from hospitals, police stations and fire stations shall be maintained through the use of steel road plates over open trenches. Pedestrian access to schools, health facilities, and other premises frequently accessed by the public will be maintained with the use of walking boards.	Contractor/ NWSC	-
		f) The laying of pipelines, backfilling and temporary reinstatement shall follow trench excavation as quickly as possible and trenches will not be left open for extended periods.	Contractor	-
	8.5.2 Air pollution	a) Construction work will be undertaken by an experienced and duly registered contractor with a verifiable sense of environmental awareness and responsibility	Contractor	-

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
Construction and operation phase		b) Travel speeds of construction vehicles along the road especially at trading/ business centres will be controlled using humps and setting travel speeds not exceeding 40km/h	Contractor	-
		c) A maintenance programme for equipment and vehicles will be implemented, to ensure air emissions like particulates, SO_2 and NO_2 are minimised.	Contractor	-
		d) Trucks will be covered during haulage of construction materials to reduce on spillage of materials	Contractor	
		e) Stockpiles of friable material will be grassed in order to prevent wind erosion;	Contractor	
		f) Workers will be provided with PPE and the use of PPE shall be enforced	Contractor	Already covered
		g) All surfaced roads shall be subject to road cleaning and un-surfaced roads to dust suppression, the methodology and frequency of which shall be included in the Contractor's Traffic Management Plan	Contractor	-
Construction and operation phase	8.5.3 Generation of noise and vibrations	a) Care will be exercised when selecting the working equipment to avoid use of old equipment or damaged equipment with high level of noise emissions that would have a negative impact on the environment. Equipment will be properly maintained and kept fully functional. Servicing of all construction vehicles and machinery will be done regularly and during routine servicing operations, the effectiveness of silencing equipment (e.g. exhaust silencers) will be checked and if found defective will be replaced.	Contractor	-
		b) Construction workers will be made aware of the silent nature of workplaces they are operating in and advised to limit verbal noise or other forms of noise. For example, metallic objects or tools can be passed on to a colleague rather than dropping or throwing them with loud bangs. Construction truck drivers will be required to switch off vehicle engines while offloading materials. According to National Environment (Noise Standards and Control) Regulations, 2003; noise levels at construction sites should not exceed 60 dBA and 50 dBA during the day and night, respectively.	Contractor	-
		c) All generators and heavy duty equipment will be insulated or placed in enclosures to minimize disrupting ambient noise levels. Pumps, generators and other mobile equipment will be sited as far as practicable from housing and other noise sensitive locations. Regular maintenance, monitoring and, where necessary, the use of silencing equipment will be employed with the aim of reducing noise emissions	Contractor	-
		d) The contractor will submit detailed information on the noise levels which will be generated by the specific methods and equipment proposed and the actions that will be taken to minimise the noise impact. Equipment shall be operated within their specifications and capacity (for example, avoid overloading machines).		
		e) Noise levels emanating from machinery, vehicles and noisy construction activities will kept at a minimum (within the national noise level limits) for the safety, health and protection of people in the nearby buildings. The vehicles that are excessively noisy shall not be operated until corrective measures have been taken.	Contractor	40,000,000
		f) During periods of inactivity, equipment will be switched off whenever possible. Where appropriate, residents living in the vicinity of where construction activities are taking place will be kept informed of the contractor's proposed working schedule (through implementation of the Community Liaison Management Plan) and will be advised on the times and duration of any abnormally noisy activity likely to cause concern.	Contractor	-
		g) Project vehicles will have a restricted speed limit of 40 km/h through settlements and trading centres to minimise noise.	Contractor	-
		h) No construction activities will take place at night for sites where the closest residence is within less than 150 m from the project site, the operations on site shall be restricted to the hours 6.00 -22.00.	Contractor	-
		i) The noise due to blasting operation lasts for a very short period. Primary blasting shall be carried out with adequate preventive measures to control the noise to the permissible limits. Consideration for the nearest habitation shall be at a distance of 500 m from the site boundary. Before blasting is undertaken all the relevant permissions shall be obtained from the Ministry of Internal Affairs Uganda.	Contractor	20,000,000
		j) Sequential timer blast machine or other approved methods shall be used for primary blasting and there shall be no secondary blasting. The boulders shall be broken using a hydraulic rock breaker. Proper maintenance of the noise generating parts of the machines shall be undertaken. Air silencers of suitable type that can modulate the noise of the engines of machinery can shall also be put in use and maintained effectively.	Contractor	5,000,000
		k) Ear muffs shall be given to all the workers operating or working close to any machine and full PPE for any persons participating in blasting activities. Periodical monitoring of noise levels and blast vibrations will be practiced and the contract shall ensure that the necessary noise/vibration meters for taking measurements are available.	Contractor	10,000,000
		l) The contractor shall also use control measures like wet drilling to avoiding blasting during high wind speed and development of green belt within the safety barrier of the specific project site and shall ensure that there is no impact of blasting activity in the surrounding area.	Contractor	15,000,000
		m) Construction activities in the identified sensitive areas (Bobi Health Centre III (N428086.2, E284815.65), St Thomas O.T.T Primary School (N428498.25, E280335.42), Bobi Sub-county (N428512.54, E282704.61), Ministry of Energy Offices (N421542.49, E248677.74), Koro Abili C.O.U Primary School (N423536.66, E299479.75), St. Peter Paul Catholic Church (N428598.34, E280554.22), MTN Mast (N423534.44,	Contractor	-

PHASE	IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	RESPONSIBILITY	ESTIMATED ANNUAL COST (UGX)
		E299676.99) St. Joseph Catholic Church (N429801.34, E276378.46), Minakulu Primary School (N430713.94, E272720.91) Jeroline School (N425855.36, E289522.13), St Baptist Church (N422771.5, E303450.33), Adel Primary School (N431255.18, E270057.49) and St Thomas More Primary School- Minakulu (N423038.87, E302369.94)) shall be scheduled during weekends, stockpiling supplies and materials shall also be done during noncritical times to minimize transport nose. The maximum allowed noise level should be 45dBA for night and 55dBA for evening and day. Measurement of noise level should be performed before the start up with the working activities and during work peaks (of particular importance when project activities take place in the immediate vicinity of the primary school). Restriction or suspension of pipe laying activities during critical times (such as school exam or test times) shall be abided to.		
		ESTIMATED GRAND TOTAL COST		***744,200,000***

Table 86: Environmental and social monitoring plan

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
POSITIVE IMPACTS							
8.2.1 Income to material/ equipment suppliers and contractors	a) Project will promote local procurement where technically or commercially reasonable and feasible.	Number of local businesses benefiting from construction related procurement	Gulu, Omoro, Oyam and Karuma project areas	Review of project procurement documents	Before and during commencement of construction	NWSC/ District Local Governments of Project Area.	To be catered for partly under the project meetings Faciltation for the District officials 10,000,000
	b) For earth materials, procurement will be made from legitimate sources to avoid encouraging environmental degradation	All quarries from which materials (sand, stone) are obtained are licensed by the local authorities	Gulu, Omoro, Oyam and Karuma project areas	Review of project procurement documents	Before and during construction	NWSC/MWE/ District Local Governments of Project Area	
8.2.2 Employment	a) NWSC shall ensure that all personnel to be involved in implementation of this ESMP are adequately qualified. A training programme for the NWSC staff to implement the ESMP shall be facilitated by the project to ensure that staff have the appropriate skills.	Number of NWSC staff trained to implement the ESMP	Project Area	Review of training records	Before and during construction	MWE	
	b) Unskilled labour will be recruited exclusively from local community, and semi-skilled labour will be recruited preferentially from such communities, provided that they have the requisite qualification, competence and desired experience.	Number of local people (unskilled and semi-skilled) employed during construction phase	Gulu, Omoro, Oyam and Karuma project areas	Review of employee list and key informat interviews with employees	Before and during construction	NWSC/ District Local Governments of Project Area	
	c) Contractors will be encouraged to pay a "living wage" to all workers.	Record of contractors' employment activities on a monthly basis, including number of jobs created by employment type (skilled / semi-skilled / unskilled); number of jobs by gender, employment type and geographical area; total man hours and wages paid, by employment type, gender and geographical area; and rate of employee turnover by gender and area.	Gulu, Omoro, Oyam and Karuma project areas	Review of workers' payment schedules and interviews with workers' heads or leaders	Before and during construction	NWSC/ District Local Governments of Project Area	
	d) A training programme for artisans (builders, carpenters, plumbers) in the project area could be facilitated by the project to ensure skills transfer during the construction period.	Number of local people trained during construction phase	Gulu, Omoro, Oyam and Karuma project areas	Review of records	Before and during construction	NWSC/ District Local Governments of Project Area	
	e) Contractor will develop and implement Labour Influx Management Plan, Workers Camp Management Plan and Code of Conduct. An example of the code of conduct for contractors and sub-contractors is provided in Appendix G.	Number of cases reported	Gulu, Omoro, Oyam and Karuma project areas	Review of plans and their mode of implementation. Interview with workers about their awareness of the respective plans	Throughout construction	NWSC/ District Local Governments of Project Area	
8.2.3 Infrastructure improvement	The extent to which development becomes a positive or negative impact will be determined by the effectiveness of the planning framework. Such induced developments should be of a type that is desirable and sustainable and for this to happen, all future developments must be undertaken within the framework of proactive government policy and strict planning and environmental enforcement by the responsible Local Government.	Number of complaints	Project area	Visual observation and project documents related to the said infrastructure	Prior to commencement of construction	District Local Governments of Project Area	5,000,000

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
8.2.4 Improved Health and Economic Status of Households and Communities	a) Users will be educated on the proper use, regular cleaning and effective maintenance of both the household and public facilities. The communities will be sensitised about proper disposal of wastewater generated as a result of improved water supply and how to use water sparingly with minimal or no wastage	Clinical records of reported cases. Reduced incidences of illness at household level.		Review of Clinical records of reported cases.		NWSC/ District Local Governments of Project Area	
	b) Water tariffs will be set taking into consideration the different levels of users. The users should also be educated to avoid wasteful use of the resources	Number of new connections; public majority comfortable water tariffs.	NWSC Offices/ Consumer bills		Regularly as need arises	NWSC/ District Local Governments of Project Area	
NEGATIVE ENVIRONMENTAL IMPACTS							
8.3.1 Degradation of Soils	**Construction phase**						
	a) A waste management plan will be developed prior to start of construction activities.	Number of complaints of poor management of waste from communities around the site and road; and complaints from authorities	Supervisor's Office / District Environmental Office	Review of complaints records	Before construction	NWSC/ District Local Governments of Project Area	Covered in 8.2.2
	b) Topsoil and subsoil removed from the site during site preparation will be stored properly (away from runoff and possible contaminants) for reuse elsewhere or for backfilling and reinstatement. Topsoil will be protected through separation from subsoil and storage in a manner that, as far as possible, retains the soil structure and minimises the risk of topsoil loss. For the water pipelines, the trenches will be subsequently backfilled with subsoil, followed by topsoil as soon as possible. In order to prevent loss of fertility and degradation of the seed bank within stored topsoil (where present), the topsoil will be stored for as short a time as possible, allowing for engineering constraints.	Reported cases of top soil or overburden dumped at non-designated sites	Project sites & Contractor's/ Supervisor's Office	Review of complaints records	Throughout construction	NWSC/ District Local Governments of Project Area	
	c) Contractor will avoid use of old equipment and damaged equipment that is most likely to have oil leakages thus contaminate the soils and the Contractor will ensure that equipment is properly maintained and fully functional to avoid leakages that may contaminate soils.	Soil quality parameters	Project sites & Contractor's/ Supervisor's Office	Review of records or reports	Maintenance of equipment throughout construction	NWSC/ District Local Governments of Project Area	
	d) During reinstatement, the trench back-fill material will be compacted to a level similar to the original surrounding soils to avoid subsidence as a consequence of rain water channelling.	Absence or Presence of gullies or channels	Project sites and sources of materials	Direct observations		NWSC	
	e) Recreation of a stable landform that mirrors the pre-disturbed condition (e.g. contours, shape, level of compaction, etc.) as this will minimise the risk of preferential erosion and therefore facilitate natural revegetation.	Visual appearance of the landscape	Project sites and sources of materials	Direct observations	Through out construction activities and during operation (maintenance activities)	NWSC/ District Local Governments of Project Area	
	f) Upon completion of subsoil and topsoil reinstatement, disturbed areas will be inspected jointly by the construction contractor and NWSC personnel for stability, relief, topographic diversity, acceptable surface water drainage capabilities, and compaction.	Visual appearance of landscape in comparison with undisturbed areas	Project sites and sources of materials	Direct observations	At completion of the project activity	NWSC/ District Local Governments of Project Area	
	g) All waste generated during site preparation and construction will be transported to an authorized disposal area. The contractor will seek guidance from the respective District Local Governments in project area on the final disposal point.	Complaints from communities around the site and road of poor management of waste.	Project sites & Contractor's/ Supervisor's Office	Review of complaints records	Throughout construction	NWSC/District Local Governments of Project Area	See 8.2.2
	h) Waste shall not be taken out of the Site without a Waste Manifest.	Waste Manifest	Project sites & Contractor's/ Supervisor's Office	Review of records and reports	Throughout construction	NWSC/District Local Governments of Project Area	
	i) A Spill kit will be maintained onsite to clean-up any accidental spills.	Presence of spill kits at all project sites where there is potential of accidental spills	Project sites	Site and project office inspection	Throughout construction	NWSC/District Local Governments of Project Area	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	j) Retention ditch will be provided such that runoff from the project site does not go directly into the Victoria Nile. It will only be released after quality assessment to ensure that it meets the national discharge standards.	Water/ stormwater quality	Project sites & Contractor's/ Supervisor's Office	Review of monthly reports	During construction whenever it rains	NWSC/DWRM/ District Local Governments of Project Area	
	Operation phase						
	a) Cut-off drain will be provided around the waterworks to avoid intrusion of storm water and stormwater within the water works will be guided away from chemical storage areas using cut-off drains around them.	Victoria Nile water quality data upstream and downstream of the water treatment plant effluent discharge point	NWSC Area Office/ DWRM Zonal Office/ District Environmental Office	Review of water quality reports and site inspection; Sampling and laboratory analysis at an independent laboratory, e.g NEMA laboratory	Monthly throughtout operation of the plant	DWRM/ NEMA	8,000,000
	b) Staff operating the plant will be trained/ sensitised on proper management of waste associated with the operation of the water treatment plant to avoid soil contamination.	Records of staff training	NWSC Area Office	Review of record and interview of staff randomly	Before commissioning of the water treatment plant		
	c) Periodic tests will be done to assure the quality of effluent from filter press or sludge conditioning basins and treated sludge meets the national effluent discharge standards (see sub-section 4.4.2), to avoid partially sludge from reaching the soils.	Effluent/ Sludge quality data	NWSC Area Office / District Environmental Office	Review of water quality and environmental audit reports	Throughout operation of water treatment plant	DWRM/ NEMA/ District Local Governments of Project Area	
8.3.2 Pollution of water resources	**Construction phase**						
	a) All construction equipment will be kept in good operating condition to avoid oil or fuel leakages that might contaminate water resources	Water quality data	Contractor's/ Supervisor's Office	Review of maintenance records and physical state of equipment/ vehicles	Throughout construction	NEMA/NWSC/ District Local Governments of Project Area	12,000,000
	b) Workers' camp and associated facilities will be connected to septic tank or other wastewater systems which are appropriate and of sufficient capacity for the number of workers and local conditions. The facilities for this purpose will be inspected regularly to ensure proper functioning. Camp site selection shall involve several factors, including; the size and conditions of the site and availability of resources; the safety, security and protection it offers and cultural and social considerations. Choosing a site shall involve consideration of access, coexistence with surrounding communities, topography, trees and vegetation, the potential impact on the environment, environmental causes of disease and other public health issues. The Contractor shall conduct the necessary environmental and social assessments according to national and World Bank Environment and Social Safeguards Policies and acquire approvals from NEMA and the supervising engineer prior to establishment of new camp sites.	Presence of properly operating sanitation facilities on site	Workers' camp and sites for the different project components	Site inspection	Throughtout construction	NWSC/ District Local Governments of Project Area (District Health Inspector and DEO)	
	c) Stockpile areas for materials such as sand, gravel, stone, laterite, lime and topsoil, as well as overburden dumps will be located away from water courses and will be surrounded by perimeter or cut-off drains with sediment and other pollutant traps located at drain exits. Cut-off drains will be maintained throughout the subsequent operation phase	Presence of well functioning cut-off drain and banded storage area located away from water courses	Contractor's/ Supervisor's Office	Site inspection	Throughout construction	NWSC/DWRM/ District Local Governments of Project Area (DEOs and DNRO)	
	d) All hazardous wastes including material soiled with hazardous wastes and empty containers of hazardous materials shall be stored in a designated area on site for regular removal and disposal by a registered contractor in accordance with the National Environment (Waste Management) Regulations, 1999. All other wastes generated during site preparation and construction will be transported by the	Collection and disposal records	Project sites & Contractor's/ Supervisor's Office	Site inspection and review of waste collection and disposal manifest	Throughout construction	NWSC/ District Local Governments of Project Area (DEOs and DNRO)	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	contractor or a company that has been specifically contracted to an authorized disposal area.						
	e) Fuel handling and oil spill measures will be implemented to prevent, control and address spill or leaks. Fuel storage and dispensing on site shall not be allowed. Fuel and oil handling will be assigned to trained personnel and procedures for fuel storage, operation of mobile fuel tankers and refuelling areas will be well defined. Impermeable sheets, spill mats, and drip trays will also be provided in the appropriate areas to curb fuel and oil leakage to the ground. This will be done at designated places at the contractor's camp and in accordance with relevant standards set by the Energy Regulation Board and Uganda Bureau of Standards.	Water quality data as per effluent discharge standards	Project sites & Contractor's/ Supervisor's Office	Review of water quality and environmental audit reports	Monitoring throughout construction	NEMA/NWSC/ District Local Governments of Project Area	
	f) Construction activities will largely be carried out during the dry season to avoid sediment transport to the nearby land, water courses and roads	Schedule of construction activities	Project sites & Contractor's/ Supervisor's Office	Review of activity schedules	Throughout construction phase	NWSC/DWRM/ NEMA/ District Local Governments of Project Area (DEOs and DNRO)	
	g) Any cleaning and hydrotest water which could cause contamination of surface (or ground) waters will be tested and treated as necessary prior to discharge, including debris and sediment removal.	Material data sheets and water quality tests and points of discharge	Project sites & Contractor's/ Supervisor's Office	Review of water quality and environmental audit reports	During pipe testing	NWSC/ District Local Governments of Project Area (DEOs and DNRO)	
	h) NWSC will ensure the contractor complies with its environmental management policies, ESIA recommendations and national regulations	General working environment/ Monitoring reports	All project sites	Review of environmental monitoring and audit reports; site inspection	Monthly throughout the construction phase	NWSC/ District Local Governments of Project Area (DEOs and DNRO)	
	i) The contractor shall ensure that appropriate monitoring of the water quality is done during the construction phase to prevent contamination of the Nile water when construction activities are being undertaken (both upstream and downstream the intake should be monitored and monthly reports produced)	Water quality during construction activities	Intake site and along wetlands/swamps	Review of water quality and environmental audit reports	Throughout construction phase	NWSC/DWRM/ NEMA/ District Local Governments of Project Area (DEOs and DNRO)	
	j) In open waters, especially during construction of the intake, plastic curtains will be used to contain and confine resuspension of bottom silt to minimize turbidity in surrounding and downstream areas, using longer support spans and restricting construction to dry weather where possible.	Water quality during construction activities	Intake site and along wetlands/swamps	Review of water quality and environmental audit reports	Throughout construction phase	NWSC/DWRM/ NEMA/ District Local Governments of Project Area (DEOs and DNRO)	
	Operation phase						
	a) Daily/Monthly quality tests for raw water shall be undertaken by NWSC to properly monitor the changes in raw water quality overtime	Water quality data and number of complaints from communities around project sites	NWSC Office/ WTP	Review of water quality and environmental audit reports	Throughout Operation	NEMA/DWRM	5,000,000
	b) Vehicles and machinery/ equipment will be maintained, repaired and refuelled at an offsite garage/workshop.						
8.3.3 Improper management of waste	**Construction phase**						
	a) The Contractor will be required to prepare a Waste Management Plan.	Record/ Evidence of Waste management Plan being used by Contractor	Project sites & Contractor's/ Supervisor's Office	Review of environmental monitoring reports	Throughout construction	NWSC/ District Local Governments of Project Area	10,000,000
	b) The contractor and NWSC Area Management will work hand in hand with the respective Local governments to facilitate sound waste handling and disposal from the site. All wastes must be taken to the approved dumpsites.	Record of waste types and estimated quantity disposed/ diverted for reuse	Project sites & Contractor's/ Supervisor's Office	Review of environmental monitoring reports	Throughout construction	NEMA/NWSC/ District Local Governments of Project Area	
	c) Proof of delivery and safe disposal of waste will be provided and records maintained at all times.				Throughout construction	NEMA/NWSC/ District Local Governments of Project Area	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	d) The contractor will provide his own facilities (e.g. mobile toilets) which should be adequate at construction sites.	Presence of mobile toilets at construction sites/ sanitary hire agreements	Project sites & Contractor's/ Supervisor's Office	Site inspection	Throughout construction	NEMA/NWSC/ District Local Governments of Project Area	
	e) Workers' camp and associated facilities will be connected to septic tank or other wastewater systems which are appropriate and of sufficient capacity for the number of workers and local conditions. The facilities for this purpose will be inspected regularly to ensure proper functioning.	Presence of properly operating sanitation facilities on site	Workers' camp and sites for the different project components	Site inspection	Throughtout construction	NWSC/ District Local Governments of Project Area (District Health Inspector and DEO)	
	Operation phase						
	a) Adequate operation and management of the facilities will ensured to avoid improper management of waste and solid waste is collected by a firm licensed by NEMA and that the collected waste is disposed of at dumpsite or landfill approved by NEMA	No accumulation of waste in facilities' vicinity. No complaint of littered waste from community and authority; internal and external Environmental Audit reports	NWSC Area Office	Abrupt site inspection	Throughout operation of the facilities	NEMA/ Oyam District Local Government (DEO)	2,000,000
	b) NWSC together with the respective District Local Governments will ensure that the solid waste is collected by a firm licensed by NEMA and that the collected waste is disposed of at dumpsite or landfill approved by NEMA						
	c) Adequate bins will be provided to prevent access by vermin at the WTP	Presence of vermin free bins and/ or skips at the water treatment plant	WTP site	Abrupt site inspection	Throughout operation	Oyam District Local Government (DEO)	
8.3.4 Disturbance or Destruction of Archaeological / Cultural Heritage	**Construction phase**						
	a) A 'chance find' procedure will be put in place to determine actions to be taken in the event that suspected archaeological artefacts or paleontological items are encountered and they should be handed over to Ministry of trade and industry-Department of Museums and Monuments.	Record of cases with the Department of Museums and Monuments	Department of Museums and Monuments, Kampala		Throughout the construction phase	NWSC/ Ministry of trade and industry- Department of Museums and Monuments	5,000,000
	b) Construction works will be designed to ensure no damage to any cultural sites or medicinal plants that may be encountered. Where such sites cannot be avoided, culturally appropriate measures will be agreed and implemented prior to the construction activities.	Contractor's schedule and workplans	Project sites	Review of Contractor's schedule and workplans	Before commencement of construction activities	NWSC	-
	c) Compensation of the affected sites, especially the affected grave yards, will be undertaken before construction activities commence in accordance with World Bank and KFW requirements.	Proof of compensation and relocation	Project office; Project affected person's home		Before construction activities commence	District Local Governments of the affected persons/ community	20,000,000
8.3.5 Introduction of invasive species	**Construction phase**						
	a) Vehicles and equipment entering and leaving the project area will be inspected and cleaned to remove invasive species.			Check for presence of invasive species in the area and review environmental audit reports	Throughout the construction phase	NWSC/ District Local Governments of Project Area – SEOs	2,000,000
	b) When invasive species are encountered, they will be removed and destroyed, for example, by burning.				Throughout the construction phase	NWSC/ District Local Governments of Project Area – SEOs	
8.3.6 Deterioration of landscape and visual quality	**Construction phase**						
	a) Murram and subsoil will be obtained preferentially from a licensed source and in accordance with any terms of the license. "Licensed" means approved by NEMA or the respective Project District Local Governments. The contractor will provide	Copy of license(s)		Check for the license and carryout site inspection of sources of materials/ borrow pits	Before extraction of materials	NEMA/ NWSC/ District Local Governments of Project Area – SEOs	Already catered for under other activities above

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	a copy of the license to NWSC before the beginning of works at the murram/subsoil extraction location.						
	b) If no suitable licensed source of murram/subsoil is available in the area and the contractor plans to obtain the material from a private landowner, then the contractor will: ▪ Provide NWSC with a copy of the written agreement between the contractor and the owner of the murram/subsoil source in advance of the beginning of works at the location. The identity of the landowner will be certified by a certificate of ownership or a paper signed by the LC1 Chairperson and/ or Head of Clan; ▪ Engage and consult any households and/or communities in close proximity to the identified murram/topsoil source and provide evidence of these consultations to NWSC; ▪ Ensure adequate compensation on mutually agreed terms is made to people who are either physically or economically displaced by the activities of the contractor. The contractor will provide documentation of the compensation terms (minutes of consultation meetings, signed agreements with affected persons, compensation receipts etc.) to NWSC; ▪ Assess health and safety risks linked to murram/subsoil extraction and transport, and implement appropriate mitigation measures. The risk assessment will be provided to NWSC ahead of the beginning of works; and ▪ Provide a restoration plan for review, and ensure that the actions of the restoration plan are implemented to the satisfaction of concerned authorities. Sign-off from the relevant authorities will be required and copies of the sign-off will be provided to NWSC.	Copy of Agreement Evidence of compensation and Reinstatement Plan	Affected Person and Contractor's office	Check for agreement, consult with landowner and inspect the source	Before extraction of materials or commencement of construction activities	NEMA/ NWSC/ District Local Governments of Project Area – SEOs	-
	c) Surface water run-off will be controlled during earthworks. Surface water features down-slope of the earthworks will be identified, and the necessary berms and drainage channels will be installed to ensure that run-off does not collect or pond in excavated areas or quarries.	Signs of ponding of water	Project sites and Sources of materials	Site inspection	During construction and after construction activities	NEMA/ NWSC/ District Local Governments of Project Area – SEOs	
	d) Restoration of borrow pits to as close to pre-project conditions as possible will be done immediately after use in cases where they are specifically opened up for this project. Native vegetation must be used for re-seeding the excavated site.	Borrow pits restored to pre-project condition with native vegetation and vegetation growing well	Project sites and Sources of materials		After extraction of materials or construction activities	NEMA/ NWSC/ District Local Governments of Project Area – SEOs	
	e) The contractor will exercise prompt and effective response to environmental and social issues raised by supervision engineer.	Corrective measures taken in timely manner	Project sites and Sources of materials	Site inspection and response matters arising		Supervising Engineer/NWSC	
	f) There will be close monitoring of impact on natural resources with enforcement of contract or legislative options.		Project sites and Sources of materials	Site inspection and response matters arising		NEMA/ NWSC/ District Local Governments of Project Area – SEOs	5,000,000 as facilitation for district officials
8.3.7 Loss and degradation of natural habitats	**Construction phase**						
	a) Construction activities should be restricted only to the areas that must be disturbed to avoid unnecessary disturbance. Destruction of trees in Opaka Central Forest reserve along the Karuma – Gulu Highway will be avoided as much as possible	Area of restored habitat that had been disturbed.	Project sites and Sources of materials	Site inspection and consultations with stakeholders	During Construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's, District Engineers	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	b) All project workers should be sensitized to minimize damage to vegetation and flora	Record of worker sensitization about vegetation and flora.	Project sites and Sources of materials	Check for the sensitisation record and also interact with workers about the sensitisation	During Construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's, District Engineers	
	c) Close monitoring and supervision of the construction operations to ensure compliance and avoid causing further damage to undesignated project areas	Record monitoring and supervision of the construction operations about project footprint.	Project office		During Construction	District Local Governments of Project Area – SEO's, CDO's, District Engineers	
	d) Where tree cutting is inevitable, replacement planting should be done wherever feasible. No trees of protected species *(Milicia excelsa woodlot at 36N 424999E 294543N and Khaya anthotheca woodlot at 36N 429530E 277069N)* will be cut. Any trees specie to be cut will need to be replaced in public lands in the project area. The project will implement a restoration program that can be implemented in the wetlands, rivers, riparian areas. Liason with UNRA shall also me made such that any tree restoration along the transmission line sections that shall be located in the road reserve is done jointly with UNRA.	Number of community planted trees and grew in relation to the project.	Project sites and Sources of materials	Site inspection	During Construction and operation	District Local Governments of Project Area – DNROs & CDOs	
	e) The use of cut wood (and charcoal) in camp is prohibited. Instead all camps will use propane or electricity for cooking				During Construction and operation	District Local Governments of Project Area – DNROs & CDOs	
	f) Critically endangered fish include Labeo victorianus and Oreochromis esculentus in Minakulu, Ogada, Myene and Alek swamps. The contractor shall ensure that the fish habitat is not destructed while undertaking works in wetland areas (especially in Minakulu, Ogada, Myene and Alek swamps where critically endangered fish species were found) by planning for working in waters to protect fish eggs, spawning adults, organisms upon which they feed by maintaining an undisturbed vegetation buffer zone and preventing soil compaction in such areas. Construction in these sections of the pipeline shall not be carried out in the month of August since it is the wettest season and fish spawning takes place during the high rains that occur in August of every year. g) The contractor should ensure that the waterflow direction is not obstructed when pipeline is installed to ensure that fish movement routes are not destroyed, and if these fish species are potamodrometic that they can continue their movements towards the main river. NWSC shall ensure that the dimensions of the undisturbed vegetation buffer zone are maintained to avoid destruction of the fish habitat and a fish monitoring exercise prior, during and post pipeline construction to ascertain that their breeding patterns and migration routes are not interfered with shall be undertaken.	Fish habitat areas	Project areas/wetlands acting as fish habitat (Minakulu, Ogada, Myene and Alek swamps).	Areas of fish habitat left undestructed	During construction	NEMA/ NWSC/ District Local Governments of Project Area – SEOs	-
8.3.8 Risk of seismic activity	**Pre-construction phase**						
	a) The structures should be designed to exhibit some amount of ductility to tolerate dynamic loads generated from seismic activity. Reinforced concrete structures are recommended for such purposes. Pre-stressed concrete structures are also useful, but do not perform as well as reinforced concrete under earthquake conditions.	Design report	NWSC and Design Consultant's Offices	Review of design reports and drawings	Before construction	NWSC	-
	b) Appropriate design codes have been followed to reduce risks of damage to health and property						
	Pre-construction phase						

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
8.3.9 Impacts of Karuma HPP	a) Where possible, NWSC should ensure that construction works of the intake are completed before commissioning of the Karuma HPP; and not a contractor with experience of working in deep waters will be hired.		Water intake site	Consultation with UEGCL	Before commissioning of Karuma HPP	NWSC Project Manager/ Director of Capital Development and Planning	-
	b) Measures will be instituted at the intake to ensure that when the water levels approach the minimum of 1028 m, the pumps switch themselves off automatically	Water levels at intake area	Water intake	Review of recorded water levels	Throughtout operation phase	DWRM	6,000,000
NEGATIVE SOCIO-ECONOMIC IMPACTS							
8.4.1 Risk of traffic accidents	**Construction phase**						
	a) The contractor will prepare and implement a traffic management plan to be approved by supervision engineer	Traffic management plan		Effectiveness and suitability of the plan	Before construction activities commence	NWSC/ Traffic Police Office at the project area	5,000,000
	b) Contractor will adopt best transport safety practices (Journey Management Plans (JMPs)) with the goal of preventing traffic accidents and minimizing injuries suffered by project personnel and the public by: employing safe traffic control measures, including road signs and flagmen/traffic guides to warn of dangerous conditions and children crossings; and setting speed limits on all access roads in the project area and towns/ trading centres will be 40km/h for light vehicles and 30km/h for heavy vehicles; and not more than 80 km/h on the Karuma – Gulu Highway.	Record of traffic related accidents in each month of construction duration	Contractor's/ Supervisor's Office	Check for records and consult with traffic police in charge of the respective area	During construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	c) The Contractor shall provide dedicated site entrances and exits for personnel, which shall be manned 24 hours per day, 7 days per week including holidays.	Location of entry and presence of personnel manning it	Project sites		Before and during construction	NWSC	-
	d) Some roads in Gulu Municipality were recently surfaced and others are being surface under the Uganda Support to Municipality Infrastructure Development (USMID) Project. NWSC should contact Gulu Municipality early enough and request for service ducts to be installed at points where water mains will cross roads to avoid cutting through roads that have just been upgraded.	Permission to carryout activities across the infrastructure/ presence of service ducts	Contractor's/ Supervisor's Office	Check for permission and consultations with the district/ municipality authorities	Before construction activities commence	Gulu District Local Government/ Municipality	-
	e) The Contractor will have a community liaison Officer (CLO) to get feedback/complaints from communities regarding activities of the project and issues the communities think are not being done in a proper manner. The CLO would also be responsible for informing project-affected communities of the timing and duration of the construction activities across access roads and any uncertainties or potential for change.	Availability of the CLO and his/ her qualifications	Contractor's/ Supervisor's Office	Check for qualifications and records of activitity with communities	Thorughout the construction phase	NWSC	-
	f) All workers, including sub-contractors and casual labourers, will undergo an environmental, health and safety induction before commencing work on site. This will include a full briefing on site safety and rules.	Record of induction; interviewing a sample of workers on environmental, health and safety issues	Contractor's/ Supervisor's Office	Check for records of induction carried out	Before construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	g) Restrictions on hours of driving (including night time restrictions where sensitive receptors may be affected) and timing of vehicle movements will be emphasized to avoid busy periods in urban areas, particularly the start and end of school and the working day.	Activity schedule and journey management plans	Contractor's/ Supervisor's Office	Consultations with stakeholders	During construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	h) No drivers or personnel under the influence of alcohol or any drug abuse will be allowed onsite	Records of cases	Contractor's/ Supervisor's Office	Consultations with stakeholders	During construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	i) The water treatment plant and intake sites will be fenced and signalization put in place with security personnel to stop unauthorised people from accessing the site.	Presence of a sound fence all around the site	Contractor's/ Supervisor's Office	Visual observation	During construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	j) The water treatment plant and intake sites will be fenced and signalization put in place with security personnel to stop unauthorised people from accessing the site.	Presence of a fence with security personnel	Water treatment plant and intake	Quality of the fence and number of security personnel	Throughout construction	NWSC	
	k) Strict adherence to safety measures and procedures are required to minimise (or eliminate) risks of accidents or hazardous developments occurring and ensure healthy and safe conditions for all persons working on the site and the project-affected communities. To ensure occupational health and safety on construction sites, the Contractor shall be obliged to comply with all applicable Ugandan construction Health and Safety Standards as required by the Occupational Safety and Health Act of 2006. These include provisions of the Factories Act, Labour Unions Act and Workman's Compensation Act.	Documentation of instructions	Contractor's/ Supervisor's Office	Check records and availability of procedures to workers	Throughout construction	MGLSD – OHS Department /NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	l) Materials will be preferentially sourced locally to minimize transport distances.	Location of material sources and schedule of material hauling		Check procurement records or documentation	Throughout construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
8.4.2 Unsustainable use of resources	**Construction phase**						
	a) Through inductions and tool box meetings, the contractor will ensure that staff and contractors are conversant with resource conservation practices in all project activities. Conservation awareness will focus on water use efficiency and general day-to-day measures such as turning engines and air conditioning units off when machinery and offices or dwelling quarters are not in use.	Record of water usage and conservation measures being implemented	Contractor's/ Supervisor's Office	Review of water abstracted and treated records	During construction	District Local Governments of Project Area – SEO's, CDO's	
	b) The Contractor will acquire water abstraction permits with conditions to guide the amount of water to be abstracted as stipulated in the Water Supply Regulations (1999). Water abstraction will comply with rates allowed by the DWRM permit that will be obtained.	Record of water abstracted	Contractor's/ Supervisor's Office	Check for availability of abstraction permit and records of water abstracted	During construction	DWRM	
	c) Earth materials will be sourced from a NEMA-approved source in a manner that reduces environmental and social impacts. Murram will be sourced in accordance with a NWSC approved murram/ subsoil extraction plan, which will be provided by the contractor prior to the start of works.	Approval from NEMA	Contractor's/ Supervisor's Office	Check for presence of NEMA permit/ license and site inspection of the sources of materials	ESIA for probable sources of materials before construction	NEMA/ NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	d) Any new borrow pits established by the project and would not be used later, shall be restored to as close to pre-project conditions as possible immediately after use. Native vegetation must be used for re-seeding the excavated site.	Location of material sources and schedule of material hauling	Contractor's/ Supervisor's Office	Check for availability of abstraction permit and records of water abstracted	ESIA for probable sources of materials before construction	NEMA/ NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	e) The contractor's Worker Code will include clauses of conduct on water and electricity consumption	Content of code	Contractor's/ Supervisor's Office	Review of code	Before commencement of construction activities	NWSC	
	Operation phase						
	a) Catchment management plans are being developed with the aim of conserving and allowing recharge of water resources.	Increase in volumes of water in existing water resources – water levels	NWSC & DWRM Zonal Offices	Check for availability and use of the plans	Throughout operation	NWSC/ District Local Governments of Project Area – SEO's, District Engineer's, Water Officers'	30,000,000
	b) Water conservation measures will be encouraged: saving water is an efficient way of reducing the overuse of ground water resources. It is not only decreases the amount of the water withdrawn, but may also reduce the threat of pollution	Record of water usage and conservation measures being implemented	NWSC Area Office		Throughout operation	NWSC/ District Local Governments of Project Area – SEOs, District Engineer's, Water Officers'	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	c) NWSC should adhere to the stipulated limits in the water abstraction permit obtained from DWRM.	Records of water quantities abstracted daily		Check record of water abstracted and treated	Throughout operation	DWRM	Covered
8.4.3 Damage to Existing Public Infrastructure	**Construction and operation phases**						
	a) Trucks ferrying materials will be loaded commensurate with the recommended axle load for a given road to avoid or minimize damage.	Complaints from District Local Governments and communities/ Trafiic offences committed	Respective Project District Offices/ Nearest Police station/ post	Consultations with UNRA zonal office and Office of the District Engineer	During construction	Traffic Police Officers/ District Local Governments of Project Area – District Engineers	
	b) Locally sourced materials will be used, whenever possible, to minimize travel distances and expanse of road damaged.	Location of sources of materials		Site inspection and documents of procurement of materials	Before and during construction	NWSC	
	c) Special permission will have to be sought from Uganda National Roads Authority (UNRA) and Gulu District Local Government before activities at road crossing are carried out. A typical drawing for a road / highway crossing is presented in drawing WS_CD_9_4_02 in Appendix J. Similarly permission from Uganda Railways Authority will be sought for the railway crossing at Sira Dongo Road.	Evidence of permission from UNRA/Gulu Municipality/ URA	Project Office	Check for availability of permission from UNRA and URA in cases where the trenchless method was not employed	Before construction commences	UNRA/ Gulu Municipality/ URA	
	d) The trenchless technology will be used at the road and railway crossing to avoid damaging them. However, the method requires considering soil characteristics; the loads applied to the surface especially traffic and the level of water table to prevent the danger of surface caving in.	Quality of roads and railaway crossings	Road and railway crossings	Site inspection at cross points		NWSC/ UNRA/ Gulu Municipality/ URA	
8.4.4 Social misdemeanour by construction workers	**Construction phase**						
	a) The contractor will be required to develop a Labor Influx Management Plan and/or a Workers' Camp Management Plan. These will include sanctions for workers involved in criminal activities.	Presence of labour Influx Management plan		Content of the plan	Before construction commences	NWSC	
	b) As a contractual obligation, contractors shall be required to have an HIV/AIDS policy and a framework (responsible staff, action plan, etc.) to implement during project execution.	All construction workers living in a camp adhere to "No fraternization" and comply with latest entry time into camp set to avoid prostitution; and monitor complaints from the community	Workers' camp and Contractor's Office	Check for policy and interview/ consult with workers about the policy	Development of policy before construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	c) All construction workers shall be oriented and sensitized about responsible sexual behaviour in project communities.	All construction workers are aware of HIV/AIDS risk and responsible living.	Workers' camp and Contractor's Office	Check for policy and interview/ consult with workers about the policy	Before construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	d) The contractors will develop and follow a code of conduct. An example is provided in Appendix G			Check for availability of code of conduct, signed coipes by workers and interview workers about the applicabilition and appreciation of the code			
	e) The contractors will develop and follow a code of conduct. An example is provided in Appendix G				Before construction phase	NWSC	
	f) The contractor will conduct cultural sensitization training for workers regarding engagement with local community.	Records of sensitisation	Project/ contractor's office	Review of records and interview of workers	During mobilisation stage	NWSC	
	g) The contractor will endeavour to provide entertainment and events for workers within camp to reduce incentives for mixing with local community.			Inspection of workers camp	During construction	NWSC	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	h) Workers will be encouraged to get vaccinated against common and locally prevalent diseases	Number of workers vaccinated	Project/ contractor's office	Review of records	Before and during construction	NWSC/ CDO's	
	i) The contractor, where need arises, will engage an HIV service provider to be available on-site who should conduct campaigns on STDs among the workers and local community; educate workers and the community about the transmission of diseases; and implement HIV/AIDS education program and provision of condoms.	Campaigns conducted, evidence of program implemented and availability of condoms	Project sites and workers' camp	Review of records, Inspection and interview of workers	Before and during construction	NWSC/ CDO's	
8.4.5 Gender-based violence	**Construction phase**						
	a) The contractor will conduct mandatory and repeated training and awareness raising for the workforce about refraining from unacceptable conduct toward local community members, specifically women	Records for training and awareness	Project sites and workers' camp	Review of records and interview of workers	Before and during construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	b) Workers will be informed about national laws and funder's policies that make sexual harassment and gender-based violence a punishable offence which is prosecuted	Evidence that information was received by the workers	Project sites and workers' camp	Review of records and interview of workers	Before and during construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	c) Worker Code of Conduct will be part of the employment contract, and including sanctions for non-compliance (for example, termination)	Employment contract	Contractor's office	Review of employment contracts	Before and during construction	NWSC/ District Local Governments of Project Area – CDO's	
	d) The contractor, where a case arises, will cooperate with law enforcement agencies in investigating complaints about gender-based violence	Complaints handled	Contractor's office	Consultations with law enforcers and review of records	During construction	NWSC/ District Local Governments of Project Area – CDO's	
8.4.6 Child labour and school dropout	**Construction phase**						
	a) The contractor and NWSC will ensure that children and minors are not employed directly or indirectly on the project	Visual and employee's details	Contractor's office	Review of workers' details	Before and during construction	NWSC/ District Local Governments of Project Area – CDO's	
	b) The contractor will communicate the hiring criteria, minimum age and applicable laws (for example, Children Act, Cap 59) in his ESMP		Contractor's office	Review of workers' details	Before and during construction	NWSC/ District Local Governments of Project Area – CDO's	
8.4.7 Permanent Land take	**Pre-construction phase**						
	a) NWSC will ensure that the project-affected persons identified through the Resettlement Action Plan study of the project are compensated for the land and property on it in time and fairly.			Consult with compensation record or RAP implementation report			
	b) Land will be acquired in accordance with Uganda's Land Access and Compensation Procedure taking into consideration the Development Partner's requirements. Amongst others, this requires: sensitisation of community members whose property will be affected; Completion of a full inventory of privately registered and/or cultivated and grazed or other uses of the land that will be taken for the project as well as structures and graves along the access road; compensation to be paid in line with mandated rates agreed in consultation with District officials before commencement of construction activities; and ensuring that the Chief Government Valuer approves the valuation rates.	List of fully compensated PAPs against Monies paid out to them.	Project Office	Consult with compensation record or RAP implementation report	Prior to commencement of construction.	NWSC/ CGV Independent Hired External Monitor	25,000,000

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
8.4.8 Occupational health safety (OHS) Risks	**Construction and operation phases**						
	a) A qualified Health and Safety Officer will be recruited by the Contractor to oversee OHS matters on a daily basis.						
	b) All construction workers will be oriented on safe work practices and guidelines and ensure that they adhere to them all the time.	Records of workers' orientation	Project sites & Contractor's/ Supervisor's Office/ NWSC WTP	Review of records of training	At the beginning of construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	c) Use signage to warn staff and/ or visitors that are not involved in construction activities of dangerous places.	Presence of signage	Project sites & Contractor's/ Supervisor's Office	Site inspection	During construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	d) Regular drills should constantly follow on various possible incidences. This will test the response of the involved stakeholders.	Record of drills	Project sites & Contractor's/ Supervisor's Office	Records of drills	Throughout construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	e) Training will be conducted on how to prevent and manage incidences. This should involve proper handling of electricity, water etc. and sensitization on various modes of escape, conduct and responsibility during such incidences. All must fully be aware and mentally prepared for potential emergency	Records of training and details of staff trained	Project sites & Contractor's/ Supervisor's Office	Check of records of training	At the beginning of and during construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	f) Personnel will only undertake tasks for which they are trained/ qualified. A formal 'permit to work' system will be in place and strict instructions will be given for operators of equipment.	Permits for works and their qualifications	Project sites & Contractor's/ Supervisor's Office	Check workers' permits and random sampling of workers	Throughout construction and operation phases	MGLSD	
	g) Strict instructions will be given to drivers of heavy equipment and operators of equipment/ machinery. Ensure electrical safety at fabrication workshops by putting in place secure electrical connections and providing adequate insulation. All temporary electrical installations in use on site such as generators and welding sets should be adequately and effectively earthed at all times during operation	Documentation of instructions	Project sites & Contractor's/ Supervisor's Office	Site and office inspection for instructions	Throughout construction	Traffic Officers, NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	h) Supervision of works will be done regularly to ensure that safety conditions are met while any deviation from safety regulations is immediately reclaimed following the best practices regarding safety at work equipment.	Supervision record	Project sites		During construction	MGLSD/ District Local Governments of Project Area – SEO's, CDO's	15,000,000
	i) Clear communication line shall be ensured between workers and drivers of heavy equipment.	Presence of radio calls/Megaphones being utilised	Project sites		During construction	NWSC	
	j) Evacuation procedures to handle emergency situations will be developed	Presence of a documented evacuation procedure	Project sites	Check procedures and interview workers whether they are aware about the procedures	During construction	MGLSD/ NWSC	
	k) Adequate OHS personnel protective gear will be provided to the employees.	Record of PPE provided and staff; use of PPE on site	Project sites	Site inspection	During construction and operation phases	MGLSD	
	l) Strict adherence to safety measures and procedures are required to minimise (or eliminate) risks of accidents or hazardous developments occurring and ensure healthy and safe conditions for all persons working on the site. To ensure occupational health and safety on construction sites, the Contractor shall be obliged to comply with all applicable Ugandan construction Health and Safety Standards as required by the Occupational Safety and Health Act of 2006. These	Documentation of instructions	Project sites	Check for documentation	Throughout construction	NWSC/ GDLG/ GMC	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	include provisions of the Factories Act, Labour Unions Act and Workman's Compensation Act.						
	m) First aid boxes will be available at all active construction sites and at accessible locations at the water treatment plant during the operation phase.		Project sites	Visual inspection	During construction and operation phases	NWSC	
	n) An Accident log will be maintained onsite to register all injuries and to investigate their causes during both the construction and operation phases of the project.	Monthly accident log available	Project sites & Contractor's/ Supervisor's Office	Check on records	During operation	MGLSD – OHS Department	
	o) Emergency resources (e.g., fire extinguishers, stocked First Aid kits, Emergency Contacts, Doctor on Call, etc.) will be maintained at all active construction sites and at the water treatment facilities during operation.	Existence of first aid kits and communication facilities	Contractor's/ Supervisor's Office	Site inspection	At start and replemishment when need arised during of operation	MGLSD – OHS Department	
	p) The Contractor shall ensure that all areas requiring access including platforms, under platforms, underpasses, excavations, etc. have enough illumination.	Record of cases and light measurement records	Contractor's/ Supervisor's Office	Site inspection and measurement of light levels	During construction and operation phases	MGLSD – OHS Department	
	q) Excavations and rock blasting activities will be undertaken under strict guidance to avoid chances of collapse and injury, respectively.	Record of cases and light measurement records	Contractor's/ Supervisor's Office	Site inspection	During construction	NWSC/ MGLSD – OHS Department	
	r) The manufacturer's instructions and Material Safety Data Sheets (MSDS) must be followed for the storage of all chemicals used in water treatment. Storage must conform to compatibility restrictions.	Easily accessible and clear instructions and Material Data Sheets	Contractor's/ Supervisor's Office		Throughout operation of facilities	MGLSD – OHS Department	
	s) Regular fumigation of the WTP and contractor's/ workers' camp will be undertaken to kill disease vectors such as mosquitoes	Record of fumigation of facilities	Contractor's/ Supervisor's Office	Check for records of fumigation	Quarterly or as need arises	District Local Governments of Project Area where camp is located and Oyam – SEOs	
NEGATIVE CUMMULATIVE IMPACTS							
8.5.1 Disruption of traffic and communication routes	**Construction phase**						
	a) The trenchless technology will be used at major crossings like roads to avoid disruption of traffic flow.			Site inspection			
	b) Appropriate signage will be used and impacted owners will be informed ahead of disruption	Complaints from property owners	Local authorities/ communities	Consult with community members of property was affected	Before and during construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	c) Disruptions to public access shall be identified in the Contractor's Traffic Management Plan, under which suitable notice of intending delays and closures are given to all concerned parties and approved prior to commencing work. All road closures shall be separately notified and agreed with the Local gov't administration.	Minimal or no interruption in pedestrian and traffic flow	Local authorities/ communities	Consultations with local authorities	Before and during construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	d) Where access to or from an individual property is closed for a period of 2 hours or more, the owner shall be informed at least 24 hours in advance.	Complaints from property owners	Local authorities/ communities	Consult with community members of property was affected	Before and during construction	NWSC/ District Local Governments of Project Area – SEO's, CDO's	
	e) Vehicular access to and from hospitals, police stations and fire stations shall be maintained through the use of steel road plates over open trenches. Pedestrian access to schools, health facilities, and other premises frequently accessed by the public will be maintained with the use of walking boards.	Minimal or no interruption in pedestrian and traffic flow to public facilities	Nearest Police Station/ Post – Traffic Department	Consultation with the affected facility authorities/ administrators	Before and during construction	NWSC/ District Local Governments of Project Area – SEO's and CDO's	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	f) The laying of pipelines, backfilling and temporary reinstatement shall follow trench excavation as quickly as possible and trenches will not be left open for extended periods.	Complaints from affected communities	Project Office	Site inspection	Before and during construction	NWSC/ District Local Governments of Project Area – SEO's and CDO's	
8.5.2 Air pollution	**Construction phase**						
	a) Construction work will be undertaken by an experienced and duly registered contractor with a verifiable sense of environmental awareness and responsibility	Record of environmental responsiveness of the contractor/ Environmental Management Plan	Project sites & Contractor's/ Supervisor's Office	Review of qualifications of the contractor's employee in charge of EHS	During construction	NWSC/ District Local Governments of Project Area	
	b) Travel speeds of construction vehicles along the road especially at trading/ business centres will be controlled using humps and setting travel speeds not exceeding 40km/h	Number of accidents and/ or complaints reported/ Journey management records	Project sites & Contractor's/ Supervisor's Office	Review of records of traffic related accidents	During construction	NWSC	
	c) A maintenance programme for equipment and vehicles will be implemented, to ensure air emissions like particulates, SO_2 and NO_2 are minimised.	Emissions data (NOx, SO_2, CO, CO_2 and PM, etc) as per the national air quality guidelines Strict maintenance program	Project sites & Contractor's/ Supervisor's Office	Records of maintenance and inspection of vehicles/ equipment	During construction	NWSC/ District Local Governments of Project Area	
	d) Trucks will be covered during haulage of construction materials to reduce on spillage of materials	Recognition of locales of contractor's efforts to minimise dust nuisance.	Project sites & Contractor's/ Supervisor's Office		During construction	NWSC/ District Local Governments of Project Area	
	e) Workers will be provided with PPE and the use of PPE shall be enforced	Complaints of excessive fumes	Project sites & Contractor's/ Supervisor's Office	Direct observation and consultations with workers	During construction	NWSC/ District Local Governments of Project Area	
	f) All surfaced roads shall be subject to road cleaning and un-surfaced roads to dust suppression, the methodology and frequency of which shall be included in the Contractor's Traffic Management Plan	Air quality data (NOx, SO_2, CO, CO_2 and PM, etc as per the national air quality guidelines) / Environmental monitoring report	Project sites & Contractor's/ Supervisor's Office	Consultations with the local authorities - environmental officers	Monthly throughout construction	NWSC/ District Local Governments of Project Area	
8.5.3 Generation of noise and vibrations	**Construction and operation phases**						
	a) Care will be exercised when selecting the working equipment to avoid use of old equipment or damaged equipment with high level of noise emissions that would have a negative impact on the environment. Equipment will be properly maintained and kept fully functional. Servicing of all construction vehicles and machinery will be done regularly and during routine servicing operations, the effectiveness of silencing equipment (e.g. exhaust silencers) will be checked and if found defective will be replaced.	Number of complaints from the communities and authorities/ record of noise levels	Neighbouring communities	Review of complaints records and consultations with nearby communities	Before and during construction	NWSC	-
	b) Construction workers will be made aware of the silent nature of workplaces they are operating in and advised to limit verbal noise or other forms of noise. For example, metallic objects or tools can be passed on to a colleague rather than dropping or throwing them with loud bangs.	Record of noise measurements	Project sites & Contractor's/ Supervisor's Office	Review of environmental monitoring reports	Throughout construction	NWSC	-
	c) All generators and heavy duty equipment will be insulated or placed in enclosures to minimize disrupting ambient noise levels. Pumps, generators and other mobile equipment will be sited as far as practicable from housing and other noise sensitive locations. Regular maintenance, monitoring and, where necessary, the use of silencing equipment will be employed with the aim of reducing noise emissions	Complaints from the communities and authorities/ record of noise levels	Project sites & Contractor's/ Supervisor's Office	Review of complaints records and consultations with nearby communities	Before construction begins	NWSC	-
	d) The contractor will submit detailed information on the noise levels which will be generated by the specific methods and equipment proposed and the actions that	Record of noise measurements/ Environmental Monitoring reports	Project sites & Contractor's/ Supervisor's Office	Review of environmental monitoring reports	Throughout construction	NWSC/ District Local Governments of Project Area	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	will be taken to minimise the noise impact. Equipment shall be operated within their specifications and capacity (for example, avoid overloading machines).						
	e) Noise levels emanating from machinery, vehicles and noisy construction activities will kept at a minimum (within the national noise level limits) for the safety, health and protection of people in the nearby buildings. The vehicles that are excessively noisy shall not be operated until corrective measures have been taken.	Record of noise measurements/ Environmental Monitoring reports	Project sites & Contractor's/ Supervisor's Office	Review of environmental monitoring reports	Throughout construction	NWSC/ District Local Governments of Project Area	5,000,000
	f) During periods of inactivity, equipment will be switched off whenever possible. Where appropriate, residents living in the vicinity of where construction activities are taking place will be kept informed of the contractor's proposed working schedule (through implementation of the Community Liaison Management Plan) and will be advised on the times and duration of any abnormally noisy activity likely to cause concern.	Record of noise measurements/ Environmental Monitoring reports	Project sites & Contractor's/ Supervisor's Office	Review of environmental monitoring reports	Throughout construction	NWSC/ District Local Governments of Project Area	
	g) Project vehicles will have a restricted speed limit of 40 km/h through settlements and trading centres to minimise noise.	Complaints from communities about night time construction activities	Villages close of Project sites & Contractor's/ Supervisor's Office	Review of complaints records and consultations with nearby communities	Throughout construction	NWSC	-
	h) No construction activities will take place at night for sites where the closest residence is within less than 150 m from the project site, the operations on site shall be restricted to the hours 6.00 -22.00.	Complaints from communities about night time construction activities	Project sites & Contractor's/ Supervisor's Office	Review of complaints records and consultations with nearby communities	Throughout construction	NWSC	
	i) The noise due to blasting operation lasts for a very short period. Primary blasting shall be carried out with adequate preventive measures to control the noise to the permissible limits. Consideration for the nearest habitation shall be at a distance of 500 m from the site boundary. Before blasting is undertaken all the relevant permissions shall be obtained from the Ministry of Internal Affairs Uganda.	Complaints from communities about blast activities	Project sites & Contractor's/ Supervisor's Office	Review of complaints records and consultations with nearby communities	Throughout construction	NWSC/ District Local Governments of Project Area	
	j) Sequential timer blast machine or other approved methods shall be used for primary blasting and there shall be no secondary blasting. The boulders shall be broken using a hydraulic rock breaker. Proper maintenance of the noise generating parts of the machines shall be undertaken. Air silencers of suitable type that can modulate the noise of the engines of machinery can shall also be put in use and maintained effectively.	Complaints from communities about blast and vibration producing activities	Project sites & Contractor's/ Supervisor's Office	Review of complaints records and consultations with nearby communities	Throughout construction	NWSC/ District Local Governments of Project Area	
	k) Ear muffs shall be given to all the workers operating or working close to any machine and full PPE for any persons participating in blasting activities. Periodical monitoring of noise levels and blast vibrations will be practiced and the contract shall ensure that the necessary noise/vibration meters for taking measurements are available.	Complaitns from workers concerning negative impacts of blasting/vibration activities to their health	Project sites & Contractor's/ Supervisor's Office	Review of complaints records and consultations with nearby communities	Throughout construction	NWSC/ District Local Governments of Project Area	
	l) The contractor shall also use control measures like wet drilling to avoiding blasting during high wind speed and development of green belt within the safety barrier of the specific project site and shall ensure that there is no impact of blasting activity in the surrounding area.	Complaints from communities about blast activities	Project sites & Contractor's/ Supervisor's Office	Review of complaints records and consultations with nearby communities	Throughout construction	NWSC/ District Local Governments of Project Area	
	m) Construction activities in the identified sensitive areas *(Bobi Health Centre III (N428086.2, E284815.65), St Thomas O.T.T Primary School (N428498.25, E280335.42), Bobi Sub-county (N428512.54, E282704.61), Ministry of Energy Offices (N421542.49, E248677.74), Koro Abili C.O.U Primary School (N423536.66, E299479.75), St. Peter Paul Catholic Church (N428598.34, E280554.22), MTN Mast (N423534.44, E299676.99) St. Joseph Catholic Church (N429801.34, E276378.46), Minakulu Primary School (N430713.94, E272720.91) Jeroline School (N425855.36, E289522.13), St Baptist Church (N422771.5, E303450.33), Adel Primary School (N431255.18, E270057.49) and St Thomas More Primary School- Minakulu (N423038.87, E302369.94))* shall be scheduled during weekends, stockpiling supplies and materials shall also be done during noncritical times to minimize transport nose. The maximum allowed noise	Complaints from communities (especially schools)	Project sites	Review of complaints records and consultations with nearby schools	Throughout construction	NWSC	

IMPACT	MITIGATION/ENHANCEMENT COMMITMENTS	PARAMETERS TO BE MONITORED	LOCATION	MEASUREMENTS (METHODS & EQUIPMENT)	TIMING	MONITORING INSTITUTION	ESTIMATED ANNUAL COST (UGX)
	level should be 45dBA for night and 55dBA for evening and day. Measurement of noise level should be performed before the start up with the working activities and during work peaks (of particular importance when project activities take place in the immediate vicinity of the primary school). Restriction or suspension of pipe laying activities during critical times (such as school exam or test times) shall be abided to.						
ESTIMATED GRAND TOTAL							***170,000,000***

10 CONCLUSION

The proposed project has potential to significantly improve quality of life in the Project District Local Government of Gulu, Oyam, Omoro and Kiryadongo and especially the towns/ municipality being directly served. The long term socio-environmental benefits of a reliable supply of potable water include, but not limited to, reduced morbidity and increased productivity of households; and increased enrolment of children in educational institutions. In addition, project development and operation in the municipality andtowns enroute will provide considerable economic opportunity and attraction of other services.

However, development of the project can also bring with it negative impacts. Where there is adequate and reliable supply of water, for example, there is always generation of wastewater. The key significant negative impacts will mainly arise during construction of the project. NWSC should use their vast experience in their respective areas of jurisdiction in supervising the contractor such that the negative impacts are minimised. Operating and maintaining of the water treatment facility should also be done such that adverse effects arising from inadequate management of water treatment residue or wastes are avoided.

If the project is developed and infrastructure put in place operated in conformity with the legal requirements and annual audits conducted following suggestions provided in the ESMP, the benefits of this project to the nation would by far outweigh potential negative effects.

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APPENDIX A: STAKEHOLDER ENGAGEMENT

Week	**11**	Meeting date	**19 April 201819 April 2018**
		Recorded by	**Grace BAALIKOWA**
Meeting/subject	**ESIA AMD RAP FOR THE PROPOSED KARUMA-GULU WATER SUPPLY PROJECT**	Total pages	**4**
Stakeholder	**NATIONAL WATER AND SEWERAGE CORPORATION (NWSC)**		

Present	**Apology**	**Copy**	**Name**	**Organisation**	**Designation**
☒	☐	☐	Mr. Joseph Assimwe	UNRA	Senior Environmental Officer
☒	☐	☐	Mr. Brain E. Karugaba	UNRA	Environmental Specialist
☒	☐	☐	Mr. Dickens Ahimbisibwe	UNRA	Highway Engineer
☒	☐	☐	Mr. Innocent Twesigye	NWSC	Environmental Engineer
☒	☐	☐	Dr. Herbert Mpagi Kalibbala	AWE	ESIA Team Leader
☒	☐	☐	Mr. Solomon Muddukaki	AWE	Sociologist
☒	☐	☐	Ms. Grace Baalikowa	AWE	Sociologist
			Attendance list attached		

Proceedings
1. Introduction
The team was welcomed by the environmental specialist (UNRA). This was followed by self-introductions by everyone in the room.The agenda for the meeting was: • Introductions • Presentation of the project • Discussions • Closure of meeting
2. Presentation

Proceedings
Team leader made a presentation on the project to the attending members. The presentation entailed: ▪ Objectives of the presentation ▪ Project background ▪ Composition of consultant (ESIA & RAP) team ▪ Project location and description ▪ Overview of the ESIA and RP processes ▪ Anticipated impacts from project development and operation
3. Discussion

Proceedings
Question: The availability of some of the team members need to be verified. For example one of the expertise is a UNRA staff (Lukwago Wilber- Herpetologist), will he be available to carry out the assignment? **Response:** We shall have to adjust our team accordingly. It could be by the time, he was considered for the assignment was not a UNRA staff. **Suggestion:** NWSC need to apply for a permit if the water transmission line is to cross the UNRA road. During construction NWSC will need UNRA staff to monitor especially traffic and also give alternatives besides acquiring the permit. The road reserve is 14.5 metres from the centre and other roads is 7 metres from the shoulders especially when the road is approaching the town. **Suggestion:** Based on the list of stakeholders, UEGCL is missing and is one of the stakeholders who should be consulted since the intake of the water is near the dam and within 330 m upstream of the dam to karuma. **Response:** The omission of UEGCL on the list of key stakeholders to be consulted was an oversight but indeed we shall consult on them .The World Bank questioned too about the 330m distance but there are alternatives to push away from the 330 m distance. The Dam and the Reserves need to be at distance and also due to safety; the intake can't be within the Dam reserver. **Suggestion:** RAP**-** to quire right of way, NWSC need to find out if UNRA acquired the land and paid off the PAPs, because not all where UNRA roads pass land is acquired fully. **Response:** Where land is not acquired by UNRA, the institution in urgency takes precedence **Question:** When does NWSC intent to start on this project? **Response:** The project intents to start in 2019, but the initial designs are in process and ending in the month of June. Most of the designs are done and NWSC has been in touch with UEGCL that is why the distance will be extended from the Dam. **Suggestion:** NWSC needs to work with UNRA because Kamudini road will be rehabilitated, so there is need to match the schedules and compile with transportation line going on. **Response:** The suggestion is taken and will be forward to NWSC.

Stakeholder consultation record:

Name of Agency / Institution: UGANDA NATIONAL ROADS AUTHORITY (UNRA)

Purpose of consultation (*tick appropriate box*):			
Scoping	√	ESIA	√
Sensitisation		RAP	✓
Environmental Audit		Other (specify)	

Date: 19TH APRIL 2018

Project name: PROPOSED KARUMA – GULU WATER SUPPLY PROJECT

Proponent: NATIONAL WATER & SEWERAGE CORPORATION

Name of person/official met:	Designation	Contact (Telephone/mobile number/ email)	Signature/ initial
Asimwe Joseph	SEO/UNRA	0775413274	[signature]
Brian E. Kamgabe	Env. Specialist UNRA	brian.kamgabe@unra.go.ug 0782767776	[signature]
Ahimbisibwe Dickens	Highway Engineer/UNRA	0779217404	[signature]
INNOCENT TWESIGYE	ENVIRONMENTAL ENGINEER-NWSC	0773632099	[signature]
Muddukali Solomon .J.	Sociologist	0701161534	[signature]
Grace Baahikawa	Sociologist	0782409889	[signature]

Week	11	Meeting date	4 June 20184 June 2018
		Recorded by	Grace Baalikowa
Meeting/subject	ESIA AND RAP FOR THE PROPOSED KARUMA-GULU WATER SUPPLY PROJECT.	Total pages	3
Stakeholder	UGANDA WILDLIFE AUTHORITY (UWA)		

Present	Apology	Copy	Name	Organisation	Designation
☒	☐	☐	Mr. Edgar Buhanga	UWA	Deputy Director Planning
☒	☐	☐	Ms. Justine Namara	UWA	Manager EIA/OM
☒	☐	☐	Ms. Patricia Mbabazi	UWA	EIA Officer
☒	☐	☐	Mr. Samson Okot	UWA	EIA/OM-Intern
☒	☐	☐	Dr. Herbert Mpagi Kalibbala	Air Water Earth (AWE) Limited (AWE)	Team Leader
☒	☐	☐	Ms. Grace Baalikowa	AWE	Sociologist
			Attendance list attached		

Proceedings

1. Introduction

The team was welcomed by the Deputy Director Planning (UWA). This was followed by self-introductions by everyone in the room. The agenda for the meeting was:

- Self Introductions
- Presentation of the project
- Discussions
- Closure of meeting

2. Presentation

Proceedings
The Team leader made a presentation on the project to UWA EIA staff members. The presentation entailed: ▪ Objectives of the presentation ▪ Project background ▪ Composition of consultant (ESIA & RAP) team ▪ Project location and description ▪ Overview of the ESIA and RAP study processes ▪ Anticipated environmental and social impacts from project development and operation ▪ Water intake points and the connection routs ▪ Water supply to different towns and mainly Gulu Municipality
3. Discussion

Proceedings
PROPOSED PROJECT UWA is consulted as one of the stakeholders since there is Murchison falls game park in the project. **Question:** What is the connection between Karuma and Kamudini **Suggestion:** The water pipe should take the lower line rout of the side of the dam walls avoid the park as much as possible. If the pipe line is placed on the North bank, the park will be outside and no impacts. • The UWA tourism office-NUGATIC need water even though, there is avoiding forest land take. **Question:** How many meters are required as a working cordial **Response:** 7 meters are requires from the middle of the road and more 7 metres form the pipe. Then 3 metre are required as wayleaves cordials which could be in a road reserve. But for the small towns, the metres will reduce form 7 metres to less. **Suggestion:** The pipe line should be laid along the bridge and then follow the road reserve to avoid the park and land take. **Response**: Project are ongoing, this consultation help to have better design to minimise impacts. **MURCHISON FALLS NATIONAL PARK** **Question:** What is requires if the pipe line goes through the game park? **Response- UWA- EIA Team** ▪ Waste management plan for material waste, food waste and human waste ▪ Follow park regulations ▪ Apply for park entry to work in the park since it's not a long period of time, don't need a permitted ▪ Open and bury the tranches ▪ Need restoration plan especially for tress, and vegetation ▪ Develop a time plan to be spend in the park ▪ Cover the treatment to avoid animals ▪ Put a mesh and bubbled wire to avoid animals to climb **RESETTLEMENT ACTION PLAN** ▪ The RAP study will focus on issues of land take land, PAPs, the documents required for the project implementation. **Alternative** ▪ The pipe line should use the road reserve, then goes under the bridge and with the use of new technology to avoid damaging the road.

Stakeholder consultation record:

Name of Agency / Institution: **UGANDA WILDLIFE AUTHORITY (UWA)**					
Purpose of consultation (*tick appropriate box*):	**Scoping**	√	**ESIA**	√	
	Sensitisation		**RAP**		
	Environmental Audit		**Other (specify)**		
Date: 4th June 2018					
Project name: **PROPOSED KARUMA – GULU WATER SUPPLY PROJECT**					
Proponent: **NATIONAL WATER & SEWERAGE CORPORATION**					

Name of person/official met:	Designation	Contact (Telephone/mobile number/ email)	Signature/ initial
Edgar Buhanga	Deputy Director Planning	0782572521 buhanga.edgar@ugandawildlife.org	[signature]
Justine Namara	Manager EIA/OM	0772413432 justine.namara@ugandawildlife.org	[signature]
Samson Okot	EIA Officer	0778789426 samson.okot@ugandawildlife.org	[signature]
Patricia Mbabazi	Intern - EIA/OM	070503804 pmbabazi88@gmail.com	
KALIBBALA HERBERT MPAGI	TEAM LEADER - AWE	0772496457	[signature]
Grace Baalikowa	Sociologist - AWE	0757688441	[signature]

Week	11	Meeting date	**6 June 20186 June 2018**
		Recorded by	**Rhionah and Ivan**
Meeting/subject	**ESIA AND RAP FOR THE PROPOSED KARUMA-GULU WATER SUPPLY PROJECT**	Total pages	**4**
Stakeholder	**DIRECTORATE OF WATER RESOURCES DEVELOPMENT AND MANAGEMENT**		
Proponent	**NATIONAL WATER AND SEWERAGE CORPORATION**		

Present	**Apology**	**Copy**	**Name**	**Organisation**	**Designation**
☒	☐	☐	Okurut Daniel Samson	DWRM	Water Officer
☒	☐	☐	Gerald Babi	DWRM	Ag.SWO (PC)
☒	☐	☐	Odong Joseph	DWRM	A.g SWO (ESIA)
☒	☐	☐	Iragena Anthelem	DWRM	SWO
☒	☐	☐	David Kataratambi	DWRM	SWO
☒	☐	☐	Cheptoek David	DWRM	Ag.PWO (RR)
☒	☐	☐	Edward Martin Rwarinda	DWRM	Ag.Ass.commissioner (CTE)
☒	☐	☐	Okello Geatano	DWRM	AC Water Use Planning
☒	☐	☐	Kizito Daniel Mulwana	DWRM	Hydrogeologist (Trainee)
☒	☐	☐	Dr. Herbert Mpagi Kalibbala	Air Water Earth (AWE) Limited	Team Leader
☒	☐	☐	Ivan Ntege	Air Water Earth (AWE) Limited	GIS Specialist
☒	☐	☐	Ritah Nakanwagi	Air Water Earth (AWE) Limited	Environment and Natural Resources specialist
☒	☐	☐	Rhionah Christine Nassozi	Air Water Earth (AWE) Limited	Sociologist (intern)
			Attendance list attached		

Item	**Update**

1.	**Introduction**
	The team was welcomed by the Chairman (Eng. Okello). This was followed by a prayer by EMR (Ag.Ass. Commissioner (CTE) and then trailed by self-introductions. The agenda for the meeting was: • Introductions • Presentation from (AWE)Consultant • Discussions • Closure of meeting
2.	**Presentation**
	Dr. Kalibbala / Team leader made a presentation on the project to the attending members. The presentation entailed: ▪ Composition of consultant (ESIA & RAP) team ▪ Structure and Objectives of the Presentation ▪ Project background ▪ Project site location and technical description ▪ Composition of consultant (ESIA & RAP) Process ▪ Overview of the ESIA and RAP processes ▪ Anticipated impacts from project development and operation
3.	**Discussion**

ISSUES ON PROPOSED PROJECT

Question: The letter written by NWSC, there were two objectives one was about ESIA and RAP water supply and other was about sewerage collection and treatment .why is the second objective ignored?

Response: In the contract between AWE and NWSC sewerage collection and treatment was out of scope.

Question: What do red circles on the map represent?

Response: The circles on the map represent towns to be connected to that pipeline for water supply

Question: Do we have any sanitation facilities around towns?

Response: This phase of the project is mainly water supply. The sanitation component is being handled in the first phase which under implementation. However, the six towns, sanitation issue will be raised to the client.

Suggestion: The consultancy should also consider sanitation components or facilities.

ON DESIGN AND LIFE SPAN OF THE PROJECT

Question: What is NWSC up to implementing a transmission line scheme with a short design project life span of 7 years from 2018-2025?

Suggestion: NWSC should adopt the 2013 water supply design manual set for 20 -25 years of which 5 years are for planning and 20 years of implementation according the design manual for water supply projects.

Recommendation: The consultant should contact Mr. Joseph Odong (ESIA Specialist- DWRM) whether the planning should be taken out of the design life.

Question: What is a project design discharge? Is there water balance study for Karuma Hydro Power that indicates how much water is being used by the system is safe, we had an incident when you sum up?

Question: What are the design criteria used to inform the water intake, water treatment plant and other components?

Response: The site locations were informed by the feasibility studies.

ESIA STUDY PROCESSES

Comment: The water balance study should be taken care of during the detailed ESIA study since KHP is just a water user not a consumer.

Suggestion: Anticipated impacts could be used as specific conditions to be issued or not issued with permits.

Suggestion: The consultant should undertake a Water resources assessment study taking into consideration Karuma HPP and other adjacent water users to ensure that they would not be affected.

Suggestion: Although water abstraction is expected to be minimal, we request for a water assessment report.

Question: How far is the waste treatment plant from the water treatment plant and on which side of the river (Victoria Nile)? Where is the location of the discharge point and how far is the discharge point from the abstraction point?

Response: The water treatment is a complex plant comprising of all necessary unit processes and sludge treatment facilities (sludge drying bed). All these will be located within the demarcated area for the water treatment plant.

Suggestion: The study should entail other water users who could be affected downstream of the discharge point.

Question: Was the water source protection component considered under this project?

Response: The Water source protection is outside the scope of this assignment but usually the client engages a separate consultant to do the plans just like it has been handled with other projects.

Comment: If there likely impacts or other effects which may come along, identify necessary mitigation measures since source protection is a necessity.

Question: How is the sludge cake going to be handled?

Response: NWSC will work with the concerned authorities to identify the most suitable way of disposing it off. If classified as hazardous, the option is to transport to Luweero Industries where there is an approved hazardous waste handling facility otherwise it could be disposed at a sanitary or municipal landfill.

Suggestion: NWSC should develop a prototype of unit processes to determine the chemical ,biological or both characteristics of waste water

WATER INTAKE

Question: What type of intake is NWSC adopting for this water supply scheme?

Response: Reference made to the project drawings in the technical description since the intake point is susceptible to siltation.

Question: What siltation control measures will be undertaken at the intake?

Response: Control measures will be obtained from the design consultant from the detailed design of the project

Question: As the consultant, have you put into consideration the Karuma study so that the abstraction point is not within the back water curve region?

Response: Yes, and for the same reason, it was agreed to extend the intake point further upstream of the Karuma HPP dam. Further assessment will be made in this regard.

Question: About unit processes, why was pre-chlorination process included since it has an impact on the type of sludge generated and the final water quality in regard to trihalomethanes?

Response: Yes, it is known the pre-chlorination of water rich in natural organic materials leads to the formation of carcinogenic materials like trihalomethanes. We shall engage the design consultant and NWSC why this was included taking into consideration the raw water quality.

Suggestion: Pre-chlorination process can also be substituted with sand filtration.

Question: What is the pumping duration a full day or half day?

Response: The pumping duration will be requested from the design consultant during the detailed study.

On the pipeline Question: How far is the pipeline from the road shoulder and centre line?

Response: The pipeline centreline was less than 7 m from the road centre line and also less than 2 m from the drainage.

Suggestion: Taking into consideration UNRA's future plans about the expansion for the northern economic corridor, the consultant should engage UNRA about the metres between the road and the pipeline to save NWSC from future compensations

Question: Why should the pipeline cross the main road at 3 points and the railway yet their other options like the bridges and culverts which cannot impair the structural integrity of the infrastructure?

Response: We shall consult the NWSC technical team

Consultantive meeting with the Directorate of Water Resources Development and Management Officials in Entebbe

Week		Meeting date	**2 July 20182 July 2018**
		Recorded by	**Muddukaki Solomon**
Meeting/subject	**ESIA AND RAP FOR PROPOSED KARUMA-GULU WATER SUPPLY PROJECT**	Total pages	**4**
Stakeholder	**Uganda Electricity Generation Company Limited (UEGCL)**		

Present	**Apology**	**Copy**	**Name**	**Organisation**	**Designation**
☒	☐	☐	Otim Moses	UEGCL	Manager Health, Safety, Environment and Social Development
☒	☐	☐	James Otto	UEGCL	Strategy & Business Development
☒	☐	☐	Gordon Tiril	UEGCL	Project officer
☒	☐	☐	Moses Anguyo	UEGCL	Project officer
☒	☐	☐	Abel Mutyaba	Air Water Earth (AWE) Limited	Environmentalist
☒	☐	☐	Muddukaki Solomon	Air Water Earth (AWE) Limited	Sociologist
☒	☐	☐	Kalibbala H. Mpagi	Air Water Earth (AWE) Limited	Team Leader
			Full list attached		

Update
Introduction

Update
The team was welcomed by the Manager, Health, Safety, Environment and Social Development. The agenda for the meeting was: • Introductions • Brief presentation of the project by AWE team • Discussions • Close of meeting
Discussion
Community Sensitization
Question: Have you consulted or engaged the people around that project area? **Response:** Consultations have already been held with the project districts and respective communities. Consultations with lead agencies are still on-going. **Question from AWE:** To what extent was land acquired for the Karuma Hydro Power Project (Karuma HPP) so that double compensation is not made to those who were already compensated under the Karuma HPP? **Response From UEGCL:** The Resettlement Action Plan for the Karuma HPP was conducted by the Ministry of Energy and Mineral Development. It would therefore be good to directly consult with the Ministry. Any assistance in this regard will be availed to you.
The intake
Question: What is the distance between the ongoing Karuma Dam to the intake? **Response:** Approximately 330 metres was originally proposed but it was agreed to have it extended 550 metres upstream of the Karuma HPP dam. **Suggestion: It was** suggested that the consultant shares the technical designs with UEGCL so that they review all the scenarios for more comments or suggestions. **Response:** The design is still undergoing changes but the project brief and drawings will be shared with you immediately after this meeting. **Question:** When is the actual construction of the intake starting? **Response:** NWSC was planning to start the works within the coming five weeks from the date of this meeting. **Suggestion:** It was pointed out that the Karuma HPP is about to be commissioned towards the end of the this year and advised that construction of the intake be done as soon as possible before the area is flooded.
Environmental flow report

Update
Question from AWE: Was an Environmental Flow Study conducted for the Karuma HPP and if yes, can it be shared for use for this study? **Response:** Yes, the agency did the study and it will be availed. The flow is 100 m^3/s but it would also be good to carry out an independent hydrological assessment for comparison especially the backwater flow or curve.
The Catchment
Suggestion: As a mitigation measure in your report, a catchment management plan is recommended and should be developed. **Response:** development of a catchment management plan is a study on its own and given the expanse of the Victoria Nile catchment, it was not part of the scope of this study. However, NWSC develops source water project plans and it will be recommended as a mitigation measure to develop one.
Waste Disposal
Question: Where do you intend to deposit the waste generated during the construction. **Response:** NWSC and the Contractor will work with the respective district to identify the most appropriate sites for disposal of such waste.
Question: What has been the water source for Gulu? **Response:** Currently the water source is Oyitino Dam but it had a tendance of drying up during severe weather. Oyitino Dam is being refurbished for the short term measure but Victoria Nile was the preferred long term measure hence the Water Treatment Works and intake at Karuma.

Stakeholder consultation record

Name of Agency/Stakeholder: UEGCL					
Purpose of consultation (*tick appropriate box*):	Scoping:		ESIA:	✓	
	Sensitisation:		RAP:	✓	
	Environmental Audit:		Other (specify):		
Date: 21 July 2018					
Project name: KARUMA - GULU WSP					
Proponent:					

Name of person	Designation	Contact (Tel)	Sign/ initial
Jenny Oseo	SBD	0783785135	
Moses Anguyo	Projects.	0777-221186	
GORDON YIKII	PROJECTS	0752 916689	
Ofimi Moses	Projects	0776200684	
Abel Mutsch	ESIA	0702830021	
Solomon muddukales	Geologist	701161504	
Kalibbala H. Mpagi	Team Leader / AWE	0772496451	

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OHSAS 18001:2007

Stand. Doc No: AWE/024

Week		Meeting date	**17-05 2018**
		Recorded by	**Mugerwa Faith**
Meeting/subject	**Gulu District**		

Present	**Apology**	**Copy**	**Name**	**Organisation**	**Designation**
			Signed list appended		

Item	**Update**
1	**Introduction**
	AWE Team was welcomed Gulu District Headquarters. The team introduced themselves. The Team Leader made a presentation of the Project including: • Project Background • Project Description • Potential Project Impacts.
2	**Discussion**
	Project
2.1	In regard to the previous project, the compensation for the people of Pece has been delayed and we hope that this will not be done for this upcoming Project. The current project of Gulu Water and Sanitation Project has been implemented for a long period, we hope that this upcoming one will not be delayed.
2.2	**On Employment:** There was a request that the locals should be given priority when the work starts.
2.3	**On Compensation:** Compensation for Pece has been delayed and therefore civil works have not yet commenced.

Week		Meeting date	**23-05-18**
		Recorded by	**Mugerwa Faith**
Meeting/subject	**Meetings with Oyam District**		

Present	Apol	Copy	Name	Organisation	Designation

Week		Meeting date	**23-05-18**
		Recorded by	**Mugerwa Faith**
Meeting/subject	**Meetings with Oyam District**		

			Signed list appended		

Item	Update
1	**Introduction**
	AWE Team was welcomed to Oyam District Headquarters. The team introduced themselves. The Team Leader made a presentation of the Project including: • Project Background • Project Description • Potential Project Impacts.
2	**Discussion**
	Project
2.1	**Q**: The district officials inquired about what Oyam as a District needs to do in order to have NWSC services in their District; **Response**: After the project construction, distribution lines will be brought back to the communities to enable them access water form NWSC
2.2	**On Employment:** There was a request that the locals should be given priority when the work starts.
2.4	**On compensation:** The LCV of Oyam District welcomed the project and urged the developers to compensate the PAPs fairly and on time..

Week		Meeting date	**17-05-18**
		Recorded by	**Mugerwa Faith**
Meeting/subject	**Meetings with Nwoya District**		

Present	Apology	Copy	Name	Organisation	Designation
			Signed list appended		

Item	Update
1	**Introduction**

Week		Meeting date	**17-05-18**
		Recorded by	**Mugerwa Faith**
Meeting/subject	**Meetings with Nwoya District**		

<table>
<tr><td></td><td>AWE Team was welcomed to Nwoya District. The team introduced themselves.

The Team Leader made a presentation of the Project including:
• Project Background
• Project Description
• Potential Project Impacts.</td></tr>
<tr><td>2</td><td>Discussion</td></tr>
<tr><td></td><td>Project

The district officials requested that Nwoya District should also be a beneficiary to this project. Since Nwoya District is housing the water supply system.

Will towns along the main route benefit from the project?

Yes, there will be distribution lines along the road for the towns to benefit.
• The project should have enough environmental and social safeguards during civil works in order to protect the people and the bio diversity. And also take a deeper inventory on what will be lost.
• Nwoya District has murram which can be used for construction and a separate EIA should be carried out for places where murram will be excavated.
• Final technical designs need to be shared to the District and the input from the district should be considered</td></tr>
<tr><td>2.1</td><td>On Employment
• They request for employment for their locals when the project starts.
• There should be proper contract management for the workers because some of them are given unfavorable conditions.
• Sexual harassment by top management should be keenly looked at.
• Health and safety of the workers should be considered.</td></tr>
<tr><td>2.2</td><td>On Sludge management: Re-use of sludge should be considered.</td></tr>
<tr><td>2.3</td><td>On Royalties: Since Nwoya district will be housing the water treatment plant, there should some royalty paid to the District.</td></tr>
</table>

Week		Meeting date	**4-06-18**
		Recorded by	**Mugerwa Faith**
Meeting/subject	**Meetings with Kal, Pida, Lajwatek villages Koro Sub-county, Omoro District**		

Present	Apology	Copy	Name	Organisation	Designation
			Signed list appended		

Item	Update
1	**Introduction**
	AWE Team was welcomed to Koro Sub-county. The team introduced themselves. The Team Leader made a presentation of the Project including: • Project Background • Project Description • Potential Project Impacts.
2	**Discussion**
	On valuation
2.1	Q: How will the PAPs know that the government valuer has followed the standard? A: Standard will be known to the PAP.
2.2	**On Employment**
	• They request for employment for their locals when the project starts. • They should ensure that contractors hire local labour on village basis.
2.3	**On Utility** **Q**: The community inquired whether there would be a distribution line that will be able to serve the community after the project construction. **Response:** Yes, after the project construction, distribution lines will be brought back to the communities to enable them access water form NWSC **Q**: Will a PAP be able to tap water from the transmission line? **Response:** No the water, will be at a very high pressure and no one will be allowed to tap water.
	On Project Q: What is the current standard of the road reserve? A; The road reserve is 15m from the centreline of the reserve.

Week		Meeting date	**4-06-18**
		Recorded by	**Mugerwa Faith**
Meeting/subject	**Meetings with Pato and Kalamomia villages Bobi Sub-county, Omoro District**		

Present	Apology	Copy	Name	Organisation	Designation
			Signed list appended		

Item	Update
1	**Introduction**
	AWE Team was welcomed to Pato and Kalamomia Villages. The team introduced themselves. The Team Leader made a presentation of the Project including: • Project Background • Project Description • Potential Project Impacts.
2	**Discussion**
	On Compensation Q: Some areas don't have compensation from UNRA. How will NWSC as the developer deal with this? Response: UNRA and NWSC will deal with this and forge a way on how compensation will be executed. Q: When will compensation be effected? Response: Compensation will be made before the actual civil works commence. Q: Will the crops and trees be compensated for Response: Yes, all crops and tress will be compensated for using the district rates for the respective districts.
2.2	**On Project**
	The project area has already existing cables. How will both the water pipes and cables both move? NWSC and MTN will devise means on how both utilities will move together. The communities were grateful that NWSC has come up to sensitize the public because in the past some of the developers have not been sensitizing.

Week		Meeting date	**5-06-18**
		Recorded by	**Mugerwa Faith**
Meeting/subject	**Meetings Kuluotit Along and Onekdyel villages Bobi Sub-county, Omoro District**		

Present	Apology	Copy	Name	Organisation	Designation
			Signed list appended		

Item	Update
1	**Introduction**
	AWE Team was welcomed to **Kuluotit Along and Onekdyel** villages. The team introduced themselves. The Team Leader made a presentation of the Project including: • Project Background • Project Description • Potential Project Impacts.
2	**Discussion**
2.2	**On Compensation**
	Q: There was an inquiry from the community if compensation will be done before the project commences. **Response:** Yes, all PAPs will be compensated before the project commences. **Q**: In case the line affects the compound will it be compensated? **Response:** Yes, all affected property will be compensated for.
2.3	**On Utility**
	Q: How will the communities far from the transmission line be able to get water? **Response:** There will distribution lines that will distribute water back to the communities. **Q**: Will water be managed by NWSC? **Response:** Yes
2.4	**On Employment**
	Q: What is the qualification for locals to be employees? Response: Mostly the project will require unskilled labour for the locals but this will be communicated before the commencement of civil works.

Week		Meeting date	**25-07-15**
		Recorded by	**Mugerwa Faith**
Meeting/subject	**Meetings Gudu Odyak villages Bobi Sub-county, Omoro District**		

Present	Apology	Copy	Name	Organisation	Designation
			Signed list appended		

Item	Update
1	**Introduction**
	AWE Team was welcomed to Omuruhita, Ruharo central ward villages. The team introduced themselves. The Team Leader made a presentation of the Project including: • Project Background • Project Description • Potential Project Impacts.
2	**Discussion**
2.1	**Project**
	Q: In case the transmission line meets the distribution line will they be buried together? **Response:** No, the transmission line will be relocated to another place. Q: Incase water is drained from Kitagata will there be another source. **Response:** Preliminary studies were carried out and water will not be drained.
2.2	**On Compensation**
	Q: There was an inquiry from the community if compensation will be done before the project commences. **Response:** Yes, all PAPs will be compensated before the project commences.
2.3	**On Utility**
	Q: Will the communities be able to connect water to their homes individually? **Response:** Yes, but it will be cheaper to apply as a group. **Q**: Will water be managed by NWSC? **Response:** Yes.

Week		Meeting date	**6-06-18**
		Recorded by	**Mugerwa Faith**
Meeting/subject	**Meetings Idop, Obalwat villages Bobi Sub-county, Omoro District**		

Present	Apology	Copy	Name	Organisation	Designation
			Signed list appended		

Item	Update
1	**Introduction**
	AWE Team was welcomed to Omuruhita, Ruharo central ward villages. The team introduced themselves. The Team Leader made a presentation of the Project including: • Project Background • Project Description • Potential Project Impacts.
2	**Discussion**
2.1	**Project**
	Q: When will the civil works commence? **Response:** Civil works will commence after all the PAPs have been compensated but this will also be communicated in the due course. Q: Will the water be got from the main transmission line? **Response:** No, there will be distribution lines that will supply water to respective villages.
2.2	**On Compensation**
2.3	**Q**: Will land under customary Tenure be compensated for? **Response:** Yes, all land will be compensated for.

Week			Meeting date	**6-06-18**	
			Recorded by	**Mugerwa Faith**	
Meeting/subject	**Meetings Akaoidebe, Obapo, AJaliopo, Adel, Aromo, Nyango, Minakulu TC and Ngu-cuti villages Minakulu Sub-county, Oyam District**				

Present	Apology	Copy	Name	Organisation	Designation
			Signed list appended		

Item	**Update**
1	**Introduction**
	AWE Team was welcomed to Akaoidebe, Obapo, AJaliopo, Adel, Aromo, Nyango, Minakulu TC and Ngu-cuti villages. The team introduced themselves. The Team Leader made a presentation of the Project including: • Project Background • Project Description • Potential Project Impacts.
2	**Discussion**
2.1	**Project**
	Q: How will the communities be able to tap water from the main? **Response:** No, the communities will not tap water from the main but there will be distribution lines to distribute water to the homes that will need it. Q: How will be locals on the other side of the road benefit from the Project where the line will not pass benefit from the project? Response: All locals will benefit from the project whether it is on the left or right hand side of the road.
2.2	**On Grievances** Q: When will the Grievance Redress Committee be formed? Response: This will be formed during project implementation to ensure that the PAP's complaints are taken care of. Q: Will the GRC be able to handle grievances at the developer's cost? Response: The developer will handle all PAPs grievances at their cost.
2.3	**On Compensation**
2.4	**Q**: Will a PAP with a mango tree within the road reserve be compensated for? **Response**: No.

Week		Meeting date	**7-06-18**
		Recorded by	**Mugerwa Faith**
Meeting/subject	**Meetings Opati A, Kagera, Agugu-arac, Arak East and West, Alati, Bobi, Lango Opati B villages Minakulu Sub-county, Oyam District**	Total pages	**02**

Present	Apology	Copy	Name	Organisation	Designation
			Signed list appended		

Item	Update
1	**Introduction**
	AWE Team was welcomed to **Opati A, Kagera, Agugu-arac, Arak East and West, Alati, Bobi, Lango Opati B villages Minakulu Sub-County.** The team introduced themselves. The Team Leader made a presentation of the Project including: • Project Background • Project Description • Potential Project Impacts.
2	**Discussion**
	Project
2.1	**Q**: Will the water still be managed by NWSC after construction? **Response:** Yes, it will be the mandate of NWSC to manage the water supply to different communities after construction. • The communities also requested for some free water after the project implementation.
2.2	**On Employment** • They request for employment for their locals when the project starts. • There was a complaint from the communities that contractors come and they don't pay casual labourers. They should ensure that contractors hire local labour on village basis.
2.3	**On Compensation**
	There was a suggestion from the people that their land should be fully compensated because NWSC will restrict them to have any developments after the line has been constructed.

Week				Meeting date	**7-06-18**
				Recorded by	**Mugerwa Faith**
Meeting/subject			**Meetings Abang Ipiny, Abang Imalo, Akaoidebe TC, waring Amukugungu, Abako villages Myena Sub-county, Oyam District**		

Present	Apology	Copy	Name	Organisation	Designation
			Signed list appended		

Item	Update
1	**Introduction**
	AWE Team was welcomed to Abang Ipiny, Abang Imalo, Akaoidebe TC, waring Amukugungu, Abako villages**.** The team introduced themselves. The Team Leader made a presentation of the Project including: • Project Background • Project Description • Potential Project Impacts.
2	**Discussion**
2.1	**Project**
	Q: When will the project start? **Response:** It will start after compensation has been made to the PAPs and communication will be made too.
2.2	**On Utilities** Q: Will the water be paid for by the locals? Response: Yes.
2.3	**On Compensation**
2.4	**Q**: Will a PAP with any development within the road reserve be compensated for? **Response**: No.

Week		Meeting date	8-06-18
		Recorded by	**Mugerwa Faith**
Meeting/subject	**Meetings Arukolong, Barolimo, Bororboro,Pukica, Pida, Alyec, Abanya A villages Kamdini Sub-county, Oyam District**		

Present	Apology	Copy	Name	Organisation	Designation
			Signed list appended		

Item	Update
1	**Introduction**
	AWE Team was welcomed to **Arukolong, Barolimo, Bororboro,Pukica, Pida, Alyec, Abanya A** villages**.** The team introduced themselves. The Team Leader made a presentation of the Project including: • Project Background • Project Description • Potential Project Impacts.
2	**Discussion**
2.1	**Project**
	Q: When will the project start? **Response:** It will start after compensation has been made to the PAPs and communication will be made too.
2.2	**On Utilities**
	Q: Will the communities be able to connect water to their homes individually? **Response:** Yes, but it will be cheaper to apply as a group. **Q**: Will water be managed by NWSC? **Response:** Yes
2.3	**On Compensation**
	Q: There was an inquiry from the community if compensation will be done before the project commences. **Response:** Yes, all PAPs will be compensated before the project commences.

Week		Meeting date	9-06-18
		Recorded by	**Mugerwa Faith**
Meeting/subject	**Meetings Techo and Go down villages, Kamdini Sub-county, Oyam District**		

Present	Apology	Copy	Name	Organisation	Designation
			Signed list appended		

Item	Update
1	**Introduction**
	AWE Team was welcomed to **Techo and Go down** villages**.** The team introduced themselves. The Team Leader made a presentation of the Project including: • Project Background • Project Description • Potential Project Impacts.
2	**Discussion**
2.1	**Project**
	Q: Will the project cater for PAPs whose businesses have been affected by the civil works **Response:** The contractor will be required have alternative access roads for individuals whose businesses will be affected. During construction, NWSC should not leave manholes un attended too.
2.2	**On Utilities.** **Q:** Who will be in charge of protecting the NWSC pipes. **Response:** NWSC appoints personnel in their areas of jurisdiction to ensure that pipes are taken care of.
2.3	**On Compensation**
	Q: There was an inquiry from the community if compensation will be done before the project commences. **Response:** Yes, all PAPs will be compensated before the project commences. Q: Is it possible for the PAP to procure their own valuer during the valuation process? **Response:** No, NWSC procures a consultant to carry out the valuation and incase of any grievances, there will be a committee to handle such cases.
2.4	**Air pollution impacts** Air pollution impacts, such from construction activities and quarry sites should be prevented.
2.5	**Stakeholder engagement and awareness creation** Issues and criteria associated with damage to property and how they would be compensated should be addressed during project implementation. Baseline information should include record of state of structures to avoid future claims of structural damage (cracking) yet were not caused by the project.

Week		Meeting date	**9-06-18**
		Recorded by	**Mugerwa Faith**
Meeting/subject	**Meetings Techo and Go down villages, Kamdini Sub-county, Oyam District**		

2.6	**On Stakeholder Engagement and Stakeholder consultation** There should be continuous and effective communication with stakeholders at all stages of the proposed development. For instance affected persons should be provided with project timelines to enable them plan to vacate affected areas in adequate time. Information about the project should be availed to local people in native languages for effective disclosure, engagement and meaningful feedback

APPENDIX B: HYDROLOGICAL ASSESSMENT REPORT

Hydrological Assessment Report for the Proposed Karuma – Gulu Water Supply Project

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LIST OF FIGURES

1 INTRODUCTION

The purpose of this report is to describe the impact on catchment hydrology likely to be caused by the proposed Integrated Programme to Improve the Living Conditions in Gulu and Small Towns En Route in the Victoria Nile Catchment (Ipilc) – Engineering and Institutional Development. This will form part of the current Environmental & Social Impact Assessment (ESIA).

This report formed part of the Pre-feasibility Study (PFS) and described the delineation of water courses and catchment boundaries and the determination of peak rainfall intensities and flood volumes. The impacts of the anticipated changes to the surface water regime were to be quantified and possible mitigation measures proposed and assessed.

1.1 Project Area

The Nile water transmission system extends from the northern embankment of the river Nile between Kamdini and Karuma up to the existing Customs Corner Reservoir in Gulu. The transmission main routing basically follows the main road Karuma-Gulu. Gulu Municipality and surrounding urban areas, referred to as the Gulu Urban Area, were defined based on existing administrative boundaries and cover an area of about 36,534 ha. 6 small towns along the route of the transmission main shall be supplied by the Nile water transmission system, namely – from South to North – Karuma, Kamdini, Minakulu, Bobi, Palenga and Koro-Abili. Proposed supply areas host a total of about 33,000 inhabitants and cover a total area of approximately 11,000 ha. Until end of the design horizon 2040 it is expected that about 66,000 inhabitants have access to improved drinking water supply services in towns en route the transmission main. Due to limited finances, construction of the water supply systems for the towns en route will be phased, starting from a strong core but allowing for future expansion. Future supply to Opit area – as proposed by NWSC - could cover parts of Lakwana Sub-County and selected villages in in Omoro town council.

1.2 Purpose and Scope

The purpose of this report is to describe the impact on catchment hydrology likely to be caused due to pipeline corridor construction and operation phases. The study further evaluates the hydraulic parameters (flow depth, Velocity and flood lines) to provide baseline for design team to ensure limited constriction and interruption of flows by the pipeline construction and operation phase.

The scope of this assessment is limited to delineation of catchments at water crossings (especially swampy sections) within pipeline corridor, derivation of hydraulic parameters at culvert and bridge crossings and estimation of residual environmental flow at intake.

2 APPROACH & METHODOLOGY

2.1 Review Previous Studies

Previous reports, which were made available, were reviewed and relevant information utilized.

2.2 Site Visit

A site visit was conducted on 14 July 2018 in order to make in-situ observations and assessments. Local conditions were determined and a broad understanding gained of the catchment.

2.3 Assess Hydrological Impact

The hydrological impact of the proposed Karuma-Gulu Transmission line was assessed and quantified for all phases of the project, from inception to decommissioning. The following aspects were addressed:

i) The proposed project footprint was assessed and its impact on hydrology determined.
ii) Flood peaks and runoff volumes were calculated for the 50- and 100 year recurrence interval storm events.
iii) The project impact on Mean Annual Runoff (MAR) was determined.
iv) Flood lines were determined for the 100 year recurrence interval storm event.

2.3.1 Hydrological modelling of catchment areas

For baseline surface water assessments along the pipeline corridor, the catchments were delineated using ArcHydro tools using the culvert crossings as the catchment outlets. Satellite Imagery from Google earth was used in conjunction with the existing Land cover and soils shape files to assess runoff coefficients 20 catchments were identified totaling roughly to 1042.76 km^2.

For this hydrological Impact Assessment, HEC-HMS was used to compute the peak flow corresponding to design storm for the 2, 5, 10, 25 and 50 year return period. The discharges were computed for each culvert points specified under their respective options.

HECHMS version 4.2.1 designed by the Hydrologic Engineering Centre, U.S. Army Corps of Engineers was adopted for hydrology analysis of culvert peak discharges. HEC-HMS is an event-based rainfall-runoff model largely limited to single-event simulation. For hydrograph simulations, the model applies a number of empirical and physical models such as Clark's, Synder, SCS-Unit hydrograph and the Kinematic wave model to simulate runoff. The runoff volume is computed using the SCS Curve Number method, the runoff coefficient method or using the Green and Ampt loss model.

The HEC-HMS event model for the watersheds uses the following components, meteorological component, rainfall loss component, direct runoff component, river routing component and base flow component. The SCS method for watershed lag developed by Mockus in 1961 was used to estimate the time of concentration.

2.3.2 Determination of flood line

Flood lines, flow velocities and depth have been calculated based on the available STRM Digital Elevation data for the (2, 5, 10, 20, 50 and 100 year RI) design storm events and the flood plain delineated accordingly especially at the culvert and waterway crossings.

The hydraulics of the existing waterways were assessed using the HECRAS hydraulic modelling software. The cross sections through the main waterways were generated at regular intervals. This provided for important factors such as abrupt changes in channel cross section were represented as accurately as possible within the limitations of HECRAS model and the available STRM DEM data. The HECRAS model was used to model the 2,5,10, 50 and 100 year ARI hydraulic characteristics at each of the waterway crossings.

The manning's roughness applied to the model based were on the cover observations from the satellite imagery and. The cross sections were georeferenced in GIS and attributes of cross sections from DEMs to determine the geospatial location of each and to delineate the channel lengths between cross sections appropriately. Inflow hydrographs and peaks from the hydraulic analysis were used as inputs.

2.4 Hydrological Impact Report

Compilation of a hydrological impact report containing inter alia:

i) Identification and mapping of sensitive areas, affected receptors and areas of influence
ii) Direct, indirect, irreversible and cumulative impact of anticipated activities on surface water resources
iii) Compliance with legal and policy framework, including IFC Performance Standards for Environmental and Social Sustainability (2012)
iv) Recommendation of mitigating and monitoring measures
v) Evaluation and assessment of residual (post mitigation) impacts.

3 HYDROLOGICAL DETERMINANTS

3.1 Regional Hydrology

The river network in and around the project area forms part of the bigger Nile Basin network. The streams within project area flows The River flows in North - south direction in its upper reaches and then join the Koyga Nile which flows in East - West direction after Karuma falls. The main tributaries of Nile River up to Karuma falls are river Okole, Tochi on the right bank and river Nanda on the left bank up to Karuma falls.

The catchment area up to the proposed intake is 346,000 sq. km of which the Catchment area up to Jinja, located downstream of Lake Victoria is 264,160 sq km. The geographic coordinates of the dam site is 1°29'45" N, 32°49'45" E and the river bed level is 1019m respectively.

The base flow in River Kyoga Nile at Karuma site is generally dominated by the outflows from Lake Victoria and the releases from the Lake Victoria are made as per the Agreed Curve (Based on an Agreement between Uganda and Egypt (1949 and 1953), depending on Lake Victoria Levels.

The flows at Karuma intake depend mainly on the Lake Victoria outflows at Jinja, contribution of intermediate catchment between Jinja and Lake Kyoga, outflows from Lake Kyoga and contribution of the catchment between Lake Kyoga and Karuma Intake site. The Lake Victoria outflows arrive at the Lake Kyoga nearly unmodified, since minor tributaries join the river up to Lake Kyoga.

Various studies have indicated that under normal dry condition, Lake Kyoga outflows at Masindi Port downstream of Lake Kyoga are slightly less than the outflows from Lake Victoria and the loss of river flows are 20 – 50 cumecs, depending on Lake Level. However, during wet periods, Lake Kyoga catchment adds water to the river flow and increase in river flow is 50 – 70 cumecs dependent on Lake Kyoga Level. The intermediate catchment area between Masindi Port and the project site is about 7,700 sq km. From various studies, it has been concluded that flow contribution from this area during dry periods is small and can be neglected. Hence the catchment area between Masindi Port and the project site doesn't contribute much to the flows of river Kyoga Nile.

3.2 Topography, Soils and Vegetation

The soils within the catchment areas are predominantly Shallow brown sandy loams over rock or laterite and Black and grey clays often calcareous. More than 64 % of study area is under Petric Plinthosols followed by Gleysols (2%) and Acric Ferralsols (34%).

Petric Plinthosols (Acric): Shallow reddish brown or grey sandy loams and loams over laterites, often formed from basement complex granites and gneisses or from lake deposits derived from basement complex granites and gneisses. Examples are soils in the Buruli Catena mapping units. This soil is Vulnerable to erosion.

Acric Ferralsols: Shallow reddish brown or dark brown or black sandy loams or laterites, formed from basement complex gneisses and granites. Examples are soils in the Anaka Complex mapping units. This soil is Vulnerable to erosion.

Gleysols: Dark brown or grey sandy loams and sandy clay loams often calcareous of river alluvium. Examples are soils in the Undifferentiated Alluvium mapping units. This soil is not Vulnerable to erosion.

Table 1: Soil types with the catchment areas

S.No	FAO-Soil Class	Area(ha)	% Area
1	ACRIC FERRALSOLS	34,171.0	34
2	PETRIC PLINTHOSOLS(Acric)	64,688.7	64
3	GLEYSOLS	2,272.1	2

The land use land cover data has been procured from NFA (National Forest Authority) Kampala, Uganda. NFA has carried out Land use \ land cover classification using Landsat data of the year 2014.The land use/cover within the catchment areas is predominantly subsistence farmland (76%), open grasslands (6.4%) and closed grassland (5.7%).

Table 2: land cover within the catchment areas

Land cover	Area	Percentage
Annual Commercial Cropland	0.1	0.01
Closed Bushland	0.4	0.0
Closed Grassland	57.2	5.7
Dense Natural Forest	0.2	0.0
Dense Woodland	0.0	0.0
Moderate Natural Forest	16.1	1.6
Moderate Woodland	0.2	0.0
Open Bushland	33.4	3.3
Open Grassland	64.2	6.4
Plantation Forest	4.1	0.4
Settlement	29.0	2.9
Sparse Natural Forest	16.8	1.7
Sparse Woodland	0.0	0.0

Land cover	Area	Percentage
Subsistence Cropland	770.5	76.2
Water Body	0.0	0.0
Wetland	18.9	1.9
	1011.2	**100.0**

3.3 Catchment Slopes and Collector Length

The slope of a catchment is a very important characteristic in the determination of flood peaks. Steep slopes cause water to run faster and to shorten the critical duration of flood inducing storms, thus leading to the use of higher rainfall intensities in the runoff formulae. On steep slopes the vegetation is generally less dense, soil layers are shallower, and there are fewer depressions, all of which cause water to run off more rapidly.

The result is that infiltration is reduced and flood peaks are consequently even higher. The average catchment slope (SA) for the two catchments under consideration are presented in Table 3. The longest watercourse (L) consists of both the natural channel and overland flow and, along with the slope of the watercourse, determines the time of concentration for the catchment. The lengths of the two surface water collectors are given in Table 3. The centre of gravity of each sub-catchment area was calculated. This information was used to determine the centre of gravity catchment length (LC), which is the distance from the catchment outlet to the point on the longest collector opposite the centre of gravity of the catchment area. This was used to calculate the catchment lag time (TL) for both sub-catchments as presented in Table 3.

Photo 1: Papyrus and swampy sections along the pipeline corridor

Photo 2: Water ways and small streams emerging from the swamps through culvert

Photo 3: Water ponds in some sections

Photo 4: Extent of Water Level fluctuation in some waterlogged areas

Photo 5: Circular culverts

Photo 6: Box Culverts

The baseline catchment characteristics that affect the time of concentration are illustrated in Table 3. It is not anticipated that the proposed infrastructure will affect the nature of the sub-catchments and alter the rainfall- runoff response along the transmission line corridor but for only construction period.

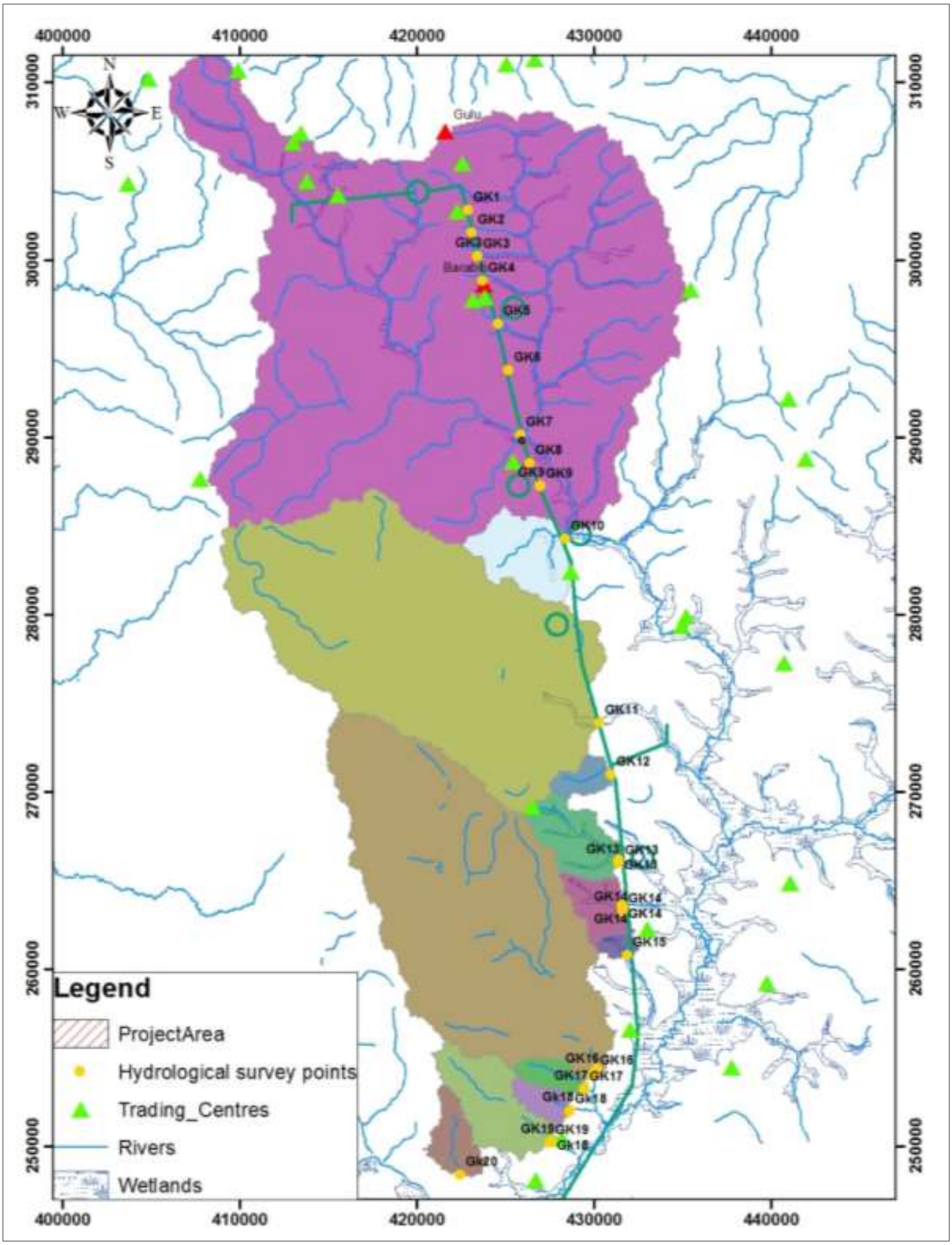

Figure 1: Delineation of catchment with outlets at culverts

Table 3: Catchment characteristics at the identified major swamps along the transmission line

Name	Area	Basin Slope%	Longest Flow Path(m)	Longest Flow Path(ft)	Composite CN	Maximum Potential Retention S	Time of Centration Tc(h)	Lag(h)
GK2	1.2	2.5	1,681.2	5,515.8	71.5	4.0	16.8	10.1
GK3	2.5	2.7	2,470.1	8,103.8	68.2	4.7	24.3	14.6
GK4	2.9	2.8	2,870.1	9,416.1	70.3	4.2	25.4	15.2
GK5	4.5	2.5	3,231.8	10,602.9	69.7	4.3	29.5	17.7
GK6	3.0	1.7	3,115.6	10,221.7	67.7	4.8	37.0	22.2
GK8	1.0	1.8	1,518.8	4,983.0	67.0	4.9	20.4	12.3
GK9	4.6	2.7	3,255.6	10,680.9	70.8	4.1	28.1	16.9
GK10	509.8	2.7	43,420.6	142,454.4	67.2	4.9	246.2	147.7
GK11	216.7	2.6	30,092.1	98,726.0	67.9	4.7	181.6	109.0
GK12	5.4	2.4	4,262.9	13,985.6	64.6	5.5	43.0	25.8
GK13	12.3	2.4	7,265.5	23,836.8	66.6	5.0	63.1	37.9
GK13_2	16.0	2.4	7,488.6	24,568.7	66.6	5.0	64.7	38.8
GK14	9.5	2.0	5,123.6	16,809.4	70.9	4.1	46.4	27.8
GK15	2.6	2.2	2,500.4	8,203.3	70.9	4.1	25.0	15.0
GK16	188.0	2.4	29,907.8	98,121.5	70.3	4.2	177.0	106.2
GK17	5.5	2.1	4,855.6	15,930.3	72.9	3.7	41.2	24.7
GK18	5.2	1.7	4,478.0	14,691.5	74.4	3.4	40.9	24.5
GK19	22.3	2.2	9,573.2	31,407.7	70.9	4.1	72.9	43.7
GK20	9.4	2.2	6,082.7	19,956.2	69.6	4.4	52.9	31.8
GK10_2	509.8	2.7	43,420.6	142,454.4	67.2	4.9	247.1	148.2
GK10_2	20.3	2.6	7,401.5	24,282.8	69.6	4.4	57.2	34.3
GK7	286.6	2.7	36,212.8	118,806.9	68.1	4.7	207.8	124.7

3.4 Climate, Rainfall & Design Storm

The area is classified as a sub humid to humid. Climatic data has been taken from the three meteorological station that are closest to the project site, that is, Gulu, Lira and Masindi by assuming and anticipating that these neighbouring areas may have similar climatic conditions as around the project site which is presented in Figure 2. From Figure 2, the monthly distribution of the Mean monthly Precipitation (MAP), occasional rains occur between April and October, while the period from November to March is often very dry. Average annual rainfall received is 1500 mm. Mean monthly rainfall ranges from 14 mm in January to 230 mm in August.

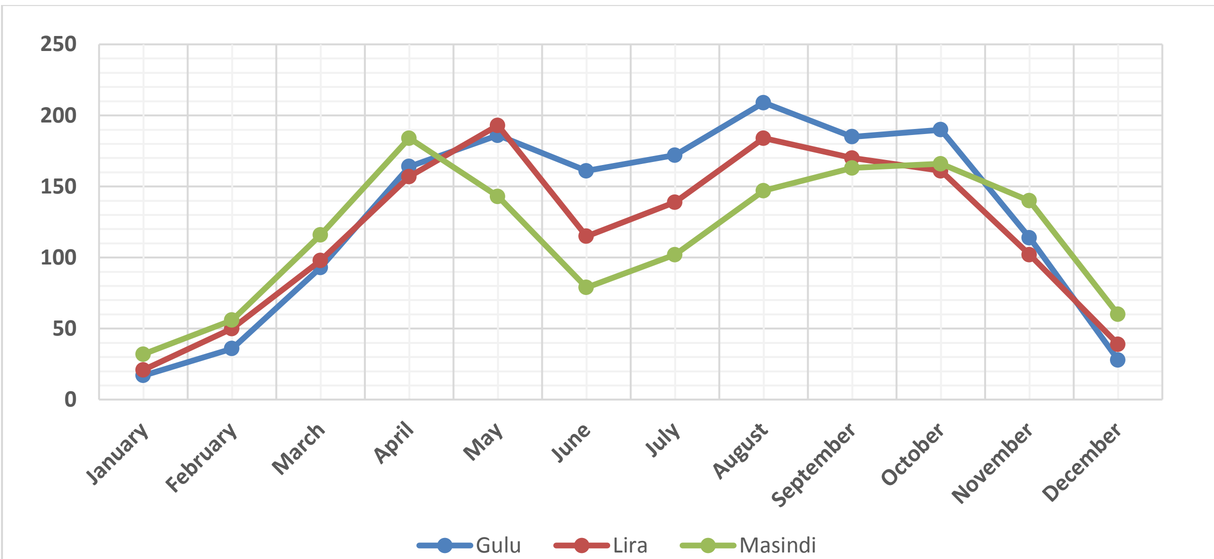

Figure 2 Mean annual rainfall for Gulu, Lira and Masindi

Micro-climate of the area is hot and humid with average relative humidity of 60%, mean maximum temperature of 29°C, mean minimum temperature of 22°C and wind speeds of 8 kph.

Table 4: Other Meteorological parameters for Lira

Month	Min Temp(°C)	Max Temp°C	Humidity%	Wind (km/day)	Sun(hours)	Rad (MJ/m²/day)	Eto (mm/day)
January	16.5	32	53	268	4.8	15.9	5.39
February	17.1	32.2	54	268	6.7	19.5	5.85
March	17.6	31.2	61	268	4.6	16.6	5.12
April	17.7	29.3	73	251	5.6	17.9	4.43
May	17.5	28	78	233	5.7	17.3	3.93
June	17	27.5	77	199	5.9	17.1	3.76
July	16.6	26.5	78	199	4.9	15.8	3.49
August	16.6	26.7	79	199	5.4	17.1	3.67
September	16.6	28	76	216	6.4	19.3	4.21
October	16.7	28.7	74	233	7	19.9	4.48
November	16.5	29.6	68	233	7.6	20.2	4.81
December	16.2	30.3	61	251	8	20.2	5.19

Month	Min Temp(°C)	Max Temp°C	Humidity%	Wind (km/day)	Sun(hours)	Rad (MJ/m²/day)	Eto (mm/day)
Average	16.9	29.2	69	235	6.1	18.1	4.53

Table 5: Other meteorological parameters for Gulu Station

Month	Min Temp°C	Max Temp°C	Humidity%	Wind km/day	Sun hours	Rad MJ/m²/day	ETo mm/day
January	16	33.1	56	268	8.5	21.5	6.02
February	16.7	33.2	57	251	8.3	22	6.04
March	17.3	32.2	63	251	7.7	21.6	5.71
April	17.3	30.1	72	190	7.1	20.1	4.66
May	17	28.7	80	173	7.7	20.1	4.17
June	16.6	28.1	78	156	7.8	19.6	4.01
July	16	27.2	80	156	6.3	17.8	3.63
August	16	27.7	80	173	6.8	19.3	3.94
September	16	28.7	77	190	7.7	21.3	4.45
October	16	29.7	74	190	7.8	21.2	4.61
November	16	30.6	69	233	7.8	20.5	4.92
December	15.6	31.1	63	251	8.2	20.7	5.25
Average	16.4	30	71	207	7.6	20.5	4.78

3.4.1 Design rainfalls

Design rainfall intensities were derived from extreme rainfall peaks obtained from fitting annual maxima's on probability distributions (Log Normal and Log-Pearson Type III). The best fitting distribution was chosen after testing the Goodness of fit.

Table 6: Peak design rainfall for different probabilities of exceedance for project area

Percent Chance Exceedance	Log Pearson Distribution		Log Normal Distribution
	Computed Curve	Expected Probability	Computed Curve
0.2	171.9	266.2	107.7
0.5	135.2	183.1	94.9
1.0	112.1	139.9	85.5
2.0	92.3	107.8	76.3
5.0	70.5	76.8	64.4
10.0	56.7	59.6	55.3
20.0	44.6	45.7	46.0
50.0	30.4	30.4	32.4
80.0	22.7	22.4	22.8
90.0	20.1	19.7	19.0
95.0	18.5	18.0	16.3
99.0	16.3	15.7	12.3

3.4.2 Intensity-duration-frequency

Where rational method is to be used for peak flow rate, rainfall intensity in mm per hour must be determined from an event with duration equivalent to the time of concentration. Rainfall intensity Frequency duration IDF were derived for each catchment based on the peak rainfall values for different recurrence periods. Probable maximum Precipitation (PMP) rainfall estimates were used to calculate design hydrographs for 10 yr, 25 yr, 50 yr, 100yr and 200yr recurrence intervals events.

Table 7: Design rainfall intensity- frequency duration (IDF) mm/hr

Duration	***Rainfall Intensity (mm/hr)***						
Return Periods(yrs)	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Rainfall Peaks	32.40	46.00	55.30	64.40	76.30	85.50	94.90
5 Mins	388.8	552.0	663.6	772.8	915.6	1026.0	1138.8
6 Mins	324.0	460.0	553.0	644.0	763.0	855.0	949.0
10 mins	194.4	276.0	331.8	386.4	457.8	513.0	569.4
20 Mins	97.2	138.0	165.9	193.2	228.9	256.5	284.7
30 Mins	64.8	92.0	110.6	128.8	152.6	171.0	189.8
1 Hour	32.4	46.0	55.3	64.4	76.3	85.5	94.9
2 Hours	16.2	23.0	27.7	32.2	38.2	42.8	47.5
3 Hours	10.8	15.3	18.4	21.5	25.4	28.5	31.6
6 hours	5.4	7.7	9.2	10.7	12.7	14.3	15.8
12 Hours	2.7	3.8	4.6	5.4	6.4	7.1	7.9
24 Hours	1.4	1.9	2.3	2.7	3.2	3.6	4.0
48 Hours	0.7	1.0	1.2	1.3	1.6	1.8	2.0
72 Hours	0.5	0.6	0.8	0.9	1.1	1.2	1.3

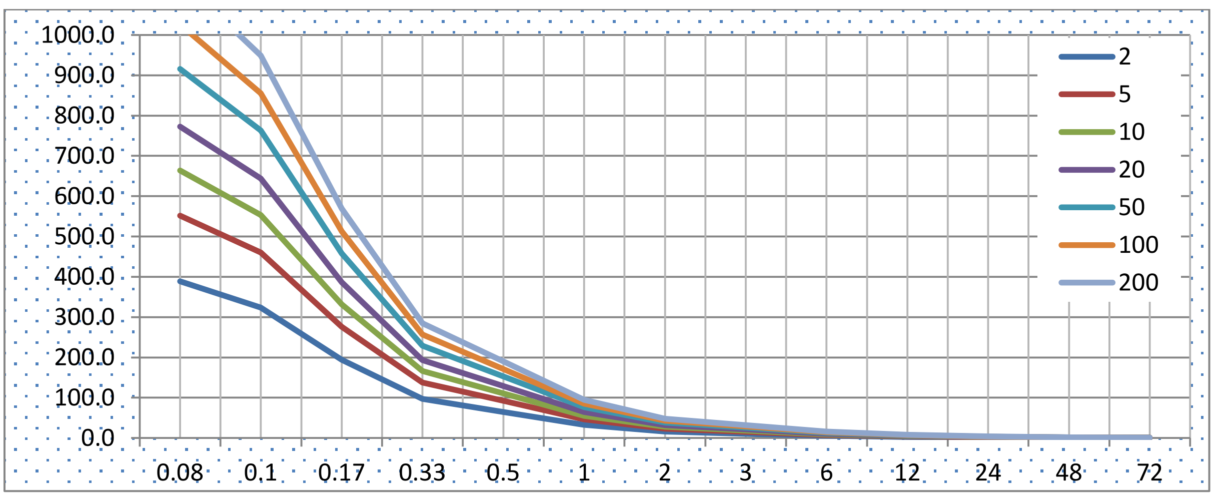

Figure 3 Rainfall intensity frequency duration curves for project area

3.4.3 Peak flow rates and volumes

Hydrological analysis of the peak flows was done in HECHMS for catchment area at Culverts and bridges, Assessment of the possibilities of modification of project area hydrology (Infiltration, evaporation e.g. at quarries and burrow pits).The results show that there is substantial amount of runoff generated with increase in catchment area and high recurrence intervals. The catchments have relatively lower peak discharges due to long lag time and attenuation effects of the swamps (Tables 8 and 9). The peak discharges reveal a flood risk and backwater effects due to obstruction of flow by construction activities or pipeline infrastructure during operation. Potential for downstream areas due to concentrated flow after passage through culverts. However it was evident that downstream crossings are mainly swamps thus less impact.

Table 8: Peak flow rates (m^3/s) at swamp sections along Gulu-Karuma transmission Line

Name	5yr	10yr	20yr	50yr	100yr	200yr	500yr
GK2	0.020	0.2	0.3	0.4	0.5	0.7	0.8
GK3	0.018	0.2	0.32	0.5	0.7	0.9	1.1
GK4	0.038	0.3	0.4	0.7	0.9	1.1	1.4
GK5	0.041	0.4	0.6	0.9	1.1	1.4	1.9
GK6	0.014	0.2	0.3	0.4	0.6	0.7	0.9
GK7	0.3	3.2	4.9	7.7	10.1	12.7	16.6
GK8	0.006	0.08	0.12	0.21	0.3	0.4	0.5
GK9	0.1	0.4	0.7	1.0	1.3	1.6	2.1
GK10	0.32	4.3	6.9	10.9	14.3	18.2	23.9
GK11	0.2	2.7	4.2	6.6	8.6	10.9	14.2
GK12	0.006	0.16	0.31	0.5	0.7	0.9	1.2
GK13	0.021	0.4	0.6	1	1.3	1.6	2.2
GK13_2	0.03	0.5	0.8	1.2	1.6	2.1	2.7
GK14	0.1	0.6	0.9	1.3	1.7	2.1	2.7
GK15	0.035	0.3	0.4	0.6	0.8	1.0	1.3
GK16	0.4	3.0	4.5	6.8	8.8	11.0	14.1
GK17	0.1	0.5	0.7	1.0	1.2	1.5	1.9
GK18		0.5	0.7	1.0	1.3	1.6	2.0
GK19	0.1	0.9	1.4	2.0	2.6	3.2	4.2
GK20	0.1	0.5	0.7	1.1	1.4	1.7	2.3
GK10_2	0.1	0.9	1.4	2.2	2.8	3.5	4.5

Table 9: Peak flow volumes ($1000m^3$) at swamp sections along Gulu-Kuruma transmission line

Name	5yr	10yr	20yr	50yr	100yr	200yr	500yr
GK2		10.8	16.1	24	30.7	38	48.6
GK3	1.50	16.7	26	40.5	53.0	66.9	87.2
GK4	2.9	23.5	35.6	53.8	69.4	86.5	111.4
GK5	4.0	34.5	52.7	80.3	104.0	130.1	168.1
GK6	1.5	18.9	29.8	46.6	61.2	77.5	101.4
GK7	166.1	1,888.4	2,958.1	4,602.8	6,033.6	7,615.8	9,935.5
GK8	0.4	6.1	9.7	15.4	20.3	25.8	33.9
GK9	5.2	39.0	58.6	88	113.2	140.8	180.8
GK10	222.7	3,053.0	4,860.0	7,662.2	10,113.8	12,835.4	16,839.9
GK11	118.6	1401.1	2202.4	3436.8	4511.9	5701.7	7447.6
GK12	0.8	24.4	41.1	67.6	91.2	117.7	157.2
GK13	4.4	69.6	112.1	178.3	236.5	301.2	396.7

Name	5yr	10yr	20yr	50yr	100yr	200yr	500yr
GK13_2	5.7	90.5	145.8	231.9	307.6	391.8	516.1
GK14	10.9	81.3	121.9	182.9	235.1	292.2	375
GK15	3.0	22.2	33.4	50.1	64.3	80	102.6
GK16	190.2	1525.1	2307	3486.7	4499.5	5609.6	7223.9
GK17	9.3	55.7	81.4	119.4	151.6	186.5	236.8
GK18	11.3	59.4	85.2	123	154.8	189.1	238.3
GK19	25.7	190.8	286.2	429.3	551.8	685.8	880.2
GK20	8.1	71.5	109.4	166.8	216.2	270.6	349.9
GK10_2	17.5	154.5	236.2	360.1	467.0	584.4	755.6

3.4.4 Hydraulic analysis at swamps

The flood hydrographs for the hydraulic structures were used as inflows to HECRAS model to simulate the flood plain redistributions of flows upstream of the study area. The flow area and top width for cross-sections in swamps sections likely to be transversed by the transmission line are indicated in Table 10. The analysis of flow characteristics (width of flow, depth of flow, flow velocity, etc.) and the quantum of downstream flow depth as presented in the Table 10. The water depth does not exceed 2m which is typical for most swamps.

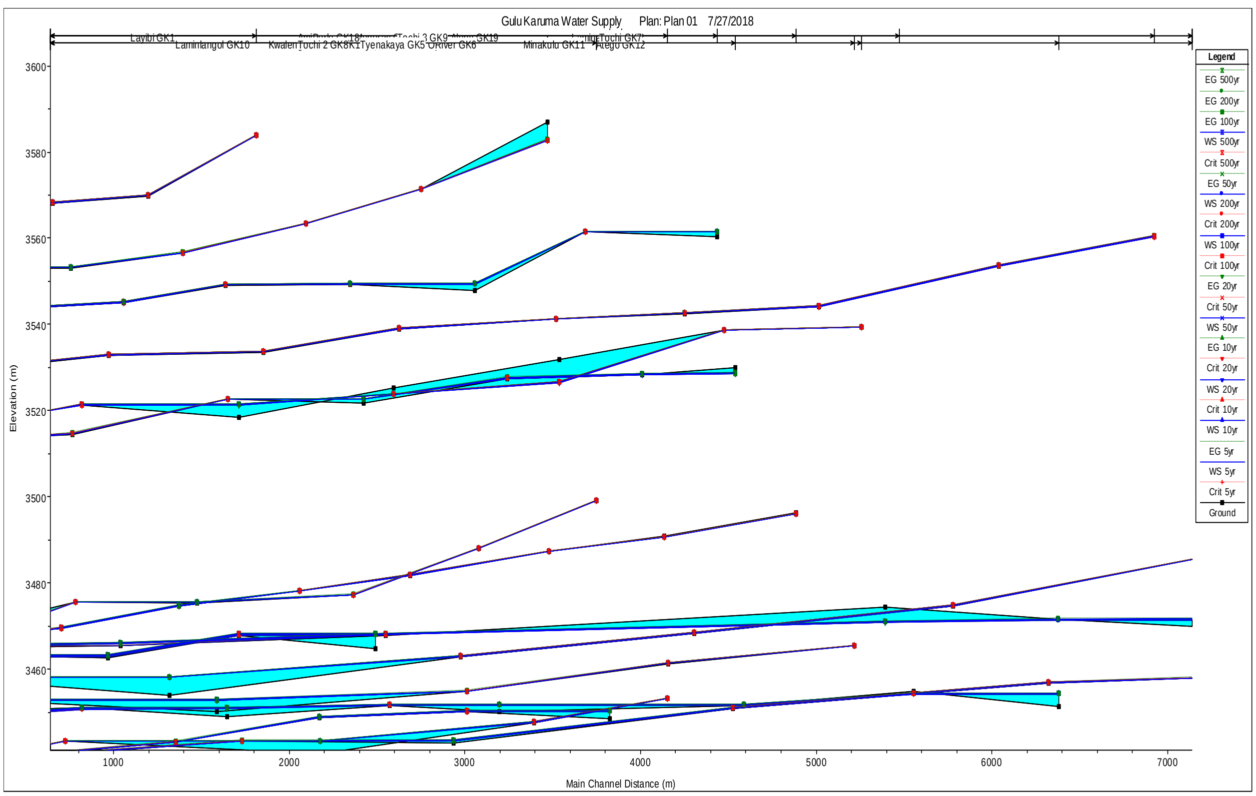

Figure 4 Water surface profiles along swamp sections

Table 10: Hydraulic performance of Major drainage crossings-for different return periods

Swamp Section	River Station	Profile	Q Total	Min Ch El	W.S. Elevation	Critical W.S.	E.G. Elevation	E.G. Slope	Velocity Chnl	Flow Area	Top Width	Froude # Chl
			(m^3/s)	(ft)	(ft)	(ft)	(ft)	(m/m)	(m/s)	(m^2)	(m)	
GK1	531.3	5yr	0.02	3569.9	3569.9	3569.9	3569.9	0.0041	0.38	0.05	3.2	0.94
		10yr	0.2	3569.9	3569.9	3569.9	3570.0	0.0035	0.63	0.32	7.8	1
		20yr	0.3	3569.9	3569.9	3569.9	3570.0	0.0033	0.69	0.44	9.2	1.01
		50yr	0.4	3569.9	3570.0	3570.0	3570.0	0.0030	0.71	0.56	10.4	0.98
		100yr	0.5	3569.9	3570.0	3570.0	3570.0	0.0031	0.76	0.66	11.3	1.01
		200yr	0.7	3569.9	3570.0	3570.0	3570.0	0.0030	0.82	0.85	12.8	1.02
		500yr	0.8	3569.9	3570.0	3570.0	3570.0	0.0028	0.82	0.98	13.7	0.98
GK2	684.0	5yr	0.02	3563.3	3563.3	3563.3	3563.3	0.0043	0.36	0.06	3.7	0.94
		10yr	0.2	3563.3	3563.4	3563.4	3563.4	0.0038	0.61	0.33	8.9	1.03
		20yr	0.3	3563.3	3563.4	3563.4	3563.4	0.0033	0.65	0.46	10.6	0.99
		50yr	0.4	3563.3	3563.4	3563.4	3563.4	0.0035	0.71	0.57	11.8	1.03
		100yr	0.5	3563.3	3563.4	3563.4	3563.4	0.0031	0.72	0.7	13.1	1
		200yr	0.7	3563.3	3563.4	3563.4	3563.4	0.0029	0.76	0.92	15.0	0.99
		500yr	0.8	3563.3	3563.4	3563.4	3563.5	0.0032	0.82	0.98	15.5	1.04
GK3	1194.4	5yr	0.02	3547.8	3549.4		3549.4	0	0	76.9	99.6	0
		10yr	0.2	3547.8	3549.5		3549.5	0	0	87.6	106.3	0
		20yr	0.32	3547.8	3549.5		3549.5	0	0	90.1	107.8	0
		50yr	0.5	3547.8	3549.5		3549.5	0	0.01	93.3	109.6	0
		100yr	0.7	3547.8	3549.5		3549.5	0	0.01	95.4	110.9	0
		200yr	0.9	3547.8	3549.5		3549.5	0	0.01	97.8	112.3	0
		500yr	1.1	3547.8	3549.6		3549.6	0	0.01	99.6	113.3	0
GK4	1294.5	5yr	0.04	3533.6	3533.6	3533.6	3533.6	0.00417	0.4	0.09	5.3	0.96
		10yr	0.3	3533.6	3533.7	3533.7	3533.7	0.000386	0.28	1.09	17.99	0.36
		20yr	0.4	3533.6	3533.7	3533.7	3533.7	0.000401	0.3	1.33	19.89	0.37
		50yr	0.7	3533.6	3533.7	3533.7	3533.7	0.003297	0.76	0.92	16.53	1.03
		100yr	0.9	3533.6	3533.8	3533.7	3533.8	0.000423	0.38	2.4	26.69	0.4
		200yr	1.1	3533.6	3533.8	3533.7	3533.8	0.000424	0.39	2.79	28.77	0.4
		500yr	1.4	3533.6	3533.8	3533.8	3533.8	0.002744	0.84	1.66	22.18	0.99

Swamp Section	River Station	Profile	Q Total	Min Ch El	W.S. Elevation	Critical W.S.	E.G. Elevation	E.G. Slope	Velocity Chnl	Flow Area	Top Width	Froude # Chl
			(m^3/s)	(ft)	(ft)	(ft)	(ft)	(m/m)	(m/s)	(m^2)	(m)	
GK5	1149.6	5yr	0.04	3527.4	3527.5	3527.5	3527.5	0.004096	0.5	0.08	3.2	1.01
		10yr	0.4	3527.4	3527.6	3527.6	3527.6	0.003035	0.79	0.5	7.96	1.01
		20yr	0.6	3527.4	3527.6	3527.6	3527.6	0.002809	0.85	0.7	9.4	1
		50yr	0.9	3527.4	3527.6	3527.6	3527.7	0.002745	0.94	0.96	10.99	1.01
		100yr	1.1	3527.4	3527.6	3527.6	3527.7	0.002674	0.98	1.13	11.91	1.01
		200yr	1.4	3527.4	3527.6	3527.6	3527.7	0.002538	1.02	1.38	13.16	1
		500yr	1.9	3527.4	3527.7	3527.7	3527.7	0.00241	1.08	1.77	14.9	1
GK6	997.7	5yr	0.01	3518.4	3521.3		3521.3	0	0	550.33	378.87	0
		10yr	0.2	3518.4	3521.4		3521.4	0	0	565.09	383.91	0
		20yr	0.3	3518.4	3521.4		3521.4	0	0	567.6	384.77	0
		50yr	0.4	3518.4	3521.4		3521.4	0	0	570.7	385.82	0
		100yr	0.6	3518.4	3521.4		3521.4	0	0	575.53	387.45	0
		200yr	0.7	3518.4	3521.4		3521.4	0	0	577.61	388.14	0
		500yr	0.9	3518.4	3521.4		3521.4	0	0	581.43	389.43	0
GK7	1780.3	5yr	0.3	3474.4	3470.8		3470.8	0.000883		1.66	39.15	0
		10yr	3.2	3474.4	3470.9		3470.9	0.000285		14.98	117.59	0
		20yr	4.9	3474.4	3471.0		3471.0	0.000321		19.71	134.89	0
		50yr	7.7	3474.4	3471.0		3471.0	0.00029		28.76	162.92	0
		100yr	10.1	3474.4	3471.1		3471.1	0.000298		34.87	179.4	0
		200yr	12.7	3474.4	3471.1		3471.1	0.000282		42.27	197.53	0
		500yr	16.6	3474.4	3471.1		3471.1	0.000296		50.78	216.49	0
GK8	1103.6	5yr	0.01	3477.2	3477.2	3477.2	3477.2	0.009558	0.36	0.02	2.1	1.27
		10yr	0.08	3477.2	3477.3	3477.3	3477.3	0.003317	0.46	0.17	6.68	0.91
		20yr	0.12	3477.2	3477.3	3477.3	3477.3	0.003662	0.53	0.23	7.63	0.98
		50yr	0.21	3477.2	3477.3	3477.3	3477.3	0.003638	0.61	0.35	9.42	1.01
		100yr	0.3	3477.2	3477.3	3477.3	3477.3	0.003155	0.63	0.48	11.07	0.97
		200yr	0.4	3477.2	3477.3	3477.3	3477.3	0.003263	0.68	0.59	12.25	1
		500yr	0.5	3477.2	3477.3	3477.3	3477.3	0.00298	0.7	0.72	13.55	0.97
GK9	695.1	5yr	0.1	3478.2	3478.2	3478.2	3478.2	0.004149	0.26	0.39	42.07	0.86

Swamp Section	River Station	Profile	Q Total	Min Ch El	W.S. Elevation	Critical W.S.	E.G. Elevation	E.G. Slope	Velocity Chnl	Flow Area	Top Width	Froude # Chl
			(m^3/s)	(ft)	(ft)	(ft)	(ft)	(m/m)	(m/s)	(m^2)	(m)	
		10yr	0.4	3478.2	3478.2	3478.2	3478.2	0.003801	0.35	1.13	71.92	0.9
		20yr	0.7	3478.2	3478.2	3478.2	3478.2	0.004439	0.43	1.63	86.17	1
		50yr	1	3478.2	3478.2	3478.2	3478.2	0.006047	0.53	1.9	92.96	1.18
		100yr	1.3	3478.2	3478.2	3478.2	3478.2	0.002607	0.41	3.16	120.1	0.81
		200yr	1.6	3478.2	3478.2	3478.2	3478.2	0.006128	0.6	2.68	110.6	1.22
		500yr	2.1	3478.2	3478.2	3478.2	3478.2	0.004532	0.57	3.68	129.6	1.08
GK10	593.8	5yr	0.32	3462.9	3462.9	3462.9	3462.9	0.006233	0.49	0.65	36.54	1.17
		10yr	4.3	3462.9	3463.1	3463.0	3463.1	0.000151	0.23	18.5	194.57	0.24
		20yr	6.9	3462.9	3463.1		3463.1	0.000132	0.25	27.71	238.11	0.23
		50yr	10.9	3462.9	3463.2		3463.2	0.000108	0.26	42.11	293.53	0.22
		100yr	14.3	3462.9	3463.2		3463.2	0.000095	0.26	54.14	332.81	0.21
		200yr	18.2	3462.9	3463.2		3463.2	0.000082	0.27	66.38	344	0.2
		500yr	23.9	3462.9	3463.3		3463.3	0.000067	0.28	84.18	355.45	0.19
GK11	730.7	5yr	0.2	3448.9	3450.7		3450.7	0	0	712.3	541.65	0
		10yr	2.7	3448.9	3450.9		3450.9	0	0	799.91	564.95	0
		20yr	4.2	3448.9	3450.9		3450.9	0	0	794.03	563.42	0
		50yr	6.6	3448.9	3451.0		3451.0	0	0.01	849.4	577.69	0
		100yr	8.6	3448.9	3451.0		3451.0	0	0.01	867.7	582.33	0
		200yr	10.9	3448.9	3451.0		3451.0	0	0.01	885.27	586.76	0
		500yr	14.2	3448.9	3451.1		3451.1	0	0.01	908.97	592.67	0
GK12	1451.7	5yr	0.01	3468.3	3468.4	3468.4	3468.4	0.000813	0.1	0.06	7.4	0.37
		10yr	0.16	3468.3	3468.4	3468.4	3468.4	0.004278	0.44	0.37	18.58	0.99
		20yr	0.31	3468.3	3468.4	3468.4	3468.4	0.003716	0.49	0.64	24.45	0.96
		50yr	0.5	3468.3	3468.4	3468.4	3468.4	0.004617	0.6	0.84	28.08	1.1
		100yr	0.7	3468.3	3468.4	3468.4	3468.4	0.003933	0.61	1.15	32.83	1.04
		200yr	0.9	3468.3	3468.4	3468.4	3468.4	0.003566	0.63	1.44	36.74	1.01
		500yr	1.2	3468.3	3468.4	3468.4	3468.5	0.003315	0.65	1.83	41.49	0.99
GK13	1787.8	5yr	0.02	3450.9	3450.9	3450.9	3450.9	0.004573	0.31	0.07	5.86	0.93
		10yr	0.4	3450.9	3451.0	3451.0	3451.0	0.003861	0.61	0.65	18.28	1.04

Swamp Section	River Station	Profile	Q Total	Min Ch El	W.S. Elevation	Critical W.S.	E.G. Elevation	E.G. Slope	Velocity Chnl	Flow Area	Top Width	Froude # Chl
			(m^3/s)	(ft)	(ft)	(ft)	(ft)	(m/m)	(m/s)	(m^2)	(m)	
		20yr	0.6	3450.9	3451.0	3451.0	3451.0	0.003226	0.63	0.95	22.01	0.98
		50yr	1	3450.9	3451.0	3451.0	3451.0	0.003178	0.72	1.4	26.73	1
		100yr	1.3	3450.9	3451.0	3451.0	3451.0	0.00302	0.75	1.73	29.78	0.99
		200yr	1.6	3450.9	3451.0	3451.0	3451.0	0.002896	0.78	2.06	32.44	0.99
		500yr	2.2	3450.9	3451.0	3451.0	3451.1	0.002803	0.83	2.64	36.78	0.99
GK14	1007.3	5yr	0.1	3448.8	3448.8		3448.8	0.001088	0.07	1.36	51.03	0.14
		10yr	0.6	3448.8	3448.9		3448.9	0.000409	0.08	7.52	120.01	0.1
		20yr	0.9	3448.8	3448.8		3448.8	0.011795	0.31	2.89	74.4	0.5
		50yr	1.3	3448.8	3448.9		3448.9	0.002213	0.18	7.13	116.87	0.24
		100yr	1.7	3448.8	3448.9		3448.9	0.003688	0.24	7.2	117.44	0.3
		200yr	2.1	3448.8	3448.9		3448.9	0.001343	0.17	12.33	153.65	0.19
		500yr	2.7	3448.8	3448.9		3448.9	0.005811	0.31	8.59	128.28	0.39
GK15	1103.2	5yr	0.03	3454.8	3454.8	3454.8	3454.8	0.100561	0.53	0.07	3.83	1.29
		10yr	0.3	3454.8	3454.9	3454.9	3454.9	0.043345	0.66	0.45	10.03	0.99
		20yr	0.4	3454.8	3454.9	3454.9	3454.9	0.035796	0.66	0.61	11.59	0.92
		50yr	0.6	3454.8	3454.9	3454.9	3454.9	0.039064	0.76	0.79	13.27	0.99
		100yr	0.8	3454.8	3454.9	3454.9	3454.9	0.038968	0.81	0.99	14.79	1
		200yr	1	3454.8	3454.9	3454.9	3454.9	0.037346	0.84	1.18	16.21	1
		500yr	1.3	3454.8	3454.9	3454.9	3455.0	0.040335	0.93	1.4	17.63	1.05
GK16	779.7	5yr	0.4	3416.0	3417.2		3417.2	0	0	1021.9	1006.7	0
		10yr	3	3416.0	3417.3		3417.3	0	0	1148.6	1037.1	0
		20yr	4.5	3416.0	3417.4		3417.4	0	0	1190.0	1042.6	0
		50yr	6.8	3416.0	3417.4		3417.4	0	0	1239.2	1049.1	0
		100yr	8.8	3416.0	3417.4		3417.4	0	0.01	1274.6	1053.8	0
		200yr	11	3416.0	3417.5		3417.5	0	0.01	1308.9	1058.2	0
		500yr	14.1	3416.0	3417.5		3417.5	0	0.01	1349.9	1063.6	0
Gk17	777.0	5yr	0.1	3418.5	3418.5	3418.5	3418.5	0.035409	0.28	0.35	24.01	0.74
		10yr	0.5	3418.5	3418.6		3418.6	0.000351	0.07	6.67	104.27	0.09
		20yr	0.7	3418.5	3418.6		3418.6	0.001174	0.13	5.46	94.32	0.17
		50yr	1	3418.5	3418.6		3418.6	0.006565	0.27	3.74	78.08	0.39
		100yr	1.2	3418.5	3418.5	3418.54	3418.6	0.050718	0.6	1.99	56.98	1.03
		200yr	1.5	3418.5	3418.6		3418.6	0.001879	0.19	8.11	114.93	0.22

Swamp Section	River Station	Profile	Q Total	Min Ch El	W.S. Elevation	Critical W.S.	E.G. Elevation	E.G. Slope	Velocity Chnl	Flow Area	Top Width	Froude # Chl
			(m^3/s)	(ft)	(ft)	(ft)	(ft)	(m/m)	(m/s)	(m^2)	(m)	
		500yr	1.9	3418.5	3418.6		3418.6	0.00393	0.26	7.34	109.36	0.32
GK18	999.2	5yr	0.2	3423.1	3423.2	3423.2	3423.2	0.003709	0.57	0.35	10.54	1
		10yr	0.5	3423.1	3423.2	3423.2	3423.3	0.003267	0.69	0.73	15.22	1
		20yr	0.7	3423.1	3423.2	3423.2	3423.3	0.003234	0.74	0.94	17.3	1.02
		50yr	1	3423.1	3423.3	3423.3	3423.3	0.003128	0.8	1.25	19.9	1.02
		100yr	1.3	3423.1	3423.3	3423.3	3423.3	0.002873	0.83	1.57	22.31	1
		200yr	1.6	3423.1	3423.3	3423.3	3423.3	0.002791	0.86	1.85	24.25	1
		500yr	2	3423.1	3423.3	3423.3	3423.3	0.002732	0.91	2.21	26.47	1
GK19	1073.2	5yr	0.1	3417.4	3417.2	3417.2	3417.2	0.00064		0.73	49.95	0
		10yr	0.9	3417.4	3417.2	3417.2	3417.3	0.003923		1.92	81.04	0
		20yr	1.4	3417.4	3417.3	3417.3	3417.3	0.004232		2.6	94.29	0
		50yr	2	3417.4	3417.3	3417.3	3417.3	0.005128		3.16	103.98	0
		100yr	2.6	3417.4	3417.3	3417.3	3417.3	0.003809		4.3	121.31	0
		200yr	3.2	3417.4	3417.3	3417.3	3417.3	0.003456		5.21	133.54	0
		500yr	4.2	3417.4	3417.3	3417.3	3417.3	0.003801		6.16	145.26	0
GK20	1133.1	5yr	0.1	3443.3	3443.3	3443.3	3443.3	0.001055	0.16	0.61	47.43	0.46
		10yr	0.5	3443.3	3443.31	3443.31	3443.3	0.00755	0.51	0.98	59.97	1.27
		20yr	0.7	3443.3	3443.32	3443.32	3443.3	0.003269	0.4	1.73	79.59	0.88
		50yr	1.1	3443.3	3443.33	3443.33	3443.3	0.003368	0.46	2.4	93.77	0.91
		100yr	1.4	3443.3	3443.33	3443.33	3443.3	0.003699	0.5	2.78	100.86	0.97
		200yr	1.7	3443.3	3443.33	3443.33	3443.4	0.003797	0.53	3.18	107.94	0.99
		500yr	2.3	3443.3	3443.34	3443.34	3443.4	0.003515	0.56	4.11	122.66	0.98

3.4.5 Environmental flow analysis at the proposed intake

The minimum flow required to sustain the aquatic environment is expressed as a percentage of the Mean Annual Flow with different percentages used for wet and dry seasons. This discharge method is based on Historical flow records at the river section. The minimum flow requirement for the water course is expressed as a percentage of the Mean Annual flow at specific sites in this regard Kamdini. The flow data of 90 % dependable year (1946) is taken for calculation of environmental flow as it indicates that 90% of the times the river flow will be available for releasing environmental flow in the downstream. The mean average annual flow for 90 % dependable year is 494 Cumec and is considered for calculation of Environmental flow.

In addition, the Karuma HPP is Run of River scheme where the project will operate continuously and reservoir filling is one time process only. Therefore the minimum flow will be required only for 10 km stretch of river in between the dam site and Tail race outfall of project. The stretch excluding this 10 km will be having normal flow conditions.

Table 11: The following computations were made for corresponding different percentages of recommended Mean annual flow

Health of the Habitat	Recommended minimum flow as a percentage of the mean annual flow in cumec			
	Wet Season	Mean Flow. wet	Dry Season	Min. Flow. dry
Optimum	60% to 100%	296.4-494	60% to 100%	296.4-494
Outstanding	40%	197.6	60%	296.4
Excellent	30%	148.2	50%	247
Good	20%	98.8	40%	197.6
Fair or Degrading	10%	49.4	30%	148.2
Poor or degrading	10%	49.4	10%	49.4
Severe	0% to 10%	0 to 49.4	0% to 10%	0 to 49.4

From Table 11, 50 cumec is taken as Environmental flow as it will be enough to maintain fair or poor habitat condition the affected stretch of 10 km. Tenant 1976 related various levels of Mean Annual Runoff (MAR) with values of depth, width and velocity. The Assumption was that velocity, depth and width is dependent on and can be determined from MAR. On the other hand, values of velocity, depth and width which are suitable for different levels of ecological functions and services are obtained from different studies. Therefore sustainability of 50 cumec flow is checked velocity, depth, and width for a certain level of ecological function in the downstream. However, for the Karuma HPP, DWRM recommended an environmental flow of 100 cumec taking into consideration other planned uses along the Nile.

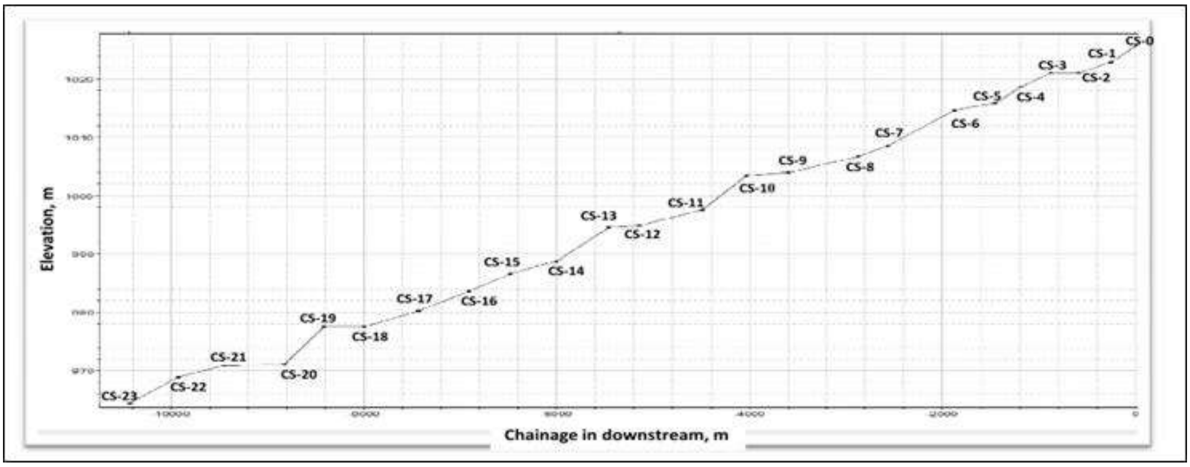

Figure 5 L profile of river in between dam site and Tail race outfall of Karuma HE project

Plate 2: Map showing falls/rapids and pools in Kyoga Nile River between dam site and TR outfall

For studying the requirement of environmental flow vis-a-vis the flow depth and velocity profiles that would be available upon release of environmental flow, an analysis was undertaken using the HEC-RAS software. For the purpose of this study, the cross sections are taken at regular intervals in the river stretch between dam site and TRC outfall especially near impoundments/pools and rapids to have representative river morphology. The cross sections are extracted from Shuttle Radar Topographic Mission (SRTM) data as well as from Google earth imagery. At the upstream boundary of the model, the altered flow series i.e. 50 cumec discharge is defined whereas at the downstream boundary normal depth is specified. The results of simulation are given in Table 12.

Table 12: Flow characteristics for river stretch in between dam site and Tail race outfall of Karuma HPP (50 Cumec Environmental Flow)

River Station	Chainage (m)	Q Total (m^3/s)	Channel elevation (m)	Water surface elevation (m)	Depth of flow (m)	Velocity in channel (m/s)	Top width of flow (m)
CS-0	0	50	1025.65	1026.53	0.88	1.26	95.71
CS-1	-252	50	1022.91	1025.64	2.73	0.11	250.15
CS-2	-585	50	1021.08	1025.63	4.55	0.07	307.6
CS-3	-873	50	1021.08	1022.88	1.8	2.57	34.17
CS-4	-1185	50	1018.64	1020.05	1.41	0.34	135.05
CS-5	-1450	50	1015.9	1020.03	4.13	0.08	228.69
CS-6	-1875	50	1014.68	1016.05	1.37	2.66	27.1
CS-7	-2563	50	1008.58	1009.71	1.13	0.38	193.9
CS-8	-2873	50	1006.75	1009.66	2.91	0.16	178.04
CS-9	-3595	50	1004.01	1009.65	5.64	0.12	137.75
CS-10	-4025	50	1003.4	1004.47	1.07	3.15	21.41
CS-11	-4490	50	997.61	998.77	1.16	1.02	62.49
CS-12	-5136	50	994.87	998.07	3.2	0.16	166.06
CS-13	-5455	50	994.56	995.12	0.56	2.06	54.7
CS-14	-6000	50	988.77	990.19	1.42	0.44	148.95
CS-15	-6483	50	986.64	987.56	0.92	1.74	52.04
CS-16	-6911	50	983.59	984.91	1.32	1.02	76.06
CS-17	-7434	50	980.24	984.2	3.96	0.06	283.53
CS-18	-7998	50	977.49	984.2	6.71	0.04	295.49
CS-19	-8411	50	977.49	978.36	0.87	3.28	22.83
CS-20	-8822	50	971.09	972.72	1.63	0.5	112.8
CS-21	-9450	50	970.79	972.56	1.77	0.2	225.27
CS-22	-9925	50	968.96	969.74	0.78	1.4	98.74
CS-23	-10425	50	964.39	965.38	0.99	1.27	77.2

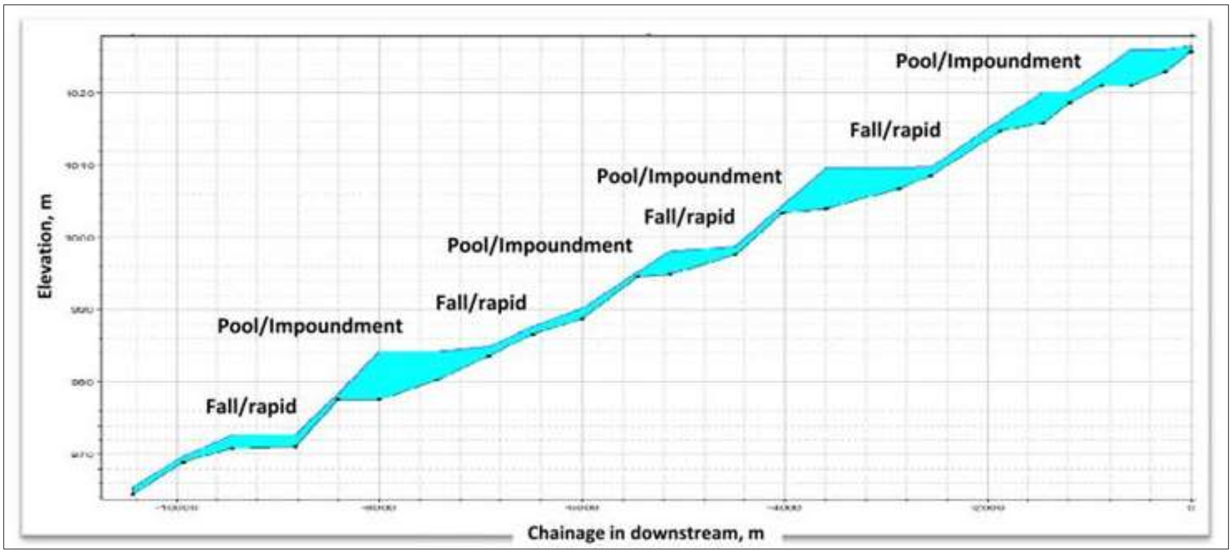

Plate 3: Bed profile and water surface profile for river stretch in between dam site and tail race outfall of Karuma HPP (50 cumec environmental flow)

From above analysis, it is clear that the proposed minimum flow is sufficient for the survival of aquatic species in between proposed weir site and Tail race outfall. Provision of fish ladder along with minimum flow release from weir will ensure the survival of riverine ecology.

Ecological Demand Estimation: Twenty three cross sections are considered in between proposed weir site and Tail race outfall of Karuma HPP (CS 0 to CS 23). The average cross sectional depth ranges between minimum 0.56 m to maximum 5.64 m in the downstream of proposed weir site on Karuma River. On the basis of studies referred above, the analysis of flow characteristics (width of flow, depth of flow, flow velocity, etc.) and the quantum of downstream flow depth as presented in the Table 12**,** it suggests that proposed minimum flow is sufficient for the survival of aquatic species in between proposed weir site and Tail race outfall. Provision of fish ladder along with minimum flow release from weir will ensure the survival of riverine ecology.

However, scrupulous consultation with the Directorate of Water Resource Management (DWRM) Technical Staff conducted on 24th June 2011 recommended to increase the ecological flow to 100 cumecs. Therefore, the Environmental flow was revised from 50 cumecs to 100 cumecs and scenario of flow characteristics for river stretch in between dam site and Tail race outfall of Karuma HE project for 100 cumec is depicted in Table 13.

Table 13: Flow characteristics for river stretch in between dam site and Tail race outfall of Karuma HPP (100 Cumec Environmental Flow)

River Station	Chainage (m)	Q Total (m3/s)	Channel Elevation (m)	Water Surface Elevation (m)	Depth of Flow (m)	Velocity in channel (m/s)	Top Width of flow (m)
CS-0	0	100	1025.65	1026.81	1.16	1.33	138.62
CS-1	-252	100	1022.91	1026.06	3.15	0.18	264.74
CS-2	-585	100	1021.08	1026.06	4.98	0.12	323.04
CS-3	-873	100	1021.08	1023.26	2.18	2.88	46.51
CS-4	-1185	100	1018.64	1020.45	1.81	0.49	151.94
CS-5	-1450	100	1015.9	1020.43	4.53	0.13	233.51
CS-6	-1875	100	1014.68	1016.47	1.79	3.15	35.86
CS-7	-2563	100	1008.58	1010.31	1.73	0.40	212.31
CS-8	-2873	100	1006.75	1010.28	3.53	0.24	184.74
CS-9	-3595	100	1004.01	1010.26	6.25	0.20	155.26
CS-10	-4025	100	1003.40	1004.88	1.48	3.91	25.70
CS-11	-4490	100	997.61	999.15	1.54	1.36	66.42
CS-12	-5136	100	994.87	998.35	3.48	0.27	179.43
CS-13	-5455	100	994.56	995.38	0.82	2.55	60.22
CS-14	-6000	100	988.77	990.57	1.80	0.58	166.51
CS-15	-6483	100	986.64	987.89	1.25	2.05	67.38
CS-16	-6911	100	983.59	985.40	1.81	1.02	118.14
CS-17	-7434	100	980.24	984.81	4.57	0.10	300.19
CS-18	-7998	100	977.49	984.81	7.32	0.06	299.35
CS-19	-8411	100	977.49	978.74	1.25	4.03	27.47
CS-20	-8822	100	971.09	973.00	1.91	0.75	122.16
CS-21	-9450	100	970.79	972.73	1.94	0.34	235.99

River Station	Chainage (m)	Q Total (m3/s)	Channel Elevation (m)	Water Surface Elevation (m)	Depth of Flow (m)	Velocity in channel (m/s)	Top Width of flow (m)
CS-22	-9925	100	968.96	969.95	0.99	1.68	132.8
CS-23	-10425	100	964.39	965.69	1.30	1.51	96.55

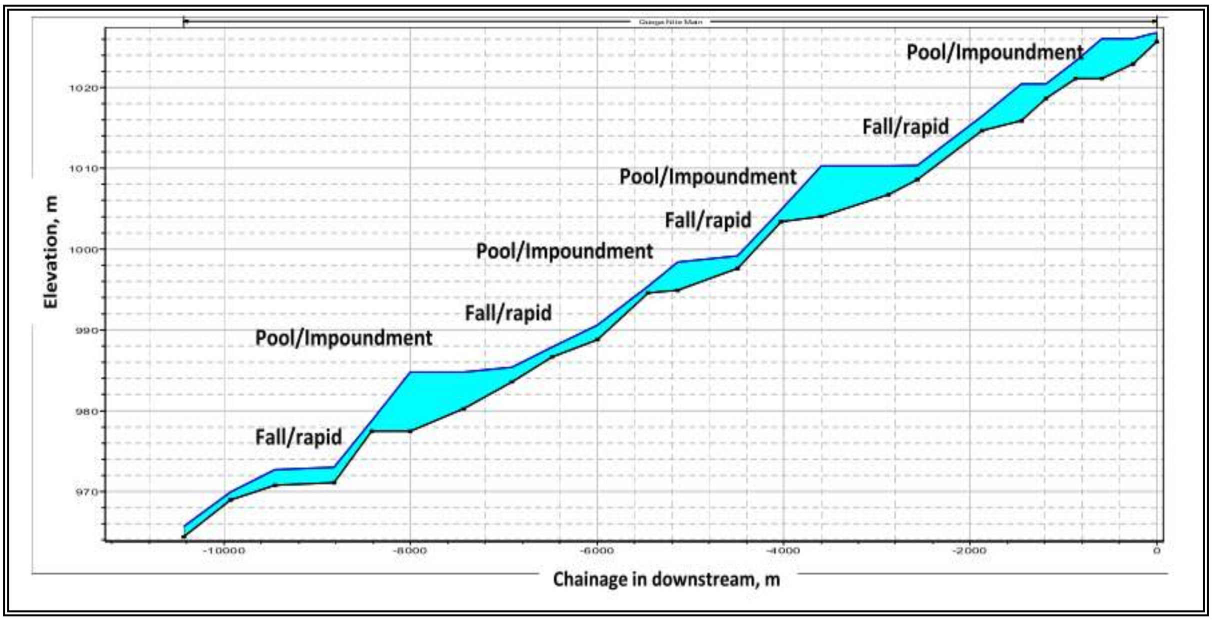

Plate 4: Bed profile and water surface profile for river stretch in between dam site and Tail Race outfall of Karuma HE project (100 Cumec Environmental flow)

Table 14: Flow characteristics for river stretch in between dam site and Tail race outfall of Karuma HPP at present

River Station	Chainage (m)	Q Total (m3/s)	Channel Elevation (m)	Water Surface Elevation (m)	Depth of Flow (m)	Velocity in channel (m/s)	Top Width of flow (m)
CS-0	0	50	1025.65	1026.53	0.88	1.26	95.71
CS-1	-252	50	1022.91	1025.64	2.73	0.11	250.15
CS-2	-585	50	1021.08	1025.63	4.55	0.07	307.6
CS-3	-873	50	1021.08	1022.88	1.8	2.57	34.17
CS-4	-1185	50	1018.64	1020.05	1.41	0.34	135.05
CS-5	-1450	50	1015.9	1020.03	4.13	0.08	228.69
CS-6	-1875	50	1014.68	1016.05	1.37	2.66	27.1
CS-7	-2563	50	1008.58	1009.71	1.13	0.38	193.9
CS-8	-2873	50	1006.75	1009.66	2.91	0.16	178.04
CS-9	-3595	50	1004.01	1009.65	5.64	0.12	137.75
CS-10	-4025	50	1003.4	1004.47	1.07	3.15	21.41
CS-11	-4490	50	997.61	998.77	1.16	1.02	62.49
CS-12	-5136	50	994.87	998.07	3.2	0.16	166.06
CS-13	-5455	50	994.56	995.12	0.56	2.06	54.7

River Station	Chainage (m)	Q Total (m3/s)	Channel Elevation (m)	Water Surface Elevation (m)	Depth of Flow (m)	Velocity in channel (m/s)	Top Width of flow (m)
CS-14	-6000	50	988.77	990.19	1.42	0.44	148.95
CS-15	-6483	50	986.64	987.56	0.92	1.74	52.04
CS-16	-6911	50	983.59	984.91	1.32	1.02	76.06
CS-17	-7434	50	980.24	984.2	3.96	0.06	283.53
CS-18	-7998	50	977.49	984.2	6.71	0.04	295.49
CS-19	-8411	50	977.49	978.36	0.87	3.28	22.83
CS-20	-8822	50	971.09	972.72	1.63	0.5	112.8
CS-21	-9450	50	970.79	972.56	1.77	0.2	225.27
CS-22	-9925	50	968.96	969.74	0.78	1.4	98.74
CS-23	-10425	50	964.39	965.38	0.99	1.27	77.2

4 APPLICABLE LAWS AND POLICIES

4.1 The National Environmental Act, CAP 153

Act to provide for sustainable management of the environment.

Limits on the use of lakes, wetlands and rivers: Subject to subsection (2), no person shall, in relation to a river or lake, carry out any of the following activities

a) Excavate, drill, tunnel or disturb the bed otherwise;
b) Deposit any substance m a lake or river or in, on or under its bed, if that substance would or is likely to have adverse effects on the environment;
c) Divert or block any river from its normal course

Management of river banks: The authority (NEMA) shall, in consultation with the lead agency, take all measures it considers necessary in order to protect the banks of rivers and the shores of lakes in Uganda from human activities that will adversely affect the rivers and the lakes.

Restrictions on the use of wetlands: No person shall, destroy, damage or disturb any wetland in a manner that has or is likely to have an adverse effect on any plant or animal or its habitat. The Authority shall, in consultation with the lead agency, and by statutory order, specify the traditional uses of wetlands which shall be exempted from the application of subsection (1).

Management of wetlands: The authority shall, with the assistance of the local environment committees, district environment committees and the lead agency, identify wetlands of local, national and international importance as ecosystems and habitats of species of fauna and flora and compile a national register of wetlands.

4.2 The National Environment (Wetlands, River Banks and Lake Shores Management) Regulations, No. 3/2000

The objective of this Part of the Regulations is to:

a) Provide for the conservation and wise use of wetlands and their resources in Uganda;
e) Ensure that wetlands are protected as habitats for species of fauna and flora;
h) Minimize and control pollution.

Application for a person to use a river banks or lake shore: A person who intends to carry out any of the following activities shall make an application to the executive Director in Form A set out in the First Schedule to these Regulations. (b) Excavate, drill, tunnel or otherwise disturb the river bank or lake shore.

5 KEY ISSUES AND SCENARIOS

5.1 Changes in Catchment Characteristics

Construction activities could include clearing vegetation, removing soil, importing fill, and the physical, chemical, and biochemical changes associated with bulldozing, grading, and soil compaction. Though these activities may be carried out along the transmission line corridor, they are a small scales thus not likely to alter the catchment characteristics. The pipeline corridor is to be constructed using the cut and cover method after excavation, the area would be restored to its previous condition. Excessive wetland drainage or diversion not expected and that there will be no unnatural impedance to flow.

5.2 Alteration of Natural Water Courses

Construction activities within riparian and wetland zones may cause the destruction or alteration of the site's hydrology, vegetation, and hydric soils. Impacts to wetlands and riparian corridors may impair water quality by influencing varying degrees of one or more of their hydrologic, edaphic (physical and chemical characteristics of soil), and biotic (living organisms) functions. Generally Minor localized alteration of natural drainage patterns until trench settlement is complete are expected.

5.3 Changes in Peak Runoff & Discharge Volumes

The calculation of baseline and anticipated post-mitigation peak runoff flows and volumes are presented in Section 3.1.3 of this report. The excavation for laying pipeline will be done to depth of not more than 1.2m. If the construction is done in the dry season or early in the dry wet, there is limited possibility of alerting the peak flow rates and volumes. The catchment for the respective swamps are relatively flat with long Lag times. This implies the peak are significantly small, however large peak volumes are contributed and sustained for days due to recharge and attenuation effects of the swamps.

5.4 Increased Sediment Yield

Unrestored excavated soils can be easily eroded downstream through the culvert crossing. Excessive erosion of excavated soils can clog the culvert inlets blocking flows. Increased sediment loading could increase nutrient concentrations, harm benthic biota, reduce fish habitat, and, depending on the organic content of suspended sediment, decrease dissolved oxygen levels in receiving waters. Although open "cut-and-cover" crossing of streams would be avoided wherever possible). These impacts include increasing the amount of sediment suspended in the water during construction through erosion and the discharge of pumped groundwater. Erosion of excavated material and subsequent sedimentation in stream channels can also harm both rearing and spawning habitat of fish. Temporary minor erosion and sedimentation could occur if trenches are dug or other excavation is carried out.

5.5 Increase in Pollutant Load

In addition, construction runoff may include debris from demolition such as lime and cement, petroleum fuels, and construction chemicals. Accidental spills of petrochemicals and construction chemicals could also occur, although there is little likelihood of such spills because of normal precautions taken to prevent them.

6 IMPACT ASSESSMENT

6.1 Impact of the Removal and Alteration of Natural Water Courses on Catchment

Since the construction works and pipeline is running parallel the Gulu-kampala road within the road reserve, limited and short term alteration of the water courses is expected. Construction method selection and restoration should be mindful of the season, saturation level, and stability of the soils at the time of construction. At some sections where possible the contractors should apply trenchless techniques to raise the pipeline above the maximum water levels as indicated in section3.14 to ensure there is obstruction of flows. If the pipeline is not installed at the appropriate height, it may trap a lot of debris resulting into backwater effects which may flood the upstream sections near the culvert crossings.

Short-term disturbances to wetlands are expected during construction of the pipelines. If the right-of-way is restored to its preconstruction profile excavated trenches are carefully reconstructed, then long-term impacts on wetland function are not expected. It is anticipated that wetland hydrologic function along the pipeline route will be effectively restored within the short-term.

Mitigation measures: Disruption of surface flow patterns following construction is likely to be minor along the route. In the event that construction or maintenance activities result in changes in surface water regimes, corrective action in consultation with the appropriate authorities will be undertaken to resolve the issue. The residual effect is reversible in the short-term and of low to medium magnitude. The significance is therefore considered to be moderate to low during the construction and operational phases of the project.

Residual Impact: With the implementation of the mitigation measure, impact intensity and magnitude will be reduced in the during the construction phase. The impact significance would accordingly reduce to MINOR.

6.2 Changes in Peak Runoff & Discharge Volumes

Comparison between the baseline, construction and operation phase reveal no possible net change in both peak flow and volume. There will be no significant water level fluctuations due to proposed construction. However the contractor may need to implement alternative methods due to seasonality during construction, significant changes to soil conditions and other unanticipated issues encountered during trenching or excavation that delay or alter flows but to lesser extent.

The positive significance is considered to be **LOW** during the construction phase of the project.

6.3 Impact Assessment on Water Quality

In-water construction activities such as trench excavation and placement of bedding material for outfalls or conveyance pipelines would have short-term impacts on water quality. Excavation of pipe trenches would release sediments into the water column. These sediments would temporarily increase turbidity and would decrease light transmission in the water near excavation sites. The relative magnitude of water quality impacts on both freshwater would vary, depending on the extent or area of construction and proximity to receiving water bodies, however along the corridor there are immediate big water bodies though the whole river network drains towards the Nile.

Mitigation measures: The selection of appropriate water body crossing techniques (i.e. boring of crossings) and implementation of surface erosion controls and riparian vegetation restoration are likely to substantially reduce the potential for adverse effects on surface water quality at watercourses crossed by the route.

Trenching through the swampy sections may proceed when the pipe section is ready to lay. Once trenching commences construction through the wetland should proceed continuously until the crossing is completed, back filled and restored in order to minimize the length of time the trench is open.

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APPENDIX C: WATER QUALITY

NATIONAL WATER AND SEWERAGE CORPORATION

CENTRAL LABORATORY - BUGOLOBI

P.O BOX 7053 KAMPALA Email: waterquality@nwsc.co.ug

CERTIFICATE OF ANALYSIS

CLIENT: Air Water Earth **Serial No: ES/RF/2018/1164**

Address: Bugolobi-Kampala **Sampled by: Client's Staff**

Date Sample Received: 22/08/2018 **Date of Report: 3/9/2018**

Parameters	Units	Karuma Upstream	National Standards for Environmental Water
Sample Number	--	K3907/2018/C/B	
Ammonia-N	mg/L	0.13	10.0
B.O.D	mg/L	5.04	50
Bact: Faecal coliforms	CFU/100mL	15	5000
Bact: Total coliforms	CFU/100mL	4000	10000
COD	mg/L	27	100
Colour (apparent)	PtCo	75	500
Fat, Oil & Grease (FOG)	mg/L	0.0	10.0
Nitrate-N	mg/L	0.04	10.0
Nitrite-N	mg/L	0.0	10.0
Total Nitrogen (TN)	mg/L	4	20.0
Total Phosphorous (TP)	mg/L	0.10	10.0
Total Suspended Solids (TSS)	mg/L	5	100
Turbidity	NTU	4.36	300

Remarks

The water sample showed complying physiochemical and bacteriological characteristics compared to the National Standards for Environmental water

ANALYSED BY: Robinah Muhairwe & Kennedy Araa

AUTHORISED BY: **Manager Central Laboratory Services : ....**

APPROVED BY: **Senior Manager - Water Quality Management Department : ....**

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CERTIFICATE OF ANALYSIS

CLIENT: Air Water Earth | **Serial No: ES/RF/2018/1164**

Address: Bugolobi-Kampala | **Sampled by: Client's Staff**

Date Sample Received: 22/08/2018 | **Date of Report: 3/9/2018**

Parameters	Units	Karuma Downstream	National Standards for Environmental Water
Sample Number	--	**K3912/2018/C/B**	
Ammonia-N	mg/L	0.12	10.0
B.O.D	mg/L	8.76	50
Bact: Faecal coliforms	CFU/100mL	30	5000
Bact: Total coliforms	CFU/100mL	**28000**	10000
COD	mg/L	22	100
Colour (apparent)	PtCo	66	500
Fat, Oil & Grease (FOG)	mg/L	0.09	10.0
Nitrate-N	mg/L	0.07	10.0
Nitrite-N	mg/L	0.036	10.0
Total Nitrogen (TN)	mg/L	19	20.0
Total Phosphorous (TP)	mg/L	0.12	10.0
Total Suspended Solids (TSS)	mg/L	12	100
Turbidity	NTU	4.72	300

Remarks

The water sample showed complying physiochemical characteristics compared to the National Standards for Environmental water. However, the bacteriological characteristics of the water sample did not comply with the National Standards for Environmental water

ANALYSED BY: Robinah Muhairwe & Kennedy Araa

AUTHORISED BY: **Manager Central Laboratory Services :** ....

APPROVED BY: **Senior Manager - Water Quality Management Department :** ....

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CLIENT: Air Water Earth | **Serial No: ES/RF/2018/1164**

Address: Bugolobi-Kampala | **Sampled by: Client's Staff**

Date Sample Received: 22/08/2018 | **Date of Report: 3/9/2018**

Parameters	Units	Layibi BH	National Standards for Environmental Water
Sample Number	--	K3909/2018/C/B	
Ammonia-N	mg/L	0.01	10.0
B.O.D	mg/L	4.26	50
Bact: Faecal coliforms	CFU/100mL	20	5000
Bact: Total coliforms	CFU/100mL	100	10000
COD	mg/L	7	100
Colour (apparent)	PtCo	0	500
Fat, Oil & Grease (FOG)	mg/L	0.0	10.0
Nitrate-N	mg/L	0.02	10.0
Nitrite-N	mg/L	0.0	10.0
Total Nitrogen (TN)	mg/L	**46**	20.0
Total Phosphorous (TP)	mg/L	0.46	10.0
Total Suspended Solids (TSS)	mg/L	0	100
Turbidity	NTU	0.27	300

Remarks
The water sample showed complying physiochemical and bacteriological characteristics with exception of TN as compared to the National Standards for Environmental water

ANALYSED BY: Robinah Muhairwe & Kennedy Araa

AUTHORISED BY: **Manager Central Laboratory Services :** ....

APPROVED BY: **Senior Manager - Water Quality Management Department :** ....

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CERTIFICATE OF ANALYSIS

CLIENT: Air Water Earth **Serial No: ES/RF/2018/1164**

Address: Bugolobi-Kampala **Sampled by: Client's Staff**

Date Sample Received: 22/08/2018 **Date of Report: 3/9/2018**

Parameters	Units	Minakulu Tap	National Standards for Environmental Water
Sample Number	--	**K3908/2018/C/B**	
Ammonia-N	mg/L	0.03	10.0
B.O.D	mg/L	3.04	50
Bact: Faecal coliforms	CFU/100mL	90	5000
Bact: Total coliforms	CFU/100mL	100	10000
COD	mg/L	12	100
Colour (apparent)	PtCo	0	500
Fat, Oil & Grease (FOG)	mg/L	0.0	10.0
Nitrate-N	mg/L	0.03	10.0
Nitrite-N	mg/L	0.0	10.0
Total Nitrogen (TN)	mg/L	18	20.0
Total Phosphorous (TP)	mg/L	0.47	10.0
Total Suspended Solids (TSS)	mg/L	0	100
Turbidity	NTU	0.83	300

Remarks

The water sample showed complying physiochemical and bacteriological characteristics compared to the National Standards for Environmental water

ANALYSED BY: Robinah Muhairwe & Kennedy Araa

AUTHORISED BY: **Manager Central Laboratory Services :** ....

APPROVED BY: **Senior Manager - Water Quality Management Department :** ....

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CLIENT: Air Water Earth **Serial No: ES/RF/2018/1164**

Address: Bugolobi-Kampala **Sampled by: Client's Staff**

Date Sample Received: 22/08/2018 **Date of Report: 3/9/2018**

Parameters	Units	Kamdini Tap	National Standards for Environmental Water
Sample Number	--	**K3910/2018/C/B**	
Ammonia-N	mg/L	0.01	10.0
B.O.D	mg/L	4.38	50
Bact: Faecal coliforms	CFU/100mL	25	5000
Bact: Total coliforms	CFU/100mL	100	10000
COD	mg/L	8	100
Colour (apparent)	PtCo	4	500
Fat, Oil & Grease (FOG)	mg/L	0.0	10.0
Nitrate-N	mg/L	0.04	10.0
Nitrite-N	mg/L	0.01	10.0
Total Nitrogen (TN)	mg/L	**33**	20.0
Total Phosphorous (TP)	mg/L	0.17	10.0
Total Suspended Solids (TSS)	mg/L	0	100
Turbidity	NTU	0.48	300

Remarks

The water sample showed complying physiochemical and bacteriological characteristics with exception of TN as compared to the National Standards for Environmental water

ANALYSED BY: Robinah Muhairwe & Kennedy Araa

AUTHORISED BY: **Manager Central Laboratory Services :** ....

APPROVED BY: **Senior Manager - Water Quality Management Department :** ....

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CLIENT: Air Water Earth **Serial No: ES/RF/2018/1164**

Address: Bugolobi-Kampala **Sampled by: Client's Staff**

Date Sample Received: 22/08/2018 **Date of Report: 3/9/2018**

Parameters	Units	Minakulu P.S (Borehole)	National Standards for Environmental Water
Sample Number	--	**K3913/2018/C/B**	
Ammonia-N	mg/L	0.02	10.0
B.O.D	mg/L	0.90	50
Bact: Faecal coliforms	CFU/100mL	0	5000
Bact: Total coliforms	CFU/100mL	0	10000
COD	mg/L	2	100
Colour (apparent)	PtCo	0	500
Fat, Oil & Grease (FOG)	mg/L	0.0	10.0
Nitrate-N	mg/L	0.04	10.0
Nitrite-N	mg/L	0.01	10.0
Total Nitrogen (TN)	mg/L	19	20.0
Total Phosphorous (TP)	mg/L	0.48	10.0
Total Suspended Solids (TSS)	mg/L	0	100
Turbidity	NTU	1.87	300

Remarks

The water sample showed complying physiochemical and bacteriological characteristics compared to the National Standards for Environmental water

ANALYSED BY: Robinah Muhairwe & Kennedy Araa

AUTHORISED BY: **Manager Central Laboratory Services :** ....

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Address: Bugolobi-Kampala | **Sampled by: Client's Staff**

Date Sample Received: 22/08/2018 | **Date of Report: 3/9/2018**

Parameters	Units	Myene Swamp	National Standards for Environmental Water
Sample Number	--	**K3906/2018/C/B**	
Ammonia-N	mg/L	1.75	10.0
B.O.D	mg/L	12.3	50
Bact: Faecal coliforms	CFU/100mL	40	5000
Bact: Total coliforms	CFU/100mL	1600	10000
COD	mg/L	19	100
Colour (apparent)	PtCo	408	500
Fat, Oil & Grease (FOG)	mg/L	0.19	10.0
Nitrate-N	mg/L	0.06	10.0
Nitrite-N	mg/L	0.012	10.0
Total Nitrogen (TN)	mg/L	9	20.0
Total Phosphorous (TP)	mg/L	0.21	10.0
Total Suspended Solids (TSS)	mg/L	12	100
Turbidity	NTU	22.8	300

Remarks

The water sample showed complying physiochemical and bacteriological characteristics compared to the National Standards for Environmental water

ANALYSED BY: Robinah Muhairwe & Kennedy Araa

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CLIENT: Air Water Earth **Serial No: ES/RF/2018/1164**

Address: Bugolobi-Kampala **Sampled by: Client's Staff**

Date Sample Received: 22/08/2018 **Date of Report: 3/9/2018**

Parameters	Units	Tochi Swamp	National Standards for Environmental Water
Sample Number	--	**K3905/2018/C/B**	
Ammonia-N	mg/L	1.0	10.0
B.O.D	mg/L	9.3	50
Bact: Faecal coliforms	CFU/100mL	90	5000
Bact: Total coliforms	CFU/100mL	1600	10000
COD	mg/L	16	100
Colour (apparent)	PtCo	334	500
Fat, Oil & Grease (FOG)	mg/L	1.98	10.0
Nitrate-N	mg/L	0.08	10.0
Nitrite-N	mg/L	0.021	10.0
Total Nitrogen (TN)	mg/L	5	20.0
Total Phosphorous (TP)	mg/L	0.20	10.0
Total Suspended Solids (TSS)	mg/L	21	100
Turbidity	NTU	38.7	300

Remarks

The water sample showed complying physiochemical and bacteriological characteristics compared to the National Standards for Environmental water

ANALYSED BY: Robinah Muhairwe & Kennedy Araa

AUTHORISED BY: **Manager Central Laboratory Services : ....**

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CLIENT: Air Water Earth **Serial No: ES/RF/2018/1164**

Address: Bugolobi-Kampala **Sampled by: Client's Staff**

Date Sample Received: 22/08/2018 **Date of Report: 3/9/2018**

Parameters	Units	Bobi HC	National Standards for Environmental Water
Sample Number	--	**K3904/2018/C/B**	
Ammonia-N	mg/L	0.21	10.0
B.O.D	mg/L	2.4	50
Bact: Faecal coliforms	CFU/100mL	40	5000
Bact: Total coliforms	CFU/100mL	200	10000
COD	mg/L	10	100
Colour (apparent)	PtCo	0	500
Fat, Oil & Grease (FOG)	mg/L	0.0	10.0
Nitrate-N	mg/L	0.02	10.0
Nitrite-N	mg/L	0.001	10.0
Total Nitrogen (TN)	mg/L	8	20.0
Total Phosphorous (TP)	mg/L	0.38	10.0
Total Suspended Solids (TSS)	mg/L	0	100
Turbidity	NTU	0.33	300

Remarks

The water sample showed complying physiochemical and bacteriological characteristics compared to the National Standards for Environmental water

ANALYSED BY: Robinah Muhairwe & Kennedy Araa

AUTHORISED BY: **Manager Central Laboratory Services :** ....

APPROVED BY: **Senior Manager - Water Quality Management Department :** ....

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APPENDIX D: BIODIVERSITY REPORT

DESCRIPTION OF THE BIOLOGICAL ENVIRONMENT IN THE PROPOSED PROJECT AREAS FOR THE ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT OF THE PROPOSED KARUMA – GULU WATER SUPPLY PROJECT

1 GENERAL INTRODUCTION

The proposed route for the Water pipeline from Karuma to Gulu traverses largely human impacted and/or modified landscapes in which the land cover is mostly dominated by settlement and cultivation. Because of such a scenario most of the area to be traversed by the proposed project is considered of low biodiversity value.

The route of the proposed pipeline route, demonstrates that the slightly over 70 km traverses a number of townships all of which as was observed during the surveys have associated areas of cultivation and/or for grazing livestock (Figure 1).

The proposed project starts with abstraction of water from River Nile South East of the Karuma Hydro Power project. The water will then be pumped a little over 300 m into the area proposed for the Water treatment plant from where, the water will then be piped to a reservoir in Gulu town with a proposed intermediate reservoir in the Bobi area.

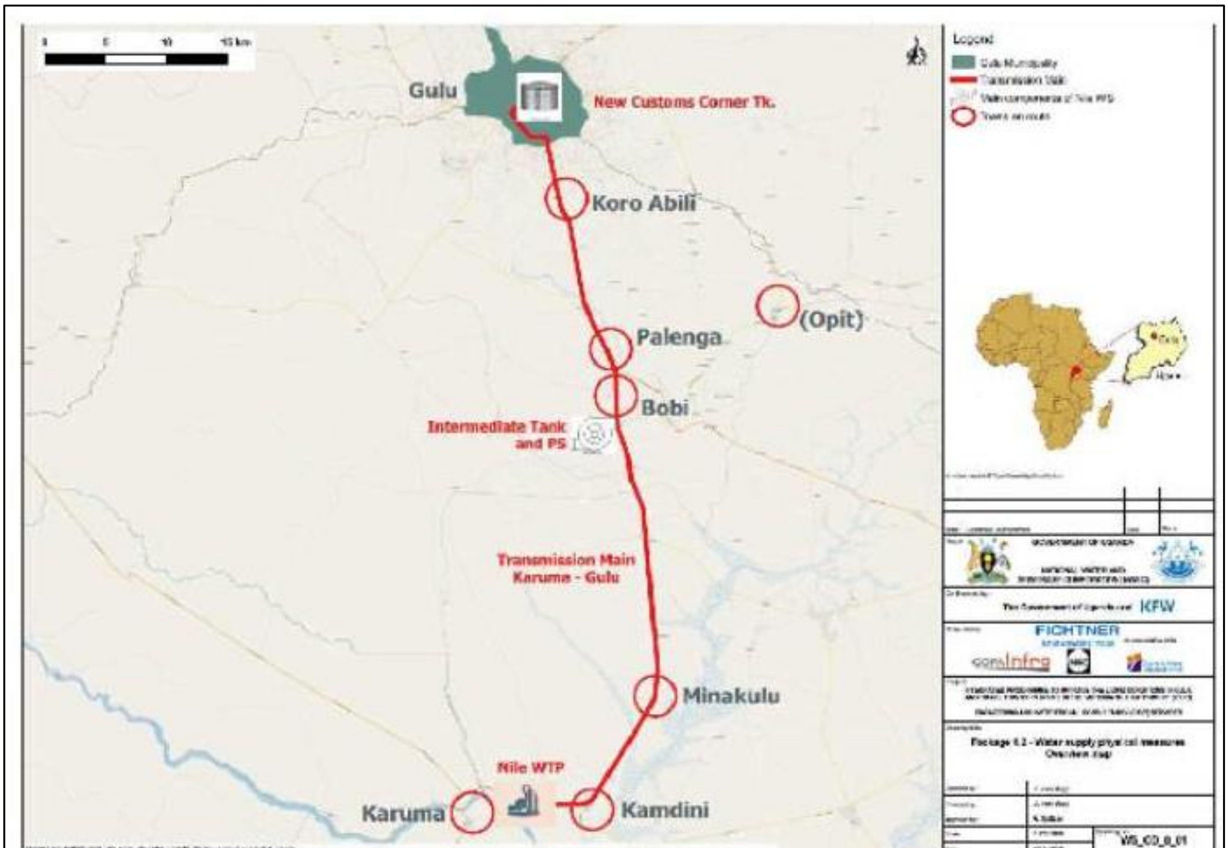

Figure 1 Orientation map for the Gulu –Karuma water pipeline

For the surveys, a reconnaissance was conducted, to identify the location and distribution of areas that carried some natural/semi-natural vegetation and that therefore may still hold some importance for biodiversity. In doing this we recognised the fact that human environmentnts also hold levels of biodiversity but these have a continual human footprint/presence and hence will not be of major importance for biodiversity conservation.

General coordinates and landcover description for the areas at which the baseline surveys were conducted are presented in Table 1 while some habitat futures that characterised the areas of natural/semi-natural vegetation cover in which the surveys for the baseline were conducted are illustrated in Table 2.

Table 1: Coordinates of the general areas in which baseline surveys were conducted

Coordinate in UTM (36N)	Project component	Phytosociological description of study sites
0423989E 297619N	Water pipeline from Karuma to Gulu and intermediate tank	*Tectona-Toona* woodlots contiguous with Acacia-Vitex-Sida bishland
0425521E 291714N		*Albizia-Brachiaria-Aframomum* wooded grassland
0425578E 291563N		*Acacia-Erythrina* woodland
425870E 290059N		*Echinochloa-Persicaria-Ipomoea* riverine vegetation
0427115E 287001N		Papyrus swamp
0428378E 284236N		Papyrus swamp
0429272E 277842N		*Phragmites-Leersia* swamp
0429530E 277069N		Seasonally flooded bushed wooded grassland of *Albizia coriaria-Triumfetta rhomboidea contiguous with permanent wetland of Echinochloa pyramidalis-Phoenix reclinata*
0430285E 273964N		*Cyperus-Echinochloa* swamp (Minakulu swamp)
0430950E 271087N		*Cyperus-Leersia-Setaria* swamp at one extreme and the other *Phragmites-Typha* swamp
0431633E 263550N		*Leersia-Cyperus-Bulbostylis* flooded grassland
0431862E 260939N		*Acacia-Mimosa-Miscanthus* swampy woodland (Ngaato swamp)
0431769E 257460N		Degraded *Mimosa-Cyperus* swamp
0430298E 254551N		*Cyperus-Phoenix-Echinochloa* swamp (Nyere swamp)
0427648E 250367N		*Cyperus-Phoenix-Aeschynomene* swamp (Alenyi swamp)
0422486E 248389N		Degraded *Echinochloa-Mimosa-Setaria* swamp
0418965E 248565N	Water abstraction, Access road, water treatment plant and start of pipeline	*Acacia-Panicum-Pennisetum* Lightly wooded bushed grassland of on rocky ground
0418879E 248772N		*Panicum-Pennisetum* grassland fallow of in quarry
0418963E 248994N		*Panicum-Setaria-Imperata grassland fallow*

0418873E 249127N		*Panicum-Pennisetum* grassland fallow with cassava-Maize garden mosaics
0419050E 249316N		*Panicum-Pennisetum* grassland fallow with cassava-Maize garden mosaics
0419193E 249414N		*Panicum-Pennisetum* grassland fallow with cassava-Maize garden mosaics

Table 2: Location impressions of some of the areas that were surveyed

Photograph	Description
 	The general area around 0425521E 291714N which was characterized by *Albizia-Brachiaria-Aframomum* wooded grassland The area was previously used as a murrum borrow pit on which natural vegetation cover has regrown to give a land cover that can be exploited by several groups of animals. The area from which marrum was excavated was never restored leaving a large depression which very likely holds water in the wet season forming a temporal resource for water dependent flora and fauna
	The local owner of the land at this location has a number of bee hives deployed

Photograph	Description
	Uphill in the same area extends into a finer woodland but further removed from the area of direct impact
	Small patch of vegetation in the vicinity of 0423989E 297619N has a *Tectona-Toona* woodlot contiguous with *Acacia-Vitex-Sida* bush-lands pictured here

Photograph	Description
	
	
 	Opaka Central forest reserve (in the vicinity of 36N 424900E 295148N) planted with *Tectona grandis, Eucalyptus and Pine.* In some sections the undergrowth is quite denseforming suitable habitat for understorey species. Any impacts of the pipeline to the forest reserve will be at the edge next to the road

Photograph	Description
	A view into Tochi swamp (36 N 425870 290059) that is permanent wetland with papyrus and other swamp vegetation
	The survey area around coordinate 36 N 427115 287001 has areas of seasonal inundation but extends into permanent papyrus swamp
	Bobi swamp (36 N 429272 277842) is an area of papyrus swamp but intergrades into areas without permanent standing water with bushes and surrounding agricultural activities.

Photograph	Description
	
	Papyrus swamp At a number of locations the proposed route will cross through areas of natural papyrus swamp (including Minakulu, Ngaato, Nyeere, Agada, Alek, Myene, Aleny & Tochi) all off which have natural vegetation caver similar to that shown in these two figure
	

<table>
<tr><th>Photograph</th><th>Description</th></tr>
<tr><td></td><td rowspan="2">Acacia-Panicum-Pennisetum Lightly wooded bushed grassland of on rocky ground at water abstraction point 36N 0418965E 248565N</td></tr>
<tr><td></td></tr>
<tr><td></td><td>Land cover quite converted through stone quarrying activities in the areas around coordinate 36N 0418879E 248772N</td></tr>
</table>

Photograph	Description
	

Whereas most of the area to be traversed by the proposed pipeline route is heavily modified by human activities, there are areas that retain some level of importance for biodiversity. The route will marginally cross one protected area Opaka Central Forest reserve which even then is now an area of plantation forestry but with good understorey vegetation in sections.

1.1 Objectives of the Surveys

The surveys for this report were commissioned to capture baseline biodiversity along the route that would be traversed by the proposed pipeline. For the surveys we selected a number of representative taxa that included:

i) Vegetation and flora
ii) Fish
iii) Invertebrates – using butterflies
iv) Amphibians
v) Reptiles
vi) Birds and
vii) Mammals

These taxa are commonly assessed in surveys for completing ESIAs in Uganda and therefore have comparative information that can be found if needed. They are typically easy and quick to survey and their taxonomy is fairly well known.

Surveys were done for species occurrence, relative abundance and habitat suitability for species. In the various checklists that were collected, these were assessed to identify if any species of conservation concern (either endemic, rare or listed on the IUCN or Ugandan list of threatened species and in the case of fish if any were of considerable commercial and/or nutritional value).

An impact assessment was also done for the different taxa for which we collected data. For plants, the surveys focused on the preffered side of road where the transmission pipeline could be installed but for animal taxa because they move around the surveys recorded species observed on both sides of the road if/when observed.

1.2 Rationale

Environmental impact assessments are undertaken through the conducting of systematic examination of the likely environmental consequences of proposed projects. The results of the assessment are intended to provide decision-makers with a balanced assessment of the environmental implications of the proposed action and the alternatives that could be considered. The overall goal of an EIA is to achieve better developmental interventions through protecting the environment.

1.3 Methods and Materials

Standard methods were followed for the survey of the different taxa. The details of these are presented in the different subsections.

2 VEGETATION, HABITATS AND FLORA STUDIES

2.1 Introduction

Due to the increasing global destruction of habitats, studies of species diversity and communities within different habitats are critically important (De vries, 1997). This is because effective prescription of conservation protocols and mitigation of human activities that negatively affect organisms and their habitats highly depend on such studies. In recent years a higher percentage of losses in habitats and organisms is attributed to human activities including infrastructural development and urbanization (Hill *et al*. 2001). These two human activities are key drivers of decline in diversity and abundance in many animal groups and because of this many species are currently threatened with extinction (Fox *et al*. 2010).

Infrastructural developments for providing safe water from lakes, rivers and dams through treatment and distribution systems to consumers may not only affect hydrological cycles but also have impacts on biodiversity. Lowering of the water table, impediment of drainage in various channels and change of flow direction may reduce area biodiversity (Zane-Satterfield, 2005). Besides, the debris particles and chemicals that may go with back wash are key pollutants that can lower the quality of habitats consequently killing flora and fauna.

Plants satisfy the criterion specified for good indicator groups of habitat condition always used for environmental evaluation and monitoring (Kalema *et al.*, 2010). Plants are the primary terrestrial and ecotone habitat component due to their capability of providing cover, shelter, and food to faunal species. This coupled with their ability to act as major indicators of change in environmental conditions makes them better candidates of the survey. Plants are good indicators of changes in physical environment such as water availability, soil chemistry, air composition, etc. (Wheater 1999). Changes in these factors affect plants directly and such effects are easy to observe. Short term environmental effects may include sudden withering of then healthy plants and even death of some species.

2.2 Objectives

The vegetation and flora studies aimed at:

i) Ascertaining species richness and diversity, identifying species of conservation concern in terms of rarity and current conservation status both locally and internationally
ii) Evaluation of the ecological sensitivity of the proposed sites for water intake, treatment, reservoir and distribution systems
iii) Identification of the likely negative impacts on flora and vegetation
iv) Proposition of mitigation measures and a monitoring protocol to check effectiveness of the mitigation protocol

2.3 Methods and Materials

2.3.1 Study areas

The study areas were those where the proposed water project is anticipated to cause impacts on the biological component. Sites that were studied wholly were around the water abstraction point along river Nile at Karuma, and the proposed water treatment plant, while points were selected along the pipeline route and access road. Study points were identified considering their naturalness, ecological sensitivity and habitat variability. Efforts were made to give greater attention to the points where most disturbances are expected. All sample sites were geo-referenced and characterization was based on the floristic and landscape features observed at the different sites.

2.3.2 Sampling methods

Systematic-random sampling was applied in the study points selected during scoping. Within these points records of features of landscape and environment including vegetation assemblages were made at the specific points. Species of plants recorded were assessed on the DAFOR scale - standing for dominant, abundant, frequent, occasional and rare species. At each study point, quadrats were established randomly according to nature and size of the habitat from which vegetation type, plant species, presence of disturbances and presence of species of conservation interest including invasive species were made in an area of 50x50m^2. The vegetative communities in the study area were classified basing on Langdale-Brown *et al*. (1964) system. This system recognizes 22 ecosystem types, identified by letters between A to Z. Although the Langdale-Brown (A-Z) system is over 50 years old, it was used in preference to the National Biomass Study 2003 for several reasons as indicated by Van Breugel *et al*. (2011). The A-Z system is based on plant community composition rather than just plant biomass, which was more relevant to the goal of characterizing vegetation identifying plant species and sensitive habitats. Secondly, although much of Uganda's vegetation has been extensively altered over the past two-three decades, the A-Z system can still be considered to epitomize the potential of an area to support an ecosystem type relevant to environmental impacts study (Kalema, *et al*., 2010; Pomeroy, *et al*., 2002). The A-Z system provides 22 vegetative categories opposed to the 13 adopted by the National Biomass System (USAID 2014), this greater level of resolution could necessitate assessment of the potential impacts of water abstraction and distribution systems on ecosystems to greater details. The records generated from each day of field work were used to provide a detailed characterization of vegetation types, generation of species list and illustration of existing forms of disturbances. The species of plants recorded were further analysed into growth forms, ecological type, threat levels according to IUCN (2018) and the National data base of threatened species by WCS (2016). Presence of any form of legal protection by Uganda's acts on conservation of biodiversity by organs such as NFA and WID was also quoted.

2.3.3 Data analysis

The field records were analysed in five different ways:

a) Critical habitats and vegetation in terms of landscape features

According to Begon *et al*. (2006) an Ecosystem is a more or less discrete community of organisms and the abiotic conditions at a site while a habitat is a set of requirements necessary for the survival of an organism. An ecosystem is one of the higher levels of interaction between organisms and their abiotic components and from surveys these are indicated by the plants' community structure in the landscape. Examples of vegetation types include forests, grasslands, bush lands while an ecosystem can also be an individual feature such as a tree providing support to a variety of flora and fauna. Habitat characterization was further done through ascertaining habitat preferences of fauna components to a particular ecosystem. Field observation and use of the Langdale-brown *et al*. (1964) system made the basis for analysis of landscape cover types.

b) Compilation of Species lists and richness

Compilation of species list for each vegetation type as well as intermediate encounters enabled generation of a general species list for the water project area. This species list was confirmed after identification of all the plants encountered during the surveys as well as identification of specimens collected. Identification of specimens was done from Makerere University herbarium. This list was crucial in a way that it facilitated further analyses including conservation status and invasiveness.

c) Existing forms of disturbances

Different forms of disturbances at each of the study points were recorded and pictorial illustrations are provided in here. An ecosystem was rated of low conservation value if it was heavily degraded by one disturbance or by a combination of disturbances to none recoverable levels an example here is a built up area in many small towns along Karuma-Gulu road representing totally degraded vegetation.

d) Species threat levels and invasiveness

The conservation status for each species was obtained from the published most recent IUCN (2018) red data list and the National red list of Uganda's threatened species (WCS 2016). Invasive species considered here included those that are exotic and have threats to native species at both individual and ecosystem levels. Further consideration was made basing on species richness and presence of species that requires special protection from local jurisdictions.

2.4 Findings

2.4.1 Vegetation types and critical habitats

Karuma-Gulu water project traverses Savannah vegetation of various phytosociological characteristics. For example the area around the water intake along river Nile is in lightly wooded bushed grassland of *Acacia polyacantha, Panicum maximum and Pennisetum polystachion* on a rocky ground. The pipeline from the intake to the water treatment plant traverses through bushed grasslands of *Panicum maximum* and *Pennisetum polystachion* grassland fallows and a stone quarry area, while the treatment plant and the access road traverse areas of *Panicum-Pennisetum* grassland fallows with cassava-Maize garden mosaics. The pipeline route from Karuma to Gulu traverses various plant communities outstanding among them are wetlands with various phytosociological characteristics. Most of the habitats the project is anticipated to traverse are already transformed; however, there are wetlands some of which are still natural while others are degraded. Irrespective of the degradation levels, wetlands are vital ecosystems for both amphibious and aquatic organisms they have to be given due protection from vandalism. Photos 1 - 10 below give a pictorial illustration of the state of vegetation at various sites of the project area from Karuma-Gulu.

Photo 1: *Acacia-Panicum-Pennisetum* Lightly wooded bushed grassland of on rocky ground at water abstraction point 36N 0418965E 248565N

Photo 2: *Panicum-Pennisetum* grassland fallow of in quarry 36N 0418879E 248772N

Photo 3: *Panicum-Setaria-Imperata* grassland fallow near 36N 0418963E 248994N

Photo 4: *Panicum-Pennisetum* grassland fallow near 36N 0419193E 249414N

Photo 5: *Albizia-Brachiaria-Aframomum* wooded grassland near 36N 0425521E 291714N

Photo 6: *Acacia-Erythrina* wooded grassland *Acacia-Erythrina* woodland near 36N 0425578E 291563N

Photo 7: *Cyperus-Phoenix-Echinochloa* swamp (Nyere swamp) near 36N 0430298E 254551N

Photo 8: Acacia-Vitex-Sida bush land near 36N 0423989E 297619N

Photo 9: *Leersia-Cyperus-Bulbostylis* seasonally flooded grassland near 36N 0431633E 263550N

Photo 10: *Tectona grandis* NFA forest reserve at 36N 424900E 295148N

A site is recognized as sensitive if it contains i) threatened taxa in accordance with IUCN conservation assessment protocol, ii) rare species, iii) endemic species, presence of iv) fragile watersheds, v) steep slopes, and vi) riparian areas (Lucie *et al.* 2016). In this regard, extra care should be taken to minimise disturbances and prevent pollution during the water works in wetlands. At some point the pipeline route passes through a Forest reserve (Photo 8) however there will be no big impact here if the pipe is passed in the road reserve besides the vegetation here is not natural.

2.4.2 Species lists and richness

A total of 22 study points along the pipeline, entire sites for water abstraction and water treatment plant as well as the entire access road transect were sampled and it was found out that the water project traverses through an area with 173 species of plants belonging to 45 families. Majority of these were in form of herbs with a percentage composition of 34.1, followed by trees and grasses with 20.1 and 19.1 respectively. The percentage composition of plants' growth forms along Karuma-Gulu project area is shown in Figure 2.

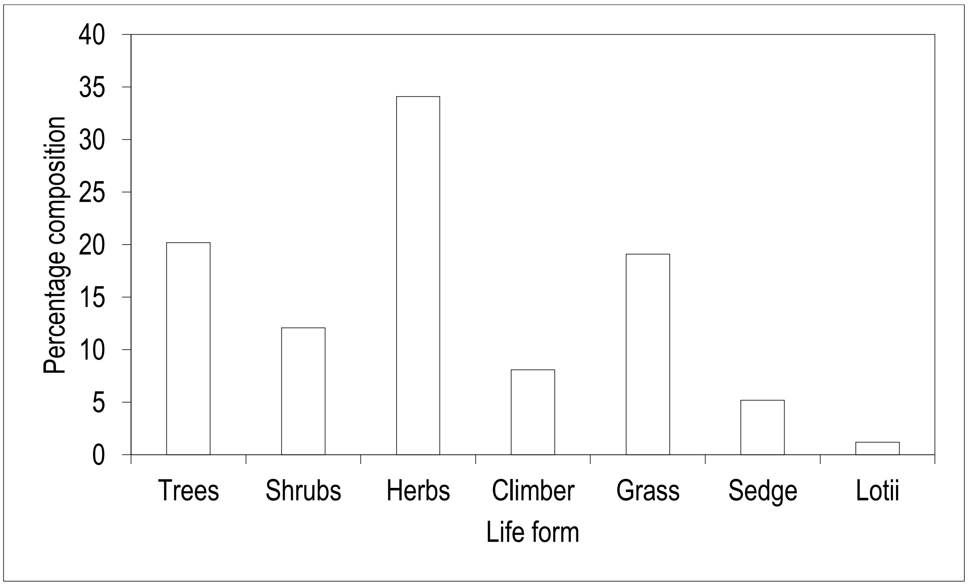

Figure 2 Percentage composition by growth form of plant species

From Figure 2 it is evident that in general the selected sites for the project have very little woody biomass which would take long to be replaced compared to the easily replaceable non woody biomass. The high species richness of the area is as a result of habitat diversity and degradation of some of the habitats for example wetlands and bushed grasslands such that many are now fallows which are characteristic of high species diversity. The names, families and assessment on the DAFOR scale of the plant species encountered are given in Appendix 1. Only six plant species *Cyperus papyrus, Leersia hexandra,* *Echinochloa pyramidalis, Setaria sphacelata, Cynodon dactylon* and *Acacia polyacantha* which is the only woody species were over all dominant in the project area.

At the intake site (Photo 1) only one tree species *Acacia polyacantha* was the dominant tree, other small trees and shrubs are sporadic in *Panicum maximum* and *Pennisetum polystachion* dominated fallows. These two grasses are characteristic of fallow lands a justification of already existing degradation from stone quarrying activities at the site. The pipe line (Photo 2) from the abstraction point to the water treatment plant has small and few bushes scattered in rock excavations, on rocks, roads and heaps of stones. In both sites the species richness was generally very low due the intensive disturbance from stone works.

The project area has species of socio-economic importance. Some of these species provide high valued timber, poles for electricity transmission and roofing materials for houses as well as fruit trees and food crops. Trees with high valued timber and poles were *Khaya anthotheca, Markhamia lutea, Maesopsis eminii, Milicia excelsa, Eucalyptus* sp and *Griveria robusta*. Fruit trees were *Mangifera indica, Persea americana* and *Psidium guajava*. Many of the food crops in gardens and dominant crops were *Manihot esculenta, Musa sp* and *Zea mays*. Even though most of these trees are not on the IUCN or WCS lists of threatened species, they have to be preserved because of their socio economic importance.

2.4.3 Existing forms of disturbances

Cultivation, brick making and stone quarrying were the dominant disturbance in the project area. While stone quarrying was localised to the rocky sites near the Nile the former two disturbances are easily seen in the entire project area mainly in the wetlands. Cultivation is both subsistence with gardens dominated by *Manihot esculenta* and *Musa* sp and plantation with *Eucalyptus* spp, *Pinus pinus* and *Tectona grandis*. The photos below (Photos 11 – 14), give a pictorial illustration of some of the major forms of disturbances to the vegetation in the proposed project area. The implication of this observation is that some natural ecosystems are already threatened with degradation. Therefore the anticipated disturbances should not take these ecosystems to irrecoverable limits. This is because when vegetation is cleared, complex patterns usually emerge within remnants and these normally disrupt several parameters within species communities as well as modifying ecosystem structural properties.

2.4.4 Species Threat levels and National legal protection

There were two tree species that fall under the IUCN list of threatened species *Khaya anthotheca* and *Milicia excelsa* which are vulnerable (VU) and Near Threatened (NT) respectively worldwide (IUCN 2018). From the national red list data for threatened species of Uganda *Khaya anthotheca* and *Milicia excelsa* are both Endangered (EN). According to WCS (2016) these species were assessed as such due to increasing reduction in their geographical distribution and consequently their numbers as a result of environmental degradation. This implies that the species and their immediate habitats require protection from any form of destructive disturbances. It is also worth noting that *Markhamia lutea*, *Maesopsis eminii* and *Milicia excelsa* are listed by the National Forestry and Tree planting Act 2003 scheduled VI because of their economic importance and threats from human activities. Photo 15 gives a pictorial illustration of some of the threatened species.

Photo 11: Plantation of Pinus pinus along the road at 36N 424900E 295148N

Photo 12: Brick making I a degraded swamp along the road at 36N 422486E 248389N

Photo 13: Cultivation at wetland fringes at 36N 430285E 273964N

Photo 14: Heaps of stones in a quarry through which the pipeline from abstraction point pass at 36N 418965E 248565N

In all four scenarios illustrated in Photo 15, these don't represent natural stands, but trees planted by local resident land owners.

2.4.5 Invasive (noxious) plant species

Several invasive species of plants were encountered along the project area. *Mimosa pigra, Senna spectabilis, Imperata cylindrica* and *Ricinus communis* were frequently encountered along. The pictorial illustration of some of these species is provided in the Photo 16.

Invasive species flourish due to disturbances that alter the environment to favourable levels (Klinger & Brooks 2009). After establishment the area now has novel species and consequently habitats. Due to their great dispersal characteristics, high tolerance to unsuitable conditions, large reproductive capacities and high growth rates invasive species easily overtake the natives. Changes at individual and at ecosystem level render native species and habitats unsuitable for many species thus altering population growth, disturbance regimes and geomorphology (Davis 2009). Disturbances of some magnitude are anticipated during and after construction therefore these species require careful management and monitoring.

Milicia excelsa woodlot (Neat threatened, NT by IUCN, Endangered, EN by WCS and protected by NFA act 2003) Located at 36N 424999E 294543N

Markhamia lutea (protected by NFA act 2003) located at 36N 423972E 297577N

Khaya anthotheca woodlot (Vulnerable, VU by IUCN, Endangered, EN by WCS) located at 36N 429530E 277069N

Individual of *Maesopsis eminii* (protected by NFA act 2003) at 36N 421095E 248802N

Photo 15: Some of the trees of conservation importance

Mimosa pigra in a wetland at 36N 431395E 266179N

Tithonia diversifolia in road side swamp at 36N 430950E 271087N

Photo 16: Invasive species in the project area

2.5 Discussion and Recommendations

Discharge of wastes from water treatment plants if poorly managed has the potential to cause adverse effects to the environment and biodiversity (Popmeu & Alves, 2005; Ausden, 2007). In situations where water is abstracted from a river such effects can be observed downstream. Such effects usually culminate into total habitat conversion or loss especially if supplemented with infrastructure set up. Additionally, habitat quality usually deteriorates due to pollutants that may be contained in back wash (Zane-Satterfield, 2005). This therefore, implies that attention has to be given to management of debris, particles and chemicals from construction materials and thorough screening of back wash waters for chemical pollutants.

3 FISHERIES

3.1 Introduction

Uganda's total surface area covered by water is 18%. There are over 160 minor lakes and many rivers, floodplains, swamps and man-made fishing ponds all of which are critical fish breeding and nursery grounds. The major lakes include Victoria, Albert, and George/Edward and major river; the Victoria Nile which flows out of Lake Victoria at Owens Falls Dam and through the northern tip of Lake Albert, north to Sudan (Albert Nile); extensive local fisheries along most of its' length.

Ecologically wetlands form the transitional zone between land and water, where saturation with water is the dominant factor determining the nature of soil and the types of plant and animal community's living in and on it. An immense variety of species of micro-organism, plants, insects, amphibians, reptiles, birds, fish and mammals are the part of a wetland ecosystem. Globally, wetlands constitute one of the most sensitive, biologically productive and vital ecosystems in the world (*http://www.epa.gov/watertrain*, *http://wwf.panda.org/our_work/water/intro/value/*). They cover 5% of the earth's ice-free land surface and in East Africa; Uganda has the largest percentage of wetland coverage.

Fisheries resources are among the most significant natural endowments in Uganda not only because of their magnitude and diversity, but also because they represent a major source of protein in the diet of most Ugandan, in addition to employment and income for over 1 million people gaining from the most valuable resource from the water bodies; fish (http://www.firi.go.ug/PDFs/PROFILE%20EDITED_22_2_2014.pdf).

3.1.1 Fish species in Uganda

In 1991 it was estimated that 2546 species of fish populated the world belonging to 969 genera, 254 families, and 40 orders. Around 80% of fish population around the globe was represented by the Indian fishes. Depending upon the habitats and characteristics there are a variety of fish around the world existing as fresh water, tropical, marine, cold water and aquarium fishes. In Uganda, there are fresh water fishes; fishes that are found in the water bodies such as lakes and rivers in which the salinity is less than 0.05% comprising a total diversity of at least 500 species (NARO, 2013, http://www.firi.go.ug/PDFs/PROFILE%20EDITED_22_2_2014.pdf). The most common species are *Lates niloticus, Oreochromis niloticus, Clarias gariepinus, Rastriniobola argentia* and *Protopterus* spp.

3.1.2 Importance of fisheries

a) Ecological importance of the wetland fisheries

Wetlands are one of the most productive ecosystems comparable to tropical evergreen forests in the biosphere and play a significant role in the ecological sustainability of a region – values that have been recognised the world over (see for example Schuyt and Brander 2004). Wetlands provide great volumes of food that attract many animal species (Schuyt and Brander 2004). These animals use wetlands for part of or all of their life cycle. Dead plant leaves and stems break down in the water to form small particles of organic material called "detritus". This enriched material is fed on by many small aquatic insects, shellfish and small fish that are food for larger predatory fish, reptiles, amphibians, birds and mammals. Wetlands serve as sources of Municipal/Town council water systems in many parts of Uganda and also as sink for waste water and sewage from the urban centers.

b) Socio-economic importance of the wetland fisheries

Fish provides nutrients and micronutrients that are essential to cognitive and physical development, especially in children, and are an important part of a healthy diet. The water from the wetland system is primarily used by the communities for domestic purposes, watering livestock and construction works. The communities that are farming in the wetland also tap the water to support their agricultural production and include fish farming. In several parts of Uganda, communal hunting in the wetland is a common practice. The hunting is usually preceded by burning of the wetland vegetation mainly in the dry season. Commonly hunted animals include; edible rats and Sitatungas.

Fishing in the wetland is normally done during the dry season when the water in some part of the wetland has receded. Most commonly caught fish include mud fish and lung fish and types of fishing methods used include; hook and line, traps and gillnets.

Wetland vegetation is sourced for materials for various domestic uses. Building poles, firewood, medicine and craft materials are some of the materials obtained. Some communities practicing apiculture which use the existing vegetation for siting their bee hives.

Other forms of importance include; economic security, empowerment, recreational services, cultural services, Human health and well-being, Knowledge transfer and capacity building.

3.2 Methords

3.2.1 Study area

The study area was along the Gulu-Oyam Tochi wetland system. This lies in Gulu and Oyam districts traversing through the sub-counties of Aber, acaba, Ngai, Minakulo and Myene (Oyam district) and Ongako, Bobi, Koro, Layibi Division, Lwakwana and Abok**.**

3.2.2 Data collection methods

Interviews with fishermen, market surveys, onsite seining and on- site analysis were the methods used to collect the data.

a) Interviews with fishermen

Fishermen were targeted during their fish catching hours and here they were interviewed. Analysis and identification was made of the fish they had caught species and questions were directed to the fishermen on the nature of common species caught. Fishermen selling fish on road near the target swamps were also interviewed and here useful information on edible species was obtained.

b) Market surveys

Markets of Apworocero and Kamdini were surveyed. Here the fish species that were being sold were identified and information was gathered on the most commonly sold/bought fish species, uncommon species and other levels of rarity or commonness.tion was all collected. Market surveys were considered a data collection area since most of the fish species sold there were caught in the swamps of the area.

c) Active fishing

At suitable locations, siene nets were used to dredge and capture fishes for identification. Scenes of various activities undertaken in the experimental fishing are shown in Photos 17 to 20.

Photo 17: Team of local persons that assisted in the experimental fishing checking in the siene net for captured fish

Photo 18: The fisheries biologist taking note of fish captured

Photo 19: Example habitat in a the wetland habitats in which experiment fishing was conducted

Photo 20: Fish captured in an experimental fishing turn

3.3 Results

Five major swamps and three minor swamps were sampled (Table 3) for they presented a good potential for fishing.

Table 3: Coordinates of areas where surveys for fish were conducted

Survey area	Coordinates
Tochi swamp	425845˚N 290128˚E
Minakulu swamp	430190˚N 273940˚E
Ogada swamp	431309˚N 266162˚E
Alek swamp	431632˚N 263295˚E
Myene swamp	430257N 254514E
Aleny swamp	427494˚N 250510˚E
Palenga	426033˚N 292106˚E
Bobi Swamp	430849˚N 271165˚E
-no local name found-	427037˚N 286992˚E

Fish were captured in the experimental fishing but we also surveyed local fishers' catches to compile the checklists of fish in the fifferent survey areas. Some of the fish species are of commercial value as they are captured and sold in the market while others are captured for domestic consumption. Some of the fish captured in the experimental fishing are shown in Photo 21.

1) Petrocephalus castoma; 2) Labeo victorianus; 3) Schilbe mystus; 4) Synodonti afro fischeri; 5) Synodontis species 2; 6) Poecilia reticulata and 7) Petrocephalus castoma

Photo 21: Examples of fish species captured in the experimental fishing

Overall we recorded at least 20 species some of which are only identified to genus level. A summary of the fish capture results for the project area is presented in Tables 4 and 5. Although all fish can be consumed, the very small sized species are not commonly consumed by humans.

The species richness varied from as few as 4 species for the most species poor area to as many as 12 species for areas that were richer in species captured. Records for each area we surveyed represent at most three repeats of experimental fishing, and it is likely that there may be more species of fish than we recorded. Going by the fish species recorded from the surveys, it maybe concluded that the areas with a higher species richness of fish are more important than those with smaller numbers. However, because the wetlands we surveyd are a series in an interconnected system, it is likely that the various species may be as widely occurring as the wetland system that is to be traversed by the project.

Table 4: Fish diversity recorded in the project area

Overall list of species	The most widely occurring species	Species recorded in only a few locations	Number of edible species
Alestes baremoze *Bagrus docmak*	*Clarias gariepinus* *Haplochromis* sp 1	*Alestes baremoze* *Bagrus docmak*	*Alestes baremoze* *Bagrus docmak*

Overall list of species	The most widely occurring species	Species recorded in only a few locations	Number of edible species
Clarias gariepinus	*Haplochromis* sp 2	*Lates niloticus*	*Clarias gariepinus*
Haplochromis sp. 1	*Haplochromis* sp *3*	*Mormyrus caschives*	*Labeo victorianus*
Haplochromis sp. 2	*Haplochromis* sp 4		*Lates niloticus*
Haplochromis sp. 3	*Haplochromis* sp 5		*Mormyrus kanume*
Haplochromis sp. 4	*Labeo victorianus*		*Oreochromis niloticus*
Haplochromis sp.5	*Mormyrus kanume*		*Orochromis leucosticus*
Labeo victorianus	*Oreochromis niloticus*		*Oreochromis esculentus*
Lates niloticus	*Orochromis leucosticus*		*Protopterus aethiopicus*
Mormyrus kanume	*Oreochromis esculentus*		*Synodontis afrofisheri*
Mormyrus caschives	*Poecilia reticulata*		*Tilapia zilli*
Oreochromis niloticus	*Protopterus aethiopicus*		
Orochromis leucosticus	*Synodontis afrofisheri*		
Oreochromis esculentus			
Protopterus aethiopicus			
Poecilia reticulata			
Synodontis afrofisheri			
Synodontis sp			
Tilapia zilli			

Table 5: Fish species recorded in the different survey areas

Species	**425845N 290128E**	**426033N 292106E**	**430190N 213940E**	**430849N 271165E**	**431309N 266162E**	**431632N 263295E**	**430257N 254514E**
Alestes baremoze	√		√		√		√
Bagrus docmack	√						√
Clarias gariepinus	√	√	√	√	√	√	√
Haplochromis spp	√	√	√		√	√	√
Labeo victorianus			√		√		√

Lates niloticus			√		√	√	
Mormyrus kanume.	√	√	√		√		√
Oreochromis niloticus		√	√		√	√	√
Poecilia reticulata	√	√	√	√	√	√	
Protopterus aethiopicus	√	√	√	√			√
Synodontis spp	√	√	√	√	√		√
Oreochromis esculentus		√	√		√	√	
Oreochromis sp						√	
Tilapia zilli		√	√		√	√	√

The conservation status of the species of fish found is presented in Table 6. Two species (*Labeo victorianus* and *Oreochromis esculentus*) are listed as critically endangered. The wetland habitats are important range areas for these species and therefore loss of habitat is a key contributing factor to their endangerement as is the case for several other taxa.

Table 6: Conservation statust of some of the fishes recorded

Species	**IUCN Conservation status**
Alestes baremoze	LC
Clarias gariepinus	LC
Labeo victorianus	CE
Mormyrus kanume	LC
Oreochromis niloticus	NE
Oreochromis esculentus	CE
Poecilia reticulata	NE
Bagrus docmak	LC
Cyprinus carpio	VU
Lates niloticus	LC
Mormyrus caschives	LC
Orochromis leucosticus	LC
Protopterus aethiopicus	LC
Synodontis afrofisheri	LC

Key to acronyms in the table: CE - Critically endangered, NE - Not evaluated, LC - Least Concern, VU - Vulnerable

4 HEPERTILES

4.1 Introduction

A study with the aim of determining the potential impacts of the proposed water transmission line from Karuma (River Nile) to Gulu on hepertiles. Hepertiles, like many other groups of organisms, are facing worldwide population declines, range contractions, and species extinctions. The single most important cause of amphibian declines globally is habitat degradation, largely as a result of human activities (Blaustein *et al.,* 1998). It is imperative that conservation action such as this study be taken to reverse this trend and maintain hepertilian diversity.

Given their sensitivity to habitat alteration and pollution, amphibians may serve as indicators of overall environmental health. Many species of amphibians provide both indirect and direct benefits to humans. Amphibians are bio indictors of an altered ecosystem and are very sensitive environmental monitors; and significant declines could indicate deterioration in the quality of the environment. This role as indicators can be based on the assumption that the adverse effects of environmental degradation will be reflected in reduction of diversity (Magurran, 1988). Amphibians unlike people breathe at least partly through their skin making them much sensitive to environmental disturbance (IUCN/SSC, 2003).

They have also been used in assays to determine the effect of water–borne pollutants. Most frog species have both aquatic and terrestrial life stages that signify changes in both types of environment. The tadpoles, the eggs and embryos of frogs in wetlands are very sensitive indicators of any adverse changes in the water chemistry (Channing, 2001).

Ecologically, amphibians are important; they are mostly predators, acting as primary and secondary carnivores. Their prey consists mostly of insects, some of which are pests to crops or disease vectors. They are also inter-linked in food chains, often acting as food for other vertebrates, such as, birds and snakes.

4.2 Study Area and Methods

4.2.1 Study Area

The study was completed along Karuma - Gulu Highway for the transmission line and along River Nile for water abstraction and water treatment plant. The area was characterised by permanently saturated cyperus swamps (Table 1), wooded grasslands, grassy fallow, gardens and settlements.

Table 7: Survey points at the proposed water treatment plant site and along the transmission line with associated habitat description

Coordinate in UTM (36N)	Phytosociological description of study sites	Project sites	Habitat groupings
0423989E 297619N	Tectona-Toona woodlots contiguous with Acacia-Vitex-Sida bushland	Transmission line	Wood land
0425521E 291714N	Albizia-Brachiaria-Aframomum wooded grassland	Transmission line	Wood land
0425578E 291563N	Acacia-Erythrina woodland	Transmission line	Wood land
425870E 290059N	Echinochloa-Persicaria-Ipomoea riverine vegetation	Transmission line	Swamp
0427115E 287001N	Papyrus swamp	Transmission line	Swamp
0428378E 284236N	Papyrus swamp	Transmission line	Swamp
0429272E 277842N	Phragmites-Leersia swamp	Transmission line	Swamp
0429530E 277069N	Seasonally flooded bushed wooded grassland ofAlbiziacoriaria-Triumfettarhomboidea contiguous with permanent wetland of Echinochloa pyramidalis-Phoenix reclinata	Transmission line	Seasonal flooded marsh
0430285E 273964N	Cyperus-Echinochloa swamp (Minakulu swamp)	Transmission line	Swamp
0430950E 271087N	Cyperus-Leersia-Setaria swamp at one extreme and the other Phragmites-Typha swamp	Transmission line	Swamp
0431633E 263550N	Leersia-Cyperus-Bulbostylisflooded grassland	Transmission line	Swamp
0431862E 260939N	Acacia-Mimosa-Miscanthus swampy woodland (Ngaato swamp)	Transmission line	Swamp
0431769E 257460N	Degraded Mimosa-Cyperus swamp	Transmission line	Swamp
0430298E 254551N	Cyperus-Phoenix-Echinochloa swamp (Nyere swamp)	Transmission line	Swamp
0427648E 250367N	Cyperus-Phoenix-Aeschynomeneswamp (Alenyi swamp)	Transmission line	Swamp
0422486E 248389N	Degraded Echinochloa-Mimosa-Setariaswamp	Transmission line	Swamp
0418965E 248565N	Acacia-Panicum-Pennisetum Lightly wooded bushed grassland of on rocky ground	Transmission line	Wood
0418879E 248772N	Panicum-Pennisetum grassland fallow of in quarry	Raw water intake abstraction / water treatment plant	Grass fallow

Coordinate in UTM (36N)	Phytosociological description of study sites	Project sites	Habitat groupings
0418963E 248994N	Panicum-Setaria-Imperata grassland fallow	Raw water intake / water treatment plant	Grass fallow
0418873E 249127N	Panicum-Pennisetum grassland fallow with cassava-Maize garden mosaics	Access road	Grass fallow
0419050E 249316N	Panicum-Pennisetum grassland fallow with cassava-Maize garden mosaics	Access road	Grass fallow
0419193E 249414N	Panicum-Pennisetum grassland fallow with cassava-Maize garden mosaics	Access road	Grass fallow

Source: Primary data

4.2.2 Methods

The common methods available for surveying amphibians are reviewed in Heyer *et al*., (1994). These include visual encounters, egg surveys, call surveys, terrestrial cover boards, dip nets, seines, aquatic funnel traps, and terrestrial pitfall traps. The method to be used is dictated in most cases by the habitat type. Field data was obtained by conducting a survey of amphibians and reptiles along the different sections of the project area. Species observed were counted and recorded; counting was done to give an estimate of each species relative proportions in the project area. The conservation status of the hepertofauna was reported using the IUCN red listing (IUCN 2016) and the National redlist (2016).

a) Visual encounter surveys (VES)

Visual encounter survey method is commonly used to determine the species richness of an area Heyer *et al*., (1994), to compile a species list and to estimate relative abundances of species within an assemblage. This involved walking through the project area searching and recording species and numbers of amphibians and reptiles. It involved turning logs or stones, inspecting retreats, watching out for surface-active species listening and or recording any amphibians calling.

b) Audio/acoustic surveys

This is survey based on listening to sound produced by the amphibians. Males of many anuran species vocalize. Sexually mature male frogs and toads call to attract mates and establish territories. Consequently, vocal species can be identified by their distinctive unique calls, and an approximation of their relative abundance can be estimated by the number of calls heard. Several stops were made in the project sites and along transect, to listen, identify and record any frogs or toads heard calling. The reptiles and amphibians were identified using standard reference texts key of which was Schiotz (1999). The IUCN red list was used in the species threat categorization of the amphibians and reptiles.

c) Local consultations

This is a slightly modified Pooled Local Expert Opinion (PLEO) method on local informants. This method is vital for assessing species presence, density and range estimations and is based on residents with good knowledge on fauna in the area (van der Hoeven *et al*., 2004).

4.3 Results

Overall 113 amphibians were recorded representing 23 species from eight families (Table 8); while 163 reptiles were recorded representing 31 species from 12 families (Table 9). Amphibians were mostly recorded from sites close to water with fewer species being recorded away from water. Amphibian diversity was generally low compared to that of reptiles Table 10), the highest being recorded in the permanently flooded swamps, these swamps provide the adequate ecological requirements need by most amphibians. Amphibian relative abundance was dominated by *Ptychadena mascareniensis* 16% followed by *Amietophrynus maculatus* and *Hyperolius viridiflavus* (Photo 22 (c) and (d)) with 11% and 8% respectively); *P mascareniensis* and *Hyperolius viridiflavus* are from Family Hyperolidea which represented the most species (Table 8). Family Hyperolidae was represented by the most species, this large family of small to medium-sized, brightly colored frogs contains more than 250 species in 19 genera with seventeen genera being native to sub-Saharan Africa (Shiotz, 1999).

All identified amphibian species belong to Order Anura. According to Channing (2001), order Anura has the most surviving species with about 4,000 members worldwide. It consists of several families of frogs and toads of which eight were recorded for this study. Family Ranidae constitute the highest number of species followed closely by Bufonidae and Hyperolidae. The richness of these families is attributable to the agility of members which enable them escape and cross the matrices of disturbed landscape.

Reptilian species were recorded from all the sampled points, but most were in locations that were drier without standing water such as grasslands and woodlands. A few species recorded in the swampy / marshy areas such as *Phylothamnus angolensis* are quite versatile on habitat occupancy. Some species such as *Agama agama* and *Naja melanoleuca* were recorded from most sites. Diversity was generally high in all sampled habitats, much as the drier areas were represented by the highest number of species; diversity was highest in permanently flooded swamps (Table 10). *Agama agama* was the most abundant 22% followed by *Philothamnus semivariegatus* and *Trachylepis maculirabris* at 15% and 12% respectively (Table 9).

Table 8: Amphibian species in habitats along the Karuma-Gulu water transmission with their threat status

Family	Species	English Name	Conservation status
Arthroleptidae	*Leptopelis sp*	Tree frog	LC
	Phrynobatrachus mababiensis	Mababe puddle toad	LC
	Phrynobatrychus natalensis	Natal puddle toad	LC
Bufonidae	*Amietophrynus gutturalis*	Guttural Toad	LC

Family	Species	English Name	Conservation status
	Amietophrynus maculatus	Flat-backed Toad	LC
	Amietophrynus regularis	Common African toad	LC
	Amietophrynus vittatus	Lake Victoria Toad	LC
Dicroglossidae	*Hoplobatrachus occipitalis*	Crowned bull frog	LC
Hyperolidae	*Hyperolius acuticeps*	Sharp nosed reed frog	DD
	Hyperolius cinnamomeoventris	Cinnamon bellied reed frog	LC
	Hyperolius kivuensis	Kivu reed frog	LC
	Hyperolius sp	Reed frog	LC
	Hyperolius viridiflavus	common reed frog	LC
	Kassina snegalensis	Senegal kassina	LC
	Afrixalus quadrivitatus	Four-Lined Spiny Reed Frog	LC
Pipidae	*xenopus laevis*	African Clawed Frog	LC
Ptychadenidae	*Ptychadena anchietae*	Anchieta's ridged frog	LC
	Ptychadena mascareniesis	Mascarene Grass Frog	LC
	Ptychadena oxyrhynchus	Sharp nosed ridged frog	LC
	Ptychadena porosissima	Grass land ridged frog	LC
Pyxicephalidae	*Amietia angolensis*	Angola river frog	LC
Ranidae	*Amnirana galamensis*	Glam white lippe frog	DD

Table 9: Reptile species in habitats along the Karuma-Gulu water transmission with their threat status

Family	Scientific name	English name	Conservation status
Agamidae	*Agama agama*	Orange headed agama	LC
Chamaeleonidae	*Chamaeleo bitaeniatus*	Side stripped chameleon	LC
	Chamaleo gracilis	Gracefull chameleon	LC
Gekkonidae	*Hemidactylus brookii*	Brooks'gecko	LC
	Hemidactylus mabouia	Tropical house gecko	LC
Scincidae	*Trachylepis maculirabris*	Speckle-Lipped skink	LC
	Trachylepis quinquetaeniata	Rainbow skink	LC
	Trachylepis striata	Striped skink	LC
	Trachylepis variabilis	Variable skink	LC
Varanidae	*Varanus niloticus*	Nile monitor lizard	LC

Family	Scientific name	English name	Conservation status
Boidae	*Python sebae*	East African rock python	LC
Colubridae	*Crotaphopeltis degeni*	Yellow flanked snake	LC
	Crotaphopeltis hotamboeia	White lipped snake	LC
	Hapsidophrys lineata	Black linned green snake	LC
	Lamprophis olivaceus	Olive house sanke	LC
	Natriciteres olivacea	Olive marsh snake	LC
	Philothamnus angolensis	Angola green snake	LC
	Philothamnus bequaerti	Bequaerti's green snake	LC
	Philothamnus heterolepidotus	Slender green snake	LC
	Philothamnus semivariegatus	Spotted bush snake	LC
	Psammophis sibilans	Hissing Sand-snake	LC
	Psamophis mosambicus	Olive sand snake	LC
Elapidae	*Dendroaspis polylepis*	Black mamba	LC
	Elapsoidea laticincta	Sudanese Garter-snake	LC
	Naja melanoleuca	Water cobra	LC
Lamprophiidae	*Prosymna sp*	Speckled Shovel-snout	LC
Pelomedusidae	*Pelomedusa subrufa*	Marsh terrapin	LC
	Pelusios williamsi	Williams' hinged terrapin	LC
Typhlopidae	*Typhlops lineolatus*	Lineolate blind snake	LC
Viperidae	*Bitis arietans*	Puff adder	LC
	Bitis nascornis	Rhinoceros viper	LC

Table 10: Species diversity from generalized habitats from the study area

General habitat	Amphibians	Reptiles
Wooded grasslands	0.89	1.73
Seasonally flooded marsh	1.73	2.02
Permanently flooded swamp	2.98	2.66
Grassland	1.95	2.13

Reptiles were dominated by *Trachylepis maculirabris*, *Varanus niloticus* and *Naja melanoleuca,* the former two species are from Order Sauria. These are mostly lizards with well developed limbs making them more agile hence covering and colonizing more ground compared to their limbless cousins in the Order Serpentes (Cogger, 2000). Species from Order Sauria are also very adaptive with some preferring being comensal (*Agama agama* and *Trachylepis striata*) while others occupy various habitat strata (Gerlach, 2005).

Basing on the rarefaction curves (Figures 3 and 4), it can be concluded that for both amphibians and reptiles, we probably recorded all possible species since the curves attained the asymptote, while in woodlands and grasslands the asymptotes were not attained implying more surveys could yield more species. However the smoothed averages of the individual curves represent the statistical expectation of species accumulation curve per sampling habitat.

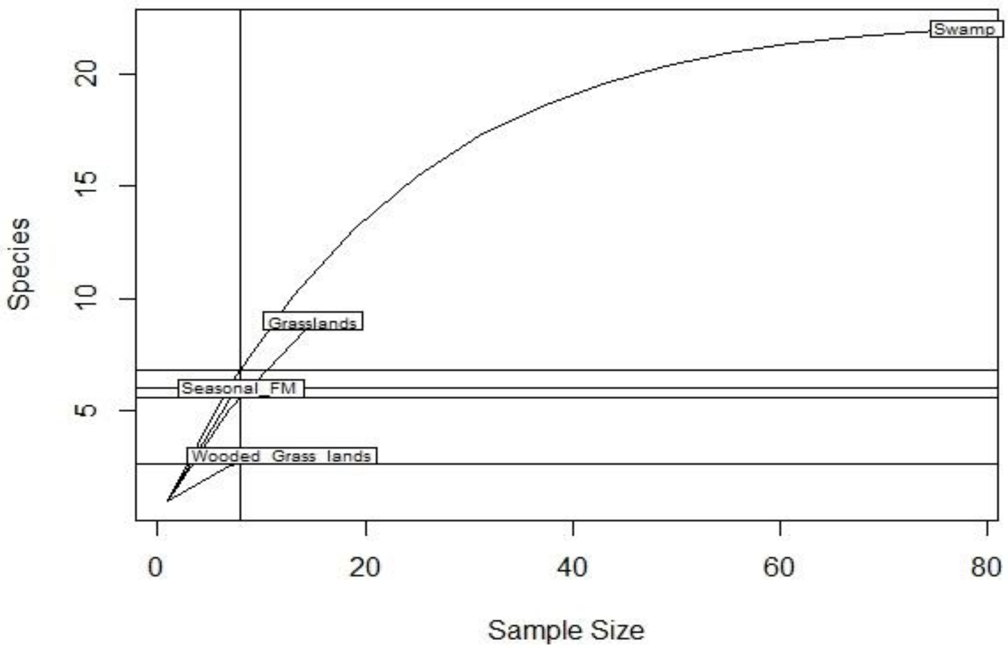

Figure 3 Rarefaction curve for amphibians in generalized sampling habitats along the Karuma-Gulu water transmission line

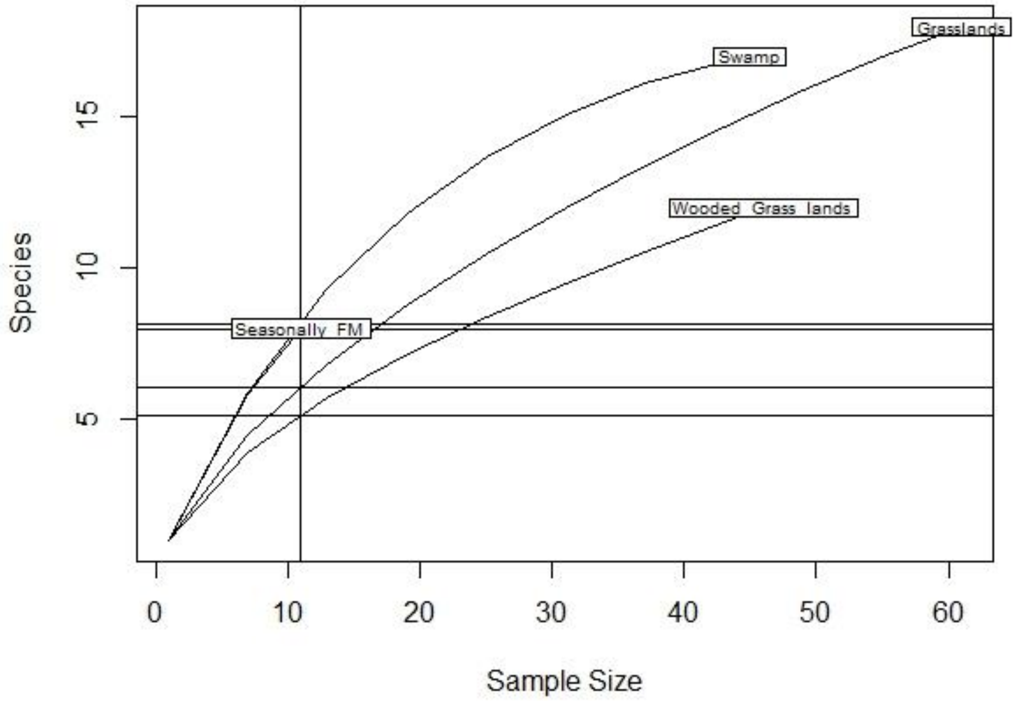

Figure 4 Rarefaction curve for reptiles in generalized sampling habitats along the Karuma-Gulu water transmission line

(a) Hoplobatrachus occipitalis

(b) Kassina senegalensis

(c) *Amietophrynus maculatus*

(d) *Hyperolius viridiflavus*

Photo 22: Some amphibian species recorded in the major swamps along the project area

Conservation status: Some of the hepertile species recorded have not been evaluated and some are listed as data deficient by IUCN (2016), those that have been evaluated are of least concern due to their widely occuring distribution and not known to be going under any population decline or threatening decline in their habitat quality IUCN (2016). It should be noted that most the ecological aspects of most hepertilian species in Uganda are poorly known. Several species are also listed as data deficient (Table 3 and 4) owing to their unknown ecology.

4.4 Conclusions

The sites visited represent a mosaic of seminatural habitats, bushed fallows, replanted forest reserves and scrubby bushland, many of which are degraded but still have potential for regeneration once protected and restocked. There is a string of permanently flooded cyperus swamps with natural habitats and acting as a refugia for many hepertilian fauna including threatened species, Compared to most taxa, hepertilian populations are particularly sensitive to habitat alterations and as such referred to as ecological indicators. Some species have extremely limited ranges while others are widely dispersed in a variety of localities and climatic regions. This explains the fact that most amphibian species were recorded in swamps, flood plains and close to ponds, while the more adaptive reptiles were recorded from various sites. These are mostly lizards with well developed limbs making them more agile hence covering and colonizing more ground (Cogger, 2000). Species from Order Sauria are also very adaptive with some preferring being comensal (*Agama agama* and *Trachylepis striata*) while others occupy various habitat strata (Gerlach, 2005).

5 INVERTEBRATES

5.1 Introduction

Butterflies populate the entire land area of the earth except for the Polar Regions and the most arid deserts (Larsen, 1991). Apart from their diurnal activity, they are amongst the most colourful and conspicuous of the invertebrate taxon, which has prompted more research on their activity and taxonomy (Plumptre *et al*. 2003). Butterflies are considered important flagships for insect conservation (New *et al*., 1995) and are important ecological indicators as they signal the presence/abundance of other species, or signal chemical/physical changes in the environment through changes in their own presence or abundance (Simberloff,1998).

Many butterfly species migrate over long distances as many as 3,000 miles which enables pollination across long distances (Ghazanfar *et al*., 2016). In Uganda, about 1245 butterfly species have been recorded from a variety of habitats and it is thus feasible to evaluate the butterfly fauna of the region as well as deriving reasonably accurate comparisons of sites and subsequently identify conservation requirements (Kasangaki *et al*., 2012). The present study aims to collect baseline data for butterfly diversity in a proposed water treatment plant, water reservoir and a water pipeline route from Karuma to Gulu.

5.2 Methods

Random surveys for butterflies were carried out in 35 sites along the proposed water pipeline route, access road, water treatment plant and reservoir in areas which appeared to be more pristine. Sampling was done from 9:00 am till 5:00 pm which is the peak time for butterfly activity using both visual identification and hand held aerial sweep nets for those specimens which could not be readily identified in the field. Collected specimens were placed in an envelope and stored for further identification using a field guide by Larsen (1996). The observed butterflies were categorized in five categories on the basis of their abundance in a given sample location. VC - very common - (> 100 sightings), C - common - (50–100 sightings), NR - not rare - (15–50 sightings), R - rare - (2–15 sightings), VR - very rare (1–2 sightings) (Tiple *et al.* 2006). All voucher specimens collected during the present research were deposited at Makerere University Zoology Museum.

5.3 Findings

The general areas in which the surveys for butterflies were conducted are similar to those listed in Table 1 but because actual field implementation might different slightly, the general locations where the butterfly surveys were conducted are defined in Table 11.

Table 11: General coordinates around which butterfly surveys were conducted.

Site		Easting	Northing
Site 1	36 N	423971	297629
Site 2	36 N	425525	291705
Site 3	36 N	431662	263298
Site 4	36 N	424917	295095
Site 5	36 N	425849	290260
Site 6	36 N	426305	288673
Site 7	36 N	427125	286967
Site 8	36 N	428382	284236

Site		Easting	Northing
Site 9	36 N	429263	277831
Site 10	36 N	429603	276516
Site 11	36 N	430262	273954
Site 12	36 N	430976	270878
Site 13	36 N	431396	266207
Site 14	36 N	427706	250479
Site 15	36 N	431876	260948
Site 16	36 N	431734	257204
Site 17	36 N	430257	254514
Site 18	36 N	418841	248657

A total of 36 butterfly species belonging to 23 genera and five families (Hesperiidae, Lycaenidae, Nymphalidae, Papilionidae and Pieridae) were recorded in this survey (Table 12). A complete list of the butterfly species and the sites where they were recorded is included in Table 13. Nymphalidae was the most diverse family with 16 species (44.4%) followed by Pieridae with 9 species (25.0%) as shown in Figure 5. Only four species each of the families Lycaenidae and Hesperiidae were recorded while Papilionidae had the least number of species recorded (n=3, 8.3%). The family Nymphalidae is the largest family of butterflies while Papilionidae has few species.

Table 12: Habitat preference of the butterfly species recorded

Butterfly grouping	Common name	Ecological Type	Status
Hesperiidae			
Eretis lugens	Savanna Elf	W	UC
Eretis herewardi	-	f	R
Lepella lepeletier	Lepeletier's sylph	f	VR
Metisella midas	Golden Sylph	W	VR
Lycaenidae			
Azanus natalensis	Natal Babul Blue	W	C
Leptotes pirithous	Common Zebra Blue	W	C
Ypthima asterope	Common Three-Ring	W	C
Zizeeria knysna	African Grass Blue	W	UC
Nymphalidae			
Acraea encedon	Common Acraea	O	UC
Acraea eponina	Orange Acraea	W	C
Bicyclus angulosus	Startled Bush Brown	O	UC
Bicyclus campinus	Chirinda Bush Brown	f	C
Bicyclus safitza	Common Bush Brown	W	C
Bicyclus vulgaris	Vulgar Bush Brown	W	C
Danaus chrysippus	African Queen	M	C

Butterfly grouping	Common name	Ecological Type	Status
Hamanumida	Guineafowl	W	UC
Junonia chorimene	Golden Pansy	O	UC
Junonia oenone	Dark Blue Pansy	W	C
Junonia terea	Soldier Commodore	W	C
Melanitis leda	Common Evening Brown	W	UC
Neptis saclava	Small Spotted Sailor	W	R
Neptis serena	River Sailor	W	C
Vanessa cardui	Painted Lady	M	VR
Ypthimomorpha	Swamp Ringlet	f	R
Papilionidae			
Graphium leonidas	Veined Swordtail	M	VR
Papilio demodocus	Citrus Swallowtail	M	UC
Papilio nireus	Narrow G-banded Swallowtail	f	VR
Pieridae			
Belenois creano	African Caper	M	VR
Captosilia florella	African Emigrant	M	VR
Dixeia charina	African Small White	O	VR
Eronia leda	Autumn Leaf Vagrant	W	VR
Eurema hapale	Marsh Grass Yellow	S	C
Eurema hecabe	Common Grass Yellow	M	C
Eurema regularis	Regular Grass Yellow	W	C
Mylothris rubricosta	Eastern Swamp Dotted Border	S	C
Nepheronia	Blue Vagrant	f	R

Key: *W Widespread species; O – Open habitat species; M – Migratory species; f – Forest edge/ woodland species; and S – Swamp/ wetland species*

Table 13: Occurrence of species across sites

Species/ SItes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Acraea encedon														P					1
Acraea eponina						P			P									P	3
Azanus natalensis						P	P												2
Belenois creano									P										1
Bicyclus angulosus				P													P	P	3
Bicyclus campinus		P		P		P			P			P			P				6
Bicyclus safitza																		P	1
Bicyclus vulgaris						P					P						P		3
Captosilia florella			P														P		2
Danaus chrysippus			P				P	P					P			P		P	6
Dixeia charina													P						1
Eretis lugens	P			P		P			P										4
Eretis herewardi	P		P			P													3
Eronia leda								P											1
Eurema hapale								P											1
Eurema hecabe						P			P	P			P					P	5
Eurema regularis		P			P	P	P	P	P	P	P	P	P		P	P	P		13
Graphium leonidas						P			P										2
Hamanumida daedalus							P						P					P	3

Species/ SItes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Junonia chorimene	**P**		**P**			**P**		**P**		**P**			**P**						6
Junonia oenone			**P**		**P**				**P**	**P**						**P**		**P**	6
Junonia terea	**P**	**P**				**P**	**P**			**P**							**P**	**P**	7
Lepella lepeletier			**P**																1
Leptotes pirithous						**P**	**P**												2
Melanitis leda							**P**			**P**		**P**	**P**					**P**	5
Metisella midas			**P**																1
Mylothris rubricosta								**P**			**P**	**P**	**P**	**P**	**P**	**P**			7
Nepheronia thalassina	**P**																		1
Neptis saclava						**P**	**P**												2
Neptis serena	**P**	**P**	**P**						**P**			**P**				**P**	**P**	**P**	8
Papilio demodocus						**P**						**P**					**P**	**P**	4
Papilio nireus						**P**												**P**	2
Vanessa cardui																	**P**		1
Ypthima asterope											**P**			**P**			**P**		3
Ypthimomorpha itonia		**P**					**P**												2
Zizeeria knysna						**P**													1

Junonia terea *Mylothris rubicosta* *Leptotes pirithous*

Photo 23: Three of the commonest butterfly species in the project area

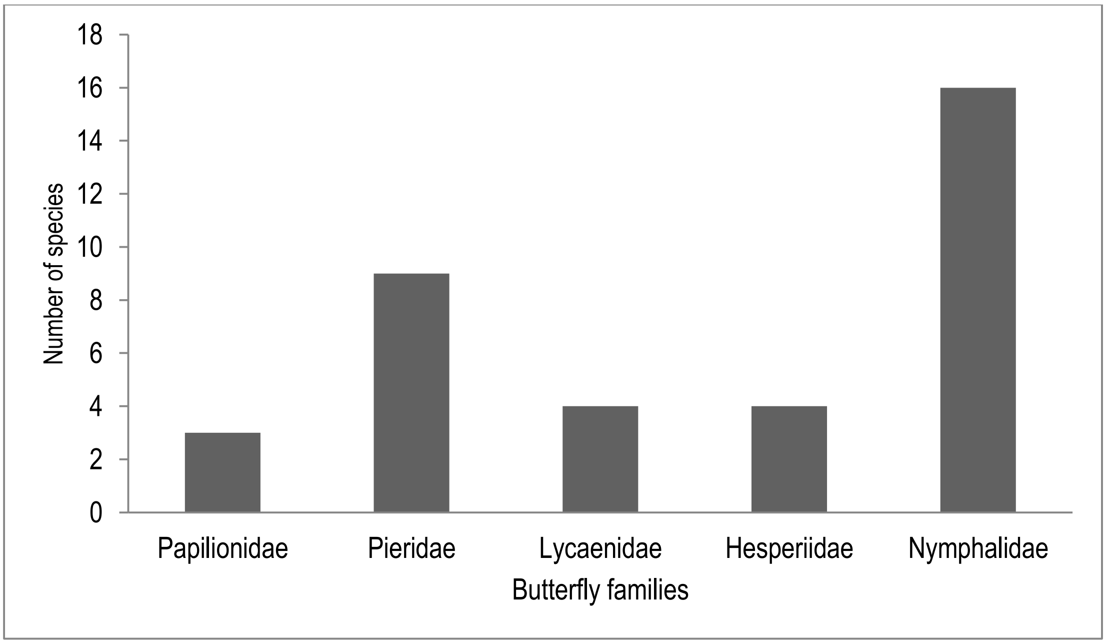

Figure 5 Family composition of butterflies recorded in the project area

The occurrence status was decided on number of encounters of the species in the study sites: Very Rare (VR) – 1 to 2 sightings; Rare (R) – 3 to 4 sightings; Uncommon (UC) – 5 to 10 sightings; Common (C) – 11 to 16 sightings in study sites. From this classification, Nymphalidae had the highest number of common species followed by Pieridae (Table 12) though this classification might have been subjective as the sites were surveyed for short periods of time some of the survey days were very wet which could have affected butterfly activity.

There were 8 widely occurring butterfly species which were recorded in five or more of the sampled sites (Table 12) though *Eurema regularis*, and *Neptis serena* ranked highest in distribution. None of the butterfly species recorded in the proposed project area is listed as threatened under the National Red list for Uganda by WCS (2016). From Table 12, it is also clear the butterfly species recorded have varying habitat preferences with 50% of the species occurring in a wide range of habitats ranging from agricultural landscapes, woodlands, forested areas and wetland areas. Two species *Eurema hapale* and *Mylothris rubicosta* are wetland specialists but are not tied to any particular wetland microhabitat to make the developments very critical to their survival in the proposed project area.

The results depict the temporal nature of the surveys, and it is believed that if surveys lasted longer the species record for the different survey locations might have been different from that recorded. The species richness in different survey areas ranged from as few as 2 species to 16 species for the richest survey area. All survey areas had some human activity footprint which no doubt affects the overall species richness of taxa in an area.

5.4 Recommendations

Minimize impact in swamps as activity in these areas might affect species which prefer such habitats which at first sight might seem very common as they are usually encountered in large numbers but consideration should be given to the rate at which wetlands are being degraded.

NWSC should carryout sampling during annual environmental audits for accurate biodiversity estimation over long term as most of the short-term surveys focus on the under storey hence putting less emphasis on the canopy dwelling species (especially for areas with trees) resulting in poorly informed conservation decisions.

6 BIRDS

6.1 Introduction

Occurrence, composition and habitat use by birds can be and has been used to examine change in the habitat without instruments. This is because; studying the presence and behavior of birds can inform us about changing ecosystems. Any living organism that is used in such a manner to measure environmental conditions is called an indicator species.

As with other native organisms, birds help maintain sustainable population levels of their prey and predator species and, after death, provide food for scavengers and decomposers. Many birds are important in plant reproduction through their services as pollinators or seed dispersers.

A number of birds' characteristics, make them an indicator taxon of choice since surveys of this taxon can be completed with limited amount of equipment, they are easy to observe and identify and they mostly active during the day.

6.2 Methods

Birds were surveyed for in habitats in areas identified to present the best opportunity for survival of biodiversity (these are in general terms describbed in Table 1). Because the proposed pipeline is within 30m buffer of the road the survyes were meant to look just in the areas. However because butterflies, birds and mammals move around, they can cover more distance thnan 30m in a single bout of activity. The method that we used aimed at collecting a total species list at every survey location. The surveys were started between 7:00 - 8:00 am and we spent 30 minutes at each survey location each survey day before driving to the next. All species seen or heard were recorded at any distance within the survey area.

6.3 Results and discussions

A total of 71 species of birds were recorded for the project area. The full list is presented in Appendix 4. The individual survey area results showed generally low species richness and very different species assemblages. Only a few of the species were recorded in more than a few survey areas. It is howeververy likely that more of the species recordd will be widely occurring ieven in areas where we didn’t record them at this oint in time. This is because biodiversity patterns have a temporal signature and therefore different species could be recorded in an area on different survey occasions.

In Appendix 4 the bulk of the results are for:

i) areas along the proposed pipeline route from the start of the access road from the tarmac to Gulu town;
ii) The results in the red highlight are for results from the water abstraction point to the proposed water treatment plant;
iii) The blue highlight shows results from the area for the proposed treatment plant; and
iv) The results in the purple highlight represent the access road

The nature of these different sections of the proposed project, are described in Table 1. The bird species recorded are generally open environment species not tied to a particular habitat type.

In these results of these surveys, only three species (Table 14) listed in the “Bird Atlas of Uganda” as of conservation concern are shown. Although listed by Carswell (2005) in the Atlas as of conservation concern, these species have a relatively wide occurrence in Uganda. No evidence was found of nesting for any of these species, which would make the areas a critical habitat for their reproduction.

Table 14: Species of birds of conservation interest recorded in the project area

Atlas Number	Species	Threat
28	Purple Heron *Ardea purpurea*	R-NT
95	African Marsh Harrier *Circus ranivorus*	R-NT
539	Spot-flanked Barbert *Tricholaema lachrymose*	R-RR

Key: R-NT – Regional near threatened, R-RR – species of regional responsibility having a considerable extent of their range in Uganda (See Carswell *et al* 2005)

The list includes 5 species of raptors for which a good population would be a good indicator of healthy populations of their prey. All except the first species (Table 15), are quite wide ranging species in the country.

Table 15: Species of raptors recorded in the project area

Atlas Number	Species	Threat
95	African Marsh Harrier *Circus ranivorus*	R-NT
96	African Harrier-Hawk Polyboroides typus	
129	Lizard Buzzard K*aupifalco monogrammicus*	
138	Black Kite *Milvus migrans*	
147	Grey Kestrel Falco ardosiaceus	

7 MAMMALS

7.1 Introduction

A lot of the landscape traversed by the proposed waterline project is considerably human impacted and converted through agriculture, settlement, extractive use and others, the prospects for survival of large mammals has been reduced considerably. In the areas of wetland however extensive areas of near natural vegetation survive and will continue to provide refuge for species that can survive in human impacted habitats.

7.2 Methods

Mammals as a group are a very diverse taxonomic group of animals that range in size from very small ones (shrews and bats weighing about3-4 gm) to large ones that weigh up to several tons. Some mammals are active during the day and if medium or large sized can be observed, inventoried or their ecology studied. Most small sized mammals are however quite cryptic and/or nocturnal in habit that observation approaches are not good enough for studies of these.

The foregoing therefore means that different approaches are required to document the presence as well as study the ecology of mammals.

To understand the patterns of occurrence of mammals in the different areas surveyed, the methods used included:

a) Trapping with Sherman traps – In places where traps could be deployed without the risk of losing them to local people, we used Sherman traps to capture small mammals and therefore gain a quick insight about which small mammals occurred in the different survey areas. Traps were left in place for 2 nights and moved to other survey areas. In addition weused the nature of the habitats to compile a list of potential species on small mammals that could be in the areas surveyed.

b) Spoor tracking - Spoor tracking is considered to be the world's oldest science, enabling detailed sampling of mammalian species without the need for trapping or direct observation. Spoors were recorded and documented during general fieldwork.

c) Scats and pellets – mammal sats were oportunisticaly searched for to provide information on species occurrence.

d) Roadkill Direct Observation: All mammals observed dead on the roads were examined, geo-referenced and catalogued.

7.3 Results and discussions

Most the area surveyed showed no potential for ranging and conservation of large mammals. Large mammal species will usually avoid areas of human habitation, or will be vagrant in such areas where they will likely be killed for meat as soon as they are seen.

The survey area with the green highlight (Table 16) in the general abstraction and piping area to the water treatment plant was the only location where many signs of large mammals were recorded. The majority of these as spoor prints of the species (Photo 24).

Hippopotamus print

Striped Jackal print

Baboob Print

Duiker Print

Photo 24: Example foot prints of mammals recorded in the general areabewteen water abstraction and water treatment plant area.

The species that were recorded in the different locations that were surveyed are listed in Table 16. For most of the survey areas we recorded only the occurrence of small mammals and also the potential for occurrence of small sized carnivores (genets and Mongooses). Overall we recorded 28 species with the rodent species being more widely occurring than the othe taxa.

Table 16: Mammal species occurrence recorded in the different survey areas

Order	Species	0423989E 297619N	0425521E 291714N	424900E 295148N	425870E 290059N	0427115E 287001N	0427136E 286970N	0429530E 277069N	0430285E 273964N	0418965E 248565N	0418879E 248772N
Artiodactyla	*Bush Duiker*			p							
	Common Bush Duiker									p	p
	Hippopotamus									p	
	Reed buck			p							
Carnivora	*African Civet*									p	
	Genet		p								
	Large grey Mongoose	p	p							p	
	Leopard									p	
	Marsh Mongoose				P					p	
	Serval									p	
	Side Stripped Jackal									p	

Order	Species	0423989E 297619N	0425521E 291714N	424900E 295148N	425870E 290059N	0427115E 287001N	0427136E 286970N	0429530E 277069N	0430285E 273964N	0418965E 248565N	0418879E 248772N
	Slender Mongoose	p	p						p		p
Chiroptera	*Lavia fron*							p			
	Nycteris thebaica								p		
Insectivora	*Crocidura olivieri*			p		p					
Lagomorpha	*Grass Hare*					p					
Primates	*Olive Baboon*									p	
Rodentia	*Aethomys hindei*	p	p		P	p	p				
	Alexander's tree squirrel	p		p							
	Dasymys incomtus		p		P	p	p				
	Lemniscomys striatus	p	p		P	p	p				
	Lophuromys flavopunctatus	p	p		P	p	p				
	Lophuromys sikapusi	p	p		P	p	p				
	Mastomys natalensis	p	p	p	P	p	p				
	Mus mintoides	p	p	p	P	p	p				
	Oenomys hypoxanthus	p			P	p	p				
	Praomys jacksoni	p									
	Striped ground Squirel	p								p	

A summary of the species richness by order of the species recororded in the project area is provided in Table 17. There were overall more rodent species than any of the other orders, and for three orders we only recorded one species in each.

Table 17: Distribution of mammal species recorded by order

Order	Number of species
Artiodactyla	4
Carnivora	8
Chiroptera	2
Insectivora	1
Lagomorpha	1
Primates	1
Rodentia	11
Grand Total	**28**

The survey area highlighted green in Table 16 with the most species of large mammals is much closer to Bugungu Wildlife reserve and Murchison Fall National park and it should not be suprising that these species extend their ranging into this survey area. This particular survey area has a prominent human foor print as members of the local community are present every day excavating and breaking rocks for sale. This means therefore that the general area is only utilisied by the mammals at night.

Hippos and Leopard are the only mammals species recorded in the project area by IUCN as threatened but we don't consider the part of the project area where they were recorded as a critical part of their range and or habitat.

8 IDENTIFICATION OF POTENTIAL IMPACTS AND MITIGATION PROPOSALS

In general the area to be traversed by the proposed water pipeline project is of low biodiversity conservation potential. Most areas are either semi-natural and /or settled, builtup and cultivated. They nonetheless maintain a vital function as refugia and or transit habitats for what biodiversity can survive in human modified habitats. The likely key impacts include:

i) Habitats loss
ii) Piling construction materials like sand, cement, bricks, metals, plastics, polythene and paper
iii) Pollution of the watercourses and wetlands from excavation and machinery leages if the happen
iv) Sedimentation
v) Increased turbidity
vi) Acoustic shock
vii) Destruction of stream cover
viii) Introduction of water pollutants
ix) Interruption of fish migration
x) Interruption of fish spawning
xi) Mortality from toxic spills
xii) Reduction in usable habitat

Mitigation proposals

i) Effective treatment of water before discharge back into the river;
ii) Prevent overstocking debris and construction materials on the river and in wetlands to enable resilience of habitats;
iii) Planting of trees, shrubs and herbs within and around abstraction and treatment areas. These provide food sources, artificial nests, hibernation sites and hospitable terrains for species dispersal;
iv) Unnecessary clearance of vegetation has to be avoided most especially in wetlands as well as pristine woodlands and bush lands;
v) Prevent as much as possible the cutting of any tree of conservation concern;
vi) Erosion and silting control measures have to be provided and implemented most especially for all construction works in wetlands; and
vii) Unnecessary fluctuations of water flow in wetlands have to be prevented in order to minimise variability between natural and artificial flow rates and in some situations alternative drainage maybe created to avoid localised floods. Hoses and sludge pumps can be useful for this purpose.

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Appendices

Appendix 1: List of plants in Karuma-Gulu water project sites

Family	Species	DAFOR SCALE	Growth form and Ecotype	Threat level IUCN	WCS	Uganda's Legal protection
Acanthaceae	*Acanthus polystachyus* Del.	O	Shrub	NA	NA	
Acanthaceae	*Asystazia gangetica*	O	Herb	NA	NA	
Acanthaceae	*Dyschoriste radicans*	F	Herb	NA	NA	
Acanthaceae	*Justicia exigua exigua* Benoist	F	Herb	NA	NA	
Acanthaceae	*Barleria ventricosa*	O	Herb	NA	NA	
Amaranthaceae	*Achyranthus aspera* L.	R	Herb	NA	NA	
Amaranthaceae	*Aerva lanata*	R	Herb	NA	NA	
Amaranthaceae	*Gomphrena celosioides*	R	Herb	NA	NA	
Amaryllidaceae	*Boophone disticha*	R	Herb	NA	NA	
Anacardiaceae	*Rhus vulgaris*	R	Shrub	NA	NA	
Annonaceae	*Anona senegalensis*	R	Tree	NA	NA	
Apiaceae	*Centella asiatica* (L.) Urban	F	Herb	NA	NA	
Araliaceae	*Cussonia arborea*	O	Tree	NA	NA	
Arecaceae	*Borassus aethiopum*	O	Tree	NA	NA	
Arecaceae	*Phoenix reclinata* Jacq.	A	Tree	NA	NA	

				Threat level		
Family	Species	DAFOR SCALE	Growth form and Ecotype	IUCN	WCS	Uganda's Legal protection
Asparagaceae	*Asparagus flagelaris*	R	Shrub	NA	NA	
Apocynaceae	*Secamone punctulata*	R	Woody Climber	NA	NA	
Asteraceae	*Ageratum conyzoides* L.	O	Herb	NA	NA	
Asteraceae	*Aspilia africana*	R	Herb	NA	NA	
Asteraceae	*Bidens pilosa*	F	Herb	NA	NA	
Asteraceae	*Conyza floribunda*	F	Herb	NA	NA	
Asteraceae	*Conyza sumatrensis*	R	Herb	NA	NA	
Asteraceae	*Cyathula sp.*	R	Herb	NA	NA	
Asteraceae	*Galinsoga quadrifida*	R	Herb	NA	NA	
Asteraceae	*Tithonia diversifolia*	F	Shrub	NA	NA	
Asteraceae	*Tridax procumbens* L.	O	Herb	NA	NA	
Asteraceae	*Vernonia auriculifera*	R	Shrub	NA	NA	
Bignoniaceae	*Kigelia africana*	R	Tree	LC	NA	
Bignoniaceae	*Markhamia lutea* (Benth.) K.Schum.	R	Tree	NA	NA	NFA Act 2003
Bignoniaceae	*Philenoptera laxiflora*	O	Tree	LC	NA	
Bignoniaceae	*Stereospermum kunthianum*	O	Tree	NA	NA	
Capparaceae	*Crateva adansonii*	R	Tree	NA	NA	
Colchicaceae	*Gloriosa superba*	R	Herb	NA	NA	

				Threat level		
Family	Species	DAFOR SCALE	Growth form and Ecotype	IUCN	WCS	Uganda's Legal protection
Combretaceae	*Combretum adenogonium*	F	Tree	NA	NA	
Combretaceae	*Combretum collinum*	F	Tree	NA	NA	
Combretaceae	*Combretum molle*	R	Tree	NA	NA	
Combretaceae	*Terminalia schimperiana*	A	Tree	NA	NA	
Commelinacea	*Commelina benghalensis*	A	Herb	LC	NA	
Convolvulaceae	*Astripomoea malvacea*	O	Herb	NA	NA	
Convolvulaceae	*Ipomoea aquatica*	R	Herb	NA	NA	
Convolvulaceae	*Ipomea rubens*	F	Herbaceous Climber	NA	NA	
Convolvulaceae	*Lepistemon owariense* (P. Beauv.) Hall. fil.	F	Herbaceous Climber	NA	NA	
Cucurbitaceae	*Dyplocyclos palmatus*	R	Herbaceous Climber	NA	NA	
Cucurbitaceae	*Luffa cylindrica*	R	Herbaceous Climber	NA	NA	
Cucurbitaceae	*Momordica foetida* Schum.	O	Herbaceous Climber	NA	NA	
Cyperaceae	*Bulbostylis filamentosa*	R	Sedge	NA	NA	
Cyperaceae	*Bulbostylis* sp.	R	Sedge	NA	NA	
Cyperaceae	*Cyperus cyperoides*	F	Sedge	LC	NA	
Cyperaceae	*Cyperus denudatus* L.f.	O	Sedge	NA	NA	
Cyperaceae	*Cyperus difformis*	R	Sedge	LC	NA	
Cyperaceae	*Cyperus iria* L.	F	Sedge	LC	NA	

Family	Species	DAFOR SCALE	Growth form and Ecotype	Threat level IUCN	WCS	Uganda's Legal protection
Cyperaceae	*Cyperus papyrus*	D	Sedge	LC	NA	
Cyperaceae	*Kyllinga alba*	O	Sedge	NA	NA	
Cyperaceae	*Murdania simplex*	O	Sedge	NA	NA	
Dioscoraceae	*Dioscorea sp*	F	Woody climber	NA	NA	
Euphorbiaceae	*Acalypha bipartita* Müll.Arg.	A	Shrub	NA	NA	
Euphorbiaceae	*Acalypha ornata*	F	Woody herb	NA	NA	
Euphorbiaceae	*Acalypha villicaulis*	R	Woody herb	NA	NA	
Euphorbiaceae	*Alchornea cordifolia*	A	Short tree/shrub	NA	NA	
Euphorbiaceae	*Euphorbia hirta* L.	F	Herb	NA	NA	
Euphorbiaceae	*Euphorbia heterophylla*	O	Herb	NA	NA	
Euphorbiaceae	*Ricinus communis* L.	O	Shrub	NA	NA	
Euphorbiaceae	*Shirakiopsis elliptica* (Hochst.) Esser	O	Tree	NA	NA	
Fabaceae	*Abrus canensens*	R	Herbaceous climber	NA	NA	
Fabaceae	*Abrus precatorius*	F	Herbaceous climber	NA	NA	
Fabaceae	*Acacia hockii*	R	Shrub	NA	NA	
Fabaceae (Mimosoideae)	*Acacia polyacantha* Willd	D	Tree	NA	NA	
Fabaceae (Mimosoideae)	*Acacia sieberiana*	O	Tree	NA	NA	
Fabaceae	*Aeschynomene indica*	F	Herb	LC	NA	

				Threat level		
Family	Species	DAFOR SCALE	Growth form and Ecotype	IUCN	WCS	Uganda's Legal protection
Fabaceae	*Aeschynomene uniflora*	R	Shrub	NA	NA	
Fabaceae (Mimosoideae)	*Albizia coriaria* Oliv.	F	Tree	NA	NA	
Fabaceae (Mimosoideae)	*Albizia grandbracteata*	F	Tree	NA	NA	
Fabaceae (Mimosoideae)	*Albizia zygia*	F	Tree	NA	NA	
Fabaceae	*Alysicarpus glumaceus*	F	Herb	NA	NA	
Fabaceae	*Alysicarpus rugosus*	O	Herb	NA	NA	
Fabaceae	*Chamaecrista kirki*	O	Herb	NA	NA	
Fabaceae	*Crotalaria brevidens*	F	Herb	NA	NA	
Fabaceae	*Crotalaria pallida*	R	Herb	NA	NA	
Fabaceae	*Crotalaria spinosus*	R	Herb	NA	NA	
Fabaceae (Papilionoideae)	*Desmodium salicifolium*	F	Herb	LC	NA	
Fabaceae	*Desmodium triflorum*	F	Herb	NA	NA	
Fabaceae (Papilionoideae)	*Erythrina abyssinica* Lam. ex DC.	O	Tree	NA	NA	
Fabaceae	*Indigofera arrecta*	O	Herb	NA	NA	
Fabaceae	*Indigofera hirsuta*	F	Herb	NA	NA	
Fabaceae (Papilionoideae)	*Indigofera spicata* Forssk.	A	Herb	NA	NA	
Fabaceae (Mimosoideae)	*Mimosa pigra* L.	A	Shrub	NA	NA	
Fabaceae	*Piliostigma thonningii*	F	Tree	NA	NA	

Family	Species	DAFOR SCALE	Growth form and Ecotype	Threat level IUCN	WCS	Uganda's Legal protection
Fabaceae	*Pseudarthria hookerii*	O	Shrub	NA	NA	
Fabaceae	*Rhynchosia minima*	O	Herb	NA	NA	
Fabaceae	*Rhynchosia viscosa*	R	Herb	NA	NA	
Fabaceae (Caesalpinioideae)	*Senna hirsuta*	F	Shrub	NA	NA	
Fabaceae (Caesalpinioideae)	*Senna occidentalis*	F	Herb	NA	NA	
Fabaceae (Caesalpinioideae)	*Senna spectabilis*	O	Tree	LC	NA	
Fabaceae (Papilionoideae)	*Sesbania sesbani*	O	Shrub	NA	NA	
Fabaceae	*Tephrosia pumila*	F	Herb	NA	NA	
Fabaceae	*Tephrosia vogelii*	R	Herb	NA	NA	
Fabaceae	*Vigna unguiculata*	R	Herb	NA	NA	
Hymenocardiaceae	*Hymenocardia acida*	O	Shrub	NA	NA	
Lamiaceae	*Hoslundia opposita* Vahl	A	Shrub	NA	NA	
Lamiaceae	*Plectranthus sp.*	R	Herb	NA	NA	
Lamiaceae	*Tectona grandis*	F	Tree	NA	NA	
Malvaceae	*Corchorus olitorius*	O	Herb	NA	NA	
Malvaceae	*Grewia trichocarpa*	O	Tree	NA	NA	
Malvaceae	*Hibiscus cannabinus* L.	R	Herb	NA	NA	
Malvaceae	*Sida acuta Burm.* fil.	F	Herb	NA	NA	

Family	Species	DAFOR SCALE	Growth form and Ecotype	Threat level IUCN	WCS	Uganda's Legal protection
Malvaceae	*Sida ovata*	R	Herb	NA	NA	
Malvaceae	*Sida rhombifolia* L.	F	Herb	NA	NA	
Malvaceae	*Triumffeta annua*	F	Herb	NA	NA	
Malvaceae	*Triumffeta macrophylla*	F	Shrub	NA	NA	
Meliaceae	*Khaya anthotheca*	O	Tree	VU	EN	
Menispermaceae	*Cissamperos mucronata*	O	Herbaceous Climber	NA	NA	
Moraceae	*Milicia excelsa* (Welw.) C.C. Berg	O	Tree	NT	EN	
Moraceae	*Ficus capensis*	R	Tree	NA	NA	
Moraceae	*Ficus elastica*	R	Tree	NA	NA	
Moraceae	*Ficus natalensis*	O	Tree	NA	NA	
Moraceae	*Ficus vallis-choude*	A	Tree	NA	NA	
Myrtaceae	*Psidium guajava* L.	O	Tree	NA	NA	
Nyctaginaceae	*Boerhavia coccinia*	O	Herb	NA	NA	
Nymphaeaceae	*Nymphaea lotus*	R	Lotus	NA	NA	
Nymphaeaceae	*Nymphaea nouchali*	R	Lotus	LC	NA	
Onagoraceae	*Ludwigia abyssinica*	F	Herb	NA	NA	
Onagoraceae	*Ludwigia adscendens*	O	Herb	NA	NA	
Phyllanthaceae	*Bridelia scleroneura* Müll.-Arg.	O	Tree	NA	NA	

Family	Species	DAFOR SCALE	Growth form and Ecotype	Threat level IUCN	WCS	Uganda's Legal protection
Phyllanthaceae	*Flueggea virosa* (Roxb. ex Willd.) Royle	F	Shrub	NA	NA	
Phyllanthaceae	*Phyllanthus neumelarius*	F	Shrub	NA	NA	
Poaceae	*Brachiaria brizantha*	F	Grass	NA	NA	
Poaceae	*Brachiaria decumbens*	F	Grass	NA	NA	
Poaceae	*Brachiaria leersioides*	O	Grass	NA	NA	
Poaceae	*Brachiaria scalaris*	R	Grass	LC	NA	
Poaceae	*Chloris gayana*	F	Grass	NA	NA	
Poaceae	*Chloris pycnothrix*	F	Grass	NA	NA	
Poaceae	*Cynodon dactylon* (L.) Pers.	D	Grass	NA	NA	
Poaceae	*Dactyloctenium aegyptium*	F	Grass	NA	NA	
Poaceae	*Digitaria longiflora* (Retz.) Pers.	O	Grass	NA	NA	
Poaceae	*Echinochloa pyramidalis*	D	Grass	LC	NA	
Poaceae	*Eleusin africana*	F	Grass	NA	NA	
Poaceae	*Eleusin indica*	O	Grass	NA	NA	
Poaceae	*Hyparrhenia filipendula*	O	Grass	NA	NA	
Poaceae	*Hyperthelia dissoluta*	O	Grass	NA	NA	
Poaceae	*Imperata cylindrica* (L.) Raeusch.	F	Grass	NA	NA	
Poaceae	*Merines repens*	O	Grass	NA	NA	

				Threat level		
Family	**Species**	**DAFOR SCALE**	**Growth form and Ecotype**	**IUCN**	**WCS**	**Uganda's Legal protection**
Poaceae	*Miscanthus sp.*	R	Grass	NA	NA	
Poaceae	*Leersia hexandra* Sw.	D	Grass	NA	NA	
Poaceae	*Panicum maximum* Jacq.	O	Grass	NA	NA	
Poaceae	*Panicum repens*	R	Grass	LC	NA	
Poaceae	*Paspalum scrobiculatum*	O	Grass	LC	NA	
Poaceae	*Pennisetum polystachion*	A	Grass	LC	NA	
Poaceae	*Pennisetum purpureum*	F	Grass	LC	NA	
Poaceae	*Phragmites mauritianus*	F	Grass	NA	NA	
Poaceae	*Setaria megaphylla*	O	Grass	NA	NA	
Poaceae	*Setaria sphacelata* (Schumach.) Stapf & C.E.Hubb. ex	D	Grass	NA	NA	
Poaceae	*Sporobolus festivus* Hochst. ex A.Rich.	F	Grass	NA	NA	
Poaceae	*Sporobolus pyramidalis*	O	Grass	NA	NA	
Poaceae	*Sporobolus stapfianus*	R	Grass	LC	NA	
Polygonaceae	*Persicaria senegalensis*	F	Herb	LC	NA	
Polypodiaceae	*Platycerium elephantotis* Schweinf.	R	Herb	NA	NA	
Rhamnaceae	*Maesopsis eminii* Engl.	R	Tree	NA	NA	
Rhamnaceae	*Ziziphus pubescens*	R	Tree	NA	NA	

Family	Species	DAFOR SCALE	Growth form and Ecotype	Threat level IUCN	WCS	Uganda's Legal protection
Rubiaceae	*Spermacoce princeae*	O	Herb	NA	NA	
Sapindaceae	*Allophylus africana*	R	Shrub	NA	NA	
Solanaceae	*Physalis minima*	R	Herb	NA	NA	
Solanaceae	*Solanum incanum* L.	R	Shrub	NA	NA	
Typhaceae	*Typha domingensis*	O	Herb	LC	NA	
Urticaceae	*Urena lobata* L.	F	Shrub	NA	NA	
Verbenaceae	*Vitex doniana*	A	Tree	LC	NA	
Vitaceae	*Ampelocissus africana*	O	Herbaceous Climber	NA	NA	
Vitaceae	*Cissus quadrangularis*	R	Herbaceous Climber	NA	NA	
Vitaceae	*Cyphostema adonocoule*	F	Herbaceous Climber	NA	NA	
Vitaceae	*Cyphostema serpens*	R	Herbaceous Climber	NA	NA	
Zingberaceae	*Aframomum alboviolacium*	O	Herb	NA	NA	

Key: LC=Least concern, NA=Not assessed, EN=Endangered, VU=Vulnerable, IUCN=International Union for Conservation of Nature, WCS=Wildlife Conservation status. D=Dominant, A=Abundant, F=Frequent, O=Occasional, R=Rare

Appendix 2: Occurrence of various amphibian species at different sampling habitats in the study area

Family	Common species	Wooded lands	Grass	Seasonally marsh	flooded	Swamp	Grasslands
Hyperoliidae	*Afrixalus quadrivitatus*		0		0	4	0
Pyxicephalidae	*Amietia angolensis*		0		0	3	0
Bufonidae	*Amietophrynus gutturalis*		0		0	3	0
Bufonidae	*Amietophrynus maculatus*		4		2	5	1
Bufonidae	*Amietophrynus regularis*		0		0	4	0
Bufonidae	*Amietophrynus vittatus*		0		0	3	1
Ranidae	*Amnirana galamensis*		0		0	0	5
Dicroglossidae	*Hoplobatrachus occipitalis*		0		0	6	1
Hyperolidae	*Hyperolius acuticeps*		0		1	3	0
Hyperolidae	*Hyperolius cinnamomeoventris*		0		0	4	1
Hyperolidae	*Hyperolius kivuensis*		0		0	4	0
Hyperolidae	*Hyperolius sp*		0		0	2	0
Hyperolidae	*Hyperolius viridiflavus*		1		0	7	1
Hyperolidae	*Kassina snegalensis*		0		1	5	0
Arthroleptidae	*Leptopelis sp*		0		0	2	0
Arthroleptidae	*Phrynobatrachus mababiensis*		0		2	3	0
Arthroleptidae	*Phrynobatrychus natalensis*		0		1	2	1
Ptychadenidae	*Ptychadena anchietae*		0		0	1	1
Ptychadenidae	*Ptychadena chrysogaster*		0		0	2	0
Ptychadenidae	*Ptychadena mascareniesis*		7		1	7	3
Ptychadenidae	*Ptychadena oxyrhynchus*		0		0	1	0
Ptychadenidae	*Ptychadena porosissima*		0		0	3	0
Pipidae	*xenopus laevis*		0		0	4	0

Appendix 3: Occurrence of various reptilian species at different sampling habitats in the study area

Scientific name	Wooded Grass lands	Seasonally flooded marsh	Swamp	Grasslands
Agama agama	7	1	2	26
Bitis arietans	2	0	1	2
Bitis nascornis	1	0	0	0
Chamaeleo bitaeniatus	1	0	0	1
Chamaleo Gracilis	1	0	2	1
Crotaphopeltis degeni	0	2	0	0
Crotaphopeltis hotamboeia	0	*0*	3	2
Dendroaspis polylepis	0	*0*	0	1
Elapsoidea laticincta	1	*1*	0	0
Hapsidophrys lineata	2	0	0	0
Hemidactylus brookii	0	*0*	1	1
Hemidactylus mabouia	0	*0*	2	0
Lamprophis olivaceus	0	0	1	1
Naja melanoleuca	1	2	7	0
Natriciteres olivacea	0	0	2	0
Pelomedusa subrufa	0	1	0	0
Pelusios williamsi	0	0	2	0
Philothamnus angolensis	0	2	4	0
Philothamnus bequaerti	0	0	0	1
Philothamnus heterolepidotus	0	0	1	0
Philothamnus semivariegatus	23	1	0	1
Prosymna meleagris	0	0	0	1
Psammophis sibilans	1	0	0	1
Psamophis mosambicus	1	0	3	0
Python sebae	0	*0*	2	0
Trachylepis maculirabris	5	0	6	8
Trachylepis quinquetaeniata	0	0	0	3
Trachylepis striata	0	0	3	2

Trachylepis variabilis	0	0	0	2
Typhlops lineolatus	0	0	0	1
Varanus niloticus	0	1	3	6

Appendix 4: Birds recorded in the different areas of the project area

Atlas Number	Species	Threat	0423989E 297619N	0425521E 291714N	424900E 295148N	0425578E 291563N	425870E 290059N	0426301E 288710N	0427136E 286970N	0429272E 277842N	0429530E 277069N	0430285E 273964N	0431360E 266223N	0431633E 263550N	0427648E 250367N	0418965E 248565N	0418879E 248772N	0418963E 248994N
17	Long-tailed Cormourant *Phalacrocorax africanus*															p		
28	Purple Heron *Ardea purpurea*	R-NT										p						
42	Hamerkop *Scopus umbretta*															p		
51	Hadada Ibis *Bostrychia hagedash*						p						p					
95	African Marsh Harrier *Circus ranivorus*	R-NT			p											p		
96	African Harrier-Hawk Polyboroides typus															p		
129	Lizard Buzzard K*aupifalco monogrammicus*								p	p								
138	Black Kite *Milvus migrans*				p													
147	Grey Kestrel Falco ardosiaceus															p		
190	Helmetted Guineafowl *Numida meleagris*		P					p										
198	African Emerald Cuckoo *Chrysococcyx cupreus*				p													
201	Black Crake *Amaurornis flavivorostris*												p		p			
345	Tawny Flanked Prinia *Prinia subflava*							p		p	p					p	p	
346	Ring-necked Dove *Streptopelia capicola*							p				p						

Atlas Number	Species	Threat	0423989E 297619N	0425521E 291714N	424900E 295148N	0425578E 291563N	425870E 290059N	0426301E 288710N	0427136E 286970N	0429272E 277842N	0429530E 277069N	0430285E 273964N	0431360E 266223N	0431633E 263550N	0427648E 250367N	0418965E 248565N	0418879E 248772N	0418963E 248994N
351	Laughing Dove *Streptopelia senegalensis*							p								p		
355	Blue-Spotted Wood-Dove *Turtur afer*					p		p										
358	African Green-Pigeon *Treron calva*							p										
367	Brown Parrot *Poicephalus meyeri*		P					p										
376	Eastern Grey Plantain-eater *Crinifer zomurus*						p								p			
391	Klaa's Cuckoo *Chrysococcyx klaas*							p										
406	White-browed Coucal *Centropus superciliosus*							p					p	p	p	p		
443	Little Swift *Apus affinis*		P		p	p	p	p	p	p	p	p		p	p	p		
452	African Palm Swift *Cypsurus parvus*							p		p					p			
459	Speckled Mousebird *Colius striatus*									p		p						
475	Woodland Kingfisher Halcyon senegalensis							p									p	
488	Red -Cheeked Cordon-bleu *Uraeginthus bengalus*			p		p		p								p	p	
491	Little Bee-eater *Merops pusillus*							p										
500	Broad Billed Roller *Eurystomus glaucurus*							p										
539	Spot-flanked Barbert *Tricholaema lachrymosa*	R-RR						p			p			p				
540	White-headed Barbet *Lybius leucocephalus*																p	

Atlas Number	Species	Threat	0423989E 297619N	0425521E 291714N	424900E 295148N	0425578E 291563N	425870E 290059N	0426301E 288710N	0427136E 286970N	0429272E 277842N	0429530E 277069N	0430285E 273964N	0431360E 266223N	0431633E 263550N	0427648E 250367N	0418965E 248565N	0418879E 248772N	0418963E 248994N
659	Piapiac Ptilostomus afer		P											p				
664	Fork-tailed Drongo *Dricrurus adsimilis*				p			p										
681	Arrow marked Barbler *Turdoides jardineii*								p									
705	Little Greenbul *Andropadus virens*				p													
732	Common Bulbul *Pyconotus barbatus*		P	p	p	p	p	p		p		p	p	p	p	p	p	
801	African Thrush *Tudus pelios*		P	p	p			p			p		p			p		
837	Grey-backed Camaroptera Camaroptera brachyura		P	P	p	p		p	p	p	p	p	p		p			
854	Siffling Cisiticola *Cisticola bradypterus*					p				p		p			p			
860	Winding Cisiticola *Cisiticola galactotes*											p	p	p	p			
866	Croaking Cisiticola *Cisiticola natalensis*			p						p								p
869	Stout Cisiticola *Cisiticola robustus*		P	p			p	p		p			p		p			
875	Grey-capped Wabler *Eminia lepida*							p										
925	Red-faced Crombec *Sylvietta whytii*			P														
937	Swamp flycather *Muscicapa aquatica*											p			p			
958	Chestnut Watle-eye *Dyaphorophyia castanea*							p										
968	African Paradise Flycatcher *Terpsiphone viridis*			p				p										

Atlas Number	Species	Threat	0423989E 297619N	0425521E 291714N	424900E 295148N	0425578E 291563N	425870E 290059N	0426301E 288710N	0427136E 286970N	0429272E 277842N	0429530E 277069N	0430285E 273964N	0431360E 266223N	0431633E 263550N	0427648E 250367N	0418965E 248565N	0418879E 248772N	0418963E 248994N
991	African Pied Wagtail *Motacilla aguimp*															p		
1004	Tropical Boubou *Laniarius aethiopicus*			p		p		p										
1059	Purple Starling *Lamprotornis purpureus*									p								
1076	Superb Starling *Lamprotornis superbus*				p													
1096	Copper Sunbird *Cinnyris cuprea*										p						p	
1103	Bronze Sunbird *Nectarinia kilimensis*							p						p				
1112	Olive Sunbird *Cyanomitra olivacea*				p	p												
1122	Scarlet chested Sunbird		P															
1122	Scarlet-Chested Sunbird *Chalcomitra senegalensis*															p		
1128	Variable Sunbird Cinnyris venusta		P	p				p										
1130	Green-headed Sunbird *Cyanomitra verticalis*		P															
1134	Grosbeak Weaver *Ambylospiza albifrons*														p			
1140	Fan-tailed WidowBird *Euplectes axillaris*								p	p				p		p		
1143	Nothern Red Bishop *Euplectes fransiscanus*							p								p	p	
1148	Yellow-mantled Widowbird *Euplectes macrourus*							p		p			p		p			
1170	Lesser Masked Weaver *Ploceus intermidius*						p	p	p	p					p	p		

Atlas Number	Species	Threat	0423989E 297619N	0425521E 291714N	424900E 295148N	0425578E 291563N	425870E 290059N	0426301E 288710N	0427136E 286970N	0429272E 277842N	0429530E 277069N	0430285E 273964N	0431360E 266223N	0431633E 263550N	0427648E 250367N	0418965E 248565N	0418879E 248772N	0418963E 248994N
1173	Yellow backed Weaver *Ploeseus melonocephalus*				p					p								
1175	Vieillot's Black Weaver *Ploceus nigrrimus*						p											
1184	Compact Weaver *Ploceus superciliosus*							p					p		p			
1191	Cardinal Quelea *Quelea cardinalis*									p							p	
1206	Grey headed Sparrow *Passer griseus*														p	p		
1216	Pin-tailed Whydah *Vidua macroura*							p										
1239	Afrcan Fire Finch *Lagonosticta rubricata*							p										
1266	Bronze Mannikin *Lonchura cucllata*			p					p		p	p	p		p	p		
1290	Yelow-fronted Canary *Serinus mozambicus*					p												

APPENDIX E: NEMA APPROVED TERMS OF REFERENCE FOR THE ESIA

NEMA
National Environment Management Authority
ENSURING SUSTAINABLE DEVELOPMENT

NATIONAL ENVIRONMENT MANAGEMENT AUTHORITY (NEMA)

NEMA House
Plot 17,19 & 21, Jinja Road.
P.O.Box 22255, Kampala, UGANDA.

Tel: 256-414- 251064, 251065, 251068
342758, 342759, 342717
Fax: 256-414-257521 / 232680
E-mail: info@nemaug.org
Website: www.nemaug.org

NEMA/4.5

23rd August, 2018

The Managing Director,
National Water & Sewerage Corporation,
P. O. Box 7053,
KAMPALA.

Tel: +256 414 315100

RE: APPROVAL OF THE SCOPING REPORT AND TERMS OF REFERENCE FOR THE ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED KARUMA-GULU WATER SUPPLY PROJECT

Reference is made to the Scoping Report and Terms of Reference (TOR) that was submitted to this Authority for review and approval, for carrying out the Environmental and Social Impact Assessment (ESIA) for the proposed Karuma-Gulu Water Supply Project, that will be implemented in Gulu district and six small towns located between Karuma and Gulu. This Authority has finalized the review and grants formal **APPROVAL** of the said ToR.

In addition to the scope of work detailed in the ToR, you are advised to incorporate the considerations below during the conduct of the environmental impact study and the preparation of the ESIA report.

(i) Provide clear details for the location of the different project infrastructure, including the administrative jurisdiction (Villages, Parishes, Sub County and District) of the project components and accurate sets of GPS coordinates indicating the boundary/alignment of the project infrastructure.

(ii) Provide detailed baseline information on the project area, and undertake detailed hydrological and geo-technical assessments of the project area. These should take into account information from previous studies undertaken during the Karuma Hydro Power Project ESIA and other similar studies/projects in the area.

(iii) Consult closely with the Directorate of Water Resources Management (DWRM), the Ministry of Energy and Mineral Development (MEMD) and the Karuma HPP teams, and, the relevant Roads Agencies in whose jurisdiction the project infrastructure may fall, so as to inform the EIA process and the project design. The views of the stakeholders consulted should be well documented, incorporated during the conduct of the EIA, and appended to the report.

(iv) Undertake a cumulative impact assessment to determine the potential incremental impacts of the proposed project on the environmental flows of the River Nile, taking into account the existing, on-going and planned projects within the project area. Document the findings in the EIA report and propose appropriate mitigation actions to address such impacts.

(v) Undertake and provide details of the project alternatives in the EIA report. This should include but not be limited to, an assessment of alternatives in regard to project location and sources of water, technology, design and capacity of the project.

(vi) Incorporate measures for riverbank protection, source protection and management of the catchment and/or landscapes impacted by the project. The management plans for these aspects, developed in line with the relevant guidelines provided by the Directorate of Water Resources Management, should be included in the ESIA report.

(vii) Make reference to all relevant laws, regulations and standards and identify actions that may be required to facilitate compliance with the requirements in the legal framework.

(viii) The clear and legible copy of the lay-out plans for the project infrastructure *(preferably on A-3 sized paper)*, indicating the design of the project and the project boundaries in relation to its environs, should be provided in the EIA report.

(ix) The ESIA report should provide adequate information regarding land ownership and tenure in the project area and the proposed land acquisition and resettlement strategies.

(x) Include the total project (investment) cost, including a copy of certificate of validation issued by a certified professional valuer / quality surveyor.

This is, therefore, to recommend that you proceed with carrying out the ESIA for the proposed Karuma-Gulu Water Supply Project taking into account the above-mentioned guidance. We look forward to receipt of comprehensive copies of the ESIA report, for our further action.

Please note that the approval of the TORs DOES NOT Constitute permission to start implementing any of the proposed project activities. This is not a Certificate of approval.

ANsereko 23/08/18

Patience Nsereko
FOR: EXECUTIVE DIRECTOR

APPENDIX F: CULTURAL AND HERITAGE REPORT AND ARCHAEOLOGICAL RESOURCES CHANCE FINDS PROCEDURE FOR THE PROPOSED KARUMA – GULU WATER SUPPLY PROJECT

A. CULTURAL AND HERITAGE REPORT

1 BACKGROUND

The government of Uganda through the National Water and Sewerage Corporation (NWSC) and with funding from the World Bank and the German Development Agency (KFW) is formulating a new project to supply water to Gulu and six small towns on the Karuma - Gulu Highway namely: Karuma, Kamdini, Minakulu, Bobi, Palenga and Koro-Abili. This project will boost the capacity of the existing NWSC water supply infrastructure in the region. The total capacity of the water transmission is planned to be 15,000 m^3/day at the start of the project and will be raised to 30,000 m^3/day by 2040.

Under this study an investigation of the impact of the project on the cultural heritage of the project area taking into account the known history of the area.

2 METHODOLOGY

The study involved a desktop study of the history of the area as well as a study of the customs and history of the Acholi and Lango people who inhabit in the project area. Lastly fieldwork in the project area from the water in- take location at Nora village on the northern Bank of the Nile river at Karuma ,then at the location of the water treatment plant in Nora village and along transmission route following the Karuma –Gulu Highway up to the Customs corner water reservoir in Gulu Municipality .The fieldwork investigated the presence of cultural resources like historic buildings, cultural sites, sacred traditional religion sites and the presence of archaeological resources.

3 HISTORY OF THE PROJECT AREA

The project area was like the rest of Uganda first inhabited by the hunter gatherer people. These people had been in the area since the stone age period. From 1000B.C other communities entered the area the Sudanic speaking people related to the Madi were the first to arrive in the area. They were followed by the Luo Nilotic people who entered Uganda from the present day South Sudan.

The Luo moved into Uganda as a single community up to Pumbugu near Pakwach town on river Nile .At this point the Luo community split into Three groups .One group crossed river Nile to the western side of the river and became the Alur tribe. A smaller group moved south into Bunyoro and overthrew the Chwezi dynasty establishing the dynasty of Bito rulers. Another group under the leadership of Labongo moved eastwards into the project area and formed the Acholi people after absorbing the earlier Sudanic communities they encountered in the area. The Acholi people were organized into chiefdoms ranging in various sizes. The biggest chiefdom being that of the Payera Chiefdom which provides the Paramount Chief of the Acholi people.

The Luo also mixed with the highland nilotes (Eteker) who were moving westwards north of Lake Kyoga to form the Lango people who live in Oyam District where the proposed water intake is located. The project is therefore located in the land of the Lango and Acholi people.

4 ASSESSMENT FINDINGS IN THE PROJECT AREA

4.1 Cultural Heritage

There is one cultural site in the vicinity of the project area. This is the Nora Te Kwaro cultural site near the site of the proposed water intake on the northern side of the River Nile at Karuma.

Photo 1: Mr. Moses Oyepa, the LC1 Chairman of Nora Village at the Nora Tekwaro Cultural site

This location is marked by a tree in a thicket where the local residents pray to the local spirits for protection from problems and sickness .This location will not be affected by the project infrastructure as it is 262 meters from the water in take point. The coordinates of this cultural site are 36N 0418905, UTM 0248875.

However this site was disturbed by the construction of the road to the Karuma dam and the local leadership is engaged in negotiations with the Chinese Contractor who is building the Karuma dam to pay for the relocation of the cultural site from the area

4.2 Archaeological Resources

Surface transects walks in the Nora village and in gardens along the pipeline route from Karuma to Gulu were conducted. Ancient pot shards were observed at two locations: a) 36N 0418994,Utm 0249128 at the proposed location of the water treatment plant at Karuma and at b) 36N 0431619,Utm 0256867 at Amwa area. The Roulette decorated potshards indicated that human village communities have existed in the project area since the late iron age period.(around 1000 A.D) This is corroborated by the oral history of the people in the region.

Photo 2: Pot Shards observed in Nora village

Photo 3: Close view of the roulette decorated pot shards

4.3 Cultural Property at Household Level

The Cultural properties at house hold level found in the project area during the survey were graves in the homesteads .One such homestead was encountered at Nora village at 36N0418920,UTM 0249183 belonging to Mr. Omara Francis the Defence secretary Nora village at the proposed location of the Water treatment plant. This Lango homestead has four ordinary graves. The graves are marked by a stone in the courtyard.

In Gulu Municipality at Customs corner, six graves were observed at the location planned for the new water reservoir. The coordinates of the location are 36N 0420349, Utm 0305503. The graves were found to exist at the water in- take and at the final destination of the water reservoir in Gulu. There were no grave on the route from Karuma to Gulu as the pipeline route is located in the UNRA road reserve where the population does not carry out activities. Graves can be relocated to enable development projects .The relocation rates are determined by the District boards. In this case where the project facilities are placed in the same location as the graves and homesteads, these will have to be relocated according to the Resettlement Action Program of the Project in accordance with the Gulu and Oyam district compensation rates.

Photo 4: Defense Secretary and his wife of Nora village standing on top of one of the graves in at their homestead

Photo 5: Graves at Gulu customs corner where the water reservoir is planned to be located

5 IMPACT ASSESSMENT OF PROJECT ON CULTURAL HERITAGE RESOURCES

Resource	Impact Level	Recommendation
Graves at Nora village proposed water treatment plant and at Gulu Reservoir location	High The graves are located where project facilities will be constructed.	Relocation
Cultural site at Nora village	Low The site is located at a distance (262m) from project water in-take.	To be left *insitu*
Surface Archaeological materials observed (Pot Shards)	Medium The receptor sensitivity of the materials is low and they can coexist with the pipeline	To be left *insitu*

6 CONCLUSION

Although there are physical cultural resources in the project area, these cannot delay or obstruct the implementation of the Karuma -Gulu water supply project .Observations during the survey of the proposed water supply routes as well as inquiries during the consultative meetings indicated that there were no clan sites or headquarters or heritage sites such as cathedrals or palaces that would be affected by the project implementation.

As regards archaeological resources, the pot shards observed fitted in the general pattern of the samples of potshards of Uganda and there is already a representative sample at the Uganda museum.

There was no evidence of underground archaeological artifacts being present although their existence cannot be ruled out. A procedure for handling chance finds will have to come into effect in the case of significant archaeological discoveries during the construction phase of the pipeline routes. The pipelines will be underground and trenches will have to be dug to lay the pipes.

The consultant was informed by the local authorities along the route that due to the LRA insurgency which had ended a few years ago, chance finds of human remains hurriedly buried without any grave marking could be encountered. Therefore a chance finds procedure to this effect was developed and is appended as an annex to this report.

REFERENCE/ BIBLIOGRAPHY

Peoples and Cultures of Uganda by Fountain Publishers (fourth Edition)

B. CHANCE FINDS MANAGEMENT PROCEDURE

ABBREVIATIONS

CFP: Chance Finds Procedure

ESMP: Environment and Social Management Plan

IFC: International Finance Corporation

KIP: Key performance indicators

MTTI: Ministry of Tourism, Trade & Industry

NEMA: National Environment Management Authority

PS: Performance Standard

RAP: Resettlement Action Plan

DEFINITIONS

Chance find: Tangible cultural heritage encountered unexpectedly during project implementation.

Chance find procedure: A project-specific procedure that outlines actions to be taken if previously unknown cultural heritage is encountered.

1 INTRODUCTION

This Chance Finds Procedure (CFP) is proposed for the Karuma – Gulu Water Supply Project, implementation of which will be a responsibility of the contractor.

1.1 Purpose of the CFP

This CFP will serve the following purposes:

- translate commitments in the ESIA into implementation procedures that will protect physical cultural resources during construction of the project;
- Serves as a key tool the contractor can utilise to manage and monitor preservation of resources of cultural heritage significance; and
- Provide transparency to stakeholders that commitments made in the ESIA in regard to preservation of finds of heritage value are actually being fulfilled.

This CFP provides:

- Responsibilities for implementation of the procedure;
- Impact management measures to be implemented;
- Verification and monitoring; and
- Records and reporting requirements.

1.2 Objective of CFP

Through its contractor, NWSC seeks to ensure that impacts on cultural heritage resources are minimized as far as possible. Thus the overall objective of this CFP is to describe an approach and procedures to be undertaken by the contractor with regard to protection of chance finds encountered during project implementation.

1.3 Scope of CFP

This CFP sets out requirements for management of cultural heritage resources during project implementation. The focus of the procedure is primarily mitigation during earthworks at the project site. It is expected that earthworks will be undertaken at following sites, at which chance finds may be encountered.

- Wastewater/ sewage and sludge management facilities;
- Water pipelines and sewers;
- Borrow sites where gravel may be obtained (if any).

1.4 Definition of "Cultural Heritage"

For purposes of this CFP, cultural heritage includes:

i) Archaeological deposits and remains;

ii) Historical monuments, sites and buildings;

iii) Places of worship;

iv) Cemeteries and graveyards; and,

v) Places associated with folklore, mythology (and traditions) and the location of historical and cultural festivals, events and rituals.

1.5 Commitments

This CFP is developed based on target areas and commitments below:

Table 1: Target areas and commitments

	Target area	Commitment
1	Unidentified archaeological features	This CFP will be implemented to fulfill requirements of Uganda's Historical Monuments Act, 1967.
2	Early earthworks involving excavations (see Sec 1.4 above)	A specialist archaeologist from the *Department of Museums and Monuments* in the *Ministry of Tourism, Trade & Industry* (MTTI) will be on site at the stage of commencing civil works entailing excavations and on call to come to site to investigate, inspect and retrieve any chance finds encountered. Retrieved chance finds will be submitted to the National Museum.

1.6 Relationship to Other Project Documents

This CFP should be implemented in conjunction with:

- Contractor's environment & social management plan;
- Project overall ESMP that specified project-wide requirements for environmental and social management;
- The ESIA report for this project; and
- Resettlement Action Plan (RAP) that covers the framework and procedures to be followed during land acquisition for construction of the project.

1.7 Uganda's Historical Monuments Act, 1967

This CFP is to be executed in compliance with Uganda's *Historical Monuments Act, 1967*. In this Act, sub-section 12(1) requires that any portable object discovered in the course of an excavation is surrendered to the Minister who shall deposit it in the Museum.

Management of archeological chance finds is a responsibility of the Department of Museums and Monuments in the Ministry of Tourism, Trade & Industry.

2 CHANCE FINDS MANAGEMENT PROCEDURE

2.1 Personnel and Responsibilities

This procedure is based on three recommendations below:

i) The contractor will have a *Socio-Environmental Officer* (SEO) on the site during project construction. The contractor's SEO will closely work with the developer's socio-environmental staff to ensure compliance with national and financier's requirements as well as implementation of this chance finds procedure.
ii) During ground opening and excavations, the developer will facilitate an Archaeologist from the *Department of Museums and Monuments* in MTTI to be on site and ensure that any chance finds encountered are managed according to requirements of The Historical Monuments Act, 1967.
iii) All construction staff involved in earthworks should be trained in basis skills of recognising suspected chance finds and the procedure of notifying the SEO and Archeologist.

Specific roles of persons to be involved in implementation of this procedure are outlined below

2.1.1 Role of the contractor's Socio-Environmental Officer

The SEO is required to:

i) Communicate contents and requirements of this plan to contractor;

ii) Sensitise workers to ensure that all are aware of their responsibilities in regard to protection chance finds;

iii) Inform the Archaeologist of any chance finds encountered on site;

iv) Coordinate inspection and monitoring by the MTTI Archaeologist. The SEO should keep in close contact with the archaeologist throughout the construction period;

v) Implement measures recommended by the archaeologist for management of "chance finds" encountered;

vi) Conduct cultural heritage tool box talks to construction personnel as advised by the Archaeologist; and

vii) Maintain records (daily logs) related to archaeological finds during construction.

2.1.2 Role of the MTTI archaeologist

An archaeologist contracted (on a non-permanent basis) from the department responsible for museums and monuments in MTTI will have the following roles:

i) Archaeological monitoring of all earthworks;

ii) Advice/ guidance to the contractor with respect to halting construction activities if earthworks encounter chance finds;

iii) Conducting preliminary assessment of all previously unidentified archaeological features encountered and submission of these to the National Museum;

iv) Provision of advice on the significance and management of unidentified archaeological features encountered;

v) Processing/ excavation of any unidentified subsurface archaeological features encountered in accordance with standard procedures recommended by the Department of Museums and Monuments;

vi) Maintain watching briefs during opening up site or deep excavations at any location during construction, with clear procedures for protection and documentation of any "chance finds" encountered;

vii) Maintain monitoring records of all unidentified archaeological features encountered;

viii) Develop a set of points to be discussed in "Tool Box" sessions to create awareness among construction crews on "chance finds"/ archaeological features. Note that as part of their sensitization, workers will be required to cease work if they encounter archaeological features and report to Contractor's SEO, who will notify the Archaeologist; and

ix) Write a report for the developer upon completion of construction. This report will be submitted to the Supervising consultant, Contractor, Developer and Department of Museums and Monuments. The report will summarise findings of archaeological monitoring, describing any features encountered and their preservation significance.

The archeologist will also undertake "Watching briefs" as the primary element of management and protection of cultural heritage during project construction. Watching briefs will consist of passive visual investigation during ground breaking at excavation sites.

Objectives of the "watching briefs" will be to:

- Record subsurface archaeological features discovered during earth-moving activities;
- Provide advice to the contractor on significance of subsurface archaeological features discovered; and
- Provide advice to the contractor on areas where ground disturbing activities may continue or where necessary need to be "worked around" or stopped.

The following will be implemented during the “watching brief”:

- Prior to commencing any construction activities, the contractor will give a brief to the archaeologist about site(s) they plan to excavate;
- The archaeologist will conduct a walkover to identify site’s archaeological sensitivity through characteristics such as soil type, topography, etc.; and
- The archaeologist will witness/ observe site clearance, soil stripping and excavations for presence of subsurface archaeological features.

2.1.3 Role of the Contractor

The contractor will be required to:

i) Heed advice from the Archaeologist in respect to halting earthworks when chance finds are encountered; and

ii) Provide cultural heritage tool box talks to construction crews as advised by the Archaeologist.

2.2 General Rule When Chance Finds are Encountered

Upon identification of suspected archaeological remains, the location must not be disturbed until it is inspected by the archaeologist from MTTI.

2.3 Procedures

In the event that genuine archaeological remains are encountered, the procedures to be adopted are described in the sections below.

2.3.1 Human remains

If encountered during earthworks, human remains must be handled with dignity and respect. If identified before disturbing the ground, such a location should be staked or flagged off to prevent additional disturbance. However, for uncemented graveyards, it may not always be possible to identify, distinguish and protect a burial ground from construction activities and therefore the following procedures will be followed if suspected human remains are found:

i) Work will immediately cease in affected location and contact the contractor’s SEO who will notify the MTTI Archaeologist;
ii) If the affected location is likely to be disturbed by other workers on site, an employee will be assigned to stand watch until the archaeologist arrives;
iii) Any exposed bones will be covered with plastic sheeting but not backfilled, until the archaeologist arrives to inspect the chance finds;
iv) If excavated fill has been loaded into a truck, it will be emptied at a suitable location for inspection by the archaeologist; and
v) The contractor will resume work once the archaeologist’s inspection is completed and an instruction to recommence works issued.

2.3.2 Artefact scatters

The following procedures will be adopted when unanticipated artifact scatters are encountered:

i) The contractor will immediately stop work at the location where finds are encountered and contact the SEO who will notify MTTI Archaeologist;
ii) The affected location will be staked or flagged off to prevent further disturbances;
iii) If excavated fill has been loaded into a truck, it will be emptied at a nearby secure location for inspection by the archaeological consultant; and
iv) The contractor will resume work only after the archaeologist has completed a site inspection and given the go-ahead for works to resume.

2.3.3 Isolated artefact finds

Due to their shape and colour, which often contrasts with the surrounding soil, artifacts are easy to identify by non-archaeologists during earthworks or other activities on site.

Should an isolated artifact be observed, the following procedures will be adopted:

i) If the artifact is in imminent danger of being destroyed or damaged, it will be collected and its location marked with a flag;
ii) Whenever possible, the artifact will be left on the ground where it was found;
iii) The SEO will be notified that the location requires an archaeological inspection;
iv) The SEO will notify the archaeologist of the chance find;
v) The SEO will ensure that other workers near the location are aware of the need to avoid disturbing the area until inspected by the archaeologist; and
vi) The archaeological consultant will inspect the affected location, after which the SEO will be advised that construction works can proceed.

2.3.4 Historical remains

All types of historic archaeological materials are subsumed within this category, including isolated historical artifacts. When historic remains or suspected historic archaeological remains are encountered the following procedures will be adopted:

i) SEO will order cessation of work will and notify the archaeologist;
ii) The affected location will be staked or flagged off to prevent further disturbances;
iii) The archaeologist will determine if the materials encountered are of real historic significance; and
iv) The contractor will resume work only after the archaeologist issues instruction for the works to resume.

If isolated historic or suspected historic archaeological artifacts are observed, the following procedures will be followed:

i) If the artifact is in imminent danger of being damaged, it will be collected by the SOE and put in a bag (e.g. a Ziploc bag), along with any fragments thereof;
ii) If detached fragments are found, a label must be included with the date of the find and its position;
iii) Its depth and location must be marked with a stake or flag,
iv) Otherwise, whenever possible, the artifact mbe left on the ground at the location where it was found; and
v) The SEO will notify the archaeologist, who will determine if an inspection is required. If no follow-up inspection is necessary, the archeologist will advise the SEO that construction can continue.

3 TRAINING

General awareness training will be provided by an archaeologist from MTTI to all construction crews and the contractor's SEO. The training will incorporate information on cultural heritage, its significance, protection status of previously unidentified subsurface archaeological features in the area and construction activities that may destroy them.

This awareness will be maintained through tool-box talks that should be regularly conducted with all construction crews.

4 MONITORING

Monitoring will be done by the contractor's SEO with the principal objective being to provide assurance that:

- Project construction is compliant with this procedure; and
- Evidence is collected to demonstrate that commitments related to cultural heritage protection are being effectively met.

Key performance indicators below will be utilised in the monitoring

4.1 Key Performance Indicators

The contractor's SEO will undertake monitoring of chance finds management based on KIPs in Table 2.

Table 2: Monitoring criteria

	KIP/ measure	Rationale	Performance target	Monitoring frequency
1	Conduct cultural heritage awareness training	Ensures workers are aware of cultural heritage in the area and the possibility of sub-surface resources to be encountered.	90%	Every 3 months
2	Number of "chance finds" damaged by construction activities	Monitors effectiveness managing chance finds	Zero	Monthly

4.2 Action Tracking

All non-compliance with this procedure shall be followed up and corrective action taken. The contractor's SEO is expected to maintain an *actions tracking system* as part of archaeological monitoring. Cultural heritage management action tracking including close out of actions (solutions and preventive actions taken) will be reported quarterly by the contractor to the project developer.

5 REPORTING AND RECORD KEEPING

Records in sections below will be kept by indicated personnel.

5.1 MTTI's Archaeologist

The archaeologist will report the following to the Contractor's Socio-Environmental Officer:

- Daily log of activities on a weekly basis;
- Results of any assessments of "chance finds" as soon as the assessment is completed; and
- A detailed report of field activities, findings and conclusions following a period of major earthworks.

5.2 Contractor's Socio-Environmental Officer

The Contractor's SEO will report the following to Frontier's Socio-Environment Manager.

- Awareness records on cultural heritage resource among workers on a weekly basis;
- Bi-weekly report summarizing cultural heritage management activities;
- Action tracking system on a weekly basis; and
- Performance against key indicators (KPI).

REFERENCES

Republic of Uganda, 1967: Historical Monuments Act.

NEMA 2010: Environmental Sensitivity Atlas for the Albertine Graben, Kampala.

APPENDIX G: CONTRACTORS/ WORKERS' CODE OF CONDUCT

1 INTRODUCTION

Each employee including trainee or volunteer of a **Contractor** who have interaction with the project must sign this "Code of Conduct." In this Code, "Contractor" shall mean and apply to the contractor, its employees, sub-contractor, officers, agents, representative or those contracted through the Contractor to perform services authorized by the contract.

The contractor agrees to adhere to this Code of Conduct when providing services to this project. The Code of Conduct is in addition to all other contract requirements, policies, rules and regulations governing delivery of services. The purpose of the code is to protect vulnerable people from abuse, neglect, maltreatment and exploitation. It clarifies expectation of conduct of the parties and their employees, which includes administrative staff, care staff, support services staff and any others when interacting with the project.

Contractor, its agents or representatives authorized through it shall not abuse, sexually abuse or sexually exploit, neglect, exploit or maltreat any fellow employees or people from general public/ community. Additionally, no person shall cause physical injury to any other person.

The Contractor shall not by acting, failing to act, encouragement to engage in, or failure to deter from will cause any person to be subject to physical or mental abuse, sexual abuse or sexual exploitation, neglect, exploitation, or maltreatment. The Contractor shall not engage any person as an observer or participant in sexual acts.

Contractor understands and acknowledges that failure to comply with this Code of Conduct may result in corrective action, probation, suspension, and/or termination of contract.

Equally important to realise is that this Code also protects any person under the age of 18 years and any person 18 years of age or older who is physically or mentally **handicapped or impaired** due of mental illness, mental deficiency, physical illness or disability, or other temporary or permanent cause, to the extent that he is unable to care for his own personal safety.

2 ABUSE SHALL INCLUDE THE FOLLOWING, BUT IS NOT LIMITED TO:

a) Any type of physical hitting or corporal punishment inflicted in any manner upon the body.

b) Deprivation of life-sustaining treatment.

c) Harm or threatened harm, meaning damage or threatened damage to physical or emotional health and welfare of any person.

d) Physical injury including, but not limited to, any contusion of the skin, laceration, malnutrition, burn, fracture of any bone, subdural hematoma, injury to any internal organ, any injury causing bleeding, or any physical condition which imperils a person's health or welfare.

e) Unlawful confinement.

3 SEXUAL MISDEMEANOR WILL INCLUDE, BUT NOT BE LIMITED TO:

a) Engaging in exploitive or manipulative sexual intercourse with any person. There will be zero tolerance to sexual misdemeanor including rape, defilement of minors/ sexual child abuse, sexual harassment and elopement.

b) Taking indecent liberties with a person, or causing an individual to take indecent liberties with a person, with the intent to arouse or gratify sexual desire of any person.

c) Employing, using, persuading, inducing, enticing, or coercing a person to pose in the nude.

d) Employing, using, persuading, inducing, enticing or coercing a person to engage in any sexual or simulated sexual conduct for the purpose of photographing, filming, recording, or displaying in any way the sexual or simulated sexual conduct. This includes displaying, distributing, possessing for the purpose of distribution, or selling material depicting nudity, or engaging in sexual or simulated sexual conduct.

e) Use of profanities and obscene language in communities or when instructing others.

4 NEGLECT MAY INCLUDE BUT IS NOT LIMITED TO:

a) Denial of sufficient nutrition to any person.

b) Denial of sufficient sleep to nay person.

c) Denial of sufficient protective gear to any person.

d) Failure to provide adequate supervision; leading to drug use in workplaces, accidents and impairment of employees.

e) Failure to arrange for medical care and/or medical treatment for any person in an emergency.

f) Failure to drive courteously at all times, leading to accidents.

g) Failure to avoid damage public property.

h) Neglecting public and employee complaints.

5 DRUG ABUSE MAY INCLUDE BUT IS NOT LIMITED TO:

a) Smoking in public or smoking in undesignated areas

b) Consumption of alcohol while on duty/at work

c) Use and trading in narcotics

6 ILLEGAL TRADE ACTIVITIES WITHOUT NECESSARY LICENSES:

a) Trade in protected fauna or flora species

b) Trade in ivory or similar regulated wildlife products including game meat

c) Trade in processed, semi-processed minerals and their ores

7 FINANCIAL EXPLOITATION WILL INCLUDE, BUT IS NOT LIMITED TO:

Utilizing labor of without paying for it, or at a non-commensurate financial rate/ wage.

8 MISTREATMENT WILL INCLUDE, BUT IS NOT LIMITED TO:

a) Physical exercises, such as running laps or performing pushups,

b) Unauthorized chemical, mechanical or physical restraints except,

c) Assignment of unduly physically strenuous or harsh work.

d) Failure to behave in a polite and courteous manner to the general public

e) Requiring or forcing the individual to take an uncomfortable position, such as squatting or bending, or forcing people to repeat physical movements when used solely as a means of punishment.

f) Group punishments for misbehavior of individuals except in accordance with the written policy.

g) Verbal abuse: engaging in language whose intent or result is demeaning

h) Denial of any essential service solely for disciplinary purposes

i) Denial of visiting or communication privileges with family or significant others

j) Requiring the individual to remain silent for long periods of time solely for the purpose of punishment.

The Contractor agrees to document and report sexual abuse / sexual exploitation, neglect, maltreatment and exploitation as outlined in this Code and cooperate fully in any resulting investigation. The Contractor shall prominently display posters, notifying employees of their responsibilities and to report violations using phone numbers thereon indicated.

Contractor/ subcontractor Signed: …………………………………………. Name: …………………………………………. Date (dd/mm/yyyy): ……………………………

APPENDIX H: ENVIRONMENTAL FLOW ASSESSMENT

ANNEXURE 8.1

Estimation of Environmental Flow

Environmental Flow (EF) is the flow of water in rivers that is necessary to maintain aquatic ecosystem. In other words, a flow regime in the river, capable of sustaining a complex set of aquatic habitats and ecosystem processes are referred to as environmental flow. The desired state or the appropriate EF is defined in terms of quantity of water through time required to maintain river health in a particular state. At times, this amount of water is also referred to as in-stream flow, environmental allocation or ecological flow requirement. Failure to maintain such flows may lead to decline in the health of water dependent ecosystem. Minimum flow is a general term used to describe a flow required to maintain some feature of a river ecosystem. However, due to the complexity of the interaction between water as a habitat and the other communities (both plants and animals) in the system, no simple figure can be given for the environmental flow requirement of a river. It is related to a number of factors such as hydrologic and biotic character of critical reaches, perceived sensitivity, desired state of the river and the uses to which river flow is put. A river that is habitat to sensitive e.g. red list or endangered species, and one with other multiple users will definitely present a bigger challenge to estimate the EF for it. EF in rivers is generally needed for various purposes such as to:

- Maintain river flow conditions like flow velocity, water depth and acceptable turbidity levels, making it possible for the river to purify itself through a dilution effect of effluents and waste water input into the system.
- Maintain low flow which support livelihood of the people, who use the river for various purposes including drinking, washing, bathing, fishing, recreation and tourism, etc
- Sustain both terrestrial and aquatic ecosystem. For example, low flow provides water to wild animals; maintain soil-moisture in the banks, etc. Small floods stimulate spawning in fish and allow passage for migratory fish and germination of seeds on river banks. Large floods deposits nutrients on the banks and distribute seeds.
- Further, large floods flush sediments and natural obstructions in the river course and maintain a sufficient deep channel for navigation.

In terms of culture, environmental flows should enable the river to play its role in the cultural and spiritual live of the people around the project and any other that could be using the river water for such.

In the case of run of the river schemes, the weirs and hydroelectric power plants are constructed on the streams as indicated on the sketch (**Plate-1**). Water at the weir is carried to a certain level and then energy is produced by dropping that it to the HPP by means of penstock. In that case, the environmental flow amount which is essential for sustainability of aquatic life in the dry section of the river becomes important. The Environmental Flow water is not used in the generation of power and as a result, it decreases the power generation capacity of the scheme.

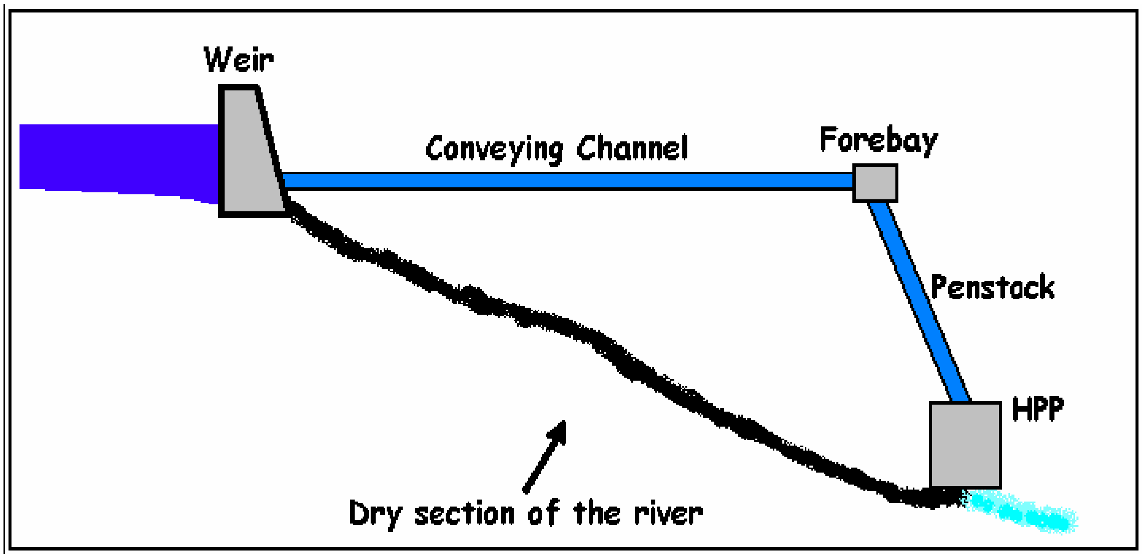

Plate 1: Schematic Sketch of a Run of the River Hydropower Scheme indicating the “dry” zone

The Karuma HPP Scenario

Karuma hydroelectric power project consist of an about 10 km river length in between Dam site and Tail Race outfall (Figure 1). As design discharge for power generation will be diverted through tunnel, therefore flow for the river stretch between dam site and Tail Race outfall of river will be altered. For sustenance of ecological balance in this stretch of river, environmental flow will be released from dam site.

Historical discharge method / the Tennant/Montana method has been used to quantify environmental water Requirements downstream the proposed Karuma Hydropower plant. The Tenant method was developed in the USA and Designed to be applicable to all stream/watercourse sizes and to warm and cold climates. (Tennant; 1976). The minimum flow required to sustain the aquatic environment is expressed as a percentage of the Mean Annual Flow with different percentages used for wet and dry seasons. This discharge method is based on Historical flow records at the river section. The minimum flow requirement for the water course is expressed as a percentage of the Mean Annual flow at specific sites in this regard Kamdini. The flow data of 90 % dependable year (1946) is taken for calculation of environmental flow as it indicates that 90% of the times the river flow will be available for releasing environmental flow in the downstream. The mean average annual flow for 90 % dependable year is 494 Cumec and is considered for calculation of Environmental flow (**Table 1**).

In addition, the Karuma HPP is Run of River scheme where the project will operate continuously and reservoir filling is one time process only. Therefore the minimum flow will be required only for 10 km stretch of river in between the dam site and Tail race outfall of project (**Plate 2**). The stretch excluding this 10 km will be having normal flow conditions.

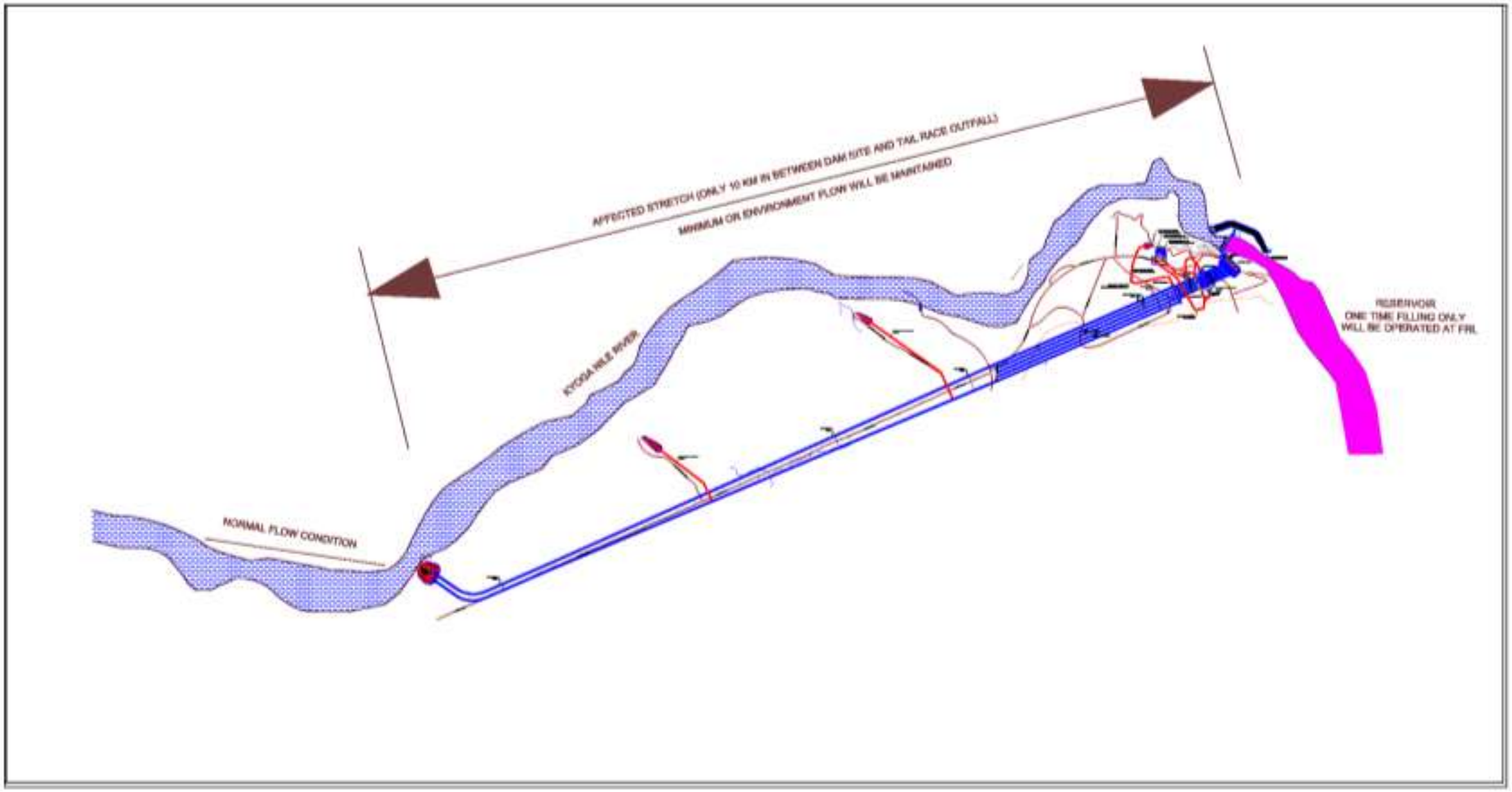

Plate 2: Map showing affected stretch of river where minimum flow is to be maintained (After this stretch flow will be normal)

Table 1: The following computations were made for corresponding different percentages of recommended Mean annual flow

Health of the Habitat	Recommended minimum flow as a percentage of the mean annual flow in cumec			
	Wet Season	Mean Flow. wet	Dry Season	Min. Flow. dry
Optimum	60% to 100%	296.4-494	60% to 100%	296.4-494
Outstanding	40%	197.6	60%	296.4
Excellent	30%	148.2	50%	247
Good	20%	98.8	40%	197.6
Fair or Degrading	10%	49.4	30%	148.2
Poor or degrading	10%	49.4	10%	49.4
Severe	0% to 10%	0 to 49.4	0% to 10%	0 to 49.4

From the above Table, 50 cumec is taken as Environmental flow as it will be enough to maintain fair or poor habitat condition the affected stretch of 10 km. Tenant 1976 related various levels of Mean Annual Runoff (MAR) with values of depth, width and velocity. The Assumption was that velocity, depth and width is dependent on and can be determined from MAR. On the other hand, values of velocity, depth and width which are suitable for different levels of ecological functions and services are obtained from different studies. Therefore sustainability of 50 cumec flow is checked velocity, depth, and width for a certain level of ecological function in the downstream.

This 10 km length of river consists of some rapids/falls as well as some pools. L profile of river stretch between the dam site and the TRC outfall is given in **Plate 3** whereas **Plate 4** shows the pools/impoundments and falls in Kyoga Nile River in this stretch. Owing to the varying gradient of the river bed under this stretch, river is flowing rapidly at few locations whereas; water pools are formed intermittently between the adjacent rapids. At the pools/impoundments, the river flow with considerably low velocity thereby creating high depth of flow whereas at rapids/falls, the flow velocity is much higher and reduced flow depth.

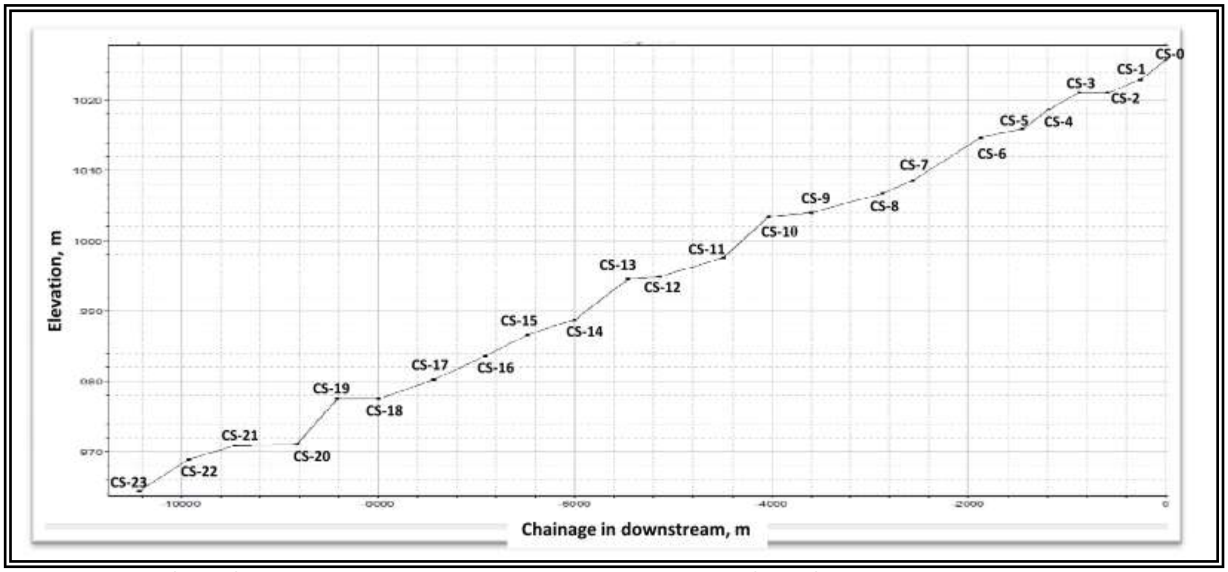

Plate 3: L profile of river in between dam site and Tail race outfall of Karuma HE project

Plate 4: Map showing falls/rapids and pools in Kyoga Nile River between dam site and TR outfall

For studying the requirement of environmental flow vis-a-vis the flow depth and velocity profiles that would be available upon release of environmental flow, an analysis was undertaken using the HEC-RAS software. For the purpose of this study, the cross sections are taken at regular intervals in the river stretch between dam site and TRC outfall especially near impoundments/pools and rapids to have representative river morphology. The cross sections are extracted from Shuttle Radar Topographic Mission (SRTM) data as well as from Google earth imagery. At the upstream boundary of the model, the altered flow series i.e. 50 cumec discharge is defined whereas at the downstream boundary normal depth is specified. The results of simulation are given in **Table 2** whereas the riverbed profile and water surface profile is given in **Plate 5**.

Table 2: Flow characteristics for river stretch in between dam site and Tail race outfall of Karuma HE project (50 Cumec Environmental Flow)

River Station	Chainage	Q Total	Channel Elevation	Water Surface Elevation	Depth of Flow	Velocity in channel	Top Width of flow
	(m)	(m3/s)	(m)	(m)	(m)	(m/s)	(m)
CS-0	0	50	1025.65	1026.53	0.88	1.26	95.71
CS-1	-252	50	1022.91	1025.64	2.73	0.11	250.15
CS-2	-585	50	1021.08	1025.63	4.55	0.07	307.6
CS-3	-873	50	1021.08	1022.88	1.8	2.57	34.17
CS-4	-1185	50	1018.64	1020.05	1.41	0.34	135.05
CS-5	-1450	50	1015.9	1020.03	4.13	0.08	228.69
CS-6	-1875	50	1014.68	1016.05	1.37	2.66	27.1
CS-7	-2563	50	1008.58	1009.71	1.13	0.38	193.9
CS-8	-2873	50	1006.75	1009.66	2.91	0.16	178.04
CS-9	-3595	50	1004.01	1009.65	5.64	0.12	137.75
CS-10	-4025	50	1003.4	1004.47	1.07	3.15	21.41
CS-11	-4490	50	997.61	998.77	1.16	1.02	62.49
CS-12	-5136	50	994.87	998.07	3.2	0.16	166.06
CS-13	-5455	50	994.56	995.12	0.56	2.06	54.7
CS-14	-6000	50	988.77	990.19	1.42	0.44	148.95
CS-15	-6483	50	986.64	987.56	0.92	1.74	52.04
CS-16	-6911	50	983.59	984.91	1.32	1.02	76.06
CS-17	-7434	50	980.24	984.2	3.96	0.06	283.53
CS-18	-7998	50	977.49	984.2	6.71	0.04	295.49
CS-19	-8411	50	977.49	978.36	0.87	3.28	22.83
CS-20	-8822	50	971.09	972.72	1.63	0.5	112.8
CS-21	-9450	50	970.79	972.56	1.77	0.2	225.27
CS-22	-9925	50	968.96	969.74	0.78	1.4	98.74
CS-23	-10425	50	964.39	965.38	0.99	1.27	77.2

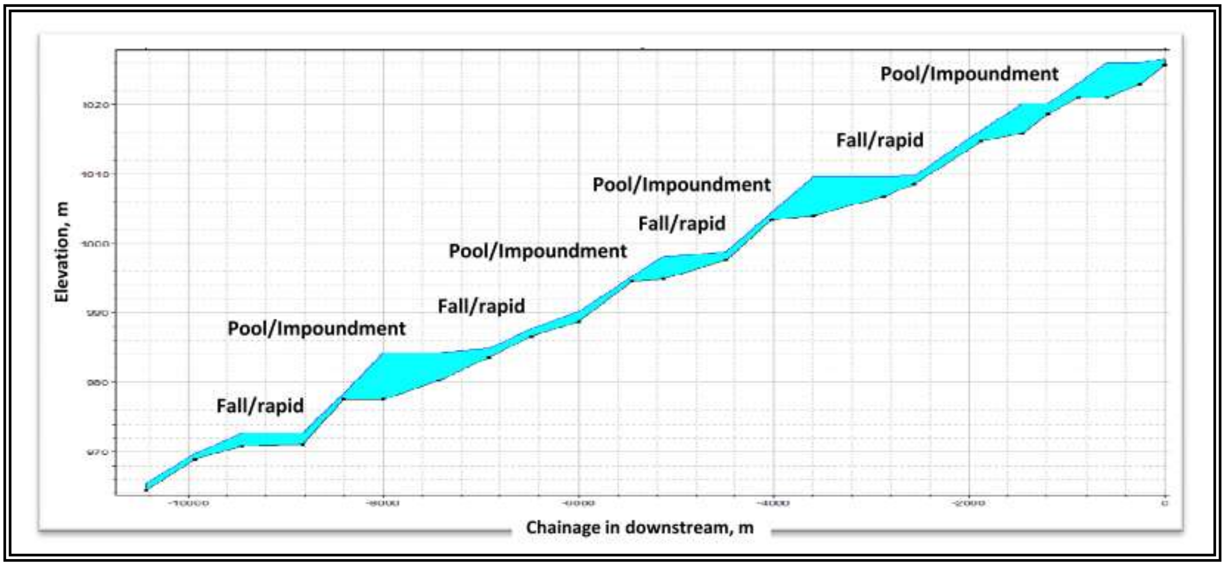

Plate 5: Bed profile and water surface profile for river stretch in between dam site and Tail Race outfall of Karuma HE project (50 cumec Environmental flow)

From above analysis, it is clear that the proposed minimum flow is sufficient for the survival of aquatic species in between proposed weir site and Tail race outfall. Provision of fish ladder along with minimum flow release from weir will ensure the survival of riverine ecology.

Ecological Demand Estimation

Twenty three cross sections are considered in between proposed weir site and Tail race outfall of Karuma HPP (CS 0 to CS 23). The average cross sectional depth ranges between minimum 0.56 m to maximum 5.64 m in the downstream of proposed weir site on Karuma River. On the basis of studies referred above, the analysis of flow characteristics (width of flow, depth of flow, flow velocity, etc.) and the quantum of downstream flow depth as presented in the **Table 2,** it suggests that proposed minimum flow is sufficient for the survival of aquatic species in between proposed weir site and Tail race outfall. Provision of fish ladder along with minimum flow release from weir will ensure the survival of riverine ecology.

However, scrupulous consultation with the Directorate of Water Resource Management (DWRM) Technical Staff conducted on 24th June 2011 recommended to increase the ecological flow to 100 cumecs. Therefore, the Environmental flow was revised from 50 cumecs to 100 cumecs and scenario of flow characteristics for river stretch in between dam site and Tail race outfall of Karuma HE project for 100 cumec is depicted in **Table 3** and **Plate 6**.

Table 3: Flow characteristics for river stretch in between dam site and Tail race outfall of Karuma HE project (100 Cumec Environmental Flow)

River Station	Chainage	Q Total	Channel Elevation	Water Surface Elevation	Depth of Flow	Velocity in channel	Top Width of flow
	(m)	(m^3/s)	(m)	(m)	(m)	(m/s)	(m)
CS-0	0	100	1025.65	1026.81	1.16	1.33	138.62
CS-1	-252	100	1022.91	1026.06	3.15	0.18	264.74
CS-2	-585	100	1021.08	1026.06	4.98	0.12	323.04
CS-3	-873	100	1021.08	1023.26	2.18	2.88	46.51
CS-4	-1185	100	1018.64	1020.45	1.81	0.49	151.94
CS-5	-1450	100	1015.9	1020.43	4.53	0.13	233.51
CS-6	-1875	100	1014.68	1016.47	1.79	3.15	35.86
CS-7	-2563	100	1008.58	1010.31	1.73	0.40	212.31
CS-8	-2873	100	1006.75	1010.28	3.53	0.24	184.74
CS-9	-3595	100	1004.01	1010.26	6.25	0.20	155.26
CS-10	-4025	100	1003.40	1004.88	1.48	3.91	25.70
CS-11	-4490	100	997.61	999.15	1.54	1.36	66.42
CS-12	-5136	100	994.87	998.35	3.48	0.27	179.43
CS-13	-5455	100	994.56	995.38	0.82	2.55	60.22
CS-14	-6000	100	988.77	990.57	1.80	0.58	166.51
CS-15	-6483	100	986.64	987.89	1.25	2.05	67.38
CS-16	-6911	100	983.59	985.40	1.81	1.02	118.14
CS-17	-7434	100	980.24	984.81	4.57	0.10	300.19
CS-18	-7998	100	977.49	984.81	7.32	0.06	299.35
CS-19	-8411	100	977.49	978.74	1.25	4.03	27.47
CS-20	-8822	100	971.09	973.00	1.91	0.75	122.16
CS-21	-9450	100	970.79	972.73	1.94	0.34	235.99
CS-22	-9925	100	968.96	969.95	0.99	1.68	132.8
CS-23	-10425	100	964.39	965.69	1.30	1.51	96.55

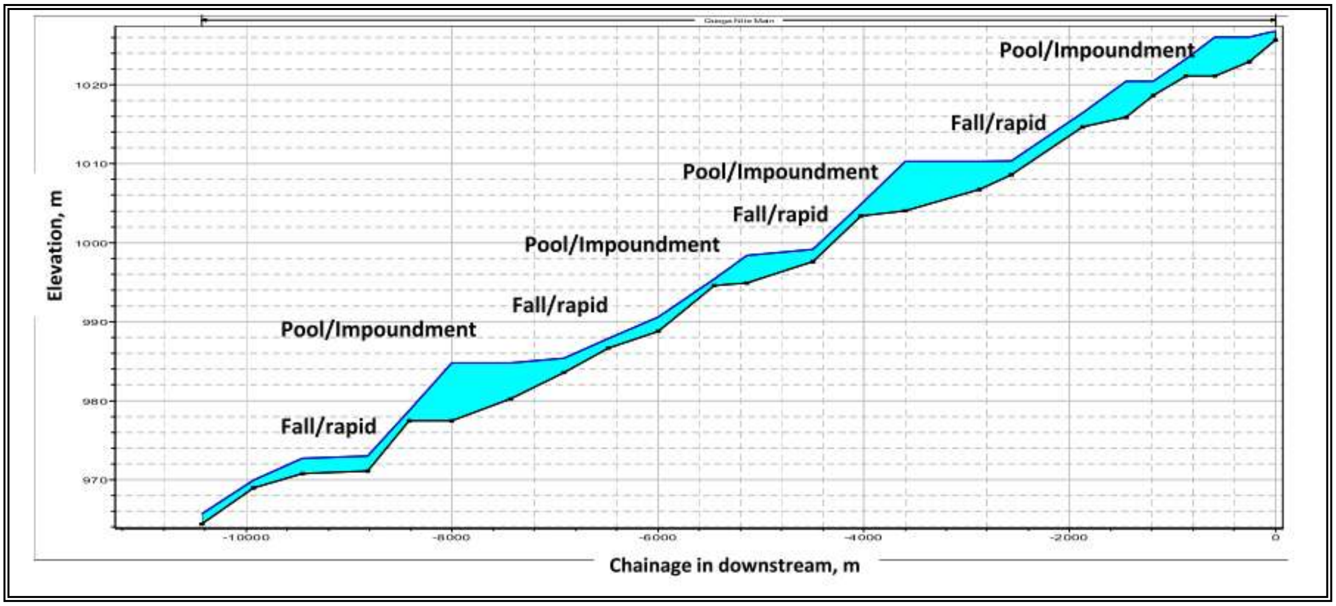

Plate 6: Bed profile and water surface profile for river stretch in between dam site and Tail Race outfall of Karuma HE project (100 Cumec Environmental flow)

Table 4: Flow characteristics for river stretch in between dam site and Tail race outfall of Karuma HE project at present

River Station	Chainage	Q Total	Channel Elevation	Water Surface Elevation	Depth of Flow	Velocity in channel	Top Width of flow
	(m)	(m3/s)	(m)	(m)	(m)	(m/s)	(m)
CS-0	0	50	1025.65	1026.53	0.88	1.26	95.71
CS-1	-252	50	1022.91	1025.64	2.73	0.11	250.15
CS-2	-585	50	1021.08	1025.63	4.55	0.07	307.6
CS-3	-873	50	1021.08	1022.88	1.8	2.57	34.17
CS-4	-1185	50	1018.64	1020.05	1.41	0.34	135.05
CS-5	-1450	50	1015.9	1020.03	4.13	0.08	228.69
CS-6	-1875	50	1014.68	1016.05	1.37	2.66	27.1
CS-7	-2563	50	1008.58	1009.71	1.13	0.38	193.9
CS-8	-2873	50	1006.75	1009.66	2.91	0.16	178.04
CS-9	-3595	50	1004.01	1009.65	5.64	0.12	137.75
CS-10	-4025	50	1003.4	1004.47	1.07	3.15	21.41
CS-11	-4490	50	997.61	998.77	1.16	1.02	62.49
CS-12	-5136	50	994.87	998.07	3.2	0.16	166.06
CS-13	-5455	50	994.56	995.12	0.56	2.06	54.7
CS-14	-6000	50	988.77	990.19	1.42	0.44	148.95
CS-15	-6483	50	986.64	987.56	0.92	1.74	52.04
CS-16	-6911	50	983.59	984.91	1.32	1.02	76.06
CS-17	-7434	50	980.24	984.2	3.96	0.06	283.53
CS-18	-7998	50	977.49	984.2	6.71	0.04	295.49
CS-19	-8411	50	977.49	978.36	0.87	3.28	22.83
CS-20	-8822	50	971.09	972.72	1.63	0.5	112.8
CS-21	-9450	50	970.79	972.56	1.77	0.2	225.27
CS-22	-9925	50	968.96	969.74	0.78	1.4	98.74
CS-23	-10425	50	964.39	965.38	0.99	1.27	77.2

Plate 7: Bed profile and water surface profile for river stretch in between dam site and Tail Race outfall of Karuma HE project (present situation)

APPENDIX I: GEOTECHNICAL INVESTIGATION REPORT

EPINEX ENGINEERING SERVICES LTD.

EES

REPORT ON GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

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JUNE 2018

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LIST OF ACRONYMS

BH	-	Borehole
BS	-	British Standard
CH	-	Fat clay
CL	-	Lean clay
CO_2	-	Carbon dioxide
GC	-	Clayey gravel
GL	-	Ground Level
GW	-	Gravel – sand mixture
kg	-	Kilogram
kN	-	Kilo Newton
kPa	-	Kilo Pascal
Ltrs	-	Litres
LL	-	Liquid Limit
LS	-	Linear Shrinkage
m	-	Meters
MH	-	Elastic silt
ML	-	Inorganic silt
mm	-	Millimeter
m^2	-	Square meters
m^3	-	Cubic meters
MPa	-	Mega Pascal
M/s	-	Messrs
µm	-	Micro Meter
OL	-	Organic silty clay
PI	-	Plasticity Index
PL	-	Plastic Limit
SC	-	Clayey sand
SPT	-	Standard Penetration Test
SW	-	Gravelly sand
TP	-	Trial Pit
UCS	-	Unconfined Compressive Strength
USCS	-	Unified Soil Classification System

1.0 INTRODUCTION

At the request of **M/s Fichtner Water & Transportation**, Epinex Engineering Services Ltd. conducted geotechnical investigations for the proposed Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment (IPILC).

The exercise, carried out in the months of April, May and June 2018 was intended to aid in the evaluation of the suitability of the in-situ strata in terms of the soils strata's bearing capacity and related soil parameters. This information will be utilized in appropriate foundation and embankment designs for the proposed construction.

In this report, the key outputs of the investigations and a documentation of the field and laboratory activities carried out, major findings and the recommendations are detailed.

1.1 Scope of Work

The scope of field work for the geotechnical investigations as per the Client's requirement was carried out at the locations: Karuma, Kamdini, Minakulu, Bobi, Palenga, Koro Abili and Gulu, all in northern Uganda. Laboratory work was carried out at the Epinex engineering Services' home office in Kampala.

The scope of work for the geotechnical investigations as per the Client's requirement was:

1. The fieldwork included the following:

   i. Rotary drilling of boreholes as follows:

- Karuma Intake Site…….2No. boreholes each to 15.0m depth,
- Access to Karuma Intake site…2No. boreholes each to 5.0m depth,
- Karuma WTP, Reservoir, Main Pump Station…5No. boreholes each to 15.0m depth,
- 6No. boreholes each to 10.0m depth at locations for 6No. water storage tanks at towns from Karuma to Gulu that include: Karuma, Kamdini, Minakulu, Bobi (1No. Pump station and 1No. Reservoir), Koro Abili; and
- Gulu (New Customs Corner – Layibi)….2No. boreholes to 15.0m depth;

ii. Conducting Standard Penetration Tests (SPTs) and obtaining disturbed samples in each borehole at 1.5m depth intervals;

iii. Retrieving undisturbed samples, 2Nos. in each borehole where the strata is cohesive;

iv. Hand auguring conducted in the pits to 5.0 m depth (or to refusal depth) and disturbed samples obtained at every 1.0 m depth intervals;

v. Excavation of trial pits (1No. for every 2km along Karuma – Gulu pipeline route – LHS) to a maximum depth of 3.0m, including obtaining disturbed samples at 1.5m depth intervals and backfilling of trial pits after the tests.
Dynamic Cone Penetrometer investigations were also undertaken in the trial pits at 1.0m depth intervals; and

vi. Determination and monitoring of the ground water level for 24 hours in each borehole and trial pit, where encountered.

2. Laboratory tests on the disturbed and undisturbed samples included:

i. Particle size distribution / Sieve analysis
ii. Classification (Unified Soil Classification System)
ii. Natural Moisture content determination
iii. Atterberg limits
iv. Triaxial tests parameters
v. Shear strength parameters
vi. Oedometer consolidation
vii. pH, Sulphates and Chlorides on Soils and Water Samples

3. Reporting
The geotechnical investigation report includes the following:

- Allowable soil bearing capacity at specific depths in the boreholes
- Ground water level
- Shear strength parameters
- Triaxial strength parameters

- Predicted settlement at depths where undisturbed samples were obtained
- Site sub-surface geology

A site plan indicating borehole positions at the intake and water treatment sites is provided in **Appendix 1a.**

1.2 Structure of the report

The report is structured in the following chapters:

Chapter 1: Introduction

Chapter 2: Project and Site Description

Chapter 3: Methodology for Field and Laboratory Work

Chapter 4: Presentation and Discussion of Field and Laboratory results

Chapter 5: Conclusions and Recommendations

APPENDICES

APPENDIX 1: FIGURES

Figure 1a: Site Map indicating Boreholes Locations at the Karuma Intake & Water Treatment Sites

Figure 1b: Simplified Geology Map of Uganda

Figure 1c: Seismic Map of Uganda

APPENDIX 2: FIELD FINDINGS AND LABORATORY TESTS RESULTS

Appendix 2a: Photographic Representation of Geotechnical Work

Appendix 2b: Borehole Logs, Hand Augers Logs & Water Table Depths

Appendix 2c: Soil Index Properties

Appendix 2d: Bearing Capacity based on SPT – N Values

Appendix 2e: Shear Resistance in Shear Box

Appendix 2f: Tri-axial Strength Test

Appendix 2g: Unconfined Compressive Strength

Appendix 2h: Dynamic Cone Penetrometer Results Sheets for Trial Pits

Appendix 2i: Consolidation Test Results

Appendix 2j: Compaction Tests Results

Appendix 2k: Chemical Test Results on Soils & Water Samples

2.0 SITE DESCRIPTION

2.1 Site location, Nature and Current Land use

Karuma intake and water treatment site is located in Kiryandongo district in the vicinity of Karuma Village and Murchison. The towns en-route the proposed Karuma – Gulu water project lie within Kiryandongo, Oyam and Gulu districts.

By the time of geotechnical investigations, the intake site was characterized by thick bushes which in some areas, grew over rocky outcrops. The water treatment site was found to be filled with riprap from the Nile River during the time of preparation for Karuma dam construction works; to depths ranging from 3.0m – 5.0m in some cases.

The proposed sites for water reservoirs at towns from Karuma to Gulu were completely new sites except at Kamdini, Minakulu and New Customs Corner where there existed reservoirs which were deemed insufficient for Gulu town water supply requirements.

2.2 Tectonics and Seismology

The site is located on a fairly stable geological unit. However, numerous faults exist within the country and tremors due to earthquakes do occur.

The site area is located within the shield area, but only Approx. 50 – 100 km from the western rift and about 70 km south of the Aswa Fault Zone. It is therefore susceptible to the potential effect of major tectonic features of regional scale.

As per Appendix 1c the site is in the main, located in Zone 2 of the Seismic Zoning of Uganda, implying a moderate (Earthquake hazards are not very high in the project area and not negligible either) likelihood of earthquake occurrence in the area. (Seismic Code of Practice for Structural designs; Uganda National Bureau of Standards, First Edition: June 2003).

2.3 Topography

Topographically, the site is predominantly near flat terrain giving rise to peneplain topography. Small raised grounds forming hummocks and ridges are also noticed at different locations, giving rise to rolling topography.

2.4 Geology

Broadly the geological set up of Karuma Intake and Water treatment sites Project area can be subdivided into two categories: overburden and bedrock.

2.5 Climate and Vegetation

The climate of the project area comprises dry and wet seasons with rainfall distributed in two wet seasons, namely: March to June and August to November. Average annual rainfall received is 1500 mm.

The project area has a bimodal rainfall pattern with a short dry spelt in July and one long dry season from late November to early March. Mean monthly rainfall ranges from 14 mm in January to 230 mm in August. The micro-climate of the area is hot and humid with an average relative humidity of 60%, mean maximum temperature of 29°C, mean minimum temperature of 22°C and wind speeds of 8 kmph.

3.0 METHODOLOGY FOR FIELD AND LABORATORY WORK

3.1 Field Investigations

Field investigations were carried out in accordance with BS 5930:1981 ‘‘Code of Practice for Site Investigations” and in association with Eurocode 7: “Geotechnical design Part 1”: General rules: BS EN 1997-1:2004 as described in this chapter.

3.1.1 Rotary Boring

A total of 17No. geotechnical investigations boreholes were drilled using a rotary drilling rig as follows:

- Karuma Intake Site…….2No. boreholes each to 15.0m depth,
- Access to Karuma Intake site…2No. boreholes each to 5.0m depth,
- Karuma WTP, Reservoir, Main Pump Station…5No. boreholes each to 15.0m depth,
- 6No. boreholes each to 10.0m depth at locations for 6No. reservoir tanks at towns from Karuma to Gulu that include: Karuma, Kamdini, Minakulu, Bobi (1No. Pump station and 1No. Reservoir), Koro Abili; and
- Gulu (New Customs Corner – Layibi)….2No. boreholes to 15.0m depth;

The main auger set-up comprised a continuous helix of blades on a central shaft, which rotated into the ground to remove materials and permit access for sampling.

Table 1.0 presents coordinates that indicate the locations for the boreholes.

Table 1.0: Locations of Boreholes Investigated

S.No.	BH Label	Coordinates (UTM 36N)	
		X (Easting)	Y (Northing)
1	BH1 - Karuma Intake	418994	248835
2	BH2 - Karuma Intake	419030	248845
3	BH1 - Access Road to Karuma Intake	419024	248949
4	BH2 - Access Road to Karuma Intake	418879	249007
5	Clear Water Tank (Reservoir Pumping Station) location - BH	418971	248869
6	Filter Wash Water/ Mineralisation/Chlorination dry chamber	418920	248921
7	Buffer Filter wash water	418971	248965
8	Filtration	418928	248947
9	Coagulation / flocculation	418934	248968
10	Karuma Reservoir	416709	245632
11	Kamdini tank reservoir - BH	426207	248746
12	Minakulu tank reservoir - BH	431340	270708
13	Bobi pump station - BH	428493	280441
14	Bobi reservoir - BH	428545	282426
15	Koro Abili reservoir - BH	423881	298097
16	New Customs Corner Tank - BH1	420217	305816
17	New Customs Corner Tank - BH2	420240	305859

3.1.2 Standard Penetration Tests

The Standard Penetration Test (SPT) which is a dynamic in-situ test used to determine the comparative strengths of underlying soils strata based on established penetration N-values was performed in all the boreholes. The tests were conducted at 1.5m depth intervals using a standard split-barrel in accordance with BS 1377:Part9:1990. The N-values obtained from this test were used in the computation of soils' allowable bearing capacity based on empirical relationships evolved by Terzaghi & peck (1948). In addition, the test was used to provide an indication of the density and consistency of the different soil layers encountered. During the exercise, a mechanism comprising a split spoon sampler of an internal diameter of 150mm was attached to SPT rods to reach the required depths. The complete assembly was driven into the ground by blows from a 65kg hammer falling freely through a height of 760mm. The blows for the first 150mm penetration were regarded as sitting blows, hence discarded. The blows for the subsequent 300mm in two sequences of 150mm were recorded and computed to derive N-values at various depths.

3.1.3 Hand Augering

Hand augering was manually carried out to an average depth of 4.5m and to shallower depths where the strata were found to be very stiff / hard.

3.1.4 Trial Pitting

Trial pitting was carried out at a longitudinal interval of 1trial pit every 2km stretch; starting from Karuma – Gulu Highway on the left hand side of the highway at the location of access to the water treatment plant.

3.1.5 Strata Sampling

During the process of undertaking SPT tests, sampling of disturbed soil samples in the boreholes was carried out using the split sampler (D - 35 samples) at 1.5m depth intervals starting at the existing ground level. Undisturbed samples were recovered at depths were relatively cohesive strata was encountered. Rock cores and cobbles were recovered at the intake and water treatment sites.

Sampling from Hand augers and trial pits was undertaken at 1.5m depth intervals.

The strata recovered from the sites were visually inspected, identified, labeled and taken to the laboratory for testing. During borehole drilling and hand augering, profiling and logging were undertaken for each investigation location as per the logs in **Appendix 2b.**

3.1.6 Ground Water Table

The standard practice of determining water table was adopted whereby in the event that ground water was encountered in a borehole, hand auger location or trial pit, the investigation location was left covered. The water level was allowed to stabilize for about 24 hours after which the actual level of the water table was measured using a tape measure.

3.2 Laboratory Testing

Laboratory testing was carried out on the samples obtained from the field to identify their physical properties, and establish parameters for predicting their strength characteristics. The tests were conducted according to the following standard methods:

Name of Test	Standard Test Method	Sample Status
Sieve Analysis	BS 1377: Part 2: 1990	Disturbed
Classification	BS 1377: Part 2: 1990	“
Natural Moisture Content	BS 1377: Part 2: 1990	“
Atterberg Limits that include:		
• Liquid Limit	BS 1377: Part 2: 1990	“
• Plastic Limit	BS 1377: Part 2: 1990	“
• Plasticity Index	BS 1377: Part 2: 1990	“
Shear Strength Tests	BS 1377: Part 7: 1990	Undisturbed
Triaxial tests parameters	BS 1377: 1990	“
Unconfined Compressive Strength (Soils Samples)	BS 1924: Part 2: 1990	“
Unconfined Compressive Strength (Rock Cores)	ASTM D 7012-07	Rock Cores
Oedometer Consolidation Tests	BS 1377: Part 5: 1990	“
pH, Sulphates and Chlorides	BS 1377: Part3: 1990	Disturbed

3.2.1 Sieve Analysis

The standard method of wet sieving which conforms to BS 1377: Part 2: 1990 was adopted. Representative specimens were taken from the samples and oven dried at temperatures between 105^{o} and 110^{o}C for 24 hours. The dried soils were later washed through a 0.075mm BS test sieve in accordance with the test method. The retained fractions were again oven-dried for 24 hours at the same temperature and then sieved through a nest of BS test sieves in a descending order of aperture sizes, using a mechanical sieve shaker. The fractions retained on each sieve were weighed and the proportions of the original samples passing given sieves were determined.

3.2.2 Natural Moisture Content

The test was carried out in accordance with BS 1377: Part 2: 1990. Representative specimens were obtained from the samples and their net weights taken. The specimens were then oven dried at temperatures between 105^{o}C and 110^{o}C for 24 hours, after which the dry weights of the specimens were taken. The ratio of moisture loss (wet mass – dry mass) to the mass of the dried soils specimens expressed as a percentage was taken as the moisture content of the specimen.

3.2.3 Atterberg Limits

3.2.3.1 Liquid Limit

Liquid limit tests were carried out using the BS cone penetrometer in accordance with BS 1377: Part 2: 1990. A BS cone penetrometer fitted with an automatic timing device that ensures 5 second penetration under an 80gm load was used. Oven-dried representative samples were ground in a mortar and sieved through a 0.425 mm BS test sieve. 200g of each of the samples passing the 0.425 mm BS test sieve were mixed thoroughly with distilled water and thereafter the water was allowed to permeate the samples overnight in an air tight container. The soils specimens were then remixed the following day with sufficient water to achieve two penetrations in the range between 15mm and 25mm. After each penetration the respective moisture contents of the specimens were determined. A moisture content penetration curve was drawn for each of the specimens from which the moisture content at 20mm penetration was taken as the liquid limit.

3.2.3.2 Plastic Limit

Plastic limit tests were carried out in accordance with BS 1377: Part 2: 1990. The samples used for the tests were prepared in the same manner as those for the liquid limit tests. The test specimens were first rolled into balls of soil pastes between the hands and then into threads between the palm and a glass plate. The plastic limits were taken as the moisture contents at which the threads develop transverse cracks when they were about 3mm diameter.

3.2.3.3 Plasticity Index (PI)

The plasticity Index was determined in conformity with BS 1377: Part 2: 1990. The plasticity index is the numerical difference between the LL and PL. PI = LL – PL.
A summary of the results of the soil index property tests is attached in **Appendix 2c.**

3.2.4 Shear Strength Tests

Direct Shear tests were performed on undisturbed samples in conformity with BS 1377: Part 7: 1990. Three specimens of sizes 60x60x20mm were prepared. The first specimen was given a fixed normal stress close to the respective overburden pressure and was sheared along its horizontal plane through its mid-depth to failure.

The same was done on the other two specimens but this time the fixed normal stresses were successively higher. The failure points were noted. A plot was made between the normal stress as the absicca and the shear stress as the ordinate. The slope of the graph was the angle of internal friction Ø and the intercept was the cohesion cu. Details of results are as indicated in **Appendix 2e.**

3.2.5 Triaxial Strength Tests (Un-drained Shear Strength Test)

The test was conducted on fine grained homogeneous soils, and involved determination of undrained shear strength, cohesion and angle of internal friction of soil specimens of cohesive soil strata when subjected to a constant confining pressure and to a strain controlled axial loading, when no change in total moisture content is allowed. It was essentially carried out to determine the shear strength parameters of the soil samples in terms of total stresses i.e. the angle of shear resistance and the cohesion. These values were then used to calculate the bearing capacity of a soil. The tests were undertaken on a set of three similar specimens subject to different confining pressures. The test procedure involved extruding soil samples from core cutters into the sampling tubes in undisturbed state, while protecting the samples from moisture loss. From the sampling tubes, the samples were driven into the 38mm diameter moulds, trimmed and removed. The length Lo, diameter and mass were measured to determine the bulk density. The specimen to be tested was first placed between end caps in the membrane quickly to prevent loss of moisture and sealed. The specimen was then centrally placed on the base of the tri-axial cell. The piston was allowed to slide down slowly until contact was made with the bearing surface. The cell was filled with water, to displace all the air and the water pressure noticed to rise and be equal to the overburden pressure. The loading ring was set to read zero as well as the axial deformation ring. The machine was switched on and force readings taken for every after 0.5mm of deformation.

For each specimen, the following parameters were determined:

- Axial force, P = reading on force measuring device * ring constant;
- Strain, e = change in length/original length;
- Initial cross sectional area, Ao;
- Area, A = Ao / (1-e); and the
- Deviator stress, (δ1-δ3) = 1000 P/A (Where P is the Force and A is the Area).

The values at failure were tabulated, and a graph of $(\delta_1 - \delta_3)/2$ against $(\delta_1 + \delta_3)/2$ plotted to determine the Cohesion (C) and Angle of friction (Φ); Where δ_1 is the deviator stress minus cell pressure and, δ_3 is the cell pressure. Details of results are as indicated in **Appendix 2f.**

3.2.6 Unconfined Compressive Strength

3.2.6.1 UCS for Soils Samples

To perform the unconfined compression test on the undisturbed samples, a sample was extruded from the sampling tube. A cylindrical sample of soil was trimmed such that the ends were reasonably smooth and the length-to-diameter ratio was on the order of two; where feasible. The soil sample was then placed in a loading frame on a metal plate; by turning a crank, the level of the bottom plate being raised.

The top of the soil sample was restrained by the top plate, which was attached to a calibrated proving ring. As the bottom plate was raised, an axial load was applied to the sample. The crank was turned at a specified rate so that there was a constant strain rate. The load was gradually increased to shear the sample, and readings were taken periodically of the force applied to the sample and the resulting deformation. The loading was continued until the soil developed an obvious shearing plane or the deformations became excessive.

The measured data were used to determine the strength of the soil specimen and the stress-strain characteristics. Finally, the sample was oven dried to determine its water content. The maximum load per unit area was taken to be the unconfined compressive strength, q_u.

In the unconfined compression test, it was assumed that no pore water was lost from the sample during set-up or during the shearing process. A saturated sample thus remained saturated during the test with no change in the sample volume, water content, or void ratio.

More significantly, the sample was held together by an effective confining stress that resulted from negative pore water pressures (generated by menisci forming between particles on the sample surface). Pore pressures were not measured in an unconfined compression test; consequently, the effective stress was undetermined. Hence, the undrained shear strength measured in an unconfined test was expressed in terms of the total stress. Detailed results are as indicated in **Appendix 2g.**

3.2.6.2 UCS for Rock Core Samples

The rock core specimen shall be tested at moisture content close to field condition as possible. The Length / Diameter ratio was preferably kept to be 2 to 3. The diameter of the specimen was noted to be greater than 10 times the diameter of largest grain size. The diameter of the samples was 100mm.

The Specimen was prepared in such a manner that the cylindrical surface was kept smooth and free from abrupt and irregularities. The surfaces of the test specimen and the two bearing discs were cleaned thereafter; the specimen was placed on the lower disc.

The axis of the specimen was carefully aligned with the center of thrust of the spherical seat. A load was continuously applied at a constant stress rate within the limits of 0.5 MPa/s to 1.0 MPa/s. The maximum load on the specimen at failure was recorded in N within 1% accuracy.

The UCS of the specimen was calculated by dividing the maximum load carried by the specimen during the test, by the average cross sectional area. Detailed results are as indicated in **Appendix 2g.**

3.2.7 Oedometer Consolidation Tests

The tests were performed in accordance with BS 1377: Part 5: 1990. A specimen of 76mm diameter and 20mm height was cut from the undisturbed sample and placed in the floating ring of the oedometer cell. Soaking of the sample was done after which the sample was loaded and readings of compression were noted at regular time intervals 0 min, ½, 1, 2, 4, 8,15,30, 1 h…..24h.

Successively higher loads were applied each after 24 hours until 7 cycles were completed. In the meantime the specific gravity of the same sample was determined. A plot was made between the cell pressure and the void ratio from which the coefficient of volume compressibility (m_v) and the preconsolidation pressure (p_c) were determined. Detailed results are as indicated in **Appendix 2i.**

3.2.8 Standard Compaction Tests (BS Light)

Five representative samples each weighing 2.5kg of material passing BS 20mm test sieve were prepared. Each specimen was thoroughly mixed with different amounts of water to give a suitable range of moisture contents i.e. two values from either side of the optimum moisture content. The five specimens were allowed to cure for at least four hours. The weight of the mould whose volume is 944m^3, together with the attached base plate was determined to the nearest 1g and taken to be M1. The extension collar was attached to the mould and the mould placed on the concrete floor. Each specimen was compacted in the mould in three layers giving each layer 25 blows (free fall) of a 2.5kg rammer. The collar was removed and excess soil removed using a straight edge so as to remain with a sample that only flushes with the mould edge. The soil sample and the mould with the attached base plate were weighed to the nearest 1g (M2). The compacted specimen was extruded from the mould and a representative portion of about 300g was used to determine the moisture content (W) at 105 ± 5°C for 24 hours. The bulk density and dry densities of each of the compacted samples was calculated. The dry densities versus moisture contents of the five specimens were plotted; a curve of best fit was drawn from which the Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) were read off at the peak of the curves. Detailed results are as indicated in **Appendix 2j.**

3.2.9 pH, Sulphates and Chlorides

3.2.9.1 Sulphate Test

The test was performed in accordance with BS: 1377: Part 3: 1990. The gravimetric method was used. A barium chloride solution was added to the water and the precipitate of barium sulphate was collected, dried and weighed. The sulphate content was then calculated in accordance with the analytical procedures – BS 1377: Part 3: 1990 (Acid – soluble sulphate content of the soil) that involved a consideration of the mass of the water used in the analysis and the mass of barium sulphate precipitated. Results are presented in **Appendix 2k**.

3.2.9.2 Chloride Test

This test was conducted in accordance with BS: 1377: Part 3: 1990. 5g of material passing 0.150mm BS test sieve was put in a beaker of 500ml volume. 50ml of distilled water was added followed by 15ml of concentrated nitric acid. The mixture was then heated to near boiling point, cooled and filtered through coarse graded filter paper. The residue was washed with distilled water and all the filtrate collected. Silver nitrate was then added to the filtrate from a burette until all the chlorides were precipitate. Titration was done with standard potassium thiocynate using ferric alum as an indicator. 3,5-5 trimethylhexan-l-ol was used to coagulate the precipitate. Results are presented in **Appendix 2k**.

3.2.9.3 pH Test on Soil Samples

Alkalinity / acidity were expressed as pH. The test was performed in accordance with BS: 1377: Part 3: 1990 and the electrometric method of pH determination were adopted. For every specimen, 10g of soil sample was dissolved in distilled water sample and placed in 100ml beaker and stirred for a few minutes then covered with a cover glass and allowed to stand for 8hours. Initially the pH meter was calibrated using a standard buffer solution. The electrode was then washed with distilled water and immersed in the dissolved sample. The corresponding readings were then taken with brief stirring between each reading. Results are presented in **Appendix 2k**.

3.2.9.4 Chemical Tests on Water Samples

Chemical tests on ground water were carried out in accordance with BS: 1377: Part 3: 1990. Ground water samples were filtered and analyzed gravimetrically by precipitating the sulphates with $Bacl_2$ and reported in mg/l (parts per million).

Tests to ascertain the chloride content in water samples were performed titrimetrically with a standard solution of potassium thiocyanate with ferric alum indicator solution (BS: 1377: Part 3: Section 7:1990). The pH value Acidity / Alkalinity in water samples was determined electrometrically in accordance with BS 1377: Part 3: Section 9: 1990. Results are presented in **Appendix 2k**.

4.0 PRESENTATION AND DISCUSSION OF FIELD AND LABORATORY RESULTS

4.1 Field Findings

Based on visual inspection, the in-situ soils strata at the intake site were generally granite rocks from a depth of 4.5m. The strata from the intake and water treatment sites were to a large extent; non-cohesive.

The strata from the boreholes at towns en-route from Karuma to Gulu; and from the hand auger locations and trial pits were of varied composition and are detailed in the logs: **Appendix 2b.**

4.1.1 Photographic Presentation

A photographic representation of field work is provided in **Appendix 2a**. However, below are some photos presenting site investigation works.

Plate 1: Rotary Drilling ***Plate 2: Hand Augering***

Plates 1&2: Geotechnical Investigation Works at the Sites

4.1.2 Ground Water Table

Ground water table was encountered at the boreholes investigation locations as per Table 2.0.

Table 2.0: Depths of Water Table in Boreholes

No.	BH Label	Water Table (m) From Existing GL
1	BH1 - Karuma Intake	1.2
2	BH2 - Karuma Intake	1.0
3	BH1 - Access Road to Karuma Intake	Not encountered
4	BH2 - Access Road to Karuma Intake	"
5	Clear Water Tank (Reservoir Pumping Station) location - BH	2.0
6	Filter Wash Water/ Mineralisation/Chlorination dry chamber	3.5
7	Buffer Filter wash water	4.0
8	Filtration	0.8
9	Coagulation / flocculation	1.0
10	Karuma Reservoir	Not encountered
11	Kamdini tank reservoir - BH	"
12	Minakulu tank reservoir - BH	"
13	Bobi pump station - BH	"
14	Bobi reservoir - BH	"
15	Koro Abili reservoir - BH	"
16	New Customs Corner Tank - BH1	"
17	New Customs Corner Tank - BH2	"

Ground water table at the **hand auger locations** was as high as 0.9m (Myene swamp CH 13+000, 13+500; Ngaato CH 16+200 and Koro Abili CH 55+050) above the existing ground level. In some other swamp locations, ground water table was found at the Existing Ground Level.

In the **trial pits**, ground water was only registered in the trial pits that were investigated at: CH 6+050 at 3.0m depth, CH 39+000 at 2.5m depth, CH 65+000 at 2.3m depth and at CH 69+000 at 2.0m depth.

4.1.3 Standard Penetration Tests

Standard penetration tests were carried out where penetration could be achieved and were not feasible for very hard strata. In circumstance where rocky strata were encountered, rock core samples were extracted. These were notably obtained in the lower depths of the intake and water treatment sites.

The SPT- N values from the intake and water treatment sites ranged from 12 (Filtration 1.50-1.95m depth) to 63 (Filter Wash Water 15.00-15.45m depth; and Coagulation/ Flocculation 10.50-10.95m depth).

N- values for Karuma Reservoir and towns en-route from Karuma - Gulu ranged from 7 (Minakulu Reservoir 6.006.45m depth) to 63 (Kamdini Tank Reservoir 4.50-4.95m depth). Details are presented in **Appendix 2d**.

4.2 Laboratory Findings

4.2.1 Classification Test Results

Laboratory classification tests were carried out for each of the soil samples recovered from the site. A summary of the index properties is presented in Table 3.0.

Table 3.0: Summary of Soil Index Properties for Sites Strata

Location	Range of Index Properties			Range of NMC (%)
	LL (%)	PL (%)	PI (%)	
Karuma Intake	28 - 41	NP - 22	NP - 19	10 - 15
Access to Karuma Intake	38 - 50	NP	-	4 - 23
Karuma Water Treatment	23 - 59	NP - 29	Nil - 31	Nil - 31
Towns en-route from Karuma - Gulu	31 - 57	NP - 26	Nil - 38	1 - 52

4.2.2 Evaluation of the Soil Bearing Capacity

4.2.2.1 Bearing Capacity Based on SPT-N Values

The maximum pressures the soils from the site are capable of resisting have been estimated from the laboratory and field N-values based on empirical relations. A summary of the range of allowable bearing capacities is presented in **Table 4.0** (See details in **Appendix 2d**). For purposes of computing the soils' bearing capacity, the following assumptions were made:

- The maximum allowable settlement in non-cohesive soils is 25mm;
- The design N-values are derived from the statistical average of all values within a depth zone equal to the footing width below the founding depth; and
- The foundation base assumed is a 2m square footing.

Table 4.0: Range of Bearing Capacities of the Sub Soils Based on SPT – N Values

Site Label	Allowable bearing capacity (kPa)	
	From	To
Karuma Intake	175 (BH1; 3.00 - 3.45m)	565 (BH2; 3.00-3.45m)
Access to Karuma Intake	285 (BH1; 1.50 - 1.95m)	430 (BH2; 4.50-4.95m)
Karuma Water Treatment	105 (Filtration; 1.50 - 3.45m)	>700 (Filter Wash Water; 13.50-15.45m & Coagulation 9.00 - 10.95m)
Karuma Reservoir	213 (12.00 - 12.45m)	>700 (4.50-4.95m)
Kamdini Reservoir	191 (9.00 - 9.45m)	>700 (3.00-4.95m)
Minakulu Reservoir	79 (6.00 - 6.45m)	>700 (1.50-1.95m)
Bobi Pump Station	426 (7.50 - 7.95m)	>700 (6.00-6.45m)
Bobi Reservoir	168 (7.50 - 9.45m)	280 (1.50-1.95m)
Koro Abili Reservoir	168 (6.00 - 6.45m)	575 (10.50-10.95m)
New Customs Corner Tank	101 (BH1; 7.50 - 7.95m)	565 (BH1; 3.00-3.45m)

4.2.2.2 Shear Box Test

The maximum pressures the soils are capable of resisting have been estimated from the shear strength parameters from the laboratory tests on undisturbed samples obtained from the boreholes at depths specified in **Table 5.0.** A 1.0m square footing was assumed along with the following additional considerations:

- Terzaghi's bearing capacity equations are valid for laboratory test results,
- Failure mechanism is by general shear;
- The factor of safety against shear failure is 3.0; the evaluations are presented in Tables of **Appendix 2e.**

Table 5.0: Range of Allowable Bearing Capacities based on Shear Strength

Investigation Location	**Allowable bearing capacity (kPa)**	
	From	**To**
a) Boreholes (General Shear Failure)		
Karuma Intake	Strata was non-cohesive	
Water Treatment site	505 (Filter wash- 6.0m)	797 (Buffer filter -7.50m)
Towns en-route Karuma - Gulu	397 (Koro Abili – 1.50m)	913 (Kamdini at 9.0m)
b) Hand Augers (Local Shear Failure)	177 (Alenyi Swamp CH: 9+362 at 3.0m)	534 (Agada Swamp CH: 25+000 at 3.0m)

4.2.2.3 Triaxial Tests

Table 6.0 presents a summary of Triaxial test results performed on undisturbed soils samples. Detailed results are presented in **Appendix 2f.**

Table 6.0: Summary of Allowable Bearing Capacities based on Triaxial Tests

Investigation Location	**Allowable bearing capacity (kPa)**	
	From	**To**
a) Boreholes (General Shear Failure)		
Karuma Intake	Strata was non-cohesive	
Water Treatment site	741 (Filter wash- 6.0m)	>700 (Buffer filter -7.50m)
Towns en-route Karuma - Gulu	429 (Koro Abili – 1.50m)	>700 (Kamdini at 9.0m)
b) Hand Augers (Local Shear Failure)	190 (Tochi Swamp CH: 47+100 at 3.0m)	611 (Atek Swamp CH: 22+200 at 3.0m)

4.2.3 Unconfined Compressive Strength Tests

4.2.3.1 UCS Tests Results on Undisturbed Soils Samples

i) Boreholes Samples

Table 7.0 presents a summary of unconfined compressive strength performed on undisturbed soils samples obtained from boreholes. Detailed results are presented in **Appendix 2g.**

Table 7.0: Summary Results for Unconfined Compressive Strength on U- Samples

BH Label	Coordinates (UTM 36N)		Depth (m)	Breaking Load (kN)	Unconfined Compressive Strength (MPa)
	X (Easting)	Y (Northing)			
Filter Wash Water	418920	248921	6.0	1.18	0.150
Buffer Filter Wash	418971	248965	7.5	1.33	0.169
Filtration	418928	248947	9.0	1.14	0.145
Karuma Reservoir	416709	245632	7.5	0.74	0.094
Kamdini Reservoir	426207	248746	9.0	0.47	0.060
Minakulu Reservoir	431340	270708	3.0	1.58	0.201
Bobi Pump Station	428493	280441	3.0	1.19	0.151
Bobi Reservoir	428545	282426	7.5	0.38	0.048
Koro Abili Reservoir - BH1	423881	298097	1.5	0.39	0.050
			6.0	0.23	0.029
New Customs Corner - BH1	420217	305816	7.5	0.17	0.022
New Customs Corner - BH2	420240	305859	3.0	0.21	0.027
			4.5	0.34	0.043

ii) Hand Augers Samples

Unconfined strength of the U- samples (all sampled at 3.0m depth) obtained from the hand auger locations ranged from 0.05MPa achieved at Agada swamp CH 25+000 to 0.402MPa registered at Ngaato swamp CH 16+200.

4.2.3.2 UCS Tests Results on Rock Core Samples

The tests performed in accordance with ASTM D 7012-07, were conducted on the core specimens that had been trimmed using a mechanical grinder to secure a flat and smooth surface at the ends. The trimming was performed to satisfy the length-to-diameter ratio ranging from 2 – 2.5, except for specimens obtained from the boreholes at the Karuma intake and access to the Intake site which had their length-to-diameter ratio ranging from 1.20 to 1.50 since some of them were moderately weathered. Results from the unconfined compressive strength tests are presented in **Table 8.0.** Details are presented in **Appendix 2g.**

Table 8.0: Summary Results for Unconfined Compressive Strength Tests on Rock Core Samples

S.No.	BH Label	Depth range	Core Diameter, Ø (mm)	Breaking Load (kN)	Unconfined Compressive Strength (MPa)
01	BH1 - INTAKE	4.50-4.95	100	312.5	39.8
02		*6.00-6.45	100	456.5	58.1
03	BH2 - INTAKE	4.50-4.95	100	380.5	48.4
04		6.00-6.45	100	434.5	55.3
05		*7.50-7.95	100	587.0	74.7
06	BH2 - ACCESS ROAD TO INTAKE SITE	1.50-1.95	100	165.0	21.0
07	CLEAR WATER TANK	3.00-3.45	100	140	17.8
08		4.50-4.95	100	220	28.0
09		6.00-6.45	100	195	24.8
10		7.50-7.95	100	385	49.0
11		9.00 -9.45	100	670	85.3
12	BUFFER FILTER WASH	12.00-12.45	100	945	120
13		13.50 -13.95	100	1120	143

From the above results it can be deduced that the unconfined compressive strength of the rock core samples at the intake site (without considering the access road to intake) ranged from 39.8MPa to 74.7MPa taking on the maximum value at 7.50m in BH2. The clear water tank and buffer filter wash boreholes' core samples had UCS results ranging from 17.8

MPa to 143MPa. The maximum values in this case were achieved in the borehole at the buffer filter wash between 12.00m and 13.95m depths.

4.2.4 Dynamic Cone Penetrometer Tests in Trial Pits

Dynamic Cone Penetrometer tests were carried out in the trial pits at 1.0m depth intervals. However, the tests could not be carried out to the maximum required depth of 3.0m in some trial pits due to hard pan; and in some cases, a high water table.

A hard pan was noted to occur at locations: CHs 9+000, 11+000, 19+000, 37+000. Other locations include: CHs 53+000 and 55+000. At these locations, the allowable bearing capacity was way beyond 700kPa.

The high water table was notably registered in trial pits at: CH 6+050 at 3.0m depth, CH 39+000 at 2.5m depth, CH 65+000 at 2.3m depth and at CH 69+000 at 2.0m depth.

Detailed results for the dynamic cone penetrometer are presented in **Appendix 2h.**

4.2.5 Consolidation Tests Results

4.2.5.1 U- Samples from Boreholes

Parameters used to estimate the magnitude and rate of compressibility of the sub soils were obtained from one dimensional consolidation tests on undisturbed samples. The results obtained are tabulated in **Table 9.0** (Details are attached in **Appendix 2i**).

Table 9.0: Summary of One-dimensional Consolidation Test Results on BHs Samples

Test Location	Depth (m)	Coefficient of Volume Compressibility (Mv) in m²/MN	Range of Mv	Remarks
Filter Wash Water	6.0	0.185	0.1 - 0.3	Medium Compressibility
Buffer Filter Wash	7.5	0.216	0.1 - 0.3	"
Filtration	9.0	0.227	0.1 - 0.3	"
Karuma Reservoir	7.5	0.342	0.3 - 1.5	High Compressibility
Kamdini Reservoir	9.0	0.470	0.3 - 1.5	"
Minakulu Reservoir	3.0	0.236	0.1 - 0.3	Medium Compressibility
Bobi Pump Station	3.0	0.277	0.1 - 0.3	"
Bobi Reservoir	7.5	0.643	0.3 - 1.5	High Compressibility
Koro Abili Reservoir - BH1	1.5	0.384	0.3 - 1.5	"
	6.0	0.572	0.3 - 1.5	"
New Customs Corner - BH1	7.5	0.741	0.3 - 1.5	"
New Customs Corner - BH2	3.0	0.642	0.3 - 1.5	"
	4.5	0.513	0.3 - 1.5	"

The Coefficient of Volume Compressibility was computed using the following formula:

Mv = (δe/δp) x 1000/ (1+e1) m²/MN (Bowles, 1997:401).

From the above remarks, consolidation is generally classified as medium when it ranges from 0.1 - 0.3m²/MN and high when M_v ranges from 0.3 - 1.5 m²/MN.

4.2.5.2 U- Samples from Hand Auger Locations

The Coefficient of Volume Compressibility of the U- samples obtained from the hand auger locations at 3.0m depths ranged from 0.055 (Low compressibility, Atek swamp CH 22+000) to 0.410 (High compressibility, Palenga swamp CH 45+000). Detailed results are presented in **Appendix 2i.**

4.2.6 Compaction Tests Results (BS Light)

CBR values for boreholes samples obtained from 1.50 – 3.45m depth from compaction tests ranged from 6% (New Customs Corner – BH2) to 18% (Clear water tank).

CBR values for the samples from hand augering exercise at a depth of 3.0m ranged from 4% (Tochi swamp CH 47+200) to 16% (Myene swamp CH13+500 & Layibi swamp CH 57+050).

Trial pits samples were characterized by CBR values ranging from 8% (CH 59+000) to 20% (CHs 15+000, 19+000, 21+000, 55+000 and 57+000). Detailed results are presented in **Appendix 2j.**

4.2.7 Chemical Tests

4.2.7.1 Chemical Tests on Soils Samples

Chemical tests on soil samples retrieved from the **boreholes** yielded pH values ranging from **6.45 to 6.64**. The **hand auger** soil samples posted pH values ranging from **6.45 to 6.78.** All the samples obtained had negligible quantities of chlorides and sulphates that may not have any adverse effect on the construction materials likely to be used **(Appendix 2k)**.

4.2.7.2 Chemical Tests on Water Samples

i) Water Samples from Boreholes

The water samples from boreholes had pH values ranging from 6.72 to 6.82. Chlorides ranged from 65mg/l to 75mg/l whereas the sulphates ranged from 20mg/l to 40mg/l. All these parameters including the organic matter, colour and odour are within permissible limits as provided for in BS: 1377: Part 3: 1990.

ii) Water Samples from Swamps

Chemical tests on the water samples obtained from the major swamps between Karuma and Gulu posted pH values ranging from 6.62 (Lminlango & Layibi swamps) to 6.80 (Aleny).

Chlorides ranged from 55mg/l (Tochi swamp) to 90mg/l (Koro Abili swamp). Except for the colour and odour which were respectively yellowish and peaty for some swamps samples, all the other parameters that include the chloride and sulphate contents are within permissible limits as provided for in BS: 1377: Part 3: 1990. Detailed results are presented in **Appendix 2k.**

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

i) Geotechnical investigations for the Improvement Programme to the Lining Conditions in Gulu and Small Towns en Route in the Victoria Nile Catchment comprised:

- Rotary Drilling of 17No. boreholes to depths ranging from 5.0m to 15.0m;
- Conducting Standard Penetration Tests (SPTs) and obtaining disturbed samples in each borehole at 1.5m depth intervals, and 2No. undisturbed samples wherever applicable, all for laboratory testing;
- Hand auguring (47No. Locations) was carried out within 16No. major swamps along Karuma – Gulu highway to an average depth of 4.5m (or to refusal depth) and disturbed samples obtained at every 1.5 m depth intervals;
- A total of 36No. trial pits (1No. for every 2km along Karuma – Gulu pipeline route – LHS) were excavated to depths ranging from 0.5m (where a hard pan was encountered) to 3.0m, including obtaining disturbed samples at 1.5m depth (where the strata could be penetrated) intervals and backfilling of trial pits after the tests;
- Dynamic Cone Penetrometer investigations were also undertaken in the trial pits at 1.0m depth intervals (where the strata could be penetrated); and ground water was monitored and recorded after at least 24 hours of investigation.

ii) The soils' consistency varied from firm to hard for the cohesive strata and from loose to very dense for the non-cohesive strata. The specific gravity of the undisturbed soil samples ranged from 2.62 to 2.84.

iii) In terms of seismicity, the site geographically falls within Zone 2 of the Seismic Zoning of Uganda, implying there is a moderate likelihood of earthquake occurrence in the area.

iv) Ground water table was encountered in the boreholes (in which ground water was encountered) at depths ranging from 0.8m (Filtration) to 3.5m (Filter Wash Water).

The water table in the hand auger pits was as high as 0.9m (Myene swamp CH 13+000, 13+500; Ngaato CH 16+200 and Koro Abili CH 55+050) above the existing ground level. In some other swamp locations, ground water table was found at the Existing Ground Level. Investigations at the hand auger points were undertaken during the rainy season.

In the **trial pits**, ground water was only registered in the trial pits that were investigated at: CH 6+050 at 3.0m depth, CH 39+000 at 2.5m depth, CH 65+000 at 2.3m depth and at CH 69+000 at 2.0m depth.

v) The **obtained allowable bearing capacities** from field SPT N-values in the boreholes ranged from 79kPa (Minakulu Reservoir at 6.00m – 6.45m depth) to >700kPa (achieved at certain depths in boreholes at Karuma, Kamdini, Minakulu and Bobi pump station reservoirs – **See Appendix 2d**).

vi) Shear strength results based on **General Shear Failure** on undisturbed samples obtained from **Water treatment site boreholes** ranged from 505kPa (Filter wash- 6.0m) to 797kPa (Buffer filter -7.50m). The values for the towns en-route Karuma – Gulu were in the range of 397kPa (Koro Abili – 1.50m) to 913kPa (Kamdini at 9.0m).

The shear strength for **hand auger** samples based on **Local Shear Failure** ranged from 177kPa (Alenyi Swamp CH: 9+362 at 3.0m) to 534kPa (Agada Swamp CH: 25+000 at 3.0m).

vii) Triaxial compression test results carried out on undisturbed samples obtained from **water treatment site boreholes** ranged from 741kPa (Filter wash- 6.0m) to >700kPa (Buffer filter -7.50m). The values for the towns en-route Karuma –

Gulu were in the range of 429kPa (Koro Abili – 1.50m) to >700kPa (Kamdini at 9.0m).

The Triaxial strength for **hand auger** samples based on **Local Shear Failure** ranged from 190kPa (Tochi Swamp CH: 47+100 at 3.0m) to 611kPa (Atek Swamp CH: 22+200 at 3.0m).

viii) Unconfined compressive strength **on boreholes** samples ranged from 0,022MPa (New Customs Corner reservoir at 7.5m depth) to 0.201MPa (Minakulu Reservoir at 3.0m depth).

The rock core samples were characterized with unconfined compressive strength ranging from 17.8MPa (Clear water tank between 3.00 – 3.45m depth) to 143MPa (Buffer Filter was between 13.50 – 13.95m depth).

Unconfined strength of the U- samples (all sampled at 3.0m depth) obtained from the **hand auger locations** ranged from 0.05MPa achieved at Agada swamp CH 25+000 to 0.402MPa registered at Ngaato swamp CH 16+200.
In general, Tenakaya, Koro Abili and Layibi swamps comprised the highest UCS values in the range 0.181MPa to 0.303MPa.

Based on Dynamic Cone Penetration tests, a hard pan was noted to occur at locations: CHs 9+000, 11+000, 19+000, 37+000. Other locations include: CHs 53+000 and 55+000. At these locations, the allowable bearing capacity was greater than 700kPa.

The high water table was notably registered in trial pits at: CH 6+050 at 3.0m depth, CH 39+000 at 2.5m depth, CH 65+000 at 2.3m depth and at CH 69+000 at 2.0m depth. at these locations, the allowable bearing capacity was generally less than 115kPa.

ix) Consolidation tests performed on the undisturbed samples obtained from boreholes between 3.0m and 9.0m depths revealed that the soils exhibited coefficients of volume compressibility ranging from 0.185m²/MN (Filter Wash

Water at 6.0m depth) to 0.741m²/MN (New Customs Corner BH1 at 7.5m depth). Consolidation is generally classified as medium when it ranges from 0.1 - 0.3m²/MN and high when Mv ranges from 0.3 - 1.5 m²/MN.

x) Standard Compaction (BS Light) posted CBR values for boreholes samples obtained from 1.50 – 3.45m depth from compaction tests ranged from 6% (New Customs Corner – BH2) to 18% (Clear water tank)

CBR values for the samples from hand augering at a depth of 3.0m ranged from 4% (Tochi swamp CH 47+200) to 16% (Myene swamp CH13+500 & Layibi swamp CH 57+050).

Trial pits samples were characterized by CBR values ranging from 8% (CH 59+000) to 20% (CHs 15+000, 19+000, 21+000, 55+000 and 57+000). Detailed results are presented in **Appendix 2j.**

xi) Chemical tests on soil samples retrieved from the boreholes yielded pH values ranging from 6.45 to 6.64. The hand auger soil samples posted pH values ranging from 6.45 to 6.78. All the samples obtained had negligible quantities of chlorides and sulphates that may not have any adverse effect on the construction materials likely to be used (Appendix 2k).

xii) Chemical tests on water samples from boreholes had pH values ranging from 6.72 to 6.82. Chlorides ranged from 65mg/l to 75mg/l whereas the sulphates ranged from 20mg/l to 40mg/l. All these parameters including the organic matter, colour and odour are within permissible limits as provided for in BS: 1377: Part 3: 1990.

xiii) The water samples obtained from the major swamps between Karuma and Gulu posted pH values ranging from 6.62 (Lminlango & Layibi swamps) to 6.80 (Aleny). Chlorides ranged from 55mg/l (Tochi swamp) to 90mg/l (Koro Abili swamp). Except for the colour and odour which were yellowish and peaty respectively for some swamps samples, all the other parameters that include the chloride and sulphate contents are within permissible limits as provided for in BS: 1377: Part 3: 1990.

5.2 Recommendations

i) Designs should be undertaken on the basis of the allowable bearing capacities obtained from field SPT-N values together with a consideration of shear strength, Triaxial strength, unconfined compressive strength; and compressibility characteristics of the soils strata.

ii) In the event that foundations are to be constructed below the ground water table for particular locations, the allowable bearing capacity to be considered in the design should be a half of the obtained allowable bearing capacity; thus catering for the effect of the high water table.

iii) The strata at the proposed sites are within acceptable limits of alkalinity. Therefore no special cement is required to be used during the construction of the foundations. In all cases therefore, readily available Portland cement, 42.5N is recommended for use for the construction works owing to its ability to ensure the achievement of good early strength for concrete. Water proof cement may also be used as necessary.

However since the foundations are likely to be constructed at depths below the ground water level in some cases, rapid hardening cement is recommended to be used for achievement of early strength of concrete for those particular locations.

iv) Appropriate design seismic acceleration values consistent with Contract Technical Specifications and Uganda Seismic Code US319:2003 must be adopted during foundation design due to the high likelihood of earthquake occurrence in the area.

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APPENDIX 1: FIGURES

Appendix 1: Figure 1a

Site Map indicating Boreholes Locations at the Karuma Intake & Water Treatment Sites

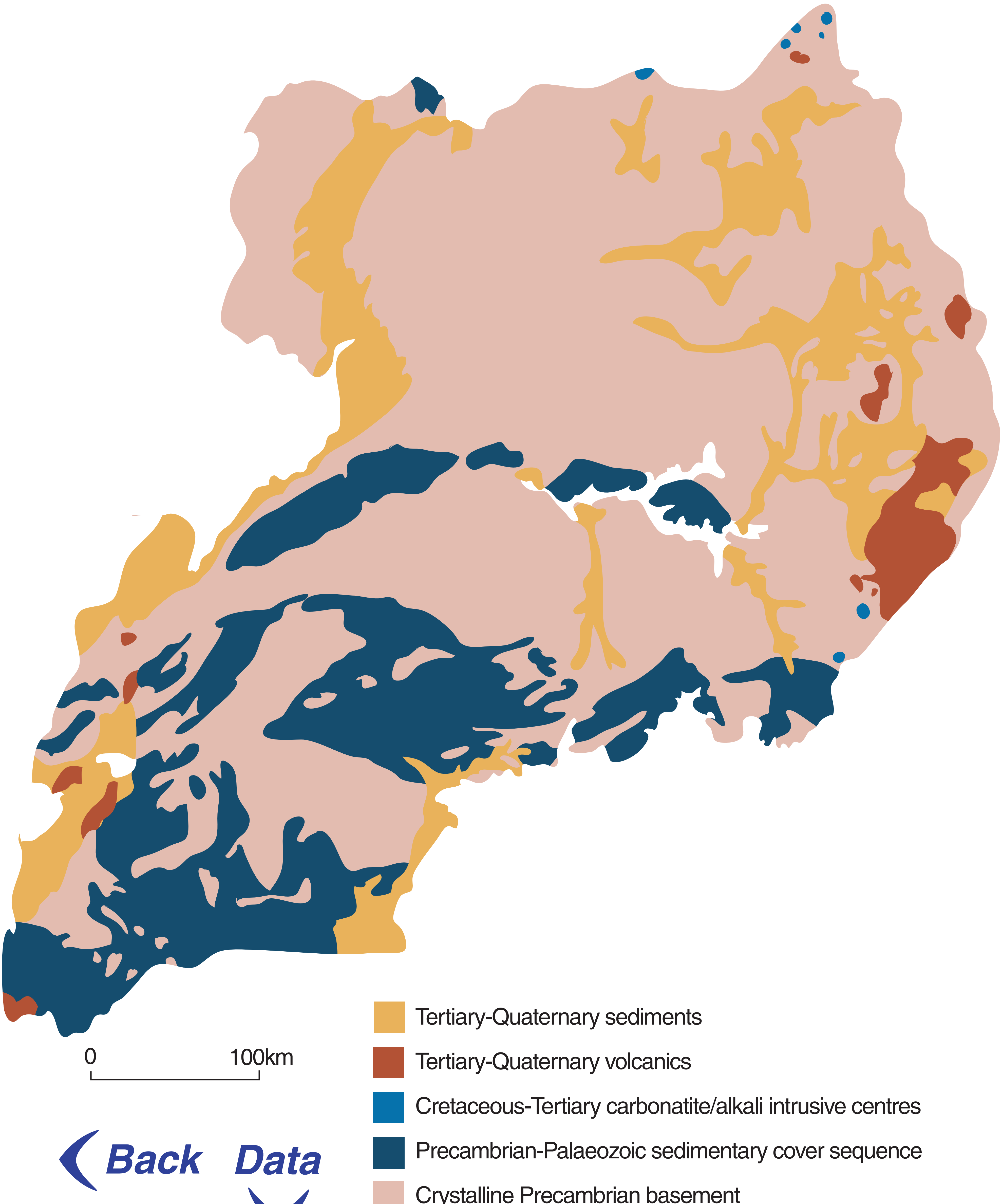
BH2, Access Road
Coagulation
Filtration
Buffer Filter
BH1, Access Road
Filter Wash
BH Clear Water Tank
BH2, Karuma Intake
BH1, Karuma Intake
R. Nile
Google Earth
© 2018 Google
Image © 2018 CNES / Airbus
N
200 m


Karuma
Karuma
BH2, Access Road
BH1, Karuma Intake
BH Clear Water Tank
BH2, Karuma Intake
R. Nile
Karuma Bridge
Karuma Village
Karuma Reservior
Google Earth
© 2018 Google
Image © 2018 CNES / Airbus
N
2 km

Appendix 1: Figure 1b

Simplified Geology Map of Uganda

Simplified Geology of Uganda



Back Data

Extracts from Mining Journal Uganda Supplement April 1996

Economic Geology

Uganda lies within the borders of the African Plate, one of the largest known regions of continental crust that contains Archaean cratons that date to at least 2,500 Ma. The Plate extends through much of eastern and central Africa, and has been modified by subsequent geological events such as high-grade metamorphism along mobile belts, the deposition of several generations of sedimentary cover, granitic and other intrusions, and the development of rift faulting.

Much of Uganda's geology has been studied in broad outline only and detailed work remains to be done. The geochronology is as yet incomplete. Two-thirds of the country is underlain for the most part by Precambrian rocks, comprised of Archaean, and Lower and Middle Proterozoic Groups of varied lithology. Tertiary and Cretaceous carbonatite, syenite and alkaline volcanic rocks are also found, and there are Pleistocene and Recent sediments and volcanics in the Rift Valley.

Archaean

The Archaean shield covers much of the southern half of Uganda, to the east of Lake Victoria, forming an extension of the Tanzanian shield. The shield here is composed chiefly of granites and gneisses. Several gold-bearing greenstone belts, comprising Nyanzian volcanics and overlying Kavirondian sediments, extend into Uganda from Kenya and Tanzania, but appear not to be as well developed as in the neighbouring countries.

The granitic metamorphic rocks in the Ugandan portion of the Tanzanian shield have commonly been described by the term "basement complex". This simplification is being replaced by more specific terms as additional information is gathered. Reconnaissance mapping indicates that much of central Uganda, and perhaps two-thirds of the country as a whole, is underlain by basement complex rocks that are interpreted as being predominantly of sedimentary origin.

The Archaean Nyanzian system comprises a sequence of dominantly mafic volcanic rocks and sediments that form greenstone belts within the basement complex in the east of the country. Also occurring in neighbouring countries, these greenstones are estimated to reach thicknesses of 5,000 m in Tanzania. The Nyanzian greenstones both host precious metals deposits and have the potential for base metals, a feature of the unit being the occurrence of steeply dipping fold axes along an east-west orientation.

Rocks of the Kavirondian system occur in association with the Nyanzian greenstones in eastern Uganda; these comprise conglomerates, coarse arkosic and feldspathic grits and quartzite resting unconformably on the Nyanzian rocks from which they are at least partly derived.

Proterozoic

Uganda's Proterozoic systems require more work on age dating and field mapping to allow better cross-border correlations. Three systems of this geological period have been identified; the Buganda-Toro, Karagwe-Ankolean and Bukoban systems.

The Lower Proterozoic Toro (or Buganda-Toro) system consists mainly of non-calcareous sediments and is found in three areas: along the north shore of Lake Victoria in the east, in the central region and as the core of the Rwenzori mountains in the southwest. A distinguishing feature is that metamorphism is higher in the central and southwestern regions than in eastern Uganda. This system contains the copper-cobalt ores found at Kilembe, and is thus of considerable economic significance to the country.

The Karagwe-Ankolean system lies within the Middle Proterozoic Kibaran Fold Belt that extends southwest from Uganda into Zaire and Zambia. Younger than the Toro system, its sedimentary features reflect shallow-water deposition with argillites, shales and sandstones in a uniform succession. The thinner sandstones and quartzites are lenticular. The rocks are deformed along north-south axes with circular intrusives of porphyritic granites lying at the cores of the anticlines. Resistant quartzite ridges surround the granite intrusives. The economic importance of this system lies in its veins of tin, tungsten and niobium-tantalum that are found around the periphery of the granites.

The Bukoban system is thought to extend across the Proterozoic-Palaeozoic boundary but there are insufficient age dates as yet to be certain. The rocks are of little economic interest. They are hardly deformed and not metamorphosed, consisting mostly of sandstones, quartzite, shales, some dolomitic limestones, red beds, cherts and lava flows.

Palaeozoic To Cainozoic

Small outliers of Karroo system sediments, ranging in age from Upper Carboniferous to Upper Jurassic or possibly Cretaceous, outcrop in a few locations in Uganda. Although this system hosts major coalfields to the south, these outliers represent the northernmost extent of Karroo sediments, and there are no commercial coal resources in Uganda.

Miocene volcanics outcrop in several areas of eastern Uganda, close to the Kenyan border and are denoted topographically by the prominent mountains of southern Karamoja region. Carbonatite ring complexes, possibly as early as Cretaceous and representing the eroded remnants of volcanoes of a similar geological suite, occur in several eastern locations.

Cainozoic rocks are either of sedimentary or volcanic origin and are found in the western Rift Valley adjoining Rwanda and Zaire. The sediments are thick, exceeding 4,000 m in fault-lined basins. Volcanics have been ejected from vents and there are hot springs in the district.

Major Structures

The major structural controls within Uganda include orogenic fold belts and shear zones in the Precambrian, and the processes of formation of the Rift Valley and later volcanic centres, followed by crustal warping during the Pleistocene that resulted in the formation of Lake Victoria. The orogenic fold belts usually follow fairly consistent trends.

Shear belts occur in the Precambrian in several areas of the country. The Aswa shear belt is the most extensive, following a northwesterly trend for over 300 km through northern Uganda and into southern Sudan. Other belts, probably of Late Precambrian age, run through the Karamoja region, Acholi and the West Nile district.

The Rift Valley extends along the western border with Zaire and encompasses Lake Albert, Lake George, Lake Edward, and the Rwenzori Mountains horst block. Sediment thicknesses of 1,800 to 4,000 m are estimated to lie within the Rift Valley, which is still locally active.

Mineral Occurrences

Extensive portions of Uganda have been exposed to prolonged and intense weathering. These processes have led to some materials being concentrated into ores, most notably gold, tin, pyrochlore (niobium, tantalum and rare earths), and apatite.

Mineral occurrences include gold in Busia in the southeast, hosted by an Archaean greenstone belt (Nyanzian-Kavirondian), whilst in the southwest at Buhweju and Kigezi, gold occurs in Lower to Middle Proterozoic metasediments.

Gold mining has taken place at Busia in both alluvial and quartz vein occurrences. However, it appears that much of the so-called alluvials are actually lateritic formations formed by weathering of huge volumes of the underlying Archaean greenstones. The lateritic profile in many areas approaches 20 m and extends over tens of square kilometres. This lateritic gold may lead to the discovery of primary sources in the greenstones beneath.

Recent exploration in the southwest in the Buhweju-Mashonga area indicates that much of the gold being extracted by artisans derives from lateritic gravel lying on kaolinised bedrock. The weathering profile in most parts of this area is 10 to 20 m thick. Quartz veins have also been noted and some are being worked.

In addition to Busia and Buhweju-Mashonga, other potential gold areas include Kigezi, Mubende and Karamoja. Karamoja, in the northeast, is of particular interest since favourable gold potential may exist in the intrusive and volcano-sedimentary rocks of Proterozoic and possibly Archaean age.

The most prospective district for base metals is in the Kilembe belt, where the volcano-sedimentary Lower Proterozoic series extends for over 90 km. The stratabound massive sulphides at Kilembe, containing copper and cobalt mineralisation, are hosted in rocks of the important Buganda-Toro system.

Apart from Kilembe, there are copper showings in the northeast at Bobong and Kaabong in Karamoja region, occurring within Karasuk Group rocks. There are also chromite occurrences in ultramafic rocks at Nakiloro, in the Karamoja district. An ultramafic rock assemblage identified at Moroto by the DGSM for further study may represent a Lower Proterozoic or Archaean layered intrusion, and in consequence holds potential as a new target area for nickel, chromium, copper and platinum-group metals mineralisation.

Other base metals have been noted. Lead, zinc and gold have been found in the Buganda-Toro Complex at Kitaka, within the Buhweju gold district. The Muko iron ore deposit occurs in Middle Proterozoic Kibaran rocks, whilst magnetite occurrences in the east, such as at Sukulu, are found in Tertiary carbonatites. Most of the cassiterite, tungsten, columbo-tantalites, beryl and lithium mineralisation is hosted by pegmatites and granites of the Buganda-Toro and Kibaran Complexes.

Amongst industrial minerals, phosphates are found in the east in Tertiary carbonatites that also host limestone, titanium and rare-earth elements. There is also limestone at Hima in the southwest, in a secondary deposit derived from calcareous tuffs and hot springs. Other industrial minerals include clay, kaolin, feldspar, diatomite, silica sand and various types of dimension stone.

Geophysical Interpretation

Geophysical surveying has revealed the potential for a number of significant features that may prove of interest in the search for further mineral resources in Uganda. Some of this information has been extrapolated from regional airborne surveying, and evidence for some of the features suggested has yet to be confirmed on the ground.

Amongst these potential targets are a regionally extensive dyke swarm hypothesised as running from Tanzania into Uganda and lying in a series of semicircular arcs through the south of the country. Aeromagnetic data suggest the presence of this feature, which has a diameter of some 600 km. Also running northwards from Tanzania are two arcuate belts of magnetic anomalies that may be related to the nickel- and cobalt-rich ultramafic bodies that occur in the border region between Tanzania and Rwanda.

Interpretation of aeromagnetics also suggests that there is potential for further copper and other base metal discoveries to the east of the Kilembe district, while other features are considered to represent the tantalum, tin, tungsten and gold mineral belt on the Uganda-Rwanda border. Furthermore, it is also possible that the gold-bearing Nyanzian greenstones are more extensive than currently known, with large areas being overlain by superficial cover.

Appendix 1: Figure 1c

Seismic Map of Uganda

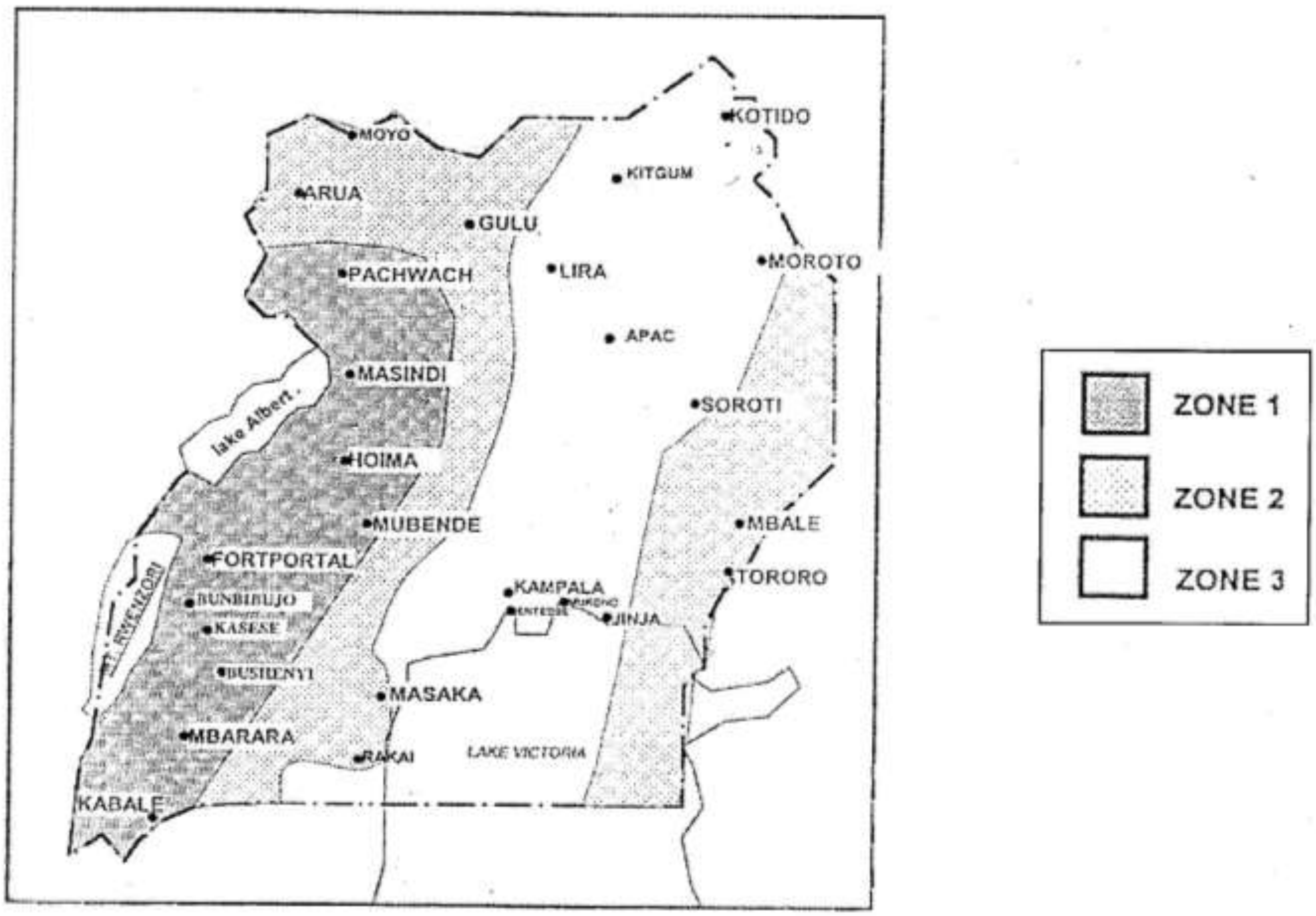


Figure 1c: Seismic zoning of Uganda

APPENDIX 2: FIELD FINDINGS AND LABORATORY TESTS RESULTS

Appendix 2a

Photographic Representation of Geotechnical Work

Plate 1.0

Plate 2.0

Plate 3.0

Plate 4.0

Plate 5.0

Plate 6.0

Plate 1.0 – 6.0: Rotary Drilling works in progress at the site

Plate 7.0

Plate 8.0

Plate 9.0

Plate 7.0 - 9.0: Standard Penetration Tests in the Boreholes

Plate 10.0

Plate 11.0

Plate 12.0

Plate 10.0 - 12.0: Field Hand Augering Exercise

Plate 13.0

Plate 14.0

Plate 15.0

Plates 13.0 – 15.0: Trial Pitting & the Conduct of Dynamic Cone Penetration Tests

Plate 16.0

Plate 17

Plate 18.0

Plate 19.0

Plate 20.0

Plate 21.0

Plate 22.0

Plate 23.0

Plate 24.0

Plate 25.0

Plate 26.0

Plates 16.0 - 26.0: Some of the Photographs from the Drilling Exercise

Appendix 2b

Borehole Logs, Hand Augers Logs & Water Table Depths

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RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment

Position of BH: Easting (X) 418994, Northing (Y) 248835 (UTM 36N)

Hole/Pit No.: BH1 - INTAKE SITE

Depth of Water Table: 1.2m from EGL

Date Started: 17.05.18

Drilling Method used: Rotary

Date Completed: 18.05.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test			
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value	Description	Remarks
1.50 1.95	= =	√	√	7 8 8	16	Dark brown gravelly sandy clay	Stiff
3.00 3.45		√	-	6 7 8	15	Greyish clayey sand	Medium dense
4.50 4.95		-	-	66 _ _	_	Dark grey rock	Moderately strong rock
6.00 6.45		-	-	_ _ _	_	Whitish grey rock	Strong rock

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RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment

Position of BH: Easting (X) 419030, Northing (Y) 248845 (UTM 36N)

Hole/Pit No.: BH2 - INTAKE SITE

Depth of Water Table: 1.0m from EGL | **Date Started:** 18.05.18

Drilling Method used: Rotary | **Date Completed:** 19.05.18

Size of hole/pit: 100mm | **Foreman:** Robert Owori

Diameter of Core: N/A | **Weather Condition/ Temperature:** Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95	o o o o o o o o o o o o o o o o o o o o o	√	-	10 13 14	27	Yellowish brown weathered rock with cobbles	Medium dense
3.00 3.45		√	-	14 18 29	47	Yellowish brown weathered rock with boulders	Dense
4.50 4.95		-	-	71 - -	-	Greyish black granite rock	Very dense
6.00 6.45		-	-	- - -	-	Blackish white granite rock	Very dense
7.50 7.95		-	-	- - -	-	Whitish grey granite rock	Very dense

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RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment

Position of BH: Easting (X) 419024, Northing (Y) 248949 (UTM 36N)

Hole/Pit No.: BH1 - ACCESS ROAD TO INTAKE SITE

Depth of Water Table: Not encountered | **Date Started:** 23.05.18

Drilling Method used: Rotary | **Date Completed:** 23.05.18

Size of hole/pit: 100mm | **Foreman:** Robert Owori

Diameter of Core: N/A | **Weather Condition/ Temperature:** Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95	x x x x x x x x x x x x x x x x x x x x x x x x	√	-	10 11 13	24	Brownish grey silty schist rock	Medium dense
3.00 3.45		√	-	14 16 16	32	Greyish yellow schist weathered sandstone	"
4.50 4.95		√	-	13 15 18	33	Greyish brown schist weathered rock	"

Position of BH: Easting (X) 418879, Northing (Y) 249007 (UTM 36N)

Hole/Pit No.: BH2 - ACCESS ROAD TO INTAKE SITE

Depth of Water Table: Not encountered | **Date Started:** 23.05.18

Drilling Method used: Rotary | **Date Completed:** 23.05.18

Size of hole/pit: 100mm | **Foreman:** Robert Owori

Diameter of Core: N/A | **Weather Condition/ Temperature:** Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95	o o o o o o o o o o o o o o o o o o o o	√	-	_ _ _	-	Blackish grey sedimentary cobbles	Medium dense
3.00 3.45		√	-	13 14 16	30	Greyish brown schist weathered rock	Medium dense
4.50 4.95		√	-	20 18 18	36	Light grey schist weathered rock	Medium dense - dense

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RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment

Position of BH: Easting (X) 418971, Northing (Y) 248869 (UTM 36N)

Hole/Pit No.: BH1 - CLEAR WATER TANK

Depth of Water Table: 2.0m from existing GL

Date Started: 19.05.18

Drilling Method used: Rotary

Date Completed: 20.05.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95	= =	√	-	6 8 9	17	Blackish brown clayey sand	Medium dense
3.00 3.45	ooooooooo ooooooooo ooooooooo	-	-	_ _ _	_	Dark grey rock with cobbles	Dense
4.50 4.95		-	-	_ _ _	_	Whitish brown rock	Moderately strong rock
6.00 6.45		-	-	_ _ _	_	"	"
7.50 7.95		-	-	_ _ _	_	"	Strong rock
9.00 9.45		-	-	_ _ _	_	Blackish grey rock	"

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RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment

Position of BH: Easting (X) 418920, Northing (Y) 248921 (UTM 36N)

Hole/Pit No.: BH1 - FILTER WASH WATER

Depth of Water Table: 3.5m from existing GL

Date Started: 11.05.18

Drilling Method used: Rotary

Date Completed: 12.05.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95		√	-	13 18 18	36	Blackish grey sand stone	Dense
3.00 3.45	ooooooooo ooooooooo ooooooooo	√	-	14 17 19	36	Dark grey cobbles with sand	"
4.50 4.95		√	-	7 13 14	27	Blackish grey sandy weathered rock	Medium dense - dense
6.00 6.45	= =	√	√	12 20 15	35	Light grey sandy clay	Stiff
7.50 7.95	ooooooooo ooooooooo ooooooooo	√	-	13 14 18	32	Dark brown gravelly sand	Dense
9.00 9.45	= = = = = = = = =	√	-	15 15 18	33	Greyish brown clayey sand	"
10.50 10.95	= =	√	√	24 27 33	60	Dark grey sandy clay	Hard
12.00 12.45	= =	√	-	20 23 30	53	Light grey sandy clay	Very stiff - hard
13.50 13.95	= oo = oo = = oo= = oo = = oo = = o	√	-	23 30 29	59	Greyish brown clayey sand with gravel	Very dense
15.00 15.45	= = = = = = = = = = = =	√	-	25 30 33	63	Yellowish brown clayey sand	"

EPINEX ENGINEERING SERVICES LTD

RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment

Position of BH: Easting (X) 418971, Northing (Y) 248965 (UTM 36N)

Hole/Pit No.: BH1 - BUFFER FILTER WASH WATER

Depth of Water Table: 4.0m from existing GL

Date Started: 21.05.18

Drilling Method used: Rotary

Date Completed: 22.05.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50	= oo oo			8			
1.95	= oo = o	√	-	13	26	Brownish yellow clayey sand with cobbles	Dense
	= oo = o			13			
3.00	= oo oo			12			
3.45	= oo = o	√	-	13	31	Greyish brown gravelly clayey sand	"
	= oo = o			18			
4.50				16			
4.95		√	-	18	41	Brownish grey weathered sand stone	"
				23			
6.00	oo oo oo			13			
6.45	oo oo ooo	√	-	14	28	Blackish grey sand with cobbles	"
	ooo oo oo			14			
7.50	= = = =			17			
7.95	= = = =	√	√	21	45	Dark grey clay - sand mixture	Stiff
	= = = =			24			
9.00	= = = =			16			
9.45	= = = =	√	-	19	43	Dark grey clay - sand mixture	"
	= = = =			24			
10.50				21			
10.95		√	-	22	49	Dark grey weathered sand stone	Dense very dense
				27			
12.00				_			
12.45		-	-	_	_	Dark grey rock	Very strong rock
				_			
13.50				_			
13.95		-	-	_	_	"	"
				_			

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RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment

Position of BH: Easting (X) 418928, Northing (Y) 248947 (UTM 36N)

Hole/Pit No.: BH1 - FILTRATION

Depth of Water Table: 0.8m from EGL

Date Started: 13.05.18

Drilling Method used: Rotary

Date Completed: 14.05.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95	= =	√	-	5 4 8	12	Yellowish grey clayey sand	Loose
3.00 3.45	= = = = = = = = = = = =	√	-	6 7 8	15	Brownish grey clayey sand	Loose - medium dense
4.50 4.95	= = = = = = = = = = = =	√	-	6 9 9	18	Dark brown clayey sand with silt	"
6.00 6.45	= = = = = = = = = = = =	√	-	11 13 14	27	Light grey clayey sand	Dense
7.50 7.95	oo oo oo oo oo oo oo oo oo oo oo oo	√	-	10 15 16	31	Yellowish brown gravelly sand	"
9.00 9.45	= =	√	√	13 16 17	33	Brown sandy clay	Stiff
10.50 10.95	= = = = = = = = = = = =	√	-	8 9 9	18	Brownish grey clayey sand	Loose - medium dense
12.00 12.45	= = = = = = = = = = = =	√	-	11 13 14	27	Dark grey clayey sand	Dense
13.50 13.95	= oo = oo ooo = ooo oo = ooo	√	-	15 15 14	29	Blackish grey clayey sand with gravel	Dense
15.00 15.45	= oo = oo ooo = ooo oo = ooo	√	-	12 15 20	35	"	Dense

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RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria

Position of BH: Easting (X) 418934, Northing (Y) 248968 (UTM 36N)

Hole/Pit No.: BH1 - COAGULATION / FLOCCULATION

Depth of Water Table: 1.0m from EGL

Date Started: 14.05.18

Drilling Method used: Rotary

Date Completed: 16.05.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95	= = = = = = = = = = = =	√	-	7 15 22	37	Brownish yellow clayey sand	Loose medium dense
3.00 3.45	= x = x= = = x =x = x = x =x = x	√	-	10 13 17	30	Greyish brown clayey sand with silt	Dense
4.50 4.95	= oo = oo ooo = ooo oo = ooo	√	-	15 22 28	50	Whitish grey clayey sand with cobbles	Dense - very dense
6.00 6.45	= = = = = = = = = = = =	√	-	19 24 30	54	Dark grey clayey sand	Very dense
7.50 7.95	= oo = oo ooo = ooo oo = ooo	√	-	20 23 24	47	Greyish brown clayey sand with cobbles	Dense
9.00 9.45	= oo = oo ooo = ooo oo = ooo	√	-	26 30 31	61	Brownish yellow coarse sand with cobbles	Very dense
10.50 10.95	= oo = oo ooo = ooo oo = ooo	√	-	21 32 31	63	Brownish grey clayey sand with cobbles	"
12.00 12.45		√	-	18 23 28	51	Greyish brown weathered sand stone	"
13.50 13.95		√	-	24 21 31	52	"	"
15.00 15.45		√	-	23 25 29	54	Blackish weathered sand stone	"

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RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment

Position of BH: Easting (X) 416709, Northing (Y) 245632 (UTM 36N)

Hole/Pit No.: BH1 - KARUMA RESERVOIR

Depth of Water Table: Not encountered | **Date Started:** 28.03.18

Drilling Method used: Rotary | **Date Completed:** 28.03.18

Size of hole/pit: 100mm | **Foreman:** Robert Owori

Diameter of Core: N/A | **Weather Condition/ Temperature:** Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95	= = == = = = = = = = =	√	-	22 11 11	22	Brownsih yellow clayey sand	Medium dense
3.00 3.45	= = == = = = = = = = =	√	-	22 22 24	46	"	Dense
4.50 4.95		√	-	30 28 28	56	Reddish brown weathered lateritic rock	Very dense
6.00 6.45	= = == = = = = = = = =	√	-	10 12 12	24	Brown clayey sand	Dense
7.50 7.95	======= ======= ========	√	√	13 14 14	28	Brown clay	Very stiff
9.00 9.45	oooo = oo = oooo = = ooo =	√	-	8 10 11	21	Reddish clayey sand with gravel	Medium dense
10.50 10.95	= = == = = = = = = = =	√	-	10 10 12	22	Reddish clayey sand	"
12.00 12.45	======= ======= ========	√	√	7 9 10	19	Reddish brown clay	Stiff
13.50 13.95	= = == = = = = = = = =	√	-	8 9 20	29	Brownish clayey sand	Dense
15.00 15.45	= = == = = = = = = = =	√	-	11 16 22	38	"	"

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RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment

Position of BH: Easting (X) 426207, Northing (Y) 248746 (UTM 36N)

Hole/Pit No.: BH1 - KAMDINI TANK RESERVOIR

Depth of Water Table: Not encountered

Date Started: 31.03.18

Drilling Method used: Rotary

Date Completed: 31.03.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95		√	-	22 25 27	52	Reddish brown lateritic rock	Very dense
3.00 3.45		√	-	21 26 30	56	Brownish yellow lateritic rock	"
4.50 4.95		√	-	30 33 30	63	"	"
6.00 6.45		√	-	17 17 19	36	Yellowish brown clayey gravel	Dense
7.50 7.95		√	-	13 14 16	30	Dark brown clayey gravel with silt	"
9.00 9.45		√	√	6 8 9	17	Yellowish brown schist clay	Stiff
10.50 10.95		√	√	6 9 9	18	"	"

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RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment

Position of BH: Easting (X) 431340, Northing (Y) 270708 (UTM 36N)

Hole/Pit No.: BH1 - MINAKULU TANK RESERVOIR

Depth of Water Table: Not encountered

Date Started: 29.03.18

Drilling Method used: Rotary

Date Completed: 30.03.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95	= =	√	-	19 30 30	60	Reddish brown clayey sand	Very dense
3.00 3.45	======= ======= ========	√	√	18 23 25	48	Reddish brown clay	Hard
4.50 4.95	oooo = oo = oooo = = ooo =	√	-	10 12 12	24	Brown clayey sand with gravel	Dense
6.00 6.45	======= ======= ========	√	√	3 3 4	7	Brownish yellow clay	Firm
7.50 7.95	======= ======= ========	√	-	4 4 5	9	"	Firm - stiff
9.00 9.45	======= ======= ========	√	-	4 5 5	10	"	"
10.50 10.95	======= ======= ========	√	-	6 7 8	15	"	Very stiff

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RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment

Position of BH: Easting (X) 428493, Northing (Y) 280441 (UTM 36N)

Hole/Pit No.: **BH1 - BOBI PUMP STATION**

Depth of Water Table: Not encountered

Date Started: 27.03.18

Drilling Method used: Rotary

Date Completed: 27.03.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95	= oo = ooo = = = oooo = = ooo= = ooo=	√	-	14 17 22	39	Brownish yellow clayey gravel	Dense
3.00 3.45	ooooooooo ooooooooo ooooooooo	√	√	21 21 23	44	Reddish brown sandy clay	Very stiff
4.50 4.95	ooooooooo ooooooooo ooooooooo	√	-	20 22 22	44	Reddish brown sandy gravel	Dense
6.00 6.45	ooooooooo ooooooooo ooooooooo	√	-	21 30 29	59	"	Very dense
7.50 7.95	= =	√	√	17 18 20	38	Reddish brown sandy clay	Stiff - very stiff
9.00 9.45	= =	√	-	18 19 20	39	Brownish yellow sandy gravel	Dense
10.50 10.95	= =	√	-	18 19 22	41	"	"

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RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment

Position of BH: Easting (X) 428545, Northing (Y) 282426 (UTM 36N)

Hole/Pit No.: BH1 - BOBI RESERVOIR

Depth of Water Table: Not encountered

Date Started: 04.04.18

Drilling Method used: Rotary

Date Completed: 04.04.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95	= oo = ooo = = = oooo = = ooo= = ooo=	√	-	13 12 12	24	Blackish yellow clayey gravel	Medium dense
3.00 3.45	ooooooooo ooooooooo ooooooooo	√	-	10 11 12	23	Reddish brown gravelly sand	"
4.50 4.95	ooooooo ooooooooo ooooooooo	√	-	9 8 10	18	Brownish yellow wethered lateritic rock	"
6.00 6.45	ooooooo ooooooooo ooooooooo	√	-	6 7 7	14	"	"
7.50 7.95	=xx==xxx== =xx==xxx== =xx=xxx==x	√	√	5 6 9	15	Reddish brown silty clay	Stiff
9.00 9.45	xxxxxxxxx xxxxxxxxx xxxxxxxxx	√	-	6 6 9	15	Brownish yellow micaceous silt	Medium dense
10.50 10.95	xxxxxxxxx xxxxxxxxx xxxxxxxxx	√	-	8 7 9	16	"	"

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RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria

Position of BH: Easting (X) 423881, Northing (Y) 298097 (UTM 36N)

Hole/Pit No.: BH1 - KORO ABILI

Depth of Water Table: Not encountered | **Date Started:** 22.05.18

Drilling Method used: Rotary | **Date Completed:** 22.05.18

Size of hole/pit: 100mm | **Foreman:** Robert Owori

Diameter of Core: N/A | **Weather Condition/ Temperature:** Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95	= =	√	√	8 10 10	20	Brownish yellow sandy clay	Stiff
3.00 3.45	= = oo = = o =oo= = =oo = ooo = =oo	√	-	6 9 10	19	Dark brown sandy clay with gravel	"
4.50 4.95	=ooo=ooo= =ooo===== =oo===ooo	√	-	13 14 16	30	Reddish yellow gravelly clay	Very stiff
6.00 6.45	=ooo=ooo= =ooo===== =oo===ooo	√	√	6 7 8	15	Brownish sandy clay with gravel	Stiff
7.50 7.95	=ooo=ooo= =ooo===== =oo===ooo	√	-	8 9 9	18	"	"
9.00 9.45	= =... = = ...= = =....= = ... = =.... = = ...	√	-	20 18 21	39	Reddish brown clayey sand	Dense
10.50 10.95	= =... = = ...= = =....= = ... = =.... = = ...	√	-	16 21 26	47	"	"

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RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment

Position of BH: Easting (X) 420217, Northing (Y) 305816 (UTM 36N)

Hole/Pit No.: BH1 - NEW CUSTOMS CORNER TANK

Depth of Water Table: Not encountered

Date Started: 23.03.18

Drilling Method used: Rotary

Date Completed: 25.03.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95	= oo = ooo = = = oooo = = ooo= = ooo=	√	-	17 19 22	41	Reddish brown weathered lateritic rock	Dense
3.00 3.45	= oo = ooo = = = oooo = = ooo= = ooo=	√	-	18 23 23	46	Reddish black weathered lateritic rock	"
4.50 4.95	=ooo=ooo= =ooo===== =oo===ooo	√	-	10 11 14	25	Brownish yellow clayey sand with gravel	Medium dense
6.00 6.45	= =... = = ...= = =....= = ... = =.... = = ...	√	-	4 5 6	11	Reddish clayey sand	Loose - medium dense
7.50 7.95	=xx==xxx== =xx==xxx== =xx=xxx==x	√	√	3 3 6	9	Brownish silty clay	Firm
9.00 9.45	======= ======= ========	√	-	5 5 6	11	Reddish yellow schist clay	"
10.50 10.95	======= ======= ========	√	√	7 5 9	14	Pinkish red schist clay	"
12.00 12.45	======= ======= ========	√	-	5 6 9	15	Yellowish pink schist clay with weathered rock	"
13.50 13.95	======= ======= ========	√	-	8 8 9	17	"	"
15.00 15.45	=x==x=x =x==xx=x xx===xx=x	√	-	8 9 10	19	Pinkish yellow schist clayey silt	Medium dense

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RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment

Position of BH: Easting (X) 420240, Northing (Y) 305859 (UTM 36N)

Hole/Pit No.: BH2 - NEW CUSTOMS CORNER TANK

Depth of Water Table: Not Encountered | **Date Started:** 25.03.18

Drilling Method used: Rotary | **Date Completed:** 26.03.18

Size of hole/pit: 100mm | **Foreman:** Robert Owori

Diameter of Core: N/A | **Weather Condition/ Temperature:** Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95	=ooo=ooo= =ooo===== =oo===ooo	√	-	18 23 26	49	Brownish clay with gravel	Stiff
3.00 3.45	======= ======= ========	√	√	7 6 6	12	Reddish brown clay	Firm
4.50 4.95	======= ======= ========	√	√	6 8 9	17	Brownish red sandy clay	"
6.00 6.45	======= ======= ========	√	-	5 6 7	13	"	"
7.50 7.95		√	-	7 8 9	17	Pinkish brown chalky rock	Medium dense
9.00 9.45		√	-	8 9 9	18	Dark red schist weathered rock	"
10.50 10.95		√	-	10 10 11	21	Pinkish brown chalky rock	"
12.00 12.45	======= ======= ========	√	-	7 8 9	17	Reddish brown schist clay	Firm
13.50 13.95	======= ======= ========	√	-	8 9 11	20	Dark grey schist clay	Firm - stiff
15.00 15.45	======= ======= ========	√	-	9 12 16	28	Yellowish brown schist weathered rock	Dense

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RECORD OF HAND AUGER INVESTIGATIONS
PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 1: KANKAYI HP 1 CH: 3+270 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 28.03.2018
Date Completed: 28.03.2018 **Weather Condition/ Temperature:** Sunny
Depth of Water Table: Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.40	======================== ========================	Dark grey clay top soil	Loose
1.50	=========::::::::::::========= ===::::::::::::::============== =:::::::::::::::::::::=========== =====:::::::::::::::==========	Greyish brown sandy clay	Firm
3.00	ooooooo::::ooooooo::::ooooo oo::::ooooooo::::oooooooo:::: oooooooo::::oooooooo::::ooo ooooo::::oooooooo::::oooooo	Light grey clayey sand with gravel	Medium dense
4.50	======:::::::::::::::::::::::::::::::: :::==::::::=======:::::::::::::::::: :::::::::::=======::::::::::::::::::: ::::=::::::=======:::::::::::::::::::	Yellowish brown clayey sand	Very dense

Hole/Pit No.: SWAMP 1: KANKAYI HP 2 CH: 3+463 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 28.03.2018 **Foreman:** Robert Owori
Date Completed: 28.03.2018 **Weather Condition/ Temperature:** Sunny
Depth of Water Table: 0.3m above Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.40	========================	Blackish grey clay top	Soft
1.50	======================== ======================== ========================	Greyish brown clay soil	Firm
3.00	::::::::::===::::::::::===::::::::::= ==::::::::::===::::::::::===:::::::: ::===::::::::::===::::::::::===:::::	Yellowish brown clayey sand	Dense
4.50	::::::::::===::::oooo:::===:::::::: ::===:::ooooo===::::::::::===::: ::::::::===::::ooooooo:::===:::::: :::::===::::ooooooo:::===::::::::	Greyish brown clayey sand with gravel	Very dense

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RECORD OF HAND AUGER INVESTIGATIONS

PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 2: AGENGI HP 1 CH: 6+000 LHS (KARUMA - GULU)

Ground Elevation at commencement: ....

Date Started: 28.03.2018 **Foreman:** Robert Owori

Date Completed: 28.03.2018 **Weather Condition/ Temperature:** Sunny

Depth of Water Table: 0.2m above Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.50	======================== ========================	Dark grey clay top soil	Loose
1.50	======================== ======================== ========================	Yellowish brown clay	Firm
3.00	======================== ======================== ========================	Grey silty clay	Very stiff
4.50	======================== ======================== ========================	Greyish brown silty clay	Very stiff

Hole/Pit No.: SWAMP 2: AGENGI HP 2 CH: 6+050 LHS (KARUMA - GULU)

Ground Elevation at commencement: ....

Date Started: 28.03.2018 **Foreman:** Robert Owori

Date Completed: 28.03.2018 **Weather Condition/ Temperature:** Sunny

Depth of Water Table: 0.1m above Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.50	======================== ========================	Dark grey clay top soil	Loose
1.50	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::=== ====::::::=======::::::=======:	Brownish grey sandy clay	Stiff
3.00	===oooo==::::::=ooooo==:::::: ===oo==::::::==ooo==::::::==oo oo===::::::=======::::::==oooo o==::::::=======::::::==oooo==	Greyish brown silty sandy clay with gravel	Very stiff

Hole/Pit No.: SWAMP 3: ALENYI HP 1 CH: 9+000 LHS (KARUMA - GULU)

Ground Elevation at commencement: ....

Date Started: 29.03.2018 **Foreman:** Robert Owori

Date Completed: 29.03.2018 **Weather Condition/ Temperature:** Sunny

Depth of Water Table: Existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.30	========================	Dark brown clay top	Loose
1.50	======================== ======================== ======================== ========================	Greyish brown clay soil	Firm
3.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::=== ====::::::=======::::::=======:	Yellowish brown sandy clay	Very Stiff
3.80	======================== ======================== ========================	Greyish brown clay soil	Hard

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RECORD OF HAND AUGER INVESTIGATIONS

PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 3: ALENYI HP 2 CH: 9+150 LHS (KARUMA - GULU)

Ground Elevation at commencement: …….

Date Started: 29.03.2018 **Foreman:** Robert Owori

Date Completed: 29.03.2018 **Weather Condition/ Temperature:** Sunny

Depth of Water Table: 0.3m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.40	========================	Black clay top soil	Loose
1.50	::::::::::===::::::::::===::::::::::= ==::::::::::===::::::::::===:::::::: ::===::::::::::===::::::::::===:::::	Greyish brown sandy clay	Firm
3.00	======================== ======================== ========================	Light grey clay	Stiff
5.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Brownish grey sandy clay	Loose

Hole/Pit No.: SWAMP 3: ALENYI HP 3 CH: 9+362 LHS (KARUMA - GULU)

Ground Elevation at commencement: …….

Date Started: 29.03.2018 **Foreman:** Robert Owori

Date Completed: 29.03.2018 **Weather Condition/ Temperature:** Sunny

Depth of Water Table: Existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.40	======================== ========================	Dark grey clay top soil	Soft
1.50	======================== ======================== ========================	Greyish brown clay	Loose
3.00	::::::::::===:::======:===:::::::: ::===:::=======:===::::::::::== =::::=======:::::::::::===::::::::	Light brown sandy clay	Firm
4.50	::::::=======ooo::::::=======o oo::::::=======ooo::::::====== =ooo::::::=======ooo::::::====	Yellowish brown silty sandy clay with gravel	Very stiff

Hole/Pit No.: SWAMP 3: ALENYI HP 4 CH: 9+393 LHS (KARUMA - GULU)

Ground Elevation at commencement: …….

Date Started: 29.03.2018 **Foreman:** Robert Owori

Date Completed: 29.03.2018 **Weather Condition/ Temperature:** Sunny

Depth of Water Table: 0.2m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.40	========================	Black clay top soil	Loose
1.50	::::::::::===::::::::::===::::::::::= ==::::::::::===::::::::::===:::::::: ::===::::::::::===::::::::::===:::::	Brownish grey sand-clay mixture	Firm
3.00	===::::oooooooo===::::ooooo ooo===::::oooooooo===::::oo oooooo===::::oooooooo===:::	Yellowish brown sand - clay mixture with gravel	Stiff
4.50	::::::::::===::::::::::===::::::::::= ==::::::::::===::::::::::===:::::::: ::===::::::::::===::::::::::===::::: ::::::===::::::::::===::::::::::===:	Brownish grey sand-clay mixture	Firm

EPINEX ENGINEERING SERVICES LTD

RECORD OF HAND AUGER INVESTIGATIONS

PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 4: MYENE HP 1 CH: 12+000 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 30.03.2018 **Foreman:** Robert Owori
Date Completed: 30.03.2018 **Weather Condition/ Temperature:** Rainy
Depth of Water Table: 0.27m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.60	======================== ========================	Dark grey clay top soil	Soft
1.50	::::::::::===::::::::::===::::::::::= ==::::::::::===::::::::::===:::::::: ::===::::::::::===::::::::::===:::::	Brown clayey sand	Loose
3.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Yellowish brown sandy clay	Firm
4.50	======================== ======================== ======================== ========================	Grey clay	Hard

Hole/Pit No.: SWAMP 4: MYENE HP 2 CH: 13+000 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 30.03.2018 **Foreman:** Robert Owori
Date Completed: 30.03.2018 **Weather Condition/ Temperature:** Rainy
Depth of Water Table: 0.9m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.40	========================	Dark grey clay top soil	Loose
1.50	======================== ======================== ========================	Brownish grey clay	Firm
3.00	========::::::::::::========== ====::::::::::::::::::::::========= =================::::::::::::	Brownish grey sandy clay	Very stiff
4.50	======================== ======================== ======================== ========================	Brownish grey clay	Hard

Hole/Pit No.: SWAMP 4: MYENE HP 3 CH: 13+100 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 30.03.2018 **Foreman:** Robert Owori
Date Completed: 30.03.2018 **Weather Condition/ Temperature:** Rainy
Depth of Water Table: 0.3m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.40	======================== ========================	Black clay top soil	Loose
1.50	======================== ======================== ========================	Greyish brown clay	Firm
3.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Light brown sandy clay	Stiff
4.50	=======xxx=======xxxxxx=== ===xxxxxxx=======xxxxxxx== =====xxxxxx=======xxxxx=== ====xxxxxx======xxxxxx====	Light brown silty clay	Hard

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RECORD OF HAND AUGER INVESTIGATIONS

PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 4: MYENE HP 4 CH: 13+200 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 30.03.2018 **Foreman:** Robert Owori
Date Completed: 30.03.2018 **Weather Condition/ Temperature:** Rainy
Depth of Water Table: 0.1m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.50	======================== ========================	Greyish brown clay top soil	Loose
1.50	======================== ======================== ========================	Yellowish brown clay	Firm
3.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Yellowish grey sandy clay	Firm
4.50	=======::::::====ooo==::::::== =====::::::===oooo==::::::==== ===::::::==oooo===::::::==ooo=	Yellowish grey sandy clay with gravel	Stiff

Hole/Pit No.: SWAMP 4: MYENE HP 5 CH: 13+500 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 30.03.2018 **Foreman:** Robert Owori
Date Completed: 30.03.2018 **Weather Condition/ Temperature:** Rainy
Depth of Water Table: 0.9m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.30	========================	Dark grey clay top soil	Soft
1.50	======================== ======================== ======================== ========================	Brownish grey clay	Stiff
3.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::=== ====::::::=======::::::=======:	Yellowish brown sandy clay	Very stiff
3.50	=======::::::=======::::::==== ===::::::=======::::::=======:::	Yellowish brown sandy clay	Hard (Refusal)

Hole/Pit No.: SWAMP 5: AMWA, OTWE HP 1 CH: 14+150 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 31.03.2018 **Foreman:** Robert Owori
Date Completed: 31.03.2018 **Weather Condition/ Temperature:** Cloudy

Depth of Water Table: 0.5m above Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.60	=======xxxxx=======xxxxx== =====xxxxx======xxxx======	Grey silty clay	Loose
1.50	=======::::::=======::::::==== ===xxx:=======::xxx:=======: ::::::=======:::xxxx=======::xx	Brownish grey sandy/ silty clay	Firm
3.00	======================== ======================== ======================== ========================	Yellowish brown clay	Very Stiff
3.60	======================== ========================	Yellowish brown clay	Hard

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RECORD OF HAND AUGER INVESTIGATIONS

PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 5: AMWA, OTWE HP 2 CH: 16+000 LHS (KARUMA - GULU)

Ground Elevation at commencement: …….

Date Started: 31.03.2018 **Foreman:** Robert Owori

Date Completed: 31.03.2018 **Weather Condition/ Temperature:** Cloudy

Depth of Water Table: 0.4m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.60	======================== ========================	Blackish clay top soil	Loose
1.50	::::::::::===::::::::::===::::::::::= ==::::::::::===::::::::::===::::::::	Brownish silty clayey sand	Firm
3.00	====:::::::::::::::::=========== =::::::::::::::::::::::::===========: ::::::::::::::::::::::::::::==========	Yellowish brown sandy clay	Very stiff
3.50	========ooo=============o oooo====================	Yellowish brown clay with gravel	Hard

Hole/Pit No.: SWAMP 6: NGAATO HP 1 CH: 16+200 LHS (KARUMA - GULU)

Ground Elevation at commencement: …….

Date Started: 31.03.2018 **Foreman:** Robert Owori

Date Completed: 31.03.2018 **Weather Condition/ Temperature:** Rainy

Depth of Water Table: 0.9m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.70	======================== ========================	Dark grey clay top soil	Loose
1.50	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Greyish brown sandy clay	Firm
3.00	::::::::::===::::::::::===::::::::::= ==::::::::::===::::::::::===:::::::: ::===::::::::::===::::::::::===:::::	Brownish silty clay	Stiff
5.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Light grey sandy clay	Loose

Hole/Pit No.: SWAMP 6: NGAATO HP 2 CH: 16+250 LHS (KARUMA - GULU)

Ground Elevation at commencement: …….

Date Started: 31.03.2018 **Foreman:** Robert Owori

Date Completed: 31.03.2018 **Weather Condition/ Temperature:** Rainy

Depth of Water Table: 0.7m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
1.00	======================== ========================	Greyish clay top soil	Loose
1.50	::::::::::===::::::::::===::::::::::=	Light brown clayey sand	Stiff
3.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Brownish sandy clay	Stiff
4.50	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Brownish sandy clay	Stiff - very stiff

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RECORD OF HAND AUGER INVESTIGATIONS

PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 6: NGAATO HP 3 CH: 20+000 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 01.04.2018 **Foreman:** Robert Owori
Date Completed: 01.04.2018 **Weather Condition/ Temperature:** Rainy
Depth of Water Table: Existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.60	======================== ========================	Greyish brown clay top soil	Soft
1.50	======================== ======================== ======================== ========================	Light brown clay	Soft
3.00	::::::::::===::::::::::===::::::::::= ==::::::::::===::::::::::===:::::::: ::===::::::::::===::::::::::===:::::	Brownish grey sandy clay	Loose
4.00	=======::::::=======::::::==== ===::::::=======::::::=======:::	Dark grey clayey sand	Very dense

Hole/Pit No.: SWAMP 6: NGAATO HP 4 CH: 20+300 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 01.04.2018 **Foreman:** Robert Owori
Date Completed: 01.04.2018 **Weather Condition/ Temperature:** Rainy
Depth of Water Table: 0.5m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.70	======================== ========================	Dark grey clay top soil	Loose
1.50	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Brownish grey sandy clay	Firm
3.00	======================== ======================== ========================	Light grey clay	Soft
4.00	======================== ======================== ========================	Light grey clay	Hard

Hole/Pit No.: SWAMP 6: NGAATO HP 5 CH: 20+390 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 01.04.2018 **Foreman:** Robert Owori
Date Completed: 01.04.2018 **Weather Condition/ Temperature:** Rainy
Depth of Water Table: 0.2m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.50	=======::::::=======::::::====	Dark brown sandy clay	Soft
1.50	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Greyish brown sandy clay	Very stiff
3.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Greyish brown sandy clay	Very stiff
3.80	=======::::::=======::::::==== ===::::::=======::::::=======:::	Greyish brown sandy clay	Hard

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PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 7: ATEK HP 1 CH: 22+000 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 02.04.2018 **Foreman:** Robert Owori
Date Completed: 02.04.2018 **Weather Condition/ Temperature:** Rainy
Depth of Water Table: 0.5m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.50	======================== ========================	Blackish brown clay top soil	Soft
1.50	======================== ======================== ======================== ========================	Brownish grey clay	Loose
3.00	======================== ======================== ========================	Yellowish clay	Firm
4.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Brownish grey sandy clay	Stiff

Hole/Pit No.: SWAMP 7: ATEK HP 2 CH: 22+100 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 02.04.2018 **Foreman:** Robert Owori
Date Completed: 02.04.2018 **Weather Condition/ Temperature:** Rainy
Depth of Water Table: 0.3m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.40	========================	Dark grey clay top soil	Soft
1.50	======================== ======================== ======================== ========================	Grey clay soil	Loose
3.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Brown sandy clay	Firm
4.00	=::::::::::::::::::::::::::::::======= ::::::=======:::::::::::::::::::::::: ::::::::::::::=====::::::=======::::	Yellowish grey clayey sand	Stiff

Hole/Pit No.: SWAMP 7: ATEK HP 3 CH: 22+200 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 02.04.2018 **Foreman:** Robert Owori
Date Completed: 02.04.2018 **Weather Condition/ Temperature:** Rainy
Depth of Water Table: 0.2m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.40	======================== ========================	Blackish clay top soil	Loose
1.50	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Greyish brown sandy clay	Firm
3.00	===============oooo===== =============ooooo===== ==============oooo====== =======oooo=============	Yellowish brown clay with gravel	Stiff

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PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 7: ATEK HP 4 CH: 22+300 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 02.04.2018 **Foreman:** Robert Owori
Date Completed: 02.04.2018 **Weather Condition/ Temperature:** Rainy
Depth of Water Table: 0.3m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.40	========================	Dark grey clay top soil	Loose
1.50	======================== ======================== ========================	Greyish brown clay	Firm
3.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Brownish grey sandy clay	Firm
4.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Yellowish grey clay - sand mixture	Very stiff

Hole/Pit No.: SWAMP 8: AGADA HP 1 CH: 25+000 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 03.04.2018 **Foreman:** Robert Owori
Date Completed: 03.04.2018 **Weather Condition/ Temperature:** Sunny
Depth of Water Table: 0.7m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.60	========================	Blackish grey clay top	Firm
1.50	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Dark grey sandy clay	Firm
3.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Light grey sandy clay	Stiff

Hole/Pit No.: SWAMP 8: AGADA HP 2 CH: 25+100 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 03.04.2018 **Foreman:** Robert Owori
Date Completed: 03.04.2018 **Weather Condition/ Temperature:** Sunny
Depth of Water Table: Existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.50	======================== ========================	Greyish clay top soil	Firm
1.50	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Yellowish grey sandy clay	Firm
3.00	==============oooooooo= ==================oooooo oooo=================== oooooooooooooooo======	Brownish silty clay with gravel	Stiff

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PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 9: ATEGO HP 1 CH: 29+050 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 03.04.2018 **Foreman:** Robert Owori
Date Completed: 03.04.2018 **Weather Condition/ Temperature:** Sunny
Depth of Water Table: 0.5m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.70	======================== ========================	Blackish grey clay top soil	Loose
1.50	=========oooo========== ===oooooo============== =============oooooo=====	Greyish brown clay with gravel	Firm
3.00	======================== ======================== ========================	Brownish yellow sandy clay	Stiff
5.00	======================== ======================== ======================== ========================	Yellowish brown silty clay	Firm

Hole/Pit No.: SWAMP 9: ATEGO HP 2 CH: 30+000 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 03.04.2018 **Foreman:** Robert Owori
Date Completed: 03.04.2018 **Weather Condition/ Temperature:** Sunny
Depth of Water Table: 0.8m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.80	======================== ========================	Brownish grey clay top soil	Loose
1.50	======================== ======================== ========================	Greyish brown clay	Firm
3.00	=======:::::=======:::::==== ===:::::=======:::::=======::: :::=======:::::=======:::::===	Brownish grey sandy clay	Stiff
4.50	=======:::::===ooo==:::::=== =ooo=:::::=======:::::====oo oo=:::::=======:::::==ooo==::	Yellowish grey sandy clay with gravel	Firm

Hole/Pit No.: SWAMP 10: MINAKULU HP 1 CH: 32+000 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 04.04.2018 **Foreman:** Robert Owori
Date Completed: 04.04.2018 **Weather Condition/ Temperature:** Sunny
Depth of Water Table: 0.1m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.40	=====^^^=====^^^=====^^^=	Blackish grey clay top	Soft
1.50	=======:::::=======:::::==== ===:::::=======:::::=======::: ...______.....______.....___	Light grey sandy clay	Firm
3.00	=======:::::=======:::::==== ===:::::=======:::::=======::: ...______.....______.....___	Dark grey sandy clay	Loose
5.00	::::::::::::::ooooo::::::::::::ooo ooooo::::::::::::::::::ooooo::::: ::::::ooooo::::::::::::::::::::::oo	Blackish grey gravelly sand	Loose

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RECORD OF HAND AUGER INVESTIGATIONS

PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 10: MINAKULU HP 2 CH: 32+100 LHS (KARUMA - GULU)

Ground Elevation at commencement: …….

Date Started: 04.04.2018 **Foreman:** Robert Owori

Date Completed: 04.04.2018 **Weather Condition/ Temperature:** Sunny

Depth of Water Table: 0.7m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
1.00	^^^^^^^^^^^^^^^^^^^^^^^^ ^^^^^^^^^^^^^^^^^^^^^^^^	Blackish top organic matter	Soft
1.50	======================== ======================== ========================	Dark grey clay	Loose
3.00	======================== ======================== ======================== ========================	Black clay	Firm
5.00	=====::::::::::::::::========== =====:::::::::::::::::::::::::======= =============:::::::::::::::::::	Dark grey sandy clay	Firm

Hole/Pit No.: SWAMP 10: MINAKULU HP 3 CH: 32+200 LHS (KARUMA - GULU)

Ground Elevation at commencement: …….

Date Started: 04.04.2018 **Foreman:** Robert Owori

Date Completed: 04.04.2018 **Weather Condition/ Temperature:** Sunny

Depth of Water Table: 0.6m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.70	=====^^^=====^^^=====^^^= ====^^^=====^^^=====^^^==	Dark black clay with organic matter	Soft
1.50	======================== ======================== ========================	Greyish brown clay	Soft
3.00	======================== ======================== ========================	Black clay	Firm
5.00	=====::::::::::::::::========== =====:::::::::::::::::::::::::======= =============:::::::::::::::::: ......=====================	Dark grey sandy clay	Stiff

Hole/Pit No.: SWAMP 10: MINAKULU HP 4 CH: 32+300 LHS (KARUMA - GULU)

Ground Elevation at commencement: …….

Date Started: 04.04.2018 **Foreman:** Robert Owori

Date Completed: 04.04.2018 **Weather Condition/ Temperature:** Sunny

Depth of Water Table: 0.6m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.40	======================== ========================	Dark brown clay top soil	Soft
1.50	======================== ======================== ========================	Yellowish grey clay	Loose
3.00	======================== ======================== ========================	Greyish brown sandy clay	Stiff
5.00	=====::::::::::::::::========== =====:::::::::::::::::::::::::======= =============:::::::::::::::::::	Yellowish brown clay with sand	Firm

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PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 10: MINAKULU HP 5 CH: 32+400 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 04.04.2018 **Foreman:** Robert Owori
Date Completed: 04.04.2018 **Weather Condition/ Temperature:** Sunny
Depth of Water Table: 0.3m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.60	======================== ========================	Blackish clay top soil	Loose
1.50	===:::::::::::::::::::::::::::::::::::: :::::::::::::::===========:::::::: :::::::::::::::::::::::::::::::::::::::===	Yellowish grey clayey sand	Medium dense
3.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Greyish brown sandy clay	Stiff
5.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Yellowish brown sandy clay	Hard

Hole/Pit No.: SWAMP 11: LMINLANGO HP 1 CH: 42+200 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 05.04.2018 **Foreman:** Robert Owori
Date Completed: 05.04.2018 **Weather Condition/ Temperature:** Sunny
Depth of Water Table: 0.6m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.50	======================== ========================	Dark grey clay top soil	Loose
1.50	===::::::::::::::::::::::::::::::======= =:::::::::::::::===========::::::: :::::::::::::=============:::::::	Grey sand - clay mixture	Stiff
3.00	===:::::::::::::::::::=========== ========:::::::::::::::::::::===== ======:::::::::::::::::::::::::::::::	Yellowish brown sand - clay mixture	Very stiff
5.00	:::::::::=======:::::::::::::::::::::: ::::::::::::::::::============= =====::::::::::::::::::::::::::::::::= ======================::::::	Greyish brown clayey sand	Loose - medium dense

Hole/Pit No.: SWAMP 11: LMINLANGO HP 2 CH: 42+300 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 05.04.2018 **Foreman:** Robert Owori
Date Completed: 05.04.2018 **Weather Condition/ Temperature:** Sunny
Depth of Water Table: 0.5m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
1.00	======================== ======================== ========================	Brownish clay top soil	Loose
1.50	======================== ========================	Dark grey clay	Firm
3.00	===:::::::::::::::::::=========== ========:::::::::::::::::::::===== ======:::::::::::::::::::::::::::::::	Grey sand - clay mixture	Firm
5.00	===============:::::::::::::::: :::::===================== ==:::::::::::::::::::::::::::::========	Yellowish grey sandy clay	Loose

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PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 12: PALENGA HP 1 CH: 45+000 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 05.04.2018 **Foreman:** Robert Owori
Date Completed: 05.04.2018 **Weather Condition/ Temperature:** Sunny
Depth of Water Table: 0.4m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.50	======================== ========================	Dark grey clay top soil	Loose
1.50	==============:::::::::::::::: :::::===================== ==:::::::::::::::::::::::::::========	Brownish grey sandy clay	Firm
3.00	==============:::::::::::::::: :::::==================ooo oo=====::::::::::::::::::::::::::=== =======ooooooo==========	Yellowish brown sandy clay with gravel	Very stiff

Hole/Pit No.: SWAMP 12: PALENGA HP 2 CH: 45+100 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 05.04.2018 **Foreman:** Robert Owori
Date Completed: 05.04.2018 **Weather Condition/ Temperature:** Sunny
Depth of Water Table: 0.5m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.60	======================== ========================	Dark brown grey clay top soil	Loose
1.50	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::=== ====::::::=======::::::=======:	Greyish brown sandy clay	Firm
3.00	=======ooo::::::=======oooo ::::::=======ooo::::::=======o oo::::::=======ooo::::::====== =ooo::::::=======ooo::::::====	Yellowish brown silty/ sandy clay with gravel	Very stiff

Hole/Pit No.: SWAMP 13: TOCHI HP 1 CH: 47+000 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 06.04.2018 **Foreman:** Robert Owori
Date Completed: 06.04.2018 **Weather Condition/ Temperature:** Sunny
Depth of Water Table: 0.4m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.30	======================== ========================	Dark brown clay top soil	Loose
1.50	======================== ======================== ======================== ========================	Brownish grey silty clay	Firm
3.00	======================== ======================== ======================== ========================	Yellowish brown silty clay	Stiff
4.50	======================== ======================== ======================== ========================	Dark grey clay	Firm

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PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 13: TOCHI HP 2 CH: 47+100 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 06.04.2018 **Foreman:** Robert Owori
Date Completed: 06.04.2018 **Weather Condition/ Temperature:** Sunny
Depth of Water Table: 0.4m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.60	======================== ========================	Dark brown clay top soil	Loose
1.50	======================== ======================== ========================	Brownish grey clay	Firm
3.00	======================== ======================== ======================== ========================	Yellowish brown clay	Stiff
4.50	======================== ======================== ======================== ========================	Dark grey clay	Stiff

Hole/Pit No.: SWAMP 13: TOCHI HP 3 CH: 47+200 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 06.04.2018 **Foreman:** Robert Owori
Date Completed: 06.04.2018 **Weather Condition/ Temperature:** Sunny
Depth of Water Table: 0.5m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.30	======================== ========================	Blackish clay top soil	Loose
1.50	======================== ======================== ========================	Yellowish brown silty clay	Firm
3.00	======================== ======================== ========================	Yellowish brown clay	Hard
4.50	::::=======ooo::::::=======o oo::::::=======ooo:::::::===== ==ooo::::::=======ooo:::::::==	Yellowish brown sandy clay with gravel	Stiff / medium dense

Hole/Pit No.: SWAMP 13: TOCHI HP 4 CH: 47+300 LHS (KARUMA - GULU)
Ground Elevation at commencement: …….
Date Started: 06.04.2018 **Foreman:** Robert Owori
Date Completed: 06.04.2018 **Weather Condition/ Temperature:** Sunny
Depth of Water Table: 0.3m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.30	======================== ========================	Dark brown clay top soil	Loose
1.50	======================== ======================== ========================	Brownish yellow clay	Firm
3.00	======================== ======================== ======================== ========================	Brown clay	Very stiff

EPINEX ENGINEERING SERVICES LTD

RECORD OF HAND AUGER INVESTIGATIONS

PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 14: TYENAKAYA HP 1 CH: 53+000 LHS (KARUMA - GULU)

Ground Elevation at commencement: …….

Date Started: 07.04.2018 **Foreman:** Robert Owori

Date Completed: 07.04.2018 **Weather Condition/ Temperature:** Sunny

Depth of Water Table: 0.1m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.40	======================== ________________________	Black clay top soil	Loose
1.50	=======:::::=======:::::==== ===:::::=======:::::=======:::	Dark grey sandy clay	Firm
3.00	=======ooo:::::=======oooo :::::=======ooo:::::=======o oo:::::=======ooo:::::======	Brownish yellow sandy clayey with gravel	Very stiff
4.50	=======:::::=======:::::==== ===:::::=======:::::=======::: :::=======:::::=======:::::===	Dark grey sandy clay	Hard

Hole/Pit No.: SWAMP 14: TYENAKAYA HP 2 CH: 53+050 LHS (KARUMA - GULU)

Ground Elevation at commencement: …….

Date Started: 07.04.2018 **Foreman:** Robert Owori

Date Completed: 07.04.2018 **Weather Condition/ Temperature:** Sunny

Depth of Water Table: Existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.60	======================== ========================	Dark brown clay top soil	Loose
1.50	::::::::::===::::::::::===::::::::::= ==::::::::::===::::::::::===::::::::	Dark grey clay - sand mixture	Firm
3.00	::::::::::===::::::::::===::::::::::= ==::::::::::===::::::::::===:::::::: ::===::::::::::===::::::::::===::::	Yellowish brown clay - sand mixture	Very stiff
4.50	::::::::::===::::::::::===::::::::::= ==::::::::::===::::::::::===:::::::: ::===::::::::::===::::::::::===::::	Yellowish brown clay - sand mixture	Very stiff

Hole/Pit No.: SWAMP 15: KORO ABILI HP 1 CH: 55+050 LHS (KARUMA - GULU)

Ground Elevation at commencement: …….

Date Started: 07.04.2018 **Foreman:** Robert Owori

Date Completed: 07.04.2018 **Weather Condition/ Temperature:** Sunny

Depth of Water Table: 0.9m above Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.50	======================== ________________________	Black clay top soil	Loose
1.50	=======:::::=======:::::==== ===:::::=======:::::=======:::	Dark grey sandy clay	Firm
2.00	=======:::::=======:::::==== ===:::::=======:::::=======:::	Dark grey sandy clay	Firm
3.00	=======ooo:::::=======oooo :::::=======ooo:::::=======o	Yellowish brown sandy clay with gravel	Stiff
4.50	=======:::::=======:::::==== ===:::::=======:::::=======:::	Dark grey sandy clay	Stiff

EPINEX ENGINEERING SERVICES LTD

RECORD OF HAND AUGER INVESTIGATIONS

PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 15: KORO ABILI HP 2 CH: 55+100 LHS (KARUMA - GULU)

Ground Elevation at commencement: …….

Date Started: 07.04.2018 **Foreman:** Robert Owori

Date Completed: 07.04.2018 **Weather Condition/ Temperature:** Sunny

Depth of Water Table: 0.6m above Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.50	======================== ========================	Black clay top soil	Loose
1.50	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Dark grey sandy clay	Firm
2.00	=======::::::=======::::::==== ===::::::=======::::::=======:::	Dark grey sandy clay	Firm
3.00	=======ooo::::::=======oooo ::::::=======ooo::::::=======o oo::::::=======ooo::::::======	Yellowish brown sandy clay with gravel	Stiff
4.50	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::=== ====::::::=======::::::=======:	Dark grey sandy clay	Stiff

Hole/Pit No.: SWAMP 16: LAYIBI HP 1 CH: 57+000 LHS (KARUMA - GULU)

Ground Elevation at commencement: …….

Date Started: 09.04.2018 **Foreman:** Robert Owori

Date Completed: 09.04.2018 **Weather Condition/ Temperature:** Sunny

Depth of Water Table: 0.4m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.40	....	Brownish sand top soil	Loose
1.50	:: :: ::	Dark brown sand	Firm
2.00	=======::::::=======::::::==== ===::::::=======::::::=======:::	Brown sandy clay	Stiff
3.00	=======::::::=======::::::==== ===::::::=======::::::=======::: :::=======::::::=======::::::===	Brown sandy clay	Very stiff

EPINEX ENGINEERING SERVICES LTD

RECORD OF HAND AUGER INVESTIGATIONS

PROJECT: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

Hole/Pit No.: SWAMP 16: LAYIBI HP 2 CH: 57+050 LHS (KARUMA - GULU)

Ground Elevation at commencement: …….

Date Started: 09.04.2018 **Foreman:** Robert Owori

Date Completed: 09.04.2018 **Weather Condition/ Temperature:** Sunny

Depth of Water Table: 0.3m above existing Ground Level

Sample		Description	Remarks according to visual inspection
Depth (m)	Material Symbol		
0.50	=======::::::=======::::::==== ===::::::=======::::::=======:::	Dark grey sandy clay top soil	Loose
2.00	========:::::::::::::::::======= ===========:::::::::::::::::::::::::: :::::::====================:: :::::::::::::::::::::::::::::::::::::======	Greyish brown sandy clay	Firm
3.00	========:::::::::::::::::======= ===========:::::::::::::::::::::::::: :::::::====================:: :::::::::::::::::::::::::::::::::::::======	Yellowish brown clay - sand mixture	Very stiff
4.50	========:::::::::::::::::======= ===========:::::::::::::::::::::::::: :::::::====================:: :::::::::::::::::::::::::::::::::::::======	Brown clay - sand mixture	Very stiff

Appendix 2c

Soil Index Properties

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR BOREHOLES SAMPLES

Label	Depth range (m)	Percentage Passing													Atterberg limits			NMC (%)	USCS	REMARKS
		Sieve 37.5 mm	28.0 mm	20.0 mm	10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.15 mm	0.075 mm	LL %	PL %	PI %			
KARUMA INTAKE BH1	1.50-1.95							100	99	94	85	72	67	61	41	22	19	15	CL	Sandy Lean Clay
	3.00-3.45					100	97	92	74	69	61	52	45	38	28	15	13	13	SC	Clayey sand
KARUMA INTAKE BH2	1.50-1.95	100	84	79	68	63	59	50	39	37	33	28	24	23	35	NP	-	10	-	Weathered rock
	3.00-3.45			100	91	83	80	67	48	43	36	25	22	19	29	NP	-	13	-	"
BH1 - ACCESS TO KARUMA INTAKE	1.50-1.95						100	97	84	81	73	62	56	52	49	NP	-	20	-	Schist rock
	3.00-3.45			100	93	80	74	52	23	19	12	8	6	4	35	NP	-	8	-	Weathered sand stone
	4.50-4.95				100	88	80	57	26	23	15	10	7	5	38	NP	-	4	-	Schist weathered rock
BH2 - ACCESS TO KARUMA INTAKE	3.00-3.45						100	97	86	81	71	60	51	44	50	NP	-	23	-	"
	4.50-4.95					100	96	93	81	78	70	61	54	49	42	NP	-	13	-	"
BH1 - CLEAR WATER TANK	1.50-1.95								100	99	86	77	68	57	43	25	18	18	SC	Clayey sand
BH1 - FILTER WASH WATER	1.50-1.95						100	99	93	62	47	25	12	5	27	NP	-	11	-	Sandstone
	3.00-3.45						100	99	97	96	87	65	57	50	26	NP	-	11	-	Cobbles with sand
	4.50-4.95					100	90	79	65	61	55	46	37	31	27	NP	-	12	-	Weathered rock
	6.00-6.45						100	99	97	94	88	78	66	54	31	9	22	26	CL	Inorganic sandy lean clay
	7.50-7.95						100	96	85	78	67	53	42	32	34	NP	-	13	-	Sand
	9.00-9.45				100	87	85	83	79	77	64	53	47	41	38	10	28	17	SC	Clayey sand
	10.50-10.95						100	99	93	90	80	66	59	54	29	13	16	19	CL	Inorganic sandy lean clay
	12.00-12.45						100	98	95	92	87	78	67	55	28	13	15	22	CL	"
	13.50-13.95						100	98	82	74	60	49	40	33	29	12	17	20	SC	Clayey sand with gravel
	15.00-15.45					100	94	88	82	65	55	50	42	25	43	19	24	19	SC	Clayey sand

LL: Liquid Limit

PL: Plastic Limit

PI: Plasticity Index

NMC: Natural Moisture Content

USCS: Unified Soil Classification System

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR BOREHOLES SAMPLES

Label	Depth range (m)	Percentage Passing													Atterberg limits			NMC (%)	USCS	REMARKS
		Sieve 37.5 mm	28.0 mm	20.0 mm	10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.15 mm	0.075 mm	LL %	PL %	PI %			
BH1 - BUFFER FILTER WASH WATER	1.50-1.95			100	71	67	65	64	54	52	46	39	35	32	42	17	25	14	SC	Clayey sand with cobbles
	3.00-3.45			100	71	67	65	64	54	52	46	39	35	32	42	17	25	16	SC	"
	4.50-4.95				100	89	78	71	62	56	48	41	35	31	27	NP	-	13	-	Weathered sandstone
	6.00-6.45					100	88	75	63	58	51	43	34	29	28	NP	-	14	-	Sand with cobbles
	7.50-7.95						100	94	86	81	72	66	53	51	29	16	13	18	CL	Inorganic Lean sandy clay
	9.00-9.45						100	96	89	76	64	61	57	52	28	13	15	21	CL	"
	10.50-10.95					100	85	73	63	56	43	38	32	29	23	NP	-	19	-	Weathered sandstone
BH1 - FILTRATION	1.50-1.95					100	86	73	61	44	35	30	25	19	59	24	35	25	SC	Clayey sand
	3.00-3.45					100	94	88	82	65	55	50	42	25	43	19	24	19	SC	"
	4.50-4.95								100	99	86	77	68	57	43	25	18	18	SC	Clayey sand with silt
	6.00-6.45								100	95	84	70	65	51	40	21	19	15	SC	Clayey sand
	7.50-7.95						100	98	94	91	80	67	59	53	38	25	13	11	SC	Gravelly sand
	9.00-9.45								100	98	91	86	73	65	34	14	20	18	CL	Sandy lean clay
	10.50-10.95					100	92	91	84	81	77	73	69	48	34	29	5	16	SC	Clayey sand
	12.00-12.45							100	87	81	73	62	54	44	40	NP	_	15	SC	"
	13.50-13.95					100	82	56	40	37	34	31	25	19	42	NP	-	20	SC	Clayey sand with gravel
	15.00-15.45					100	83	55	40	37	34	28	24	20	47	NP	-	21	SC	"

LL: Liquid Limit
PL: Plastic Limit
PI: Plasticity Index

NMC: Natural Moisture Content
USCS: Unified Soil Classification System

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR BOREHOLES SAMPLES

Label	Depth range (m)	Percentage Passing													Atterberg limits			NMC (%)	USCS	REMARKS
		Sieve 37.5 mm	28.0 mm	20.0 mm	10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.15 mm	0.075 mm	LL %	PL %	PI %			
BH1 - COAGULATION / FLOCCULATION	1.50-1.95					100	81	72	56	43	37	30	27	20	53	24	29	8	SC	Clayey sand
	3.00-3.45					100	98	93	87	74	69	60	55	51	50	27	23	18	SC	Clayey sand with silt
	4.50-4.95							100	97	84	74	65	42	38	49	23	26	16	SC	Clayey sand with cobbles
	6.00-6.45						100	98	72	66	58	52	46	40	31	14	17	14	SC	Clayey sand
	7.50-7.95							100	95	71	61	56	50	40	42	14	28	12	SC	Clayey sand with gravel
	9.00-9.45							100	96	75	65	58	51	45	49	18	31	16	SC	"
	10.50-10.95					100	99	99	92	87	69	53	39	23	40	11	29	18	SC	"
	12.00-12.45						100	98	79	64	54	44	37	32	30	NP	-	18	-	Weathered sandstone
	13.50-13.95						100	95	62	58	41	28	21	18	36	NP	-	14	-	"
	15.00-15.45				100	37	36	35	26	22	16	13	9	6	34	NP	-	11	-	"
KARUMA RESERVOIR	1.50-1.95					100	96	88	81	77	70	62	55	49	42	16	26	9	SC	Clayey sand
	3.00-3.45				100	93	90	77	62	59	54	48	43	38	34	15	19	8	SC	"
	4.50-4.95				100	46	7	6	5	5	4	3	3	2	40	16	24	1	GW	Gravel-sand mixture
	6.00-6.45				100	99	98	80	51	46	41	38	34	30	46	18	28	12	SC	Clayey sand
	7.50-7.95					100	99	91	83	82	79	75	70	66	54	18	36	22	CH	Fat clay
	9.00-9.45				100	94	92	68	63	61	59	56	53	48	49	14	35	17	SC	Clayey sand
	10.50-10.95							100	94	83	65	62	57	45	56	18	38	19	SC	Clayey sand
	12.00-12.45						100	94	89	88	85	81	77	70	54	20	34	18	CH	Fat clay
	13.50-13.95					100	88	76	64	61	56	50	46	41	36	12	24	6	SC	Clayey sand
	15.00-15.45				100	83	75	50	40	38	36	33	31	27	39	17	22	5	SC	"
KAMDINI TANK RESERVOIR	1.50-1.95		100	96	80	70	51	44	41	39	36	35	33	20	45	21	24	12	GC	Clayey Gravel
	3.00-3.45		100	92	86	71	59	51	47	42	37	35	31	24	42	23	19	13	GC	"
	4.50-4.95		100	94	79	65	57	49	42	39	36	31	25	21	43	25	18	12	GC	"
	6.00-6.45		100	93	77	67	55	44	43	41	39	37	34	21	44	22	22	11	GC	"
	7.50-7.95		100	99	78	69	52	40	39	37	35	33	31	19	45	23	22	10	GC	"
	9.00-9.45								100	99	98	97	93	80	60	23	37	52	CH	Schist fat clay
	10.50-10.95					100	99	93	92	91	85	83	80	73	63	32	31	37	CH	"

LL: Liquid Limit
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EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR BOREHOLES SAMPLES

Label	Depth range (m)	Percentage Passing													Atterberg limits			NMC (%)	USCS	REMARKS
		Sieve 37.5 mm	28.0 mm	20.0 mm	10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.15 mm	0.075 mm	LL %	PL %	PI %			
MINAKULU RESERVOIR	1.50-1.95				100	90	84	59	50	48	44	42	39	36	38	12	26	8	SC	Clayey sand
	3.00-3.45				100	95	92	83	73	71	67	62	59	55	46	19	27	13	CL	Lean clay
	4.50-4.95				100	87	80	55	45	43	40	37	35	31	40	23	17	9	SC	Clayey sand
	6.00-6.45				100	99	98	87	77	74	71	65	62	58	41	22	19	15	CL	Lean clay
	7.50-7.95					100	99	94	83	81	78	74	71	66	52	22	30	16	CH	Fat clay
	9.00-9.45						100	92	82	80	77	74	71	66	40	24	16	15	CL	Lean clay
	10.50-10.95						100	97	90	80	78	76	74	67	50	22	28	20	CL	"
BOBI PUMP STATION	1.50-1.95					100	60	54	42	36	31	27	19	12	49	25	24	26	GC	Clayey gravel
	3.00-3.45					100	97	88	82	78	69	61	56	51	43	15	28	14	CL	Lean clay
	4.50-4.95		100	66	27	18	15	9	6	6	5	5	4	3	38	14	24	5	GW	Gravel-sand mixture
	6.00-6.45		100	72	37	26	23	17	13	12	11	10	9	8	32	16	16	8	GW	"
	7.50-7.95				100	92	84	75	69	64	56	53	52	51	38	12	26	11	CL	Sandy lean clay
	9.00-9.45			100	55	26	23	18	16	15	14	13	11	9	41	15	26	6	GW	Gravel-sand mixture
	10.50-10.95			100	72	53	47	35	28	26	24	21	19	16	31	14	17	9	GW	"
BOBI SUBCOUNTY/ RESERVOIR	1.50-1.95		100	88	62	51	48	33	27	25	24	22	21	19	44	19	25	7	GC	Clayey gravel
	3.00-3.45		100	52	36	25	13	8	7	6	6	5	4	4	34	19	15	6	GW	Gravel-sand mixture
	4.50-4.95		100	82	74	56	49	37	28	27	22	20	18	15	39	20	19	10	GC	Clayey gravel
	6.00-6.45		100	85	71	62	48	39	31	28	24	21	16	13	35	23	12	8	GC	"
	7.50-7.95				100	97	96	91	78	73	68	63	58	53	39	16	23	9	CL	Lean silty clay
	9.00-9.45					100	90	85	76	72	66	60	54	47	55	NP	-	13	MH	Elastic silt
	10.50-10.95				100	92	91	86	78	75	71	66	62	57	52	NP	-	16	MH	"

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EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR BOREHOLES SAMPLES

Label	Depth range (m)	Percentage Passing													Atterberg limits			NMC (%)	USCS	REMARKS
		Sieve 37.5 mm	28.0 mm	20.0 mm	10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.15 mm	0.075 mm	LL %	PL %	PI %			
BH1 - KORO ABILI RESERVOIR	1.50-1.95					100	98	96	90	87	83	75	69	54	36	12	24	15	CL	Sandy Lean clay
	3.00-3.45				100	84	78	54	42	40	37	33	28	25	34	16	18	14	SC	Clayey sand
	4.50-4.95						100	92	81	69	61	57	52	50	31	13	18	28	CL	Gravelly Lean clay
	6.00-6.45						100	97	93	89	85	71	66	52	33	8	25	29	CL	Sandy Lean clay
	7.50-7.95							100	97	95	87	71	61	54	36	13	23	19	CL	"
	9.00-9.45						100	87	82	80	73	60	53	47	39	18	21	15	SC	Clayey sand
	10.50-10.95							100	93	76	68	65	51	44	32	21	11	17	SC	Clayey sand with gravel
BH 1 - NEW CUSTOMS CORNER TANK SITE	1.50-1.95					100	91	75	59	55	52	47	41	36	38	13	25	13	SC	"
	3.00-3.45		100	71	42	30	24	16	12	12	11	10	8	7	40	16	24	7	GC	Clayey gravel
	4.50-4.95			100	84	68	59	50	45	43	42	40	37	32	43	16	27	11	SC	Clayey sand with gravel
	6.00-6.45				100	97	90	80	67	64	61	57	51	45	45	15	30	16	SC	"
	7.50-7.95					100	98	96	92	89	87	83	75	64	50	21	29	24	CH	Fat clay
	9.00-9.45				100	97	95	79	71	68	67	62	56	50	47	18	29	17	CL	Lean clay
	10.50-10.95							100	96	92	89	80	68	62	49	25	24	15	CL	"
	12.00-12.45							100	99	99	97	93	89	86	50	21	29	15	CH	Fat clay
	13.50-13.95						100	99	94	87	82	69	59	51	43	20	23	12	CL	Lean clay
	15.00-15.45							100	97	94	88	75	62	53	42	NP	-	16	ML	Inorganic silt

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EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR BOREHOLES SAMPLES

Label	Depth range (m)	Percentage Passing													Atterberg limits			NMC (%)	USCS	REMARKS
		Sieve 37.5	28.0	20.0	10.0	6.3	5.0	2.0	0.600	0.425	0.300	0.212	0.15	0.075	LL %	PL %	PI %			
		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm						
BH 2 - NEW CUSTOMS CORNER TANK SITE	1.50-1.95				100	99	96	86	78	73	69	64	54	51	45	18	27	8	CL	Lean clay with gravel
	3.00-3.45						100	96	91	87	85	79	71	61	47	18	29	17	CL	Lean clay
	4.50-4.95						100	95	87	75	71	66	63	60	47	26	21	15	CL	Lean clay with sand
	6.00-6.45						100	99	90	86	84	81	78	74	41	22	19	20	CL	"
	7.50-7.95						100	98	88	83	81	77	71	65	51	25	26	15	CH	Fat clay
	9.00-9.45							100	97	92	87	78	68	59	48	24	24	21	CL	Lean clay
	10.50-10.95							100	95	91	83	68	59	51	47	22	25	12	CL	"
	12.00-12.45						100	99	93	88	82	73	62	54	47	25	22	25	CL	"
	13.50-13.95						100	99	95	90	87	78	68	61	39	17	22	12	CL	"
	15.00-15.45							100	97	94	91	83	77	72	57	28	29	18	CH	Fat clay

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EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR SAMPLES OBTAINED FROM SWAMPS ON THE LHS OF KARUMA - GULU HIGHWAY

Swamp Name	Label / CH from branch off to Karuma Water Treatment Plant	Depth(m)	Percentage Passing										Atterberg limits			NMC (%)	USCS	REMARKS
			10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.15 mm	0.075 mm	LL %	PL %	PI %			
KANKAYI	Point 1 (CH 3+270LHS)	1.5			100	82	71	63	57	55	53	50	42	29	13	11	CL	Sandy lean clay with cobb
		3.0			100	98	87	82	68	42	27	20	21	NP	-	8	SC	Clayey sand with gravel
		4.5				100	95	92	78	63	48	39	29	7	22	19	SC	Clayey sand
	Point 2 (CH:3+463 LHS)	1.5		100	99	99	96	95	91	83	75	70	36	17	19	32	CL	Inorganic lean clay
		3.0			100	99	95	91	82	59	42	34	26	7	19	18	SC	Clayey sand
		4.5				100	95	91	76	54	40	34	26	7	19	21	SC	"
AGENGI	Point 1 (CH 6+000LHS)	1.5			100	99	96	93	84	71	67	63	56	17	39	26	CH	Inorganic fat clay
		3.0				100	94	91	86	81	76	73	48	14	34	35	CL	Inorganic lean clay
		4.5				100	95	93	83	70	56	50	28	8	20	20	CL	"
	Point 2 (CH 6+050LHS)	1.5				100	97	94	88	76	68	64	56	14	42	31	CH	Inorganic fat clay
		3.0				100	97	95	90	84	74	67	38	13	25	33	CL	Inorganic lean clay
ALENYI	Point 1 (CH 9+000LHS)	1.5				100	98	96	88	78	71	68	38	13	25	26	CL	Inorganic lean clay
		3.0			100	98	94	91	84	71	66	65	52	14	38	27	CH	Inorganic fat clay
		3.8				100	99	98	94	90	87	86	67	17	50	39	CH	"
	Point 2 (CH 9+150LHS)	1.5				100	97	95	90	80	75	73	51	9	42	32	CH	"
		3.0			100	96	89	86	81	74	63	59	52	18	34	28	CH	"
		4.5				100	98	96	92	82	73	69	49	11	38	27	CL	Inorganic lean clay
	Point 3 (CH 9+362LHS)	1.5				100	98	96	91	84	76	71	44	15	29	36	CL	"
		3.0				100	97	96	93	86	80	78	53	15	38	25	CH	Inorganic fat clay
		4.5			100	97	92	85	80	72	65	61	56	23	33	36	CH	"
	Point 4 (CH 9+393LHS)	1.5				100	98	96	93	87	81	78	54	17	37	38	CH	"
		3.0				100	95	92	88	82	73	68	52	19	33	29	CH	"
		4.5				100	97	95	89	82	76	74	40	15	25	41	CL	Inorganic lean clay

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EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR SAMPLES OBTAINED FROM SWAMPS ON THE LHS OF KARUMA - GULU HIGHWAY

Swamp Name	Label / CH from branch off to Karuma Water Treatment Plant	Depth(m)	Percentage Passing										Atterberg limits			NMC (%)	USCS	REMARKS
			10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.15 mm	0.075 mm	LL %	PL %	PI %			
MYENE	Point 1 (CH 12+000LHS)	1.5			100	94	88	85	76	51	34	28	45	19	26	18	SC	Clayey sand
		3.0		100	98	94	90	88	83	75	70	69	44	17	27	33	CL	Inorganic lean clay
		4.5				100	97	95	87	79	73	70	53	15	38	35	CH	High plasticity fat clay
	Point 2 (CH 13+000LHS)	1.5			100	96	93	91	82	73	67	63	59	16	43	38	CH	"
		3.0	100	95	93	85	80	78	73	66	61	57	38	17	21	38	CL	Inorganic lean clay
		4.5			100	96	93	91	86	80	74	72	44	19	25	36	CL	"
	Point 3 (CH 13+100LHS)	1.5				100	94	90	79	65	58	54	40	14	26	26	CL	"
		3.0		100	97	89	84	82	78	72	65	59	42	17	25	38	CL	"
		4.5			100	99	96	94	87	79	74	70	41	28	13	32	OL	Organic silty clay
	Point 4 (CH 13+200LHS)	1.5			100	99	97	96	93	84	82	80	55	26	29	38	CH	Inorganic fat clay
		3.0				100	97	96	93	89	85	82	40	18	22	37	CL	Inorganic lean clay
		4.5		100	99	97	94	93	89	84	81	79	59	28	31	39	CH	High plasticity fat clay
	Point 5 (CH 13+500LHS)	1.5			100	98	94	92	91	83	75	72	58	23	35	35	CH	"
		3.0			100	95	91	91	90	85	81	71	50	18	32	41	CL	Inorganic lean clay
		4.5				100	99	89	87	84	80	77	49	21	28	37	CL	"

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CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR SAMPLES OBTAINED FROM SWAMPS ON THE LHS OF KARUMA - GULU HIGHWAY

Swamp Name	Label / CH from branch off to Karuma Water Treatment Plant	Depth(m)	Percentage Passing										Atterberg limits			NMC (%)	USCS	REMARKS
			10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.15 mm	0.075 mm	LL %	PL %	PI %			
AMWA, OTWE	Point 1 (CH 14+150LHS)	1.5	100	97	96	91	87	85	82	77	69	63	49	12	37	37	CL	Silty lean clay
		3.0			100	92	88	87	83	75	70	66	47	19	28	38	CL	"
		4.5			100	94	89	86	81	69	61	56	61	20	41	42	CH	High plasticity fat clay
	Point 2 (CH 16+000LHS)	1.5			100	99	97	96	92	87	83	81	55	12	43	35	CH	"
		3.0			100	97	94	94	93	92	90	89	47	21	26	35	CL	Lean clay
		4.5				100	99	97	95	92	89	87	58	13	45	36	CH	High plasticity fat clay
NGAATO	Point 1 (CH 16+200LHS)	1.5				100	96	93	87	78	64	56	37	14	23	21	CL	Sandy lean clay
		3.0				100	95	89	83	79	76	72	51	24	27	26	CH	Inorganic fat clay
		4.5			100	97	91	88	85	80	75	69	53	23	30	32	CH	"
	Point 2 (CH 16+250LHS)	1.5				100	96	94	89	81	75	73	47	18	29	29	CL	Inorganic lean clay
		3.0				100	95	90	83	74	69	63	56	21	35	27	CH	High plasticity fat clay
		4.5			100	93	89	82	79	75	70	69	58	25	33	30	CH	"
	Point 3 (CH 20+000LHS)	1.5			100	99	95	93	88	82	78	77	36	15	21	32	CL	Sandy lean clay
		3.0				100	96	94	91	83	78	75	61	24	37	30	CH	High plasticity fat clay
		4.5			100	99	94	92	88	82	79	78	52	16	36	31	CH	"
	Point 4 (CH 20+300LHS)	1.5				100	98	94	89	82	79	76	35	8	27	17	CL	Inorganic lean clay
		3.0				100	94	90	77	64	58	56	52	16	36	25	CH	High plasticity fat clay
		4.0				100	97	94	89	81	78	75	49	12	37	31	CL	Inorganic lean clay
	Point 5 (CH 20+390LHS)	1.5				100	98	96	92	86	78	73	47	13	34	28	CL	"
		3.0				100	98	96	93	88	80	74	47	17	30	22	CL	"
		3.8				100	98	97	93	87	81	79	58	20	38	35	CH	High plasticity fat clay

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CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR SAMPLES OBTAINED FROM SWAMPS ON THE LHS OF KARUMA - GULU HIGHWAY

Swamp Name	Label / CH from branch off to Karuma Water Treatment Plant	Depth(m)	Percentage Passing										Atterberg limits			NMC (%)	USCS	REMARKS
			10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.15 mm	0.075 mm	LL %	PL %	PI %			
ATEK	Point 1 (CH 22+000LHS)	1.5				100	95	91	84	74	68	65	48	11	37	21	CL	Lean clay
		3.0				100	95	91	85	77	70	67	56	18	38	25	CH	Fat clay
		4.5				100	88	79	59	42	32	30	48	11	37	24	SC	Sand-clay mixture
	Point 2 (CH 22+100LHS)	1.5				100	97	95	88	76	68	65	38	10	28	25	CL	Sandy lean clay
		3.0				100	97	95	89	79	69	64	45	11	34	25	CL	"
		4.0			100	93	84	76	64	56	41	34	46	12	34	28	SC	Clayey sand
	Point 3 (CH 22+200LHS)	1.5			100	99	92	87	78	68	63	61	49	21	28	25	CL	Silty lean clay
		3.0			100	98	94	90	82	74	70	68	40	17	23	29	CL	"
	Point 4 (CH 22+300LHS)	1.5				100	98	97	94	91	87	82	43	19	24	35	CL	"
		3.0			100	96	91	84	80	73	67	61	47	15	32	26	CL	Sandy lean clay
		4.0				100	91	81	63	49	37	33	45	13	32	26	SC	Sand-clay mixture
AGADA	Point 1 (CH 25+000LHS)	1.5				100	92	88	79	66	55	51	38	12	26	17	CL	Sandy lean clay
		3.0				100	93	90	82	73	62	55	28	6	22	20	CL	Silty lean clay
		4.5				100	92	89	80	68	60	55	36	12	24	17	CL	Lean clay
	Point 2 (CH 25+100LHS)	1.5				100	94	91	86	80	75	71	43	15	28	29	CL	"
		3.0				100	93	90	84	77	71	68	50	17	33	34	CL	"
		4.0			100	94	89	83	78	65	61	53	42	17	25	19	CL	"

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EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR SAMPLES OBTAINED FROM SWAMPS ON THE LHS OF KARUMA - GULU HIGHWAY

Swamp Name	Label / CH from branch off to Karuma Water Treatment Plant	Depth(m)	Percentage Passing										Atterberg limits			NMC (%)	USCS	REMARKS
			10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.15 mm	0.075 mm	LL %	PL %	PI %			
ATEGO	Point 1 (CH 29+050LHS)	1.5				100	93	89	82	72	65	60	29	6	23	27	CL	Lean clay
		3.0				100	89	84	77	69	65	62	49	10	39	36	CL	"
		4.5		100	98	98	89	85	78	71	66	64	43	19	24	41	CL	"
	Point 2 (CH 30+000LHS)	1.5		100	99	97	90	84	79	73	65	61	49	14	35	40	CL	"
		3.0				100	98	96	94	85	79	77	32	14	18	23	CL	"
		4.5				100	97	96	78	75	72	69	38	11	27	44	CL	"
MINAKULU	Point 1 (CH 32+000LHS)	1.5				100	97	96	91	83	81	79	53	25	28	49	CH	High plasticity fat clay
		3.0		100	98	93	89	82	79	77	73	69	48	21	27	41	CL	Lean clay
		4.5		100	99	99	86	79	67	41	20	12	28	13	15	37	SW	Gravelly sand
	Point 2 (CH 32+100LHS)	1.5	100	92	90	83	78	76	72	67	64	63	41	16	25	34	CL	Lean clay
		3.0				100	99	97	93	84	80	77	37	14	23	31	CL	"
		4.5			100	99	97	95	92	86	81	78	47	19	28	38	CL	"
	Point 3 (CH 32+200LHS)	1.5				100	98	97	92	81	73	71	43	15	28	34	CL	"
		3.0			100	99	96	94	88	81	77	76	54	25	29	35	CH	High plasticity fat clay
		4.5			100	96	93	91	87	84	79	73	49	19	30	36	CL	Silty lean clay
	Point 4 (CH 32+300LHS)	1.5			100	99	97	95	92	81	79	77	54	21	33	35	CH	High plasticity fat clay
		3.0			100	97	94	93	90	83	78	75	58	18	40	37	CH	"
		4.5	100	99	95	90	86	83	80	75	69	65	46	20	26	31	CL	Lean clay
	Point 5 (CH 32+400LHS)	1.5	100	89	85	69	59	57	53	47	43	41	52	17	35	22	SC	Clayey sand
		3.0	100	93	92	83	79	76	73	63	58	57	43	12	31	27	CL	Lean clay
		4.5		100	96	95	93	91	85	74	67	63	43	19	24	29	CL	"

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CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR SAMPLES OBTAINED FROM SWAMPS ON THE LHS OF KARUMA - GULU HIGHWAY

Swamp Name	Label / CH from branch off to Karuma Water Treatment Plant	Depth(m)	Percentage Passing										Atterberg limits			NMC (%)	USCS	REMARKS
			10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.15 mm	0.075 mm	LL %	PL %	PI %			
LMINLANGO (BOBI)	Point 1 (CH 42+200LHS)	1.5		100	98	96	83	74	59	44	38	36	39	20	19	25	SC	Sand - clay mixture
		3.0		100	95	92	76	65	50	36	27	23	36	9	27	27	SC	"
		4.5			100	98	83	75	63	50	44	41	38	17	21	25	SC	Clayey sand
	Point 2 (CH 42+300LHS)	1.5				100	98	95	88	75	70	68	43	15	28	36	CL	Sandy lean clay
		3.0		100	99	96	83	72	57	43	35	31	34	16	18	23	SC	Sand - clay mixture
		4.5				100	95	92	83	69	60	58	34	6	28	23	CL	Sandy lean clay
PALENGA	Point 1 (CH 45+000LHS)	1.5				100	99	94	90	82	76	69	47	19	28	31	CL	"
		3.0				100	99	97	94	86	80	78	43	17	26	31	CL	"
		4.5		100	95	87	84	83	80	72	68	67	53	16	37	36	CH	High plasticity fat clay
	Point 2 (CH 45+100LHS)	1.5	100	99	98	92	89	87	82	74	63	54	49	13	36	30	CH	Sandy fat clay
		3.0			100	99	98	95	89	83	79	76	45	18	27	33	CL	Sandy lean clay
		4.5		100	96	92	87	81	76	69	65	61	51	17	34	35	CH	Fat clay
TOCHI	Point 1 (CH 47+000LHS)	1.5			100	97	93	92	89	83	78	75	47	18	29	42	CL	Lean clay
		3.0		100	99	97	93	91	86	83	81	77	56	23	33	39	CH	High plasticity fat clay
		4.5		100	99	96	91	83	79	74	66	63	58	21	37	39	CH	"
	Point 2 (CH 47+100LHS)	1.5				100	99	99	97	93	88	84	39	17	22	34	CH	"
		3.0		100	99	99	97	95	89	86	80	78	61	28	33	42	CH	"
		4.5			100	97	92	86	81	75	69	60	61	25	36	36	CH	"
	Point 3 (CH 47+200LHS)	1.5					100	99	99	97	96	96	49	21	28	33	CL	Silty lean clay
		3.0	100	99	99	95	92	89	84	80	78	74	59	24	35	36	CH	High plasticity fat clay
		4.5		100	98	94	88	85	80	73	67	61	61	28	33	37	CH	"
	Point 4 (CH 47+300LHS)	1.5					100	99	99	96	94	93	58	15	43	34	CH	"
		3.0			100	98	97	97	95	89	84	82	63	16	47	41	CH	"
		4.5		100	99	94	84	81	78	71	69	66	61	21	40	39	CH	"

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EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR SAMPLES OBTAINED FROM SWAMPS ON THE LHS OF KARUMA - GULU HIGHWAY

Swamp Name	Label / CH from branch off to Karuma Water Treatment Plant	Depth(m)	Percentage Passing										Atterberg limits			NMC (%)	USCS	REMARKS
			10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.15 mm	0.075 mm	LL %	PL %	PI %			
TYENAKAYA	Point 1 (CH 53+000LHS)	1.5		100	96	89	84	79	72	61	48	38	37	13	24	44	SC	Sand - clay mixture
		3.0				100	95	93	89	82	77	74	52	20	32	35	CH	Sandy fat clay
		4.5		100	98	93	84	80	73	64	59	51	39	17	22	31	CL	Sandy lean clay
	Point 2 (CH 53+050LHS)	1.5		100	97	92	87	83	74	57	44	39	35	12	23	46	SC	Sand - clay mixture
		3.0		100	98	98	96	95	84	65	49	46	34	10	24	23	SC	"
		4.5		100	97	91	86	83	75	62	56	54	37	14	23	26	CL	Sandy lean clay
KORO ABILI	Point 1 (CH 55+050LHS)	1.5		100	99	98	95	91	81	66	58	56	38	10	28	28	CL	"
		3.0				100	98	93	84	70	58	54	39	12	27	26	CL	"
		4.5				100	95	87	80	69	64	52	32	10	22	22	CL	"
	Point 2 (CH 55+100LHS)	1.5		100	98	96	92	88	84	73	69	59	41	12	29	29	CL	"
		3.0			100	99	97	95	89	76	63	57	38	11	27	31	CL	"
		4.5				100	96	89	79	71	62	55	34	13	21	23	CL	"
LAYIBI	Point 1 (CH 57+000LHS)	1.5				100	95	90	78	60	51	48	33	10	23	22	SC	Sand - clay mixture
		3.0				100	94	88	76	65	51	43	34	13	21	24	SC	"
		4.5			100	96	90	85	79	63	54	39	32	11	21	18	SC	"
	Point 2 (CH 57+050LHS)	1.5				100	97	93	78	59	51	48	42	12	30	25	SC	"
		3.0				100	95	90	78	63	49	41	36	9	27	21	SC	"
		4.5				100	92	80	69	57	51	34	33	10	23	20	SC	"

LL: Liquid Limit
PL: Plastic Limit
PI: Plasticity Index

NMC: Natural Moisture Content
USCS: Unified Soil Classification System

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR THE ALIGNMENT SAMPLES FROM TRIAL PITS REPORTED FROM KARUMA TO GULU

CH / offset - LHS	Depth (m)	Percentage Passing													Atterberg limits			LS	NMC (%)	USCS	REMARKS
		Sieve 50.0 mm	37.5 mm	20.0 mm	10.0 mm	6.3 mm	5.0 mm	2.36 mm	0.60 mm	0.425 mm	0.30 mm	0.212 mm	0.15 mm	0.075 mm	LL %	PL %	PI %				
0+000	0.5			100	98	96	85	79	51	45	34	28	24	20	28	17	11	5	11	SC	Clayey sand with gravel
2+000	1.0		100	95	94	93	89	85	33	30	25	21	17	14	32	20	13	6	13	SC	"
4+000	1.5																0				Hard Pan
6+000	1.5							100	94	88	77	61	47	39	34	21	13	6	8	SC	Clayey sand with gravel
	2.0							100	85	76	61	48	36	30	33	21	13	6	11	SC	"
8+000	1.5		100	99	96	92	89	75	65	60	50	46	37	32	35	20	15	7	10	SC	"
9+000	1.5					100	99	93	83	77	67	56	46	40	36	20	17	8	10	SC	"
11+000	1.5							100	96	93	84	77	65	56	25	11	14	6	9	CL	Lean clay
13+000	1.5					100	98	90	82	76	65	57	54	50	25	12	13	6	11	CL	"
15+000	1.5				100	99	96	51	35	32	29	25	21	18	32	15	17	9	18	SC	Clayey sand with gravel
	3.0			100	99	98	96	56	39	37	31	28	23	20	34	16	18	9	15	SC	"
17+000	1.5						100	99	94	88	85	81	73	68	36	19	17	9	16	CL	Lean clay
	2.0						100	98	90	86	83	80	75	70	36	18	18	9	12	CL	"
19+000	1.5				100	99	96	57	44	43	40	39	34	28	25	13	11	6	15	SC	Clayey sand with gravel
	1.7																				Hard Pan
21+000	1.0				100	95	87	54	41	38	35	32	27	24	28	18	10	6	18	SC	Clayey sand with gravel
	1.6																				Hard Pan

LL: Liquid Limit **PI:** Plasticity Index

LS: Linear Shrinkage **USCS:** Unified Soil Classification System

PL: Plastic Limit

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR THE ALIGNMENT SAMPLES FROM TRIAL PITS REPORTED FROM KARUMA TO GULU

CH / offset - LHS	Depth (m)	Percentage Passing													Atterberg limits			LS	NMC (%)	USCS	REMARKS
		Sieve 50.0	37.5	20.0	10.0	6.3	5.0	2.36	0.60	0.425	0.30	0.212	0.15	0.075	LL %	PL %	PI %				
23+000	1.5																0				Hard Pan
25+000	1.5		100	65	38	20	17	11	10	9	7	5	3	1	46	20	26	12	23	GC	Clayey gravel
	3.0		100	74	29	21	18	14	12	10	9	8	7	6	26	19	7	4	16	GP	Poorly graded gravel
27+000	1.5		100	94	71	56	48	34	28	27	26	25	24	23	29	11	19	9	18	GC	Clayey gravel
	2.5				100	99	98	94	84	76	65	58	53	51	35	10	25	12	21	CL	Lean clay
29+000	1.5		100	94	75	59	52	38	31	29	24	21	17	15	36	19	17	9	23	SC	Clayey sand with gravel
	2.0		100	98	94	83	71	39	32	31	30	28	26	24	32	13	20	10	19	SC	"
31+000	1.5			100	76	52	40	13	11	10	9	7	6	5	18	8	10	5	8	GP	Poorly graded gravel
	3.0		100	92	82	71	64	62	60	58	57	56	55	54	34	15	20	9	14	CL	Gravelly lean clay
33+000	1.5							100	94	90	83	78	72	66	38	12	26	12	21	CL	Lean clay
	2.0	100	75	39	26	22	20	14	13	12	11	10	9	8	23	11	12	6	18	GP	Poorly graded gravel
35+000	1.5							100	96	92	81	71	60	54	34	12	22	11	24	CL	Lean clay
	3.0							100	95	88	76	66	54	48	36	14	22	11	21	SC	Clayey sand
37+000	1.0					100	99	96	90	83	74	61	55	46	21	9	12	6	17	SC	"
39+000	1.5							100	97	53	46	38	27	20	38	18	20	9	22	SC	Clayey sand with gravel

LL: Liquid Limit **PI:** Plasticity Index

LS: Linear Shrinkage **USCS:** Unified Soil Classification System

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EPINEX ENGINEERING SERVICES LTD.

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CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR THE ALIGNMENT SAMPLES FROM TRIAL PITS REPORTED FROM KARUMA TO GULU

CH / offset - LHS	Depth (m)	Percentage Passing													Atterberg limits			LS	NMC (%)	USCS	REMARKS
		Sieve 50.0	37.5	20.0	10.0	6.3	5.0	2.36	0.60	0.425	0.30	0.212	0.15	0.075	LL %	PL %	PI %				
41+000	1.5			100	93	79	70	50	42	40	37	35	31	28	37	22	15	8	19	SC	Clayey sand with gravel
	3.0		100	99	79	60	51	36	29	28	27	25	23	20	33	14	18	9	23	GC	Clayey gravel
43+000	1.5		100	94	64	48	40	25	23	22	21	20	18	16	36	15	21	10	25	GC	"
	3.0		100	96	75	61	52	39	36	32	29	26	24	22	39	22	18	8	22	SC	Clayey sand with gravel
45+000	1.5		100	96	61	53	42	31	25	20	19	18	15	13	39	14	25	9	24	GC	Clayey gravel
	3.0		100	92	64	57	51	35	30	27	25	21	19	17	37	21	16	9	19	SC	Clayey sand with gravel
47+000	1.5		100	95	77	65	54	42	38	34	30	26	23	20	36	17	19	9	23	SC	"
49+000	1.5		100	94	52	32	27	14	13	12	10	9	7	3	36	24	12	6	16	GP	Poorly graded gravel
51+000	1.5		100	94	84	68	62	42	28	25	21	18	15	13	38	24	14	6	19	SM	Silty sand with gravel
	3.0			100	95	87	74	62	54	43	35	30	26	22	37	20	17	8	24	SW	Gravelly sand
53+000	1.0			100	86	82	75	60	55	40	36	27	24	21	27	14	13	6	20	SW	"
55+000	1.5		100	91	82	62	54	41	31	27	23	19	14	10	32	24	8	5	18	SW	"
	1.7																				Hard Pan
57+000	1.5		100	84	71	63	50	39	25	22	18	15	11	8	26	17	9	6	14	GC	Clayey gravel
	3.0		100	97	91	81	70	26	24	23	21	20	17	14	30	10	20	10	21	SC	Clayey sand with gravel

LL: Liquid Limit

PI: Plasticity Index

LS: Linear Shrinkage

USCS: Unified Soil Classification System

PL: Plastic Limit

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

SOIL CLASSIFICATION FOR THE ALIGNMENT SAMPLES FROM TRIAL PITS REPORTED FROM KARUMA TO GULU

CH / offset - LHS	Depth (m)	Percentage Passing													Atterberg limits			LS	NMC (%)	USCS	REMARKS
		Sieve 50.0	37.5	20.0	10.0	6.3	5.0	2.36	0.60	0.425	0.30	0.212	0.15	0.075	LL %	PL %	PI %				
59+000	1.5						100	99	97	95	84	78	63	57	36	18	18	9	23	CL	Silty lean clay
61+000	1.5						100	98	90	81	72	68	64	57	32	19	13	6	19	CL	Silty lean clay
	3.0				100	98	91	84	71	67	51	43	36	32	25	10	15	7	17	SC	Clayey sand
63+000	1.5							100	99	96	88	78	63	56	34	18	16	8	18	CL	Silty lean clay
	3.0						100	97	93	84	80	75	61	42	36	20	16	8	20	SC	Clayey sand
65+000	1.5						100	99	95	90	84	75	64	58	39	18	22	9	19	CL	Silty lean clay
	2.0						100	98	91	81	72	65	59	45	41	21	20	8	19	SC	Clayey sand
TP1 from Gulu - Layibi Roundabout	1.5			100	95	84	74	49	43	40	33	24	22	21	36	17	18	9	23	SC	Clayey sand with gravel
	3.0			100	99	97	95	90	84	78	67	58	50	43	35	24	11	5	18	SC	Clayey sand
TP2 from Gulu - Layibi	1.5							100	93	79	57	41	30	24	33	16	17	8	21	SC	Clayey sand with gravel

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Appendix 2d

Bearing Capacity based on SPT – N Values

EPINEX ENGINEERING SERVICES LTD.

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CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

EVALUATION OF BEARING CAPACITY OF THE SOIL BASED ON FIELD SPT-N VALUES

BH Label	Depth range (m)	Predominant Material Fraction	Design N-Value	Unconfined Compressive Strength, qu (kPa)	Undrained Cohesion, Cu (kPa)	Ultimate Bearing Capacity, qult (kPa)	Allowable Bearing Capacity, qall (kPa)
Karuma Intake BH 1	1.50-1.95	Sandy clay	16	210	105	539	180
	3.00-3.45	Clayey sand	15	-	-	-	175
Karuma Intake BH 2	1.50-1.95	Weathered rock with cobbles	27	-	-	-	330
	3.00-3.45	Weathered rock with boulders	47	-	-	-	565
BH1 - Access to Karuma Intake	1.50-1.95	Silty Schist rock	24	-	-	-	285
	3.00-3.45	Schist weathered sand stone	32	-	-	-	380
	4.50-4.95	Schist weathered rock	33	-	-	-	390
BH2 - Access to Karuma Intake	3.00-3.45	Schist weathered rock	30	-	-	-	350
	4.50-4.95	"	36	-	-	-	430
Clear Water Tank - BH1	1.50-1.95	Clayey sand	17	-	-	-	200
Filter Wash Water - BH1	1.50-1.95	Sandstone	36	-	-	-	445
	3.00-3.45	Cobbles with sand	36	-	-	-	445
	4.50-4.95	Sandy weathered rock	27	-	-	-	310
	6.00-6.45	Sandy clay	35	459	229	1178	393
	7.50-7.95	Sand	32	-	-	-	380
	9.00-9.45	Clayey sand	33	-	-	-	390
	10.50-10.95	Sandy clay	60	786	393	2020	673
	12.00-12.45	"	53	694	347	1784	595
	13.50-13.95	Gravelly sand	59	-	-	-	>700
	15.00-15.45	Clayey sand	63	-	-	-	>700

Note:

For cohesive soils, the relationship qu = 13.1 x Design N-value is used for evaluation of the Unconfined Compressive Strength qu, the cohesion Cu = qu/2 and qult = 5.14 x Cu. qall is evaluated using a factor of safety of 3

**Allowable Bearing capacity with settlement limited to approximately 25mm for cohesionless soils read off directly from the Chart (Published by Terzaghi and Peck 1967)*

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

EVALUATION OF BEARING CAPACITY OF THE SOIL BASED ON FIELD SPT-N VALUES

BH Label	Depth range (m)	Predominant Material Fraction	Design N-Value	Unconfined Compressive Strength, qu (kPa)	Undrained Cohesion, Cu (kPa)	Ultimate Bearing Capacity, qult (kPa)	Allowable Bearing Capacity, qall (kPa)
Buffer Filter Wash Water - BH1	1.50-1.95	Sand with cobbles	26	-	-	-	300
	3.00-3.45	Clayey sand	31	-	-	-	365
	4.50-4.95	Weathered sandstone	41	-	-	-	485
	6.00-6.45	Sand with cobbles	28	-	-	-	330
	7.50-7.95	Sandy clay	45	590	295	1515	505
	9.00-9.45	"	43	563	282	1448	483
	10.50-10.95	Weathered sandstone	49	-	-	-	580
Filtration - BH1	1.50-1.95	Clayey sand	12	-	-	-	105
	3.00-3.45	"	15	-	-	-	165
	4.50-4.95	"	18	-	-	-	220
	6.00-6.45	"	27	-	-	-	310
	7.50-7.95	Gravelly sand	31	-	-	-	365
	9.00-9.45	Sandy clay	33	432	216	1111	370
	10.50-10.95	Clayey sand	18	-	-	-	220
	12.00-12.45	"	27	-	-	-	310
	13.50-13.95	Clayey sand with gravel	29	-	-	-	345
	15.00-15.45	"	35	-	-	-	410

Note:

For cohesive soils, the relationship qu = 13.1 x Design N-value is used for evaluation of the Unconfined Compressive Strength qu, the cohesion Cu = qu/2 and qult = 5.14 x Cu. qall is evaluated using a factor of safety of 3

**Allowable Bearing capacity with settlement limited to approximately 25mm for cohesionless soils read off directly from the Chart (Published by Terzaghi and Peck 1967)*

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CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

EVALUATION OF BEARING CAPACITY OF THE SOIL BASED ON FIELD SPT-N VALUES

BH Label	Depth range (m)	Predominant Material Fraction	Design N-Value	Unconfined Compressive Strength, qu (kPa)	Undrained Cohesion, Cu (kPa)	Ultimate Bearing Capacity, qult (kPa)	Allowable Bearing Capacity, qall (kPa)
Coagulation / Flocculation - BH1	1.50-1.95	Clayey sand	37	-	-	-	450
	3.00-3.45	"	30	-	-	-	350
	4.50-4.95	"	50	-	-	-	590
	6.00-6.45	"	54	-	-	-	685
	7.50-7.95	"	47	-	-	-	575
	9.00-9.45	"	61	-	-	-	>700
	10.50-10.95	"	63	-	-	-	>700
	12.00-12.45	Weathered sandstone	51	-	-	-	600
	13.50-13.95	"	52	-	-	-	670
	15.00-15.45	"	54	-	-	-	685
Karuma Reservoir - BH1	1.50-1.95	Clayey sand	22	-	-	-	260
	3.00-3.45	"	46	-	-	-	565
	4.50-4.95	Gravel - sand mixture	56	-	-	-	>700
	6.00-6.45	Clayey sand	24	-	-	-	280
	7.50-7.95	Clay	28	367	183	943	314
	9.00-9.45	Clayey sand	21	-	-	-	250
	10.50-10.95	"	22	-	-	-	260
	12.00-12.45	Clay	19	249	124	640	213
	13.50-13.95	Clayey sand	29	-	-	-	345
	15.00-15.45	"	38	-	-	-	465

Note:

For cohesive soils, the relationship qu = 13.1 x Design N-value is used for evaluation of the Unconfined Compressive Strength qu, the cohesion Cu = qu/2 and qult = 5.14 x Cu. qall is evaluated using a factor of safety of 3

**Allowable Bearing capacity with settlement limited to approximately 25mm for cohesionless soils read off directly from the Chart (Published by Terzaghi and Peck 1967)*

EPINEX ENGINEERING SERVICES LTD.

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CLIENT : M/s FICHTNER WATER & TRANSPORTATION

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EVALUATION OF BEARING CAPACITY OF THE SOIL BASED ON FIELD SPT-N VALUES

BH Label	Depth range	Predominant Material Fraction	Design N-Value	Unconfined Compressive Strength, qu (kPa)	Undrained Cohesion, Cu (kPa)	Ultimate Bearing Capacity, qult (kPa)	Allowable Bearing Capacity, qall (kPa)
Kamdini Tank Reservoir - BH1	1.50-1.95	Clayey gravel/ laterite	52	-	-	-	670
	3.00-3.45	"	56	-	-	-	>700
	4.50-4.95	"	63	-	-	-	>700
	6.00-6.45	"	36	-	-	-	425
	7.50-7.95	"	30	-	-	-	350
	9.00-9.45	Schist clay	17	223	111	572	191
	10.50-10.95	"	18	236	118	606	202
Minakulu Reservoir - BH1	1.50-1.95	Clayey sand	60	-	-	-	>700
	3.00-3.45	Clay	48	629	314	1616	539
	4.50-4.95	Clayey sand	24	-	-	-	280
	6.00-6.45	Clay	7	92	46	236	79
	7.50-7.95	"	9	118	59	303	101
	9.00-9.45	"	10	131	66	337	112
	10.50-10.95	"	15	197	98	505	168
Bobi Pump Station - BH1	1.50-1.95	Clayey gravel	39	-	-	-	465
	3.00-3.45	Clay	44	576	288	1481	494
	4.50-4.95	Gravel - sand mixture	44	-	-	-	530
	6.00-6.45	"	59	-	-	-	>700
	7.50-7.95	Sandy clay	38	498	249	1279	426
	9.00-9.45	Gravel - sand mixture	39	-	-	-	465
	10.50-10.95	"	41	-	-	-	485

Note:

For cohesive soils, the relationship qu = 13.1 x Design N-value is used for evaluation of the Unconfined Compressive Strength qu, the cohesion Cu = qu/2 and qult = 5.14 x Cu. qall is evaluated using a factor of safety of 3

**Allowable Bearing capacity with settlement limited to approximately 25mm for cohesionless soils read off directly from the Chart (Published by Terzaghi and Peck 1967)*

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EVALUATION OF BEARING CAPACITY OF THE SOIL BASED ON FIELD SPT-N VALUES

BH Label	Depth range	Predominant Material Fraction	Design N-Value	Unconfined Compressive Strength, qu (kPa)	Undrained Cohesion, Cu (kPa)	Ultimate Bearing Capacity, qult (kPa)	Allowable Bearing Capacity, qall (kPa)
Bobi Subcounty Reservoir - BH1	1.50-1.95	Clayey gravel	24	-	-	-	280
	3.00-3.45	Gravel -sand mixture	23	-	-	-	265
	4.50-4.95	Clayey gravel	18	-	-	-	220
	6.00-6.45	"	14	-	-	-	180
	7.50-7.95	Silty clay	15	197	98	505	168
	9.00-9.45	Elastic silt	15	197	98	505	168
	10.50-10.95	"	16	210	105	539	180
Koro Abili Reservoir - BH1	1.50-1.95	Clayey sand	20	-	-	-	235
	3.00-3.45	"	19	-	-	-	220
	4.50-4.95	Clay	30	393	197	1010	337
	6.00-6.45	Sandy clay	15	197	98	505	168
	7.50-7.95	"	18	236	118	606	202
	9.00-9.45	Clayey sand	39	-	-	-	465
	10.50-10.95	Clayey sand with gravel	47	-	-	-	575
New Customs Corner Tank - BH1	1.50-1.95	"	41	-	-	-	485
	3.00-3.45	Clayey gravel	46	-	-	-	565
	4.50-4.95	Clayey sand	25	-	-	-	290
	6.00-6.45	"	11	-	-	-	110
	7.50-7.95	Clay	9	118	59	303	101
	9.00-9.45	"	11	144	72	370	123
	10.50-10.95	"	14	183	92	471	157
	12.00-12.45	"	15	197	98	505	168
	13.50-13.95	"	17	223	111	572	191
	15.00-15.45	Inorganic silt	19	249	124	640	213

Note:

For cohesive soils, the relationship qu = 13.1 x Design N-value is used for evaluation of the Unconfined Compressive Strength qu, the cohesion Cu = qu/2 and qult = 5.14 x Cu. qall is evaluated using a factor of safety of 3

**Allowable Bearing capacity with settlement limited to approximately 25mm for cohesionless soils read off directly from the Chart (Published by Terzaghi and Peck 1967)*

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

EVALUATION OF BEARING CAPACITY OF THE SOIL BASED ON FIELD SPT-N VALUES

BH Label	Depth range	Predominant Material Fraction	Design N-Value	Unconfined Compressive Strength, qu (kPa)	Undrained Cohesion, Cu (kPa)	Ultimate Bearing Capacity, qult (kPa)	Allowable Bearing Capacity, qall (kPa)
New Customs Corner Tank - BH2	1.50-1.95	Clay with gravel	49	642	321	1650	550
	3.00-3.45	Clay	12	157	79	404	135
	4.50-4.95	Clay with sand	17	223	111	572	191
	6.00-6.45	"	13	170	85	438	146
	7.50-7.95	"	17	223	111	572	191
	9.00-9.45	"	18	236	118	606	202
	10.50-10.95	"	21	275	138	707	236
	12.00-12.45	"	17	223	111	572	191
	13.50-13.95	"	20	262	131	673	224
	15.00-15.45	"	28	367	183	943	314

Note:

For cohesive soils, the relationship qu = 13.1 x Design N-value is used for evaluation of the Unconfined Compressive Strength qu, the cohesion Cu = qu/2 and qult = 5.14 x Cu. qall is evaluated using a factor of safety of 3

**Allowable Bearing capacity with settlement limited to approximately 25mm for cohesionless soils read off directly from the Chart (Published by Terzaghi and Peck 1967)*

Appendix 2e

Shear Resistance in Shear Box

EPINEX ENGINEERING SERVICES LTD.

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : June 2018

EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL (GENERAL SHEAR FAILURE)

SAMPLE No.	DEPTH, D (m)	WIDTH, B (m)	BULK DENSITY, γ (Mg/m³)x10	COHESION C (KPa)	ANGLE OF FRICTION ϕ (Degrees)	BEARING CAPACITY FACT			ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLE BEARING CAPACITY q_{all} (KPa)
						Nc	Nq	N_γ			
Filter Wash Water	6.0	1.0	17.4	41	18	15.8	6.2	4.0	1516	3	505
Buffer Filter Wash	7.5	1.0	17.1	42	22	20.7	9.5	6.9	2391	3	797
Filtration	9.0	1.0	17.3	41	17	14.8	5.6	3.5	1690	3	563
Karuma Reservoir	7.5	1.0	18.2	43	22	20.7	9.5	6.9	2513	3	838
Kamdini Reservoir	9.0	1.0	17.9	34	23	22.1	10.6	7.8	2740	3	913
Minakulu Reservoir	3.0	1.0	18.6	29	21	19.1	8.5	5.9	1235	3	412
Bobi Pump Station	3.0	1.0	18.3	43	17	14.8	5.6	3.5	1161	3	387
Bobi Reservoir	7.5	1.0	18.3	26	24	23.6	11.6	8.8	2449	3	816
Koro Abili Reservoir - BH1	1.5	1.0	18.5	13	28	32.3	18.6	15.7	1191	3	397
	6.0	1.0	18.1	45	16	13.9	5.0	3.0	1374	3	458
New Customs Corner - BH1	7.5	1.0	17.9	29	24	23.6	11.6	8.8	2496	3	832
New Customs Corner - BH2	3.0	1.0	17.6	43	19	16.7	6.8	4.5	1323	3	441
New Customs Corner - BH2	4.5	1.0	17.2	30	25	25.1	12.7	9.7	2020	3	673

$$q_{ult} = CN_C sc + q_o N_q + ½\gamma B N_\gamma s\gamma$$

Where: $q_o = \gamma D$

$q_{all} = q_{ult}/F$

For :	strip	round	square
sc	1	1.3	1.3
sγ	1	0.6	0.8

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL (LOCAL SHEAR FAILURE)

HAND AUGER SAMPLE **(Swamps)**	CHAINAGE	DEPTH, D (m)	WIDTH, B (m)	BULK DENSITY, γ (Mg/m^3)x10	COHESION C (KPa)	ANGLE OF FRICTION ϕ (Degrees)	MODIFIED ANGLE OF FRICTION ϕ' (Degrees)	BEARING CAPACITY FACTORS			ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLE BEARING CAPACITY q_{all} (KPa)
								Nc	Nq	N_γ			
Kankayi	3+270	1.5	1.0	17.9	24	28	19	16.7	6.8	4.5	731	3	244
Agengi	6+000	3.0	1.0	18.2	12	28	19	16.7	6.8	4.5	675	3	225
	6+050	3.0	1.0	17.6	29	32	22	20.7	9.5	6.9	1331	3	444
Alenyi	9+000	3.0	1.0	18.4	20	25	17	14.8	5.6	3.5	722	3	241
	9+150	3.0	1.0	18.2	27	26	18	15.8	6.2	4.0	929	3	310
	9+362	3.0	1.0	18.2	8	26	18	15.8	6.2	4.0	532	3	177
	9+393	3.0	1.0	18.6	22	23	16	13.9	5.0	3.0	699	3	233
Myene	12+000	3.0	1.0	17.8	20	30	21	19.1	8.5	5.9	998	3	333
	13+000	3.0	1.0	18.1	21	29	20	17.7	7.4	5.0	922	3	307
	13+100	3.0	1.0	18.3	15	31	21	19.1	8.5	5.9	884	3	295
	13+200	3.0	1.0	18.2	21	27	18	15.8	6.2	4.0	807	3	269
	13+500	3.0	1.0	17.9	22	25	17	14.8	5.6	3.5	749	3	250
Amwa, Otwe	14+150	3.0	1.0	18.6	24	25	17	14.8	5.6	3.5	805	3	268
	16+000	3.0	1.0	18.9	14	27	18	15.8	6.2	4.0	666	3	222

$$q_{ult} = CN_C sc + q_o N_q + \tfrac{1}{2}\gamma B N_\gamma s\gamma$$

Where: $q_o = \gamma D$

$q_{all} = q_{ult}/F$

For :	strip	round	square
sc	1	1.3	1.3
sγ	1	0.6	0.8

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL (LOCAL SHEAR FAILURE)

HAND AUGER SAMPLE **(Swamps)**	CHAINAGE	DEPTH, D (m)	WIDTH, B (m)	BULK DENSITY, γ (Mg/m^3)x10	COHESION C (KPa)	ANGLE OF FRICTION ϕ (Degrees)	MODIFIED ANGLE OF FRICTION ϕ' (Degrees)	BEARING CAPACITY FACTORS			ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLE BEARING CAPACITY q_{all} (KPa)
								Nc	Nq	N_γ			
Ngaato	16+200	3.0	1.0	18.8	34	16	11	10.3	3.1	1.5	634	3	211
	16+250	3.0	1.0	19.4	40	23	15	12.9	4.4	2.5	949	3	316
	20+000	3.0	1.0	19.1	20	25	17	14.8	5.6	3.5	728	3	243
	20+300	3.0	1.0	19.0	2	36	25	25.1	12.7	9.7	873	3	291
	20+390	3.0	1.0	19.3	7	38	27	30.0	16.6	13.7	1342	3	447
Atek	22+000	3.0	1.0	18.9	30	22	14	12.2	4.1	2.2	730	3	243
	22+100	3.0	1.0	18.3	30	20	13	11.6	3.7	2.0	675	3	225
	22+200	3.0	1.0	18.2	42	30	20	17.7	7.4	5.0	1406	3	469
	22+300	3.0	1.0	18.6	32	21	14	12.2	4.1	2.2	749	3	250
Agada	25+000	3.0	1.0	18.4	25	35	25	25.1	12.7	9.7	1602	3	534
	25+100	3.0	1.0	18.3	27	24	16	13.9	5.0	3.0	782	3	261
Atego	29+050	3.0	1.0	18.6	36	18	12	10.9	3.4	1.7	707	3	236
	30+000	3.0	1.0	19.2	33	19	13	11.6	3.7	2.0	722	3	241

$$q_{ult} = CN_C sc + q_o N_q + \tfrac{1}{2}\gamma B N_\gamma s\gamma$$

Where: $q_o = \gamma D$

$q_{all} = q_{ult}/F$

For :	strip	round	square
sc	1	1.3	1.3
sγ	1	0.6	0.8

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL (LOCAL SHEAR FAILURE)

HAND AUGER SAMPLE **(Swamps)**	CHAINAGE	DEPTH, D (m)	WIDTH, B (m)	BULK DENSITY, γ (Mg/m^3)x10	COHESION C (KPa)	ANGLE OF FRICTION ϕ (Degrees)	MODIFIED ANGLE OF FRICTION ϕ' (Degrees)	BEARING CAPACITY FACTORS			ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLE BEARING CAPACITY q_{all} (KPa)
								Nc	Nq	N_γ			
Minakulu	32+000	3.0	1.0	20.1	41	16	10	9.6	2.7	1.2	686	3	229
	32+100	3.0	1.0	19.6	34	17	11	10.3	3.1	1.5	639	3	213
	32+200	3.0	1.0	19.9	37	16	10	9.6	2.7	1.2	633	3	211
	32+300	3.0	1.0	20.4	28	23	15	12.9	4.4	2.5	758	3	253
	32+400	3.0	1.0	20.1	32	21	14	12.2	4.1	2.2	770	3	257
Lminlango	42+200	3.0	1.0	19.6	38	16	10	9.6	2.7	1.2	648	3	216
	42+300	3.0	1.0	19.6	41	15	9	9.1	2.5	1.1	639	3	213
Palenga	45+000	3.0	1.0	18.7	21	24	16	13.9	5.0	3.0	678	3	226
	45+100	3.0	1.0	18.5	47	26	18	15.8	6.2	4.0	1330	3	443
Tochi	47+000	3.0	1.0	18.3	25	22	15	12.9	4.4	2.5	683	3	228
	47+100	3.0	1.0	18.1	18	24	16	13.9	5.0	3.0	611	3	204
	47+200	3.0	1.0	18.6	18	25	17	14.8	5.6	3.5	675	3	225
	47+300	3.0	1.0	18.3	16	25	17	14.8	5.6	3.5	633	3	211
Tyenakaya	53+000	3.0	1.0	18.4	21	29	20	17.7	7.4	5.0	937	3	312
	53+050	3.0	1.0	18.2	24	27	18	15.8	6.2	4.0	870	3	290
Koro Abili	55+050	3.0	1.0	18.3	22	31	21	19.1	8.5	5.9	1047	3	349
	55+100	3.0	1.0	18.3	18	32	22	20.7	9.5	6.9	1055	3	352
Layibi	57+000	3.0	1.0	18.7	32	23	15	12.9	4.4	2.5	795	3	265
	57+050	3.0	1.0	18.4	41	20	14	12.2	4.1	2.2	892	3	297

$$q_{ult} = CN_C sc + q_o N_q + \tfrac{1}{2}\gamma B N_\gamma s\gamma$$

Where: $q_o = \gamma D$

$q_{all} = q_{ult}/F$

For :	strip	round	square
sc	1	1.3	1.3
sγ	1	0.6	0.8

Appendix 2f

Triaxial Strength Tests Results

EPINEX ENGINEERING SERVICES LTD.

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : June 2018

TRIAXIAL STRENGTH TESTS - EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL

SAMPLE No.	DEPTH, D (m)	WIDTH, B (m)	BULK DENSITY, γ (Mg/m^3)x10	COHESION C (KPa)	ANGLE OF FRICTION ϕ (Degrees)	BEARING CAPACITY FACT Nc	Nq	N_γ	ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLE BEARING CAPACITY q_{all} (KPa)
Filter Wash Water	6.0	1.0	17.4	25	25	25.1	12.7	9.7	2222	3	741
Buffer Filter Wash	7.5	1.0	17.1	27	28	32.3	18.6	15.7	3630	3	1210
Filtration	9.0	1.0	17.3	26	26	27.5	14.7	11.7	3296	3	1099
Karuma Reservoir	7.5	1.0	18.2	14	27	30.0	16.6	13.7	2925	3	975
Kamdini Reservoir	9.0	1.0	17.9	12	32	44.9	29.5	27.9	5663	3	1888
Minakulu Reservoir	3.0	1.0	18.6	26	33	48.8	33.0	31.9	3707	3	1236
Bobi Pump Station	3.0	1.0	18.3	22	26	27.5	14.7	11.7	1690	3	563
Bobi Reservoir	7.5	1.0	18.3	21	24	23.6	11.6	8.8	2313	3	771
Koro Abili Reservoir - BH1	1.5	1.0	18.5	13	29	34.8	20.5	17.7	1287	3	429
	6.0	1.0	18.1	21	26	27.5	14.7	11.7	2441	3	814
New Customs Corner - BH1	7.5	1.0	17.9	22	26	27.5	14.7	11.7	2830	3	943
New Customs Corner - BH2	3.0	1.0	17.6	36	22	20.7	9.5	6.9	1520	3	507
New Customs Corner - BH2	4.5	1.0	17.2	32	23	22.1	10.6	7.8	1790	3	597

$$q_{ult} = CN_C sc + q_o N_q + \tfrac{1}{2}\gamma B N_\gamma s\gamma$$

Where: $q_o = \gamma D$

$q_{all} = q_{ult}/F$

For :	strip	round	square
sc	1	1.3	1.3
sγ	1	0.6	0.8

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : June 2018

TRIAXIAL STRENGTH TESTS - EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL

HAND AUGER SAMPLE (Swamps)	CHAINAGE	DEPTH, D (m)	WIDTH, B (m)	BULK DENSITY, γ (Mg/m³)x10	COHESION C (KPa)	ANGLE OF FRICTION ϕ (Degrees)	MODIFIED ANGLE OF FRICTION ϕ' (Degrees)	BEARING CAPACITY F			ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLE BEARING CAPACITY q_{all} (KPa)
								Nc	Nq	N_γ			
Kankayi	3+270	1.5	1.0	17.9	22	29	20	17.7	7.4	5.0	744	3	248
Agengi	6+000	3.0	1.0	18.2	15	28	19	16.7	6.8	4.5	728	3	243
	6+050	3.0	1.0	17.6	30	32	22	20.7	9.5	6.9	1348	3	449
Alenyi	9+000	3.0	1.0	18.4	42	16	10	9.6	2.7	1.2	677	3	226
	9+150	3.0	1.0	18.2	47	14	9	9.1	2.5	1.1	705	3	235
	9+362	3.0	1.0	18.2	44	17	11	10.3	3.1	1.5	765	3	255
	9+393	3.0	1.0	18.6	23	28	19	16.7	6.8	4.5	921	3	307
Myene	12+000	3.0	1.0	17.8	23	27	18	15.8	6.2	4.0	822	3	274
	13+000	3.0	1.0	18.1	22	29	20	17.7	7.4	5.0	935	3	312
	13+100	3.0	1.0	18.3	24	29	20	17.7	7.4	5.0	1005	3	335
	13+200	3.0	1.0	18.2	37	20	13	11.6	3.7	2.0	780	3	260
	13+500	3.0	1.0	17.9	25	24	16	13.9	5.0	3.0	749	3	250
Amwa, Otwe	14+150	3.0	1.0	18.6	23	26	17	14.8	5.6	3.5	774	3	258
	16+000	3.0	1.0	18.9	26	22	15	12.9	4.4	2.5	708	3	236

$$q_{ult} = CN_C sc + q_o N_q + \tfrac{1}{2}\gamma B N_\gamma s\gamma$$

Where: $q_o = \gamma D$

$q_{all} = q_{ult}/F$

For :	strip	round	square
sc	1	1.3	1.3
sγ	1	0.6	0.8

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : June 2018

TRIAXIAL STRENGTH TESTS - EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL

HAND AUGER SAMPLE (Swamps)	CHAINAGE	DEPTH, D (m)	WIDTH, B (m)	BULK DENSITY, γ (Mg/m^3)x10	COHESION C (KPa)	ANGLE OF FRICTION ϕ (Degrees)	MODIFIED ANGLE OF FRICTION ϕ' (Degrees)	BEARING CAPACITY F Nc	Nq	N_γ	ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLE BEARING CAPACITY q_{all} (KPa)
Ngaato	16+200	3.0	1.0	18.8	27	29	20	17.7	7.4	5.0	1087	3	362
	16+250	3.0	1.0	19.4	27	33	23	22.1	10.6	7.8	1441	3	480
	20+000	3.0	1.0	19.1	22	25	17	14.8	5.6	3.5	762	3	254
	20+300	3.0	1.0	19.0	17	29	20	17.7	7.4	5.0	861	3	287
	20+390	3.0	1.0	19.3	16	33	23	22.1	10.6	7.8	1143	3	381
Atek	22+000	3.0	1.0	18.9	40	15	10	9.6	2.7	1.2	657	3	219
	22+100	3.0	1.0	18.3	27	32	22	20.7	9.5	6.9	1311	3	437
	22+200	3.0	1.0	18.2	13	41	29	34.8	20.5	17.7	1832	3	611
	22+300	3.0	1.0	18.6	29	24	16	13.9	5.0	3.0	830	3	277
Agada	25+000	3.0	1.0	18.4	27	36	25	25.1	12.7	9.7	1660	3	553
	25+100	3.0	1.0	18.3	33	18	12	10.9	3.4	1.7	667	3	222
Atego	29+050	3.0	1.0	18.6	30	22	15	12.9	4.4	2.5	763	3	254
	30+000	3.0	1.0	19.2	39	17	11	10.3	3.1	1.5	709	3	236

$$q_{ult} = CN_C sc + q_o N_q + ½\gamma B N_\gamma s\gamma$$

Where: $q_o = \gamma D$

$q_{all} = q_{ult}/F$

For :	strip	round	square
sc	1	1.3	1.3
sγ	1	0.6	0.8

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : June 2018

TRIAXIAL STRENGTH TESTS - EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL

HAND AUGER SAMPLE **(Swamps)**	CHAINAGE	DEPTH, D (m)	WIDTH, B (m)	BULK DENSITY, γ (Mg/m^3)x10	COHESION C (KPa)	ANGLE OF FRICTION ϕ (Degrees)	MODIFIED ANGLE OF FRICTION ϕ' (Degrees)	BEARING CAPACITY F			ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLE BEARING CAPACITY q_{all} (KPa)
								Nc	Nq	N_γ			
Minakulu	32+000	3.0	1.0	20.1	27	21	14	12.2	4.1	2.2	699	3	233
	32+100	3.0	1.0	19.6	29	23	15	12.9	4.4	2.5	759	3	253
	32+200	3.0	1.0	19.9	36	19	12	10.9	3.4	1.7	726	3	242
	32+300	3.0	1.0	20.4	37	17	11	10.3	3.1	1.5	686	3	229
	32+400	3.0	1.0	20.1	39	18	12	10.9	3.4	1.7	766	3	255
Lminlango	42+200	3.0	1.0	19.6	36	19	13	11.6	3.7	2.0	777	3	259
	42+300	3.0	1.0	19.6	43	15	10	9.6	2.7	1.2	700	3	233
Palenga	45+000	3.0	1.0	18.7	30	20	13	11.6	3.7	2.0	668	3	223
	45+100	3.0	1.0	18.5	36	16	10	9.6	2.7	1.2	604	3	201
Tochi	47+000	3.0	1.0	18.3	26	18	12	10.9	3.4	1.7	573	3	191
	47+100	3.0	1.0	18.1	10	26	18	15.8	6.2	4.0	569	3	190
	47+200	3.0	1.0	18.6	20	25	17	14.8	5.6	3.5	730	3	243
	47+300	3.0	1.0	18.3	19	25	17	14.8	5.6	3.5	691	3	230
Tyenakaya	53+000	3.0	1.0	18.4	22	28	19	16.7	6.8	4.5	887	3	296
	53+050	3.0	1.0	18.2	26	28	19	16.7	6.8	4.5	969	3	323
Koro Abili	55+050	3.0	1.0	18.3	22	32	22	20.7	9.5	6.9	1166	3	389
	55+100	3.0	1.0	18.3	21	32	22	20.7	9.5	6.9	1140	3	380
Layibi	57+000	3.0	1.0	18.7	37	22	15	12.9	4.4	2.5	881	3	294
	57+050	3.0	1.0	18.4	25	28	19	16.7	6.8	4.5	958	3	319

$q_{ult} = CN_C sc + q_o N_q + \frac{1}{2}\gamma B N_\gamma s\gamma$

Where: $q_o = \gamma D$

$q_{all} = q_{ult}/F$

For :	strip	round	square
sc	1	1.3	1.3
sγ	1	0.6	0.8

Appendix 2g (1)

Unconfined Compressive Strength for Soils Samples

EPINEX ENGINEERING SERVICES LTD.

GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

DETERMINATION OF UNCONFINED COMPRESSIVE STRENGTH FOR THE COHESIVE SOILS SAMPLES OBTAINED FROM SITE

(Tested in Accordance with ASTM D 7012-07)

COHESIVE SAMPLES FROM BOREHOLES

BH Label	Coordinates (UTM 36N)		Depth (m)	Sample Diameter, Ø (mm)	Area (mm²)	Trimmed Length,l (mm)	Length/Diameter Ratio (l/Ø)	Weight, w (Kg)	Density (Kg/m³)	Specific Gravity	Moisture content at test (%)	Breaking Load (kN)	Unconfined Compressive Strength (MPa)
	X (Easting)	Y (Northing)											
Filter Wash Water	418920	248921	6.0	100	7855	205.0	2.05	2.81	1745.04	2.63	23	1.18	0.150
Buffer Filter Wash	418971	248965	7.5	100	7855	210.0	2.10	2.89	1751.99	2.65	16	1.33	0.169
Filtration	418928	248947	9.0	100	7855	200.0	2.00	2.95	1877.78	2.71	15	1.14	0.145
Karuma Reservoir	416709	245632	7.5	100	7855	200.0	2.00	3.11	1979.63	2.69	18	0.74	0.094
Kamdini Reservoir	426207	248746	9.0	100	7855	210.0	2.10	3.02	1830.80	2.66	48	0.47	0.060
Minakulu Reservoir	431340	270708	3.0	100	7855	200.0	2.00	2.98	1896.88	2.64	10	1.58	0.201
Bobi Pump Station	428493	280441	3.0	100	7855	250.0	2.50	3.78	1924.89	2.74	10	1.19	0.151
Bobi Reservoir	428545	282426	7.5	100	7855	200.0	2.00	3.31	2106.94	2.67	7	0.38	0.048
Koro Abili Reservoir - BH1	423881	298097	1.5	100	7855	200.0	2.00	2.84	1807.77	2.69	12	0.39	0.050
			6.0	100	7855	220.0	2.20	3.25	1880.68	2.69	27	0.23	0.029
New Customs Corner - BH1	420217	305816	7.5	100	7855	200.0	2.00	3.05	1941.44	2.62	21	0.17	0.022
New Customs Corner - BH2	420240	305859	3.0	100	7855	215.0	2.15	3.21	1900.73	2.63	15	0.21	0.027
			4.5	100	7855	200.0	2.00	2.94	1871.42	2.69	11	0.34	0.043

Notes: -Temperature at which test was performed 25°C

-All the specimens failed longitudinally

EPINEX ENGINEERING SERVICES LTD.

GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

DETERMINATION OF UNCONFINED COMPRESSIVE STRENGTH FOR THE COHESIVE SOILS SAMPLES OBTAINED FROM SITE

(Tested in Accordance with ASTM D 7012-07)

HAND AUGER - COHESIVE SAMPLES

Swamp Location	Chainage	Depth (m)	Sample Description	Sample Diameter, Ø (mm)	Area (mm²)	Trimmed Length,l (mm)	Length/Dia. Ratio (l/Ø)	Weight, w (Kg)	Density (Kg/m³)	Specific Gravity	Moisture content at test (%)	Breaking Load (kN)	Unconfined Compressive Strength (MPa)
Kankayi	3+270	1.5	Sandy lean clay	100	7855	221.0	2.21	3.12	1797.28	2.65	8	0.62	0.079
Agengi	6+000	3.0	Inorganic lean clay	100	7855	210.0	2.10	3.14	1903.55	2.73	32	0.67	0.085
	6+050	3.0	"	100	7855	207.0	2.07	3.11	1912.69	2.69	31	1.14	0.145
Alenyi	9+000	3.0	Inorganic fat clay	100	7855	224.0	2.24	3.35	1903.93	2.70	23	0.49	0.062
	9+150	3.0	"	100	7855	214.0	2.14	3.23	1921.51	2.69	25	0.63	0.080
	9+362	3.0	"	100	7855	236.0	2.36	3.54	1909.61	2.71	23	0.63	0.080
	9+393	3.0	"	100	7855	231.0	2.31	3.58	1972.99	2.71	26	0.81	0.103
Myene	12+000	3.0	Inorganic lean clay	100	7855	211.0	2.11	3.11	1876.43	2.68	31	0.72	0.092
	13+000	3.0	"	100	7855	218.0	2.18	3.16	1845.37	2.69	34	0.69	0.088
	13+100	3.0	"	100	7855	225.0	2.25	3.34	1889.81	2.72	35	0.73	0.093
	13+200	3.0	"	100	7855	236.0	2.36	3.52	1898.82	2.71	35	0.53	0.067
	13+500	3.0	"	100	7855	215.0	2.15	3.16	1871.12	2.68	38	0.54	0.069
Amwa, Otwe	14+150	3.0	Silty lean clay	100	7855	213.0	2.13	3.07	1834.90	2.69	36	0.51	0.065
	16+000	3.0	Lean clay	100	7855	195.0	1.95	2.94	1919.40	2.76	34	0.42	0.053
Ngaato	16+200	3.0	Inorganic fat clay	100	7855	215.0	2.15	3.24	1918.49	2.72	24	3.16	0.402
	16+250	3.0	Fat clay	100	7855	221.0	2.21	3.33	1918.25	2.79	24	2.18	0.278
	20+000	3.0	"	100	7855	203.0	2.03	3.04	1906.48	2.83	28	0.78	0.099
	20+300	3.0	"	100	7855	214.0	2.14	3.21	1909.61	2.83	22	0.93	0.118
	20+390	3.0	Inorganic lean clay	100	7855	201.0	2.01	2.96	1874.78	2.84	19	1.83	0.233

Notes: -Temperature at which test was performed 25°C

-All the specimens failed longitudinally

EPINEX ENGINEERING SERVICES LTD.

GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

DETERMINATION OF UNCONFINED COMPRESSIVE STRENGTH FOR THE COHESIVE SOILS SAMPLES OBTAINED FROM SITE

(Tested in Accordance with ASTM D 7012-07)

HAND AUGER - COHESIVE SAMPLES

Swamp Location	Chainage	Depth (m)	Sample Description	Core Diameter, Ø (mm)	Area (mm^2)	Trimmed Length,l (mm)	Length/Dia. Ratio (l/Ø)	Weight, w (Kg)	Density (Kg/m^3)	Specific Gravity	Moisture content at test (%)	Breaking Load (kN)	Unconfined Compressive Strength (MPa)
Atek	22+000	3.0	Fat clay	100	7855	223	2.23	3.32	1895.34	2.82	23	0.47	0.060
	22+100	3.0	Sandy lean clay	100	7855	215	2.15	3.14	1859.28	2.69	22	1.23	0.157
	22+200	3.0	Silty lean clay	100	7855	193	1.93	3.01	1985.47	2.74	25	1.74	0.222
	22+300	3.0	Sandy lean clay	100	7855	216	2.16	3.13	1844.78	2.70	23	1.07	0.136
Agada	25+000	3.0	Silty lean clay	100	7855	230	2.30	3.64	2014.78	2.73	16	1.67	0.213
	25+100	3.0	Lean clay	100	7855	215	2.15	3.17	1877.04	2.71	32	0.39	0.050
Atego	29+050	3.0	"	100	7855	210	2.10	3.12	1891.42	2.73	34	0.51	0.065
	30+000	3.0	"	100	7855	222	2.22	3.32	1903.88	2.74	19	1.58	0.201
Minakulu	Point 1	3.0	"	100	7855	231	2.31	3.47	1912.37	2.82	39	1.23	0.157
	Point 2	3.0	"	100	7855	219	2.19	3.28	1906.71	2.78	28	1.18	0.150
	Point 3	3.0	Fat clay	100	7855	203	2.03	3.03	1900.20	2.83	32	0.89	0.113
	Point 4	3.0	"	100	7855	210	2.10	3.13	1897.49	2.79	35	0.73	0.093
	Point 5	3.0	Lean clay	100	7855	214	2.14	3.19	1897.71	2.73	24	0.69	0.088
Lminlango /Bobi	42+200	3.0	Sand - clay mixture	100	7855	197	1.97	2.83	1828.83	2.65	25	0.72	0.092
	42+300	3.0	"	100	7855	206	2.06	2.97	1835.45	2.65	20	0.79	0.101
Palenga	45+000	3.0	Sandy lean clay	100	7855	223	2.23	3.29	1878.21	2.67	29	0.54	0.069
	45+100	3.0	"	100	7855	218	2.18	3.21	1874.57	2.67	30	1.36	0.173
Tochi	47+000	3.0	Fat clay	100	7855	233	2.33	3.49	1906.88	2.73	36	1.42	0.181
	47+100	3.0	"	100	7855	215	2.15	3.21	1900.73	2.72	40	0.41	0.052
	47+200	3.0	"	100	7855	218	2.18	3.26	1903.77	2.73	34	0.47	0.060
	47+300	3.0	"	100	7855	213	2.13	3.18	1900.65	2.72	40	0.47	0.060

Notes: -Temperature at which test was performed 25°C

-All the specimens failed longitudinally

EPINEX ENGINEERING SERVICES LTD.

GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

DETERMINATION OF UNCONFINED COMPRESSIVE STRENGTH FOR THE COHESIVE SOILS SAMPLES OBTAINED FROM SITE

(Tested in Accordance with ASTM D 7012-07)

HAND AUGER - COHESIVE SAMPLES

Swamp Location	Chainage	Depth (m)	Sample Description	Core Diameter, Ø (mm)	Area (mm^2)	Trimmed Length,l (mm)	Length/Dia. Ratio (l/Ø)	Weight, w (Kg)	Density (Kg/m^3)	Specific Gravity	Moisture content at test (%)	Breaking Load (kN)	Unconfined Compressive Strength (MPa)
Tyenakaya	53+000	3.0	Sandy fat clay	100	7855	210	2.10	3.11	1885.36	2.66	32	1.59	0.202
	53+050	3.0	Sand - clay mixture	100	7855	190	1.90	2.77	1856.01	2.67	19	1.73	0.220
Koro Abili	55+050	3.0	Sandy lean clay	100	7855	205	2.05	3.02	1875.46	2.69	23	2.38	0.303
	55+100	3.0	"	100	7855	200	2.00	2.93	1865.05	2.70	29	2.24	0.285
Layibi	57+000	3.0	Sand - clay mixture	100	7855	195	1.95	2.86	1867.18	2.66	21	1.42	0.181
	57+050	3.0	"	100	7855	180	1.80	2.65	1874.25	2.67	19	1.72	0.219

Notes: -Temperature at which test was performed 25°C

-All the specimens failed longitudinally

Appendix 2g (2)

Unconfined Compressive Strength for Rock Core Samples

EPINEX ENGINEERING SERVICES LTD.

GEOTECHNICAL INVESTIGATIONS FOR THE PROPOSED INTEGRATED PROGRAMME TO IMPROVE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

DETERMINATION OF UNCONFINED COMPRESSIVE STRENGTH FOR THE DIFFERENT ROCK CORE LAYERS OBTAINED FROM THE BOREHOLES

(Tested in Accordance with ASTM D 7012-07)

S.No.	BH Label	Depth range	Core Diameter, Ø (mm)	Area (mm²)	Trimmed Length,l (mm)	Length/Dia. Ratio (l/Ø)	Weight, w (Kg)	Density (Kg/m³)	Specific Gravity	Moisture content at test	Breaking Load (kN)	Unconfined Compressive Strength (MPa)
01	BH1 - INTAKE	4.50-4.95	100	7855	120.0	1.20	3.15	3341.82	3.34	0.09	312.5	39.8
02		*6.00-6.45	100	7855	120.0	1.20	4.65	4933.16	4.93	0.08	456.5	58.1
03	BH2 - INTAKE	4.50-4.95	100	7855	150.0	1.50	3.60	3055.38	3.06	0.08	380.5	48.4
04		6.00-6.45	100	7855	150.0	1.50	4.90	4158.71	4.16	0.07	434.5	55.3
05		*7.50-7.95	100	7855	150.0	1.50	5.15	4370.89	4.37	0.07	587.0	74.7
06	BH2 - ACCESS ROAD TO INTAKE SITE	1.50-1.95	100	7855	120.0	1.20	2.45	2599.19	2.60	0.09	165.0	21.0
07	CLEAR WATER TANK	3.00-3.45	100	7855	253	2.53	3.45	1736.01	1.74	0.05	140	17.8
08		4.50-4.95	100	7855	255	2.55	3.05	1522.70	1.52	0.06	220	28.0
09		6.00-6.45	100	7855	263	2.63	2.70	1306.96	1.31	0.05	195	24.8
10		7.50-7.95	100	7855	255	2.55	3.15	1572.62	1.57	0.07	385	49.0
11		9.00 -9.45	100	7855	251	2.51	4.25	2155.60	2.16	0.07	670	85.3
12	BUFFER FILTER WASH	12.00-12.45	100	7855	256	2.56	3.35	1665.94	1.67	0.08	945	120
13		13.50 -13.95	100	7855	255	2.55	3.60	1797.28	1.80	0.07	1120	143

Notes: -Rate of Loading is 0.65 MPa/s

-Temperature at which test was performed 25°C

* Failure along cleavage

-All the rest of the specimens failed longitudinally

Appendix 2h

Dynamic Cone Penetration Result Sheets for Trial Pits

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

BEARING CAPACITY BASED ON FIELD DYNAMIC CONE PENETRATION TESTS

Location (Km) Karuma - Gulu	TP Label	Depth (m)	Depth Range (m)	Thickness (m)	Average CBR (%)	Allowable Bearing Capacity (kPa)
Km 0+000 LHS	TP 1	1.00	1.00 - 1.03	0.03	25	269
Km 2+000 LHS	TP2	1.00	1.00 - 1.01	0.01	239	2409
			1.01 - 1.01	0.00	382	3839
			1.01 - 1.02	0.01	795	7969
Km 4+000 LHS	TP 3	1.00	1.00 - 1.13	0.13	39	411
			1.13 - 1.30	0.17	28	304
			1.30 - 1.532	0.23	298	3008
		2.00	2.00 - 2.08	0.08	23	269
			2.08 - 2.39	0.31	52	564
			2.39 - 2.82	0.43	127	1323
		3.00	3.00 - 3.17	0.17	27	331
			3.17 - 3.34	0.18	134	1405
			3.34 - 3.43	0.08	612	6186
Km 6+050 LHS	TP4	1.00	1.00 - 1.24	0.24	1	34
			1.24 - 1.59	0.36	3	61
			1.59 - 1.80	0.21	6	95
		2.00	2.00 - 2.39	0.39	2	66
			2.39 - 2.57	0.18	5	100
			2.57 - 2.82	0.25	3	83
Km 8+000 LHS	TP5	1.00	1.00 - 1.85	0.85	20	235
		2.00	2.00 - 2.02	0.02	35	388
			2.02 - 2.04	0.02	209	2128
			2.04 - 2.05	0.01	496	4998
		3.00	3.00 - 3.22	0.22	21	270
			3.22 - 3.26	0.04	41	471
			3.26 - 3.29	0.03	327	3331
Km 9+000 LHS	TP6	1.00	1.00 - 1.06	0.06	4	60
			1.06 - 1.25	0.19	17	193
			1.25 - 1.33	0.08	216	2185
Km 11+000 LHS	TP7	1.00	1.00 - 1.23	0.23	17	193
			1.23 - 1.27	0.04	43	454
			1.27 - 1.33	0.06	343	3455
Km 13+000 LHS	TP8	1.00	1.00 - 1.37	0.37	18	206
			1.37 - 1.38	0.01	80	826
			1.38 - 1.4	0.02	1024	10266
		2.00	2.00 - 2.09	0.09	42	459
			2.09 - 2.12	0.03	218	2220
			2.12 - 2.15	0.03	1610	16140

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

BEARING CAPACITY BASED ON FIELD DYNAMIC CONE PENETRATION TESTS

Location (Km) Karuma - Gulu	TP Label	Depth (m)	Depth Range (m)	Thickness (m)	Average CBR (%)	Allowable Bearing Capacity (kPa)
Km 15+000 LHS	TP9	1.00	1.00 - 1.54	0.54	4	69
			1.54 - 1.62	0.08	7	100
			1.62 - 1.80	0.18	8	114
		2.00	2.00 - 2.25	0.25	9	132
			2.25 - 2.46	0.21	24	286
			2.46 - 2.8	0.34	50	552
		3.00	3.00 - 3.13	0.13	29	348
			3.13 - 3.47	0.34	24	305
			3.47 - 3.53	0.06	367	3736
Km 17+000 LHS	TP 10	1.00	1.00 - 1.86	0.86	5	86
		2.00	2.00 - 2.08	0.08	6	100
			2.08 - 2.10	0.02	135	1391
			2.10 - 2.15	0.05	518	5222
Km 19+000 LHS	TP11	1.00	1.00 - 1.3	0.30	17	195
			1.30 - 1.31	0.01	55	575
			1.31 - 1.34	0.03	593	5955
Km 21+000 LHS	TP 12	0.70	0.07 - 0.70	0.00	0	13
			0.70 - 0.70	0.00	3081	30823
Km 23+000 LHS	TP13	1.00	1.00 - 1.04	0.04	20	219
			1.04 - 1.08	0.04	47	490
			1.08 - 1.19	0.11	212	2142
Km 25+000 LHS	TP14	1.00	1.00 - 1.03	0.03	24	259
			1.03 - 1.09	0.05	89	910
			1.09 - 1.24	0.16	420	4223
		2.00	2.00 - 2.12	0.12	42	460
			2.12 - 2.67	0.56	80	850
			2.67 - 2.68	0.01	1269	12740
		3.00	3.00 - 3.32	0.32	8	142
			3.32 - 3.43	0.11	19	254
			3.43 - 3.76	0.33	48	551
Km 27+000 LHS	TP15	1.00	1.00 - 1.11	0.11	24	261
			1.11 - 1.41	0.30	41	436
			1.41 - 1.58	0.17	168	1710
		2.00	2.00 - 2.04	0.04	20	238
			2.04 - 2.23	0.19	53	572
			2.23 - 2.32	0.09	522	5264
		3.00	3.00 - 3.00	0.00	302	3076
			3.00 - 3.00	0.00	795	8006
			3.00 - 3.00	0.00	7165	71706

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

BEARING CAPACITY BASED ON FIELD DYNAMIC CONE PENETRATION TESTS

Location (Km) Karuma - Gulu	TP Label	Depth (m)	Depth Range (m)	Thickness (m)	Average CBR (%)	Allowable Bearing Capacity (kPa)
Km 29+000 LHS	TP16	1.00	1.00 - 1.26	0.26	15	174
			1.26 - 1.55	0.29	22	249
			1.55 - 1.71	0.17	165	1682
		2.00	2.00 - 2.44	0.44	41	456
			2.44 - 2.61	0.17	19	239
			2.61 - 2.83	0.22	60	653
Km 31+000 LHS	TP 17	1.00	1.00 - 1.13	0.13	28	301
			1.13 - 1.39	0.26	42	446
			1.39 - 1.45	0.05	63	657
		2.00	2.00 - 2.3	0.30	50	543
			2.30 - 2.54	0.24	21	257
			2.54 - 2.83	0.30	42	473
		3.00	3.00 - 3.05	0.05	49	549
			3.05 - 3.35	0.30	185	1915
			3.35 - 3.83	0.48	76	834
Km 33+000 LHS	TP 18	1.00	1.00 - 1.34	0.34	23	256
			1.34 - 1.59	0.24	20	231
			1.59 - 1.71	0.13	25	283
		2.00	2.00 - 2.13	0.13	4359	>700
Km 35+000 LHS	TP19	1.00	1.00 - 1.1	0.10	10	121
			1.10 - 1.17	0.07	27	292
			1.17 - 1.6	0.43	37	400
		2.00	2.00 - 2.34	0.34	24	284
			2.34 - 2.54	0.20	21	258
			2.54 - 2.8	0.26	17	222
		3.00	3.00 - 3.15	0.15	12	179
			3.15 - 3.40	0.25	19	254
			3.40 - 3.71	0.31	41	479
Km 37+000 LHS	TP20	1.00	1.00 - 1.00	0.00	0	19
			1.00 - 1.00	0.00	4544	45459
Km 39+000 LHS	TP 21	1.00	1.00 - 1.24	0.24	11	133
			1.24 - 1.61	0.37	5	80
			1.61 - 1.82	0.21	7	104
		2.00	2.00 - 2.79	0.79	6	112
Km 41+000 LHS	TP22	1.00	1.00 - 1.16	0.16	11	132
			1.00 - 1.70	0.54	25	282
			1.70 - 1.81	0.11	9	124
		2.00	2.00 - 2.08	0.08	26	299
			2.08 - 2.45	0.37	62	666
			2.45 - 2.76	0.31	42	472
		3.00	3.00 - 3.27	0.27	30	361
			3.27 - 3.46	0.19	64	705
			3.46 - 3.69	0.24	101	1079

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

BEARING CAPACITY BASED ON FIELD DYNAMIC CONE PENETRATION TESTS

Location (Km) Karuma - Gulu	TP Label	Depth (m)	Depth Range (m)	Thickness (m)	Average CBR (%)	Allowable Bearing Capacity (kPa)
Km 43+000 LHS	TP23	1.00	1.00 - 1.06	0.06	18	200
			1.06 - 1.16	0.11	40	422
			1.16 - 1.69	0.59	55	581
		2.00	2.00 - 2.09	0.09	50	539
			2.09 - 2.60	0.51	75	798
			2.60 - 2.70	0.10	58	630
		3.00	3.00 - 3.1	0.10	32	380
			3.10 - 3.14	0.04	73	791
			3.14 - 3.36	0.22	290	2965
Km 45+000 LHS	TP24	1.00	1.00 - 1.12	0.12	17	192
			1.12 - 1.44	0.32	25	278
			1.44 - 1.81	0.37	22	255
		2.00	2.00 - 2.17	0.17	22	262
			2.17 - 2.54	0.38	20	249
			2.54 - 2.85	0.30	25	303
		3.00	3.00 - 3.33	0.33	21	272
			3.33 - 3.59	0.26	32	387
			3.59 - 3.83	0.24	21	282
Km 47+000 LHS	TP25	1.00	1.00 - 1.37	0.37	24	267
			1.37 - 1.55	0.18	19	220
			1.55 - 1.82	0.27	15	185
Km 49+000 LHS	TP 26	1.00	1.00 - 1.09	0.09	56	580
			1.09 - 1.47	0.38	95	977
			1.47 - 1.77	0.30	189	1923
		2.00	2.00 - 2.07	0.07	45	489
			2.07 - 2.29	0.21	77	813
			2.29 - 2.41	0.12	203	2075
Km 51+000 LHS	TP27	1.00	1.00 - 1.27	0.27	22	244
			1.27 - 1.56	0.29	33	359
			1.56 - 1.75	0.18	18	213
		2.00	2.00 - 2.21	0.21	16	201
			2.21 - 2.42	0.22	13	175
			2.42 - 2.73	0.30	25	301
		3.00	3.00 - 3.55	0.55	15	217
			3.55 - 3.7	0.16	18	250
			3.70 - 3.83	0.12	21	282

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

BEARING CAPACITY BASED ON FIELD DYNAMIC CONE PENETRATION TESTS

Location (Km) Karuma - Gulu	TP Label	Depth (m)	Depth Range (m)	Thickness (m)	Average CBR (%)	Allowable Bearing Capacity (kPa)
Km 53+000 LHS	TP28	1.00	1.00 - 1.10	0.10	5659	>700
Km 55+000 LHS	TP29	1.00	1.00 - 1.10	0.10	5460	>700
Km 57+000 LHS	TP30	1.00	1.00 - 1.24	0.24	34	363
			1.24 - 1.37	0.13	48	506
			1.37 - 1.51	0.15	37	398
		2.00	2.00 - 2.24	0.24	26	302
			2.24 - 2.4	0.17	48	525
			2.4 - 2.43	0.03	343	3476
		3.00	3.00 - 3.19	0.19	24	300
			3.19 - 3.28	0.09	65	712
			3.28 - 3.33	0.05	257	2633
Km 59+000 LHS	TP31	1.00	1.00 - 1.20	0.20	11	132
			1.20 - 1.56	0.36	18	209
			1.56 - 1.67	0.12	121	1241
Km 61+000 LHS	TP32	1.00	1.00 - 1.48	0.48	12	148
			1.48 - 1.57	0.08	9	120
			1.57 - 1.81	0.25	8	115
		2.00	2.00 - 2.24	0.24	6	103
			2.24 - 2.71	0.47	3	82
			2.71 - 2.85	0.14	30	355
		3.00	3.00 - 3.24	0.24	6	123
			3.24 - 3.71	0.47	2	92
			3.71 - 3.89	0.18	11	186
Km 63+000 LHS	TP33	1.00	1.00 - 1.83	0.83	17	832
		2.00	2.00 - 2.31	0.31	13	173
			2.31 - 2.68	0.37	8	132
			2.68 - 2.85	0.17	19	245
		3.00	3.00 - 3.60	0.59	11	180
			3.60 - 3.71	0.11	14	209
			3.71 - 3.81	0.11	17	241
Km 65+000 LHS	TP34	1.00	3.81 - 1.06	0.06	13	150
			1.06 - 1.16	0.11	2	42
			1.16 - 1.80	0.64	20	234
		2.00	1.8 - 2.28	0.28	5	93
			2.28 - 2.70	0.42	4	90
			2.70 - 2.86	0.16	3	83

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

BEARING CAPACITY BASED ON FIELD DYNAMIC CONE PENETRATION TESTS

Location (Km) Karuma - Gulu	TP Label	Depth (m)	Depth Range (m)	Thickness (m)	Average CBR (%)	Allowable Bearing Capacity (kPa)
Km 67+000 LHS	TP35	1.00	1.00 - 1.49	0.49	33	358
			1.49 - 1.55	0.06	49	519
			1.55 - 1.76	0.21	140	1433
		2.00	2.00 - 2.06	0.06	38	419
			2.06 - 2.28	0.22	74	783
			2.28 - 2.69	0.41	57	621
		3.00	3.00 - 3.08	0.08	87	928
			3.08 - 3.49	0.41	58	646
			3.49 - 3.69	0.19	370	3769
Km 69+000 LHS	TP36	1.00	1.00 - 1.28	0.28	2	44
			1.20 - 1.49	0.21	5	78
			1.49 - 1.67	0.18	7	101

Appendix 2i

Consolidation Test Results

CENTRAL MATERIALS LABORATORY

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT: M/s FICHTNER WATER & TRANSPORTATION

DATE: June 2018

SUMMARY OF CONSOLIDATION TEST RESULTS

Test Location	Depth (m)	Coefficient of Volume Compressibility (Mv) in m^2/MN	Range of Mv	Remarks
Filter Wash Water	6.0	0.185	0.1 - 0.3	Medium Compressibility
Buffer Filter Wash	7.5	0.216	0.1 - 0.3	"
Filtration	9.0	0.227	0.1 - 0.3	"
Karuma Reservoir	7.5	0.342	0.3 - 1.5	High Compressibility
Kamdini Reservoir	9.0	0.470	0.3 - 1.5	"
Minakulu Reservoir	3.0	0.236	0.1 - 0.3	Medium Compressibility
Bobi Pump Station	3.0	0.277	0.1 - 0.3	"
Bobi Reservoir	7.5	0.643	0.3 - 1.5	High Compressibility
Koro Abili Reservoir - BH1	1.5	0.384	0.3 - 1.5	"
	6.0	0.572	0.3 - 1.5	"
New Customs Corner - BH1	7.5	0.741	0.3 - 1.5	"
New Customs Corner - BH2	3.0	0.642	0.3 - 1.5	"
	4.5	0.513	0.3 - 1.5	"

CENTRAL MATERIALS LABORATORY

PROJECT: PROPOSED 220kV LOT 2: KAWANDA SUBSTATION
CLIENT: M/S EPINEX ENGINEERING SERVICES LTD.
DATE: JANUARY 2015

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-1**	DEPTHS **6.0m**		**FILTER WASH WATER**
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	24	%	BULK DENSITY	1.620	Mg/m^3
WT OF SAMPLE $ RING	252.3	g	DRY DENSITY (γ_D)	1.306	Mg/m^3
WT OF EMPTY RING	85.5	g	SPECIFIC GRAVITY	2.63	
WT OF WET SOIL	166.8	g	e_o	1.013	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1007	
RING CALIBRATION FACTOR	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.013086	0	0		
30	0.0	87.30	0.2217	0.022319	0.990767	0.02232	30.0	2.013	0.370
50	0.0	134.80	0.3424	0.034463	0.978623	0.01214	20.0	1.991	0.305
108	0.0	198.50	0.5042	0.050749	0.962338	0.01629	58.0	1.979	0.142
225	0.0	235.90	0.5992	0.060311	0.952776	0.00956	117.0	1.962	0.042
432	0.0	342.10	0.8689	0.087462	0.925624	0.02715	207.0	1.953	0.067
Average									0.185

CENTRAL MATERIALS LABORATORY

PROJECT: PROPOSED 220kV LOT 2: KAWANDA SUBSTATION
CLIENT: M/S EPINEX ENGINEERING SERVICES LTD.
DATE: JANUARY 2015

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF: **BH-1**		DEPTHS **7.50m**	**BUFFER FILTER WASH**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	16	%	BULK DENSITY	1.650	Mg/m^3
WT OF SAMPLE $ RING	251.6	g	DRY DENSITY (γ_D)	1.422	Mg/m^3
WT OF EMPTY RING	86	g	SPECIFIC GRAVITY	2.65	
WT OF WET SOIL	165.6	g	e_o	0.863	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0932	
RING CALIBRATION FACTOR	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.863030	0	0		
30	0.0	97.50	0.2477	0.023069	0.839961	0.02307	30.0	1.863	0.413
50	0.0	167.80	0.4262	0.039702	0.823328	0.01663	20.0	1.840	0.452
108	0.0	198.50	0.5042	0.046966	0.816064	0.00726	58.0	1.823	0.069
225	0.0	245.90	0.6246	0.058181	0.804849	0.01122	117.0	1.816	0.053
432	0.0	396.50	1.0071	0.093814	0.769216	0.03563	207.0	1.805	0.095
Average									0.216

CENTRAL MATERIALS LABORATORY

PROJECT: PROPOSED 220kV LOT 2: KAWANDA SUBSTATION
CLIENT: M/S EPINEX ENGINEERING SERVICES LTD.
DATE: JANUARY 2015

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF: **BH-1**	DEPTHS	**9.0m**	**FILTRATION**	
DIAMETER OF SPECIMEN	0.075 m	THICKNESS ($2H_1$)		0.02	m
VOLUME OF SPECIMEN	0.0000884 m^3				
MC BEFORE TEST	17 %	BULK DENSITY		1.680	Mg/m^3
WT OF SAMPLE $ RING	251.6 g	DRY DENSITY (γ_D)		1.436	Mg/m^3
WT OF EMPTY RING	85.2 g	SPECIFIC GRAVITY		2.71	
WT OF WET SOIL	166.4 g	e_o		0.887	
WT OF DRY SOIL	g				
		VOID RATIO FACTOR (F)		0.0944	
RING CALIBRATION FACTOR	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.887321	0	0		
30	0.0	87.40	0.2220	0.020949	0.866373	0.02095	30.0	1.887	0.370
50	0.0	125.80	0.3195	0.030153	0.857168	0.00920	20.0	1.866	0.247
108	0.0	298.50	0.7582	0.071547	0.815774	0.04139	58.0	1.857	0.384
225	0.0	397.20	1.0089	0.095205	0.792117	0.02366	117.0	1.816	0.111
432	0.0	429.00	1.0897	0.102827	0.784494	0.00762	207.0	1.792	0.021
Average									0.227

CENTRAL MATERIALS LABORATORY

PROJECT: PROPOSED 220kV LOT 2: KAWANDA SUBSTATION
CLIENT: M/S EPINEX ENGINEERING SERVICES LTD.
DATE: JANUARY 2015

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-1**	DEPTHS **7.5m**		**KARUMA RESERVOIR**
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	20	%	BULK DENSITY	1.630	Mg/m^3
WT OF SAMPLE $ RING	252.3	g	DRY DENSITY (γ_D)	1.358	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.69	
WT OF WET SOIL	166.9	g	e_o	0.980	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0990	
RING CALIBRATION FACTOR	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY: Incremental Changes Viod ratio	Pressure	$1+e_1$	m_v m^2/MN
0	0.0				0.980368	0	0		
30	0.0	87.50	0.2223	0.022007	0.958361	0.02201	30.0	1.980	0.370
50	0.0	243.60	0.6187	0.061267	0.919101	0.03926	20.0	1.958	1.002
108	0.0	367.50	0.9335	0.092429	0.887939	0.03116	58.0	1.919	0.280
225	0.0	397.50	1.0097	0.099974	0.880394	0.00755	117.0	1.888	0.034
432	0.0	435.90	1.1072	0.109632	0.870736	0.00966	207.0	1.880	0.025
Average									0.342

CENTRAL MATERIALS LABORATORY

PROJECT: PROPOSED 220kV LOT 2: KAWANDA SUBSTATION
CLIENT: M/S EPINEX ENGINEERING SERVICES LTD.
DATE: JANUARY 2015

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF: **BH-1**		DEPTHS **9.0m**	**KAMDINI RESERVOIR**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	49	%	BULK DENSITY	1.730	Mg/m^3
WT OF SAMPLE $ RING	252.4	g	DRY DENSITY (γ_D)	1.161	Mg/m^3
WT OF EMPTY RING	85.5	g	SPECIFIC GRAVITY	2.66	
WT OF WET SOIL	166.9	g	e_o	1.291	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1145	
RING CALIBRATION FACTOR	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY: Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.290983	0	0		
30	0.0	89.40	0.2271	0.026011	1.264971	0.02601	30.0	2.291	0.378
50	0.0	298.50	0.7582	0.086850	1.204133	0.06084	20.0	2.265	1.343
108	0.0	435.70	1.1067	0.126769	1.164214	0.03992	58.0	2.204	0.312
225	0.0	567.00	1.4402	0.164971	1.126011	0.03820	117.0	2.164	0.151
432	0.0	820.60	2.0843	0.238758	1.052225	0.07379	207.0	2.126	0.168
Average									0.470

CENTRAL MATERIALS LABORATORY

PROJECT: PROPOSED 220kV LOT 2: KAWANDA SUBSTATION
CLIENT: M/S EPINEX ENGINEERING SERVICES LTD.
DATE: JANUARY 2015

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-1**	DEPTHS	**3.0m**	**MINAKULU RESERVOIR**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)		0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3				
MC BEFORE TEST	10	%	BULK DENSITY		1.630	Mg/m^3
WT OF SAMPLE $ RING	252.6	g	DRY DENSITY (γ_D)		1.482	Mg/m^3
WT OF EMPTY RING	85.6	g	SPECIFIC GRAVITY		2.64	
WT OF WET SOIL	167	g	e_o		0.782	
WT OF DRY SOIL		g				
			VOID RATIO FACTOR (F)		0.0891	
RING CALIBRATION FACTOR	0.00254					

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.781595	0	0		
30	0.0	87.50	0.2223	0.019798	0.761797	0.01980	30.0	1.782	0.370
50	0.0	145.90	0.3706	0.033012	0.748583	0.01321	20.0	1.762	0.375
108	0.0	287.10	0.7292	0.064960	0.716635	0.03195	58.0	1.749	0.315
225	0.0	345.90	0.8786	0.078264	0.703331	0.01330	117.0	1.717	0.066
432	0.0	425.20	1.0800	0.096207	0.685388	0.01794	207.0	1.703	0.051
Average									0.236

CENTRAL MATERIALS LABORATORY

PROJECT: PROPOSED 220kV LOT 2: KAWANDA SUBSTATION
CLIENT: M/S EPINEX ENGINEERING SERVICES LTD.
DATE: JANUARY 2015

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-1**	DEPTHS	**3.0m**	**BOBI PUMP STATION**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)		0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3				
MC BEFORE TEST	12	%	BULK DENSITY		1.690	Mg/m^3
WT OF SAMPLE $ RING	253.5	g	DRY DENSITY (γ_D)		1.509	Mg/m^3
WT OF EMPTY RING	86.5	g	SPECIFIC GRAVITY		2.74	
WT OF WET SOIL	167	g	e_o		0.816	
WT OF DRY SOIL		g				
			VOID RATIO FACTOR (F)		0.0908	
RING CALIBRATION FACTOR	0.00254					

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0	0.00			0.815858	0	0		
30	0.0	82.50	0.2096	0.019026	0.796832	0.01903	30.0	1.816	0.349
50	0.0	234.60	0.5959	0.054102	0.761756	0.03508	20.0	1.797	0.976
108	0.0	245.80	0.6243	0.056685	0.759173	0.00258	58.0	1.762	0.025
225	0.0	267.90	0.6805	0.061781	0.754077	0.00510	117.0	1.759	0.025
432	0.0	283.50	0.7201	0.065379	0.750479	0.00360	207.0	1.754	0.010
Average									0.277

CENTRAL MATERIALS LABORATORY

PROJECT: PROPOSED 220kV LOT 2: KAWANDA SUBSTATION
CLIENT: M/S EPINEX ENGINEERING SERVICES LTD.
DATE: JANUARY 2015

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-1**	DEPTHS	**7.5m**	**BOBI RESERVOIR**
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	5	%	BULK DENSITY	1.610	Mg/m^3
WT OF SAMPLE $ RING	254.6	g	DRY DENSITY (γ_D)	1.533	Mg/m^3
WT OF EMPTY RING	86.5	g	SPECIFIC GRAVITY	2.67	
WT OF WET SOIL	168.1	g	e_o	0.741	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0871	
RING CALIBRATION FACTOR	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY: Incremental Changes — Viod ratio	Pressure	$1+e_1$	m_v m^2/MN
0	0.0	0.00			0.741304	0	0		
30	0.0	76.30	0.1938	0.016873	0.724431	0.01687	30.0	1.741	0.323
50	0.0	398.50	1.0122	0.088127	0.653178	0.07125	20.0	1.724	2.066
108	0.0	645.10	1.6386	0.142661	0.598643	0.05453	58.0	1.653	0.569
225	0.0	815.00	2.0701	0.180234	0.561071	0.03757	117.0	1.599	0.201
432	0.0	895.20	2.2738	0.197970	0.543335	0.01774	207.0	1.561	0.055
Average									0.643

CENTRAL MATERIALS LABORATORY

PROJECT: PROPOSED 220kV LOT 2: KAWANDA SUBSTATION
CLIENT: M/S EPINEX ENGINEERING SERVICES LTD.
DATE: JANUARY 2015

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-1**	DEPTHS	**1.5m**	**KORO ABILI RESERVOIR**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)		0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3				
MC BEFORE TEST	9	%	BULK DENSITY		1.670	Mg/m^3
WT OF SAMPLE $ RING	253.5	g	DRY DENSITY (γ_D)		1.532	Mg/m^3
WT OF EMPTY RING	86.5	g	SPECIFIC GRAVITY		2.69	
WT OF WET SOIL	167	g	e_o		0.756	
WT OF DRY SOIL		g				
			VOID RATIO FACTOR (F)		0.0878	
RING CALIBRATION FACTOR	0.00254					

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.755749	0	0		
30	0.0	87.50	0.2223	0.019511	0.736238	0.01951	30.0	1.756	0.370
50	0.0	267.30	0.6789	0.059603	0.696146	0.04009	20.0	1.736	1.155
108	0.0	354.20	0.8997	0.078980	0.676769	0.01938	58.0	1.696	0.197
225	0.0	480.90	1.2215	0.107231	0.648517	0.02825	117.0	1.677	0.144
432	0.0	564.30	1.4333	0.125828	0.629921	0.01860	207.0	1.649	0.054
Average									0.384

CENTRAL MATERIALS LABORATORY

PROJECT: PROPOSED 220kV LOT 2: KAWANDA SUBSTATION
CLIENT: M/S EPINEX ENGINEERING SERVICES LTD.
DATE: JANUARY 2015

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-1**	DEPTHS	**6.0m**	**KORO ABILI RESERVOIR**
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	26	%	BULK DENSITY	1.650	Mg/m^3
WT OF SAMPLE $ RING	252.3	g	DRY DENSITY (γ_D)	1.310	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.69	
WT OF WET SOIL	166.9	g	e_o	1.054	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1027	
RING CALIBRATION FACTOR	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0	0.00			1.054182	0	0		
30	0.0	84.20	0.2139	0.021966	1.032216	0.02197	30.0	2.054	0.356
50	0.0	375.30	0.9533	0.097909	0.956273	0.07594	20.0	2.032	1.868
108	0.0	514.90	1.3078	0.134328	0.919854	0.03642	58.0	1.956	0.321
225	0.0	736.90	1.8717	0.192243	0.861939	0.05792	117.0	1.920	0.258
432	0.0	821.50	2.0866	0.214314	0.839868	0.02207	207.0	1.862	0.057

Average 0.572

CENTRAL MATERIALS LABORATORY

PROJECT: PROPOSED 220kV LOT 2: KAWANDA SUBSTATION
CLIENT: M/S EPINEX ENGINEERING SERVICES LTD.
DATE: JANUARY 2015

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-1**	DEPTHS	**7.5m**	**NEW CUSTOMS CORNER**
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	22	%	BULK DENSITY	1.710	Mg/m^3
WT OF SAMPLE $ RING	252.4	g	DRY DENSITY (γ_D)	1.402	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.62	
WT OF WET SOIL	167	g	e_o	0.869	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0935	
RING CALIBRATION FACTOR	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0	0.00			0.869240	0	0		
30	0.0	85.20	0.2164	0.020226	0.849014	0.02023	30.0	1.869	0.361
50	0.0	489.70	1.2438	0.116252	0.752988	0.09603	20.0	1.849	2.597
108	0.0	698.10	1.7732	0.165724	0.703515	0.04947	58.0	1.753	0.487
225	0.0	823.90	2.0927	0.195588	0.673651	0.02986	117.0	1.704	0.150
432	0.0	987.20	2.5075	0.234355	0.634885	0.03877	207.0	1.674	0.112
Average									0.741

CENTRAL MATERIALS LABORATORY

PROJECT: PROPOSED 220kV LOT 2: KAWANDA SUBSTATION
CLIENT: M/S EPINEX ENGINEERING SERVICES LTD.
DATE: JANUARY 2015

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-2**	DEPTHS	**3.0m**	**NEW CUSTOMS CORNER**
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	14	%	BULK DENSITY	1.690	Mg/m^3
WT OF SAMPLE $ RING	252.1	g	DRY DENSITY (γ_D)	1.482	Mg/m^3
WT OF EMPTY RING	85.9	g	SPECIFIC GRAVITY	2.63	
WT OF WET SOIL	166.2	g	e_o	0.774	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0887	
RING CALIBRATION FACTOR	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.774083	0	0		
30	0.0	85.70	0.2177	0.019309	0.754774	0.01931	30.0	1.774	0.363
50	0.0	470.50	1.1951	0.106008	0.668075	0.08670	20.0	1.755	2.470
108	0.0	546.30	1.3876	0.123086	0.650997	0.01708	58.0	1.668	0.177
225	0.0	685.00	1.7399	0.154336	0.619747	0.03125	117.0	1.651	0.162
432	0.0	743.00	1.8872	0.167404	0.606679	0.01307	207.0	1.620	0.039
Average									0.642

CENTRAL MATERIALS LABORATORY

PROJECT: PROPOSED 220kV LOT 2: KAWANDA SUBSTATION
CLIENT: M/S EPINEX ENGINEERING SERVICES LTD.
DATE: JANUARY 2015

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-2**	DEPTHS	**4.5m**	**NEW CUSTOMS CORNER**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)		0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3				
MC BEFORE TEST	12	%	BULK DENSITY		1.730	Mg/m^3
WT OF SAMPLE $ RING	252.4	g	DRY DENSITY (γ_D)		1.545	Mg/m^3
WT OF EMPTY RING	85.6	g	SPECIFIC GRAVITY		2.69	
WT OF WET SOIL	166.8	g	e_o		0.742	
WT OF DRY SOIL		g				
			VOID RATIO FACTOR (F)		0.0871	
RING CALIBRATION FACTOR	0.00254					

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes Viod ratio	Pressure	$1+e_1$	m_v m^2/MN
0	0.0	0.00			0.741503	0	0		
30	0.0	84.10	0.2136	0.018600	0.722902	0.01860	30.0	1.742	0.356
50	0.0	356.40	0.9053	0.078825	0.662678	0.06022	20.0	1.723	1.748
108	0.0	487.60	1.2385	0.107843	0.633660	0.02902	58.0	1.663	0.301
225	0.0	549.10	1.3947	0.121445	0.620058	0.01360	117.0	1.634	0.071
432	0.0	684.00	1.7374	0.151281	0.590222	0.02984	207.0	1.620	0.089
Average									0.513

CENTRAL MATERIALS LABORATORY

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: June 2018

SUMMARY OF CONSOLIDATION TEST RESULTS

S.No.	Test Location	Depth (m)	Coefficient of Volume Compressibility (Mv) in m^2/MN	Range of Mv	Remarks
Kankayi	3+270	1.5	0.243	0.1 - 0.3	Medium Compressibility
Agengi	6+000	3.0	0.226	0.1 - 0.3	"
	6+050	3.0	0.099	0.05 - 0.1	Low Compressibility
Alenyi	9+000	3.0	0.115	0.1 - 0.3	Medium Compressibility
	9+150	3.0	0.140	0.1 - 0.3	"
	9+362	3.0	0.303	0.3 - 1.5	High Compressibility
	9+393	3.0	0.158	0.1 - 0.3	Medium Compressibility
Myene	12+000	3.0	0.188	0.1 - 0.3	"
	13+000	3.0	0.217	0.1 - 0.3	"
	13+100	3.0	0.106	0.1 - 0.3	"
	13+200	3.0	0.184	0.1 - 0.3	"
	13+500	3.0	0.286	0.1 - 0.3	"
Amwa, Otwe	14+150	3.0	0.246	0.1 - 0.3	"
	16+000	3.0	0.261	0.1 - 0.3	"
Ngaato	16+200	3.0	0.060	0.05 - 0.1	Low Compressibility
	16+250	3.0	0.216	0.1 - 0.3	Medium Compressibility
	20+000	3.0	0.240	0.1 - 0.3	"
	20+300	3.0	0.082	0.05 - 0.1	Low Compressibility
	20+390	3.0	0.046	0.05 - 0.1	"

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**KANKAYI SWAMP**	DEPTHS	**1.50m (CH 3+270)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	8	%	BULK DENSITY	1.620	Mg/m^3
WT OF SAMPLE $ RING	252.5	g	DRY DENSITY (γ_D)	1.500	Mg/m^3
WT OF EMPTY RING	85.6	g	SPECIFIC GRAVITY	2.65	
WT OF WET SOIL	166.9	g	e_o	0.767	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0883	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	 *Pressure*	 $1+e_1$	 m_v m^2/MN
0	0.0				0.766667	0	0		
30	0.0	45.70	0.1161	0.010254	0.756413	0.01025	30.0	1.767	0.193
50	0.0	162.40	0.4125	0.036437	0.730230	0.02618	20.0	1.756	0.745
108	0.0	234.80	0.5964	0.052681	0.713985	0.01624	58.0	1.730	0.162
225	0.0	298.30	0.7577	0.066929	0.699738	0.01425	117.0	1.714	0.071
432	0.0	368.10	0.9350	0.082589	0.684077	0.01566	207.0	1.700	0.045
Average									0.243

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**AGENGI SWAMP**	DEPTHS	**3.00m (CH 6+000)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	33	%	BULK DENSITY	1.650	Mg/m^3
WT OF SAMPLE $ RING	251.5	g	DRY DENSITY (γ_D)	1.241	Mg/m^3
WT OF EMPTY RING	86.5	g	SPECIFIC GRAVITY	2.73	
WT OF WET SOIL	165	g	e_o	1.201	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1100	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.200545	0	0		
30	0.0	99.40	0.2525	0.027779	1.172766	0.02778	30.0	2.201	0.421
50	0.0	153.20	0.3891	0.042815	1.157731	0.01504	20.0	2.173	0.346
108	0.0	267.50	0.6795	0.074758	1.125787	0.03194	58.0	2.158	0.255
225	0.0	321.90	0.8176	0.089961	1.110584	0.01520	117.0	2.126	0.061
432	0.0	392.60	0.9972	0.109720	1.090826	0.01976	207.0	2.111	0.045
Average									0.226

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**AGENGI SWAMP**	DEPTHS	**3.00 (CH 6+050)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	30	%	BULK DENSITY	1.650	Mg/m^3
WT OF SAMPLE $ RING	252	g	DRY DENSITY (γ_D)	1.269	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.69	
WT OF WET SOIL	166.6	g	e_o	1.119	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1060	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.119394	0	0		
30	0.0	110.50	0.2807	0.029743	1.089651	0.02974	30.0	2.119	0.468
50	0.0	113.70	0.2888	0.030604	1.088790	0.00086	20.0	2.090	0.021
108	0.0	114.90	0.2918	0.030927	1.088467	0.00032	58.0	2.089	0.003
225	0.0	118.30	0.3005	0.031842	1.087552	0.00092	117.0	2.088	0.004
432	0.0	121.60	0.3089	0.032730	1.086664	0.00089	207.0	2.088	0.002
Average									0.099

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**ALENYI SWAMP**	DEPTHS	**3.00 (CH 9+000)**		
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	25	%	BULK DENSITY	1.690	Mg/m^3
WT OF SAMPLE $ RING	251.5	g	DRY DENSITY (γ_D)	1.352	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.7	
WT OF WET SOIL	166.1	g	e_o	0.997	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0999	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.997041	0	0		
30	0.0	87.30	0.2217	0.022141	0.974900	0.02214	30.0	1.997	0.370
50	0.0	108.40	0.2753	0.027493	0.969549	0.00535	20.0	1.975	0.135
108	0.0	123.60	0.3139	0.031348	0.965693	0.00386	58.0	1.970	0.034
225	0.0	143.90	0.3655	0.036497	0.960545	0.00515	117.0	1.966	0.022
432	0.0	165.70	0.4209	0.042026	0.955016	0.00553	207.0	1.961	0.014
Average									0.115

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**ALENYI SWAMP**	DEPTHS	**3.00 (CH 9+150)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	25	%	BULK DENSITY	1.650	Mg/m^3
WT OF SAMPLE $ RING	253.5	g	DRY DENSITY (γ_D)	1.320	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.69	
WT OF WET SOIL	168.1	g	e_o	1.038	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1019	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.037879	0	0		
30	0.0	89.50	0.2273	0.023164	1.014715	0.02316	30.0	2.038	0.379
50	0.0	124.80	0.3170	0.032300	1.005579	0.00914	20.0	2.015	0.227
108	0.0	149.60	0.3800	0.038718	0.999161	0.00642	58.0	2.006	0.055
225	0.0	176.20	0.4475	0.045602	0.992276	0.00688	117.0	1.999	0.029
432	0.0	190.10	0.4829	0.049200	0.988679	0.00360	207.0	1.992	0.009
Average									0.140

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**ALENYI SWAMP**	DEPTHS	**3.00 (CH 9+362)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	23	%	BULK DENSITY	1.680	Mg/m^3
WT OF SAMPLE $ RING	252.5	g	DRY DENSITY (γ_D)	1.366	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.71	
WT OF WET SOIL	167.1	g	e_o	0.984	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0992	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.984107	0	0		
30	0.0	93.60	0.2377	0.023585	0.960522	0.02359	30.0	1.984	0.396
50	0.0	231.90	0.5890	0.058435	0.925673	0.03485	20.0	1.961	0.889
108	0.0	265.80	0.6751	0.066977	0.917130	0.00854	58.0	1.926	0.076
225	0.0	356.10	0.9045	0.089731	0.894376	0.02275	117.0	1.917	0.101
432	0.0	439.50	1.1163	0.110746	0.873361	0.02102	207.0	1.894	0.054
Average									0.303

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**ALENYI SWAMP**	DEPTHS	**3.00 (CH 9+393)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	26	%	BULK DENSITY	1.620	Mg/m^3
WT OF SAMPLE $ RING	252	g	DRY DENSITY (γ_D)	1.286	Mg/m^3
WT OF EMPTY RING	85.5	g	SPECIFIC GRAVITY	2.71	
WT OF WET SOIL	166.5	g	e_o	1.108	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1054	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0	0.00			1.107778	0	0		
30	0.0	96.70	0.2456	0.025885	1.081892	0.02589	30.0	2.108	0.409
50	0.0	139.80	0.3551	0.037423	1.070355	0.01154	20.0	2.082	0.277
108	0.0	167.40	0.4252	0.044811	1.062967	0.00739	58.0	2.070	0.062
225	0.0	198.50	0.5042	0.053136	1.054642	0.00833	117.0	2.063	0.034
432	0.0	213.20	0.5415	0.057071	1.050707	0.00394	207.0	2.055	0.009

Average 0.158

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**MYENE SWAMP**	DEPTHS	**3.00 (CH 12+000)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	31	%	BULK DENSITY	1.650	Mg/m^3
WT OF SAMPLE $ RING	251.5	g	DRY DENSITY (γ_D)	1.260	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.68	
WT OF WET SOIL	166.1	g	e_o	1.128	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1064	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0	0.00			1.127758	0	0		
30	0.0	87.90	0.2233	0.023753	1.104005	0.02375	30.0	2.128	0.372
50	0.0	146.60	0.3724	0.039615	1.088143	0.01586	20.0	2.104	0.377
108	0.0	187.40	0.4760	0.050640	1.077117	0.01103	58.0	2.088	0.091
225	0.0	247.50	0.6287	0.066881	1.060877	0.01624	117.0	2.077	0.067
432	0.0	298.40	0.7579	0.080635	1.047122	0.01375	207.0	2.061	0.032
Average									0.188

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**MYENE SWAMP**	DEPTHS	**3.00 (CH 13+000)**		
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)		0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3				
MC BEFORE TEST	36	%	BULK DENSITY		1.650	Mg/m^3
WT OF SAMPLE $ RING	252.5	g	DRY DENSITY (γ_D)		1.213	Mg/m^3
WT OF EMPTY RING	85.6	g	SPECIFIC GRAVITY		2.69	
WT OF WET SOIL	166.9	g	e_o		1.217	
WT OF DRY SOIL		g				
			VOID RATIO FACTOR (F)		0.1109	
RING CALIBRATION FACTOF	0.00254					

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY: Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.217212	0	0		
30	0.0	89.20	0.2266	0.025117	1.192095	0.02512	30.0	2.217	0.378
50	0.0	167.40	0.4252	0.047137	1.170075	0.02202	20.0	2.192	0.502
108	0.0	211.80	0.5380	0.059640	1.157572	0.01250	58.0	2.170	0.099
225	0.0	287.90	0.7313	0.081069	1.136144	0.02143	117.0	2.158	0.085
432	0.0	319.00	0.8103	0.089826	1.127386	0.00876	207.0	2.136	0.020
Average									0.217

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**MYENE SWAMP**	DEPTHS	**3.00 (CH 13+100)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	35	%	BULK DENSITY	1.670	Mg/m^3
WT OF SAMPLE $ RING	251.5	g	DRY DENSITY (γ_D)	1.237	Mg/m^3
WT OF EMPTY RING	85.7	g	SPECIFIC GRAVITY	2.72	
WT OF WET SOIL	165.8	g	e_o	1.199	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1099	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0	0.00			1.198802	0	0		
30	0.0	93.10	0.2365	0.025998	1.172804	0.02600	30.0	2.199	0.394
50	0.0	100.40	0.2550	0.028036	1.170766	0.00204	20.0	2.173	0.047
108	0.0	123.60	0.3139	0.034515	1.164287	0.00648	58.0	2.171	0.051
225	0.0	149.20	0.3790	0.041664	1.157139	0.00715	117.0	2.164	0.028
432	0.0	167.50	0.4255	0.046774	1.152028	0.00511	207.0	2.157	0.011
Average									0.106

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**MYENE SWAMP**	DEPTHS	**3.00 (CH 13+200)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	35	%	BULK DENSITY	1.670	Mg/m^3
WT OF SAMPLE $ RING	252	g	DRY DENSITY (γ_D)	1.237	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.71	
WT OF WET SOIL	166.6	g	e_o	1.191	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1095	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0	0.00			1.190719	0	0		
30	0.0	98.40	0.2499	0.027377	1.163342	0.02738	30.0	2.191	0.417
50	0.0	136.20	0.3459	0.037894	1.152825	0.01052	20.0	2.163	0.243
108	0.0	189.50	0.4813	0.052723	1.137996	0.01483	58.0	2.153	0.119
225	0.0	278.40	0.7071	0.077457	1.113262	0.02473	117.0	2.138	0.099
432	0.0	342.00	0.8687	0.095152	1.095567	0.01769	207.0	2.113	0.040
Average									0.184

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**MYENE SWAMP**	DEPTHS	**3.00 (CH 13+500)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	38	%	BULK DENSITY	1.720	Mg/m^3
WT OF SAMPLE $ RING	252.4	g	DRY DENSITY (γ_D)	1.246	Mg/m^3
WT OF EMPTY RING	85.9	g	SPECIFIC GRAVITY	2.68	
WT OF WET SOIL	166.5	g	e_o	1.150	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1075	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.150233	0	0		
30	0.0	96.40	0.2449	0.026325	1.123908	0.02632	30.0	2.150	0.408
50	0.0	198.40	0.5039	0.054179	1.096054	0.02785	20.0	2.124	0.656
108	0.0	276.00	0.7010	0.075370	1.074863	0.02119	58.0	2.096	0.174
225	0.0	394.20	1.0013	0.107648	1.042585	0.03228	117.0	2.075	0.133
432	0.0	489.10	1.2423	0.133563	1.016669	0.02592	207.0	2.043	0.061

Average 0.286

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**AMWA, OTWE**	DEPTHS	**3.00 (CH 14+150)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	35	%	BULK DENSITY	1.640	Mg/m^3
WT OF SAMPLE $ RING	252.2	g	DRY DENSITY (γ_D)	1.215	Mg/m^3
WT OF EMPTY RING	85.8	g	SPECIFIC GRAVITY	2.69	
WT OF WET SOIL	166.4	g	e_o	1.214	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1107	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0	0.00			1.214329	0	0		
30	0.0	45.50	0.1156	0.012796	1.201534	0.01280	30.0	2.214	0.193
50	0.0	145.80	0.3703	0.041002	1.173327	0.02821	20.0	2.202	0.641
108	0.0	251.90	0.6398	0.070839	1.143490	0.02984	58.0	2.173	0.237
225	0.0	359.50	0.9131	0.101099	1.113231	0.03026	117.0	2.143	0.121
432	0.0	419.60	1.0658	0.118000	1.096329	0.01690	207.0	2.113	0.039
Average									0.246

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**AMWA, OTWE**	DEPTHS	**3.00 (CH 16+000)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	32	%	BULK DENSITY	1.690	Mg/m^3
WT OF SAMPLE $ RING	252.3	g	DRY DENSITY (γ_D)	1.280	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.76	
WT OF WET SOIL	166.9	g	e_o	1.156	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1078	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.155740	0	0		
30	0.0	49.80	0.1265	0.013634	1.142105	0.01363	30.0	2.156	0.211
50	0.0	156.70	0.3980	0.042901	1.112838	0.02927	20.0	2.142	0.683
108	0.0	268.40	0.6817	0.073482	1.082257	0.03058	58.0	2.113	0.250
225	0.0	378.90	0.9624	0.103735	1.052005	0.03025	117.0	2.082	0.124
432	0.0	438.40	1.1135	0.120025	1.035715	0.01629	207.0	2.052	0.038
Average									0.261

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**NGAATO SWAMP**	DEPTHS	**3.00 (CH 16+200)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	24	%	BULK DENSITY	1.710	Mg/m^3
WT OF SAMPLE $ RING	252	g	DRY DENSITY (γ_D)	1.379	Mg/m^3
WT OF EMPTY RING	86.1	g	SPECIFIC GRAVITY	2.72	
WT OF WET SOIL	165.9	g	e_o	0.972	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0986	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.972398	0	0		
30	0.0	43.20	0.1097	0.010821	0.961576	0.01082	30.0	1.972	0.183
50	0.0	53.90	0.1369	0.013502	0.958896	0.00268	20.0	1.962	0.068
108	0.0	67.80	0.1722	0.016984	0.955414	0.00348	58.0	1.959	0.031
225	0.0	78.90	0.2004	0.019764	0.952634	0.00278	117.0	1.955	0.012
432	0.0	89.10	0.2263	0.022319	0.950079	0.00256	207.0	1.953	0.006
Average									0.060

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**NGAATO SWAMP**	DEPTHS	**3.00 (CH 16+250)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	25	%	BULK DENSITY	1.710	Mg/m^3
WT OF SAMPLE $ RING	252.3	g	DRY DENSITY (γ_D)	1.368	Mg/m^3
WT OF EMPTY RING	85.5	g	SPECIFIC GRAVITY	2.79	
WT OF WET SOIL	166.8	g	e_o	1.039	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1020	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0	0.00			1.039474	0	0		
30	0.0	47.80	0.1214	0.012381	1.027093	0.01238	30.0	2.039	0.202
50	0.0	126.70	0.3218	0.032817	1.006657	0.02044	20.0	2.027	0.504
108	0.0	211.80	0.5380	0.054859	0.984615	0.02204	58.0	2.007	0.189
225	0.0	328.40	0.8341	0.085060	0.954414	0.03020	117.0	1.985	0.130
432	0.0	411.20	1.0444	0.106506	0.932967	0.02145	207.0	1.954	0.053
Average									0.216

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**NGAATO SWAMP**	DEPTHS	**3.00 (CH 20+000)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	28	%	BULK DENSITY	1.720	Mg/m^3
WT OF SAMPLE $ RING	251.5	g	DRY DENSITY (γ_D)	1.344	Mg/m^3
WT OF EMPTY RING	85.7	g	SPECIFIC GRAVITY	2.83	
WT OF WET SOIL	165.8	g	e_o	1.106	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1053	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.106047	0	0		
30	0.0	87.60	0.2225	0.023430	1.082616	0.02343	30.0	2.106	0.371
50	0.0	167.30	0.4249	0.044747	1.061299	0.02132	20.0	2.083	0.512
108	0.0	219.80	0.5583	0.058789	1.047257	0.01404	58.0	2.061	0.117
225	0.0	367.90	0.9345	0.098401	1.007645	0.03961	117.0	2.047	0.165
432	0.0	419.20	1.0648	0.112123	0.993924	0.01372	207.0	2.008	0.033
Average									0.240

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**NGAATO SWAMP**	DEPTHS	**3.00 (CH 20+300)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	24	%	BULK DENSITY	1.720	Mg/m^3
WT OF SAMPLE $ RING	252	g	DRY DENSITY (γ_D)	1.387	Mg/m^3
WT OF EMPTY RING	85.9	g	SPECIFIC GRAVITY	2.83	
WT OF WET SOIL	166.1	g	e_o	1.040	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1020	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.040233	0	0		
30	0.0	48.70	0.1237	0.012619	1.027614	0.01262	30.0	2.040	0.206
50	0.0	58.30	0.1481	0.015106	1.025126	0.00249	20.0	2.028	0.061
108	0.0	98.40	0.2499	0.025496	1.014736	0.01039	58.0	2.025	0.088
225	0.0	143.90	0.3655	0.037286	1.002947	0.01179	117.0	2.015	0.050
432	0.0	147.80	0.3754	0.038296	1.001936	0.00101	207.0	2.003	0.002
Average									0.082

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**NGAATO SWAMP**	DEPTHS	**3.00 (CH 20+390)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	20	%	BULK DENSITY	1.690	Mg/m^3
WT OF SAMPLE $ RING	251.7	g	DRY DENSITY (γ_D)	1.408	Mg/m^3
WT OF EMPTY RING	85.5	g	SPECIFIC GRAVITY	2.84	
WT OF WET SOIL	166.2	g	e_o	1.017	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1008	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.016568	0	0		
30	0.0	45.30	0.1151	0.011602	1.004967	0.01160	30.0	2.017	0.192
50	0.0	47.20	0.1199	0.012088	1.004480	0.00049	20.0	2.005	0.012
108	0.0	53.60	0.1361	0.013727	1.002841	0.00164	58.0	2.004	0.014
225	0.0	56.90	0.1445	0.014572	1.001996	0.00085	117.0	2.003	0.004
432	0.0	71.80	0.1824	0.018388	0.998180	0.00382	207.0	2.002	0.009
Average									0.046

CENTRAL MATERIALS LABORATORY

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT: M/s FICHTNER WATER & TRANSPORTATION

DATE: June 2018

SUMMARY OF CONSOLIDATION TEST RESULTS

S.No.	Test Location	Depth (m)	Coefficient of Volume Compressibility (Mv) in m^2/MN	Range of Mv	Remarks
Atek	22+000	3.0	0.374	0.3 - 1.5	High Compressibility
	22+100	3.0	0.055	0.05 - 0.1	Low Compressibility
	22+200	3.0	0.068	0.05 - 0.1	"
	22+300	3.0	0.162	0.1 - 0.3	Medium Compressibility
Agada	25+000	3.0	0.059	0.05 - 0.1	Low Compressibility
	25+100	3.0	0.208	0.1 - 0.3	Medium Compressibility
Atego	29+050	3.0	0.266	0.1 - 0.3	"
	30+000	3.0	0.070	0.05 - 0.1	Low Compressibility
Minakulu	32+000	3.0	0.278	0.1 - 0.3	Medium Compressibility
	32+100	3.0	0.295	0.1 - 0.3	"
	32+200	3.0	0.378	0.3 - 1.5	High Compressibility
	32+300	3.0	0.290	0.1 - 0.3	Medium Compressibility
	32+400	3.0	0.154	0.1 - 0.3	"
Lminlango	42+200	3.0	0.077	0.05 - 0.1	Low Compressibility
	42+300	3.0	0.097	0.05 - 0.1	"
Palenga	45+000	3.0	0.410	0.3 - 1.5	High Compressibility
	45+100	3.0	0.068	0.05 - 0.1	Low Compressibility
Tochi	47+000	3.0	0.074	0.05 - 0.1	"
	47+100	3.0	0.104	0.1 - 0.3	Medium Compressibility
	47+200	3.0	0.178	0.1 - 0.3	"
	47+300	3.0	0.214	0.1 - 0.3	"

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**ATEK SWAMP**	DEPTHS	**3.00 (CH 22+000)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	22	%	BULK DENSITY	1.620	Mg/m^3
WT OF SAMPLE $ RING	252.5	g	DRY DENSITY (γ_D)	1.328	Mg/m^3
WT OF EMPTY RING	85.6	g	SPECIFIC GRAVITY	2.82	
WT OF WET SOIL	166.9	g	e_o	1.124	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1062	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes Viod ratio	Pressure	$1+e_1$	m_v m^2/MN
0	0.0				1.123704	0	0		
30	0.0	47.30	0.1201	0.012757	1.110946	0.01276	30.0	2.124	0.200
50	0.0	245.10	0.6226	0.066106	1.057598	0.05335	20.0	2.111	1.264
108	0.0	397.30	1.0091	0.107156	1.016548	0.04105	58.0	2.058	0.344
225	0.0	416.00	1.0566	0.112200	1.011504	0.00504	117.0	2.017	0.021
432	0.0	476.00	1.2090	0.128382	0.995322	0.01618	207.0	2.012	0.039

Average 0.374

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**ATEK SWAMP**	DEPTHS	**3.00 (CH 22+100)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	22	%	BULK DENSITY	1.650	Mg/m^3
WT OF SAMPLE $ RING	251.5	g	DRY DENSITY (γ_D)	1.352	Mg/m^3
WT OF EMPTY RING	86.5	g	SPECIFIC GRAVITY	2.69	
WT OF WET SOIL	165	g	e_o	0.989	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0994	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.988970	0	0		
30	0.0	45.70	0.1161	0.011544	0.977426	0.01154	30.0	1.989	0.193
50	0.0	56.10	0.1425	0.014171	0.974799	0.00263	20.0	1.977	0.066
108	0.0	58.90	0.1496	0.014878	0.974092	0.00071	58.0	1.975	0.006
225	0.0	61.00	0.1549	0.015409	0.973561	0.00053	117.0	1.974	0.002
432	0.0	69.80	0.1773	0.017631	0.971338	0.00222	207.0	1.974	0.005
Average									0.055

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**ATEK SWAMP**	DEPTHS	**3.00 (CH 22+200)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	26	%	BULK DENSITY	1.650	Mg/m^3
WT OF SAMPLE $ RING	252	g	DRY DENSITY (γ_D)	1.310	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.74	
WT OF WET SOIL	166.6	g	e_o	1.092	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1046	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.092364	0	0		
30	0.0	49.50	0.1257	0.013154	1.079210	0.01315	30.0	2.092	0.210
50	0.0	62.30	0.1582	0.016555	1.075809	0.00340	20.0	2.079	0.082
108	0.0	78.20	0.1986	0.020780	1.071584	0.00423	58.0	2.076	0.035
225	0.0	89.30	0.2268	0.023730	1.068634	0.00295	117.0	2.072	0.012
432	0.0	94.00	0.2388	0.024979	1.067385	0.00125	207.0	2.069	0.003
Average									0.068

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**ATEK SWAMP**	DEPTHS	**3.00 (CH 22+300)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	23	%	BULK DENSITY	1.690	Mg/m^3
WT OF SAMPLE $ RING	251.5	g	DRY DENSITY (γ_D)	1.374	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.70	
WT OF WET SOIL	166.1	g	e_o	0.965	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0983	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.965089	0	0		
30	0.0	53.80	0.1367	0.013427	0.951662	0.01343	30.0	1.965	0.228
50	0.0	98.10	0.2492	0.024482	0.940606	0.01106	20.0	1.952	0.283
108	0.0	159.30	0.4046	0.039756	0.925333	0.01527	58.0	1.941	0.136
225	0.0	243.90	0.6195	0.060869	0.904220	0.02111	117.0	1.925	0.094
432	0.0	356.20	0.9047	0.088896	0.876193	0.02803	207.0	1.904	0.071
Average									0.162

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**AGADA SWAMP**	DEPTHS	**3.00 (CH 25+000)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	16	%	BULK DENSITY	1.650	Mg/m^3
WT OF SAMPLE $ RING	253.5	g	DRY DENSITY (γ_D)	1.422	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.73	
WT OF WET SOIL	168.1	g	e_o	0.919	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0960	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.919273	0	0		
30	0.0	54.30	0.1379	0.013235	0.906037	0.01324	30.0	1.919	0.230
50	0.0	59.30	0.1506	0.014454	0.904818	0.00122	20.0	1.906	0.032
108	0.0	65.00	0.1651	0.015844	0.903429	0.00139	58.0	1.905	0.013
225	0.0	75.30	0.1913	0.018354	0.900919	0.00251	117.0	1.903	0.011
432	0.0	89.10	0.2263	0.021718	0.897555	0.00336	207.0	1.901	0.009
Average									0.059

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**AGADA SWAMP**	DEPTHS	**3.00 (CH 25+100)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	32	%	BULK DENSITY	1.680	Mg/m^3
WT OF SAMPLE $ RING	252.5	g	DRY DENSITY (γ_D)	1.273	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.71	
WT OF WET SOIL	167.1	g	e_o	1.129	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1065	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.129286	0	0		
30	0.0	56.20	0.1427	0.015198	1.114088	0.01520	30.0	2.129	0.238
50	0.0	134.90	0.3426	0.036480	1.092806	0.02128	20.0	2.114	0.503
108	0.0	211.00	0.5359	0.057058	1.072227	0.02058	58.0	2.093	0.170
225	0.0	289.00	0.7341	0.078151	1.051135	0.02109	117.0	2.072	0.087
432	0.0	356.40	0.9053	0.096377	1.032908	0.01823	207.0	2.051	0.043
Average									0.208

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**ATEGO SWAMP**	DEPTHS	**3.00 (CH 29+050)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	34	%	BULK DENSITY	1.620	Mg/m^3
WT OF SAMPLE $ RING	252	g	DRY DENSITY (γ_D)	1.209	Mg/m^3
WT OF EMPTY RING	85.5	g	SPECIFIC GRAVITY	2.73	
WT OF WET SOIL	166.5	g	e_o	1.258	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1129	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY: Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0	0.00			1.258148	0	0		
30	0.0	67.30	0.1709	0.019301	1.238848	0.01930	30.0	2.258	0.285
50	0.0	189.40	0.4811	0.054317	1.203831	0.03502	20.0	2.239	0.782
108	0.0	267.20	0.6787	0.076629	1.181519	0.02231	58.0	2.204	0.175
225	0.0	316.40	0.8037	0.090739	1.167409	0.01411	117.0	2.182	0.055
432	0.0	367.20	0.9327	0.105307	1.152841	0.01457	207.0	2.167	0.032

Average 0.266

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**ATEGO SWAMP**	DEPTHS	**3.00 (CH 30+000)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	20	%	BULK DENSITY	1.650	Mg/m^3
WT OF SAMPLE $ RING	251.5	g	DRY DENSITY (γ_D)	1.375	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.74	
WT OF WET SOIL	166.1	g	e_o	0.993	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0996	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0	0.00			0.992727	0	0		
30	0.0	59.10	0.1501	0.014957	0.977770	0.01496	30.0	1.993	0.250
50	0.0	65.10	0.1654	0.016475	0.976252	0.00152	20.0	1.978	0.038
108	0.0	89.30	0.2268	0.022600	0.970128	0.00612	58.0	1.976	0.053
225	0.0	93.80	0.2383	0.023739	0.968989	0.00114	117.0	1.970	0.005
432	0.0	99.20	0.2520	0.025105	0.967622	0.00137	207.0	1.969	0.003
Average									0.070

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**MINAKULU SWAM**	DEPTHS	**POINT 1**		
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	39	%	BULK DENSITY	1.650	Mg/m^3
WT OF SAMPLE $ RING	252.5	g	DRY DENSITY (γ_D)	1.187	Mg/m^3
WT OF EMPTY RING	85.6	g	SPECIFIC GRAVITY	2.82	
WT OF WET SOIL	166.9	g	e_o	1.376	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1188	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.375636	0	0		
30	0.0	62.80	0.1595	0.018947	1.356689	0.01895	30.0	2.376	0.266
50	0.0	213.70	0.5428	0.064475	1.311162	0.04553	20.0	2.357	0.966
108	0.0	259.20	0.6584	0.078202	1.297434	0.01373	58.0	2.311	0.102
225	0.0	289.10	0.7343	0.087223	1.288413	0.00902	117.0	2.297	0.034
432	0.0	326.10	0.8283	0.098386	1.277250	0.01116	207.0	2.288	0.024
Average									0.278

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**MINAKULU SWAM**	DEPTHS	**POINT 2**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	28	%	BULK DENSITY	1.670	Mg/m^3
WT OF SAMPLE $ RING	251.5	g	DRY DENSITY (γ_D)	1.305	Mg/m^3
WT OF EMPTY RING	85.7	g	SPECIFIC GRAVITY	2.78	
WT OF WET SOIL	165.8	g	e_o	1.131	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1065	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY			
						Incremental Changes		$1+e_1$	m_v
						Viod ratio	*Pressure*		m^2/MN
0	0.0	0.00			1.130778	0	0		
30	0.0	65.70	0.1669	0.017779	1.112999	0.01778	30.0	2.131	0.278
50	0.0	239.80	0.6091	0.064892	1.065886	0.04711	20.0	2.113	1.115
108	0.0	267.20	0.6787	0.072307	1.058472	0.00741	58.0	2.066	0.062
225	0.0	279.40	0.7097	0.075608	1.055170	0.00330	117.0	2.058	0.014
432	0.0	287.50	0.7303	0.077800	1.052978	0.00219	207.0	2.055	0.005
Average									0.295

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**MINAKULU SWAM**	DEPTHS	**POINT 3**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	32	%	BULK DENSITY	1.670	Mg/m^3
WT OF SAMPLE $ RING	252	g	DRY DENSITY (γ_D)	1.265	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.83	
WT OF WET SOIL	166.6	g	e_o	1.237	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1118	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0	0.00			1.236886	0	0		
30	0.0	69.20	0.1758	0.019659	1.217228	0.01966	30.0	2.237	0.293
50	0.0	289.40	0.7351	0.082214	1.154672	0.06256	20.0	2.217	1.411
108	0.0	347.80	0.8834	0.098805	1.138082	0.01659	58.0	2.155	0.133
225	0.0	378.30	0.9609	0.107469	1.129417	0.00866	117.0	2.138	0.035
432	0.0	405.20	1.0292	0.115111	1.121775	0.00764	207.0	2.129	0.017
Average									0.378

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**MINAKULU SWAM**	DEPTHS	**POINT 4**		
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	36	%	BULK DENSITY	1.720	Mg/m^3
WT OF SAMPLE $ RING	252.4	g	DRY DENSITY (γ_D)	1.265	Mg/m^3
WT OF EMPTY RING	85.9	g	SPECIFIC GRAVITY	2.79	
WT OF WET SOIL	166.5	g	e_o	1.206	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1103	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.206047	0	0		
30	0.0	65.30	0.1659	0.018295	1.187752	0.01829	30.0	2.206	0.276
50	0.0	211.70	0.5377	0.059312	1.146735	0.04102	20.0	2.188	0.937
108	0.0	276.30	0.7018	0.077410	1.128636	0.01810	58.0	2.147	0.145
225	0.0	319.40	0.8113	0.089486	1.116561	0.01208	117.0	2.129	0.048
432	0.0	387.40	0.9840	0.108537	1.097509	0.01905	207.0	2.117	0.043
Average									0.290

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**MINAKULU SWAM**	DEPTHS	**POINT 5**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	24	%	BULK DENSITY	1.640	Mg/m^3
WT OF SAMPLE $ RING	252.2	g	DRY DENSITY (γ_D)	1.323	Mg/m^3
WT OF EMPTY RING	85.8	g	SPECIFIC GRAVITY	2.73	
WT OF WET SOIL	166.4	g	e_o	1.064	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1032	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0	0.00			1.064146	0	0		
30	0.0	65.20	0.1656	0.017092	1.047054	0.01709	30.0	2.064	0.276
50	0.0	98.10	0.2492	0.025717	1.038430	0.00862	20.0	2.047	0.211
108	0.0	178.40	0.4531	0.046767	1.017379	0.02105	58.0	2.038	0.178
225	0.0	218.50	0.5550	0.057279	1.006867	0.01051	117.0	2.017	0.045
432	0.0	317.90	0.8075	0.083336	0.980810	0.02606	207.0	2.007	0.063
Average									0.154

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**LMINLANGO**	DEPTHS	**3.00 (CH 42+200)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	24	%	BULK DENSITY	1.690	Mg/m^3
WT OF SAMPLE $ RING	252.3	g	DRY DENSITY (γ_D)	1.363	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.65	
WT OF WET SOIL	166.9	g	e_o	0.944	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0972	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.944379	0	0		
30	0.0	56.50	0.1435	0.013952	0.930427	0.01395	30.0	1.944	0.239
50	0.0	76.80	0.1951	0.018965	0.925414	0.00501	20.0	1.930	0.130
108	0.0	79.30	0.2014	0.019582	0.924797	0.00062	58.0	1.925	0.006
225	0.0	86.30	0.2192	0.021311	0.923068	0.00173	117.0	1.925	0.008
432	0.0	87.90	0.2233	0.021706	0.922673	0.00040	207.0	1.923	0.001
Average									0.077

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF: **LMINLANGO**	DEPTHS	**3.00 (CH 42+300)**
DIAMETER OF SPECIMEN	0.075 m	THICKNESS ($2H_1$)	0.02 m
VOLUME OF SPECIMEN	0.0000884 m^3		
MC BEFORE TEST	19 %	BULK DENSITY	1.710 Mg/m^3
WT OF SAMPLE $ RING	252 g	DRY DENSITY (γ_D)	1.437 Mg/m^3
WT OF EMPTY RING	86.1 g	SPECIFIC GRAVITY	2.65
WT OF WET SOIL	165.9 g	e_o	0.844
WT OF DRY SOIL	g		
		VOID RATIO FACTOR (F)	0.0922
RING CALIBRATION FACTOF	0.00254		

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.844152	0	0		
30	0.0	57.90	0.1471	0.013561	0.830591	0.01356	30.0	1.844	0.245
50	0.0	89.40	0.2271	0.020938	0.823214	0.00738	20.0	1.831	0.202
108	0.0	98.40	0.2499	0.023046	0.821106	0.00211	58.0	1.823	0.020
225	0.0	109.10	0.2771	0.025552	0.818600	0.00251	117.0	1.821	0.012
432	0.0	123.60	0.3139	0.028948	0.815204	0.00340	207.0	1.819	0.009
Average									0.097

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**PALENGA**	DEPTHS	**3.00 (CH 45+000)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	28	%	BULK DENSITY	1.710	Mg/m^3
WT OF SAMPLE $ RING	252.3	g	DRY DENSITY (γ_D)	1.336	Mg/m^3
WT OF EMPTY RING	85.5	g	SPECIFIC GRAVITY	2.67	
WT OF WET SOIL	166.8	g	e_o	0.999	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0999	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0	0.00			0.998596	0	0		
30	0.0	57.30	0.1455	0.014544	0.984053	0.01454	30.0	1.999	0.243
50	0.0	265.40	0.6741	0.067364	0.931232	0.05282	20.0	1.984	1.331
108	0.0	398.50	1.0122	0.101148	0.897449	0.03378	58.0	1.931	0.302
225	0.0	489.50	1.2433	0.124246	0.874351	0.02310	117.0	1.897	0.104
432	0.0	594.00	1.5088	0.150770	0.847826	0.02652	207.0	1.874	0.068
Average									0.410

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**PALENGA**	DEPTHS	**3.00 (CH 45+100)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	29	%	BULK DENSITY	1.720	Mg/m^3
WT OF SAMPLE $ RING	251.5	g	DRY DENSITY (γ_D)	1.333	Mg/m^3
WT OF EMPTY RING	85.7	g	SPECIFIC GRAVITY	2.67	
WT OF WET SOIL	165.8	g	e_o	1.003	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1001	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.002500	0	0		
30	0.0	55.70	0.1415	0.014165	0.988335	0.01417	30.0	2.003	0.236
50	0.0	67.50	0.1715	0.017166	0.985334	0.00300	20.0	1.988	0.075
108	0.0	77.50	0.1969	0.019710	0.982790	0.00254	58.0	1.985	0.022
225	0.0	79.70	0.2024	0.020269	0.982231	0.00056	117.0	1.983	0.002
432	0.0	87.60	0.2225	0.022278	0.980222	0.00201	207.0	1.982	0.005
Average									0.068

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**TOCHI**	DEPTHS	**3.00 (CH 47+000)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	36	%	BULK DENSITY	1.720	Mg/m^3
WT OF SAMPLE $ RING	252	g	DRY DENSITY (γ_D)	1.265	Mg/m^3
WT OF EMPTY RING	85.9	g	SPECIFIC GRAVITY	2.73	
WT OF WET SOIL	166.1	g	e_o	1.159	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1079	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.158605	0	0		
30	0.0	58.30	0.1481	0.015983	1.142622	0.01598	30.0	2.159	0.247
50	0.0	74.10	0.1882	0.020314	1.138291	0.00433	20.0	2.143	0.101
108	0.0	78.90	0.2004	0.021630	1.136975	0.00132	58.0	2.138	0.011
225	0.0	85.60	0.2174	0.023467	1.135138	0.00184	117.0	2.137	0.007
432	0.0	93.10	0.2365	0.025523	1.133082	0.00206	207.0	2.135	0.005
Average									0.074

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**TOCHI**	DEPTHS	**3.00 (CH 47+100)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	39	%	BULK DENSITY	1.690	Mg/m^3
WT OF SAMPLE $ RING	251.7	g	DRY DENSITY (γ_D)	1.216	Mg/m^3
WT OF EMPTY RING	85.5	g	SPECIFIC GRAVITY	2.72	
WT OF WET SOIL	166.2	g	e_o	1.237	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1119	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.237160	0	0		
30	0.0	56.50	0.1435	0.016053	1.221107	0.01605	30.0	2.237	0.239
50	0.0	89.30	0.2268	0.025372	1.211788	0.00932	20.0	2.221	0.210
108	0.0	113.20	0.2875	0.032162	1.204997	0.00679	58.0	2.212	0.053
225	0.0	121.70	0.3091	0.034577	1.202582	0.00242	117.0	2.205	0.009
432	0.0	132.60	0.3368	0.037674	1.199486	0.00310	207.0	2.203	0.007
Average									0.104

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**TOCHI**	DEPTHS	**3.00 (CH 47+200)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	33	%	BULK DENSITY	1.720	Mg/m^3
WT OF SAMPLE $ RING	251.9	g	DRY DENSITY (γ_D)	1.293	Mg/m^3
WT OF EMPTY RING	85.5	g	SPECIFIC GRAVITY	2.72	
WT OF WET SOIL	166.4	g	e_o	1.103	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1052	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.103256	0	0		
30	0.0	54.80	0.1392	0.015570	1.087686	0.01557	30.0	2.103	0.247
50	0.0	125.60	0.3190	0.035685	1.067570	0.02012	20.0	2.088	0.482
108	0.0	162.00	0.4115	0.046027	1.057228	0.01034	58.0	2.068	0.086
225	0.0	196.50	0.4991	0.055829	1.047426	0.00980	117.0	2.057	0.041
432	0.0	245.10	0.6226	0.069638	1.033618	0.01381	207.0	2.047	0.033
Average									0.178

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF: **TOCHI**		DEPTHS	**3.00 (CH 47+300)**
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02 m
VOLUME OF SPECIMEN	0.0000884	m^3		
MC BEFORE TEST	37	%	BULK DENSITY	1.720 Mg/m^3
WT OF SAMPLE $ RING	252.2	g	DRY DENSITY (γ_D)	1.255 Mg/m^3
WT OF EMPTY RING	85.5	g	SPECIFIC GRAVITY	2.72
WT OF WET SOIL	166.7	g	e_o	1.167
WT OF DRY SOIL		g		
			VOID RATIO FACTOR (F)	0.1083
RING CALIBRATION FACTOF	0.00254			

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.166512	0	0		
30	0.0	59.40	0.1509	0.016877	1.149635	0.01688	30.0	2.167	0.260
50	0.0	165.30	0.4199	0.046965	1.119547	0.03009	20.0	2.150	0.700
108	0.0	187.20	0.4755	0.053187	1.113324	0.00622	58.0	2.120	0.051
225	0.0	216.70	0.5504	0.061569	1.104943	0.00838	117.0	2.113	0.034
432	0.0	256.30	0.6510	0.072820	1.093692	0.01125	207.0	2.105	0.026
Average									0.214

CENTRAL MATERIALS LABORATORY

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT: M/s FICHTNER WATER & TRANSPORTATION

DATE: June 2018

SUMMARY OF CONSOLIDATION TEST RESULTS

S.No.	Test Location	Depth (m)	Coefficient of Volume Compressibility (Mv) in m^2/MN	Range of Mv	Remarks
Tyenakaya	53+000	3.0	0.246	0.1 - 0.3	Medium Compressibility
	53+050	3.0	0.248	0.1 - 0.3	"
Koro Abili	55+050	3.0	0.105	0.1 - 0.3	"
	55+100	3.0	0.126	0.1 - 0.3	"
Layibi	57+000	3.0	0.328	0.3 - 1.5	High Compressibility
	57+050	3.0	0.312	0.3 - 1.5	"

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**TENAKAYA SWAI**	DEPTHS	**3.00 (CH 53+000)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	32	%	BULK DENSITY	1.620	Mg/m^3
WT OF SAMPLE $ RING	252.5	g	DRY DENSITY (γ_D)	1.227	Mg/m^3
WT OF EMPTY RING	85.6	g	SPECIFIC GRAVITY	2.66	
WT OF WET SOIL	166.9	g	e_o	1.167	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1084	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.167407	0	0		
30	0.0	41.20	0.1046	0.011341	1.156067	0.01134	30.0	2.167	0.174
50	0.0	149.80	0.3805	0.041234	1.126173	0.02989	20.0	2.156	0.693
108	0.0	254.70	0.6469	0.070109	1.097298	0.02887	58.0	2.126	0.234
225	0.0	315.60	0.8016	0.086872	1.080535	0.01676	117.0	2.097	0.068
432	0.0	413.20	1.0495	0.113738	1.053670	0.02687	207.0	2.081	0.062
Average									0.246

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**TENAKAYA SWAM**	DEPTHS	**3.00 (CH 53+050)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	21	%	BULK DENSITY	1.650	Mg/m^3
WT OF SAMPLE $ RING	251.5	g	DRY DENSITY (γ_D)	1.364	Mg/m^3
WT OF EMPTY RING	86.5	g	SPECIFIC GRAVITY	2.67	
WT OF WET SOIL	165	g	e_o	0.958	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0979	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.958000	0	0		
30	0.0	41.70	0.1059	0.010369	0.947631	0.01037	30.0	1.958	0.177
50	0.0	156.30	0.3970	0.038866	0.919134	0.02850	20.0	1.948	0.732
108	0.0	243.80	0.6193	0.060625	0.897375	0.02176	58.0	1.919	0.195
225	0.0	298.50	0.7582	0.074227	0.883773	0.01360	117.0	1.897	0.061
432	0.0	418.50	1.0630	0.104067	0.853933	0.02984	207.0	1.884	0.077
Average									0.248

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**KORO ABILI**	DEPTHS	**3.00 (CH 55+050)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	24	%	BULK DENSITY	1.650	Mg/m^3
WT OF SAMPLE $ RING	252	g	DRY DENSITY (γ_D)	1.331	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.69	
WT OF WET SOIL	166.6	g	e_o	1.022	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1011	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.021576	0	0		
30	0.0	42.30	0.1074	0.010860	1.010716	0.01086	30.0	2.022	0.179
50	0.0	89.20	0.2266	0.022901	0.998675	0.01204	20.0	2.011	0.299
108	0.0	99.30	0.2522	0.025494	0.996081	0.00259	58.0	1.999	0.022
225	0.0	108.50	0.2756	0.027856	0.993719	0.00236	117.0	1.996	0.010
432	0.0	134.70	0.3421	0.034583	0.986993	0.00673	207.0	1.994	0.016
Average									0.105

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**KORO ABILI**	DEPTHS	**3.00 (CH 55+100)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	27	%	BULK DENSITY	1.690	Mg/m^3
WT OF SAMPLE $ RING	251.5	g	DRY DENSITY (γ_D)	1.331	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.70	
WT OF WET SOIL	166.1	g	e_o	1.029	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.1014	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				1.028994	0	0		
30	0.0	45.50	0.1156	0.011725	1.017270	0.01172	30.0	2.029	0.193
50	0.0	94.80	0.2408	0.024428	1.004566	0.01270	20.0	2.017	0.315
108	0.0	134.50	0.3416	0.034658	0.994336	0.01023	58.0	2.005	0.088
225	0.0	156.40	0.3973	0.040302	0.988693	0.00564	117.0	1.994	0.024
432	0.0	176.80	0.4491	0.045558	0.983436	0.00526	207.0	1.989	0.013
Average									0.126

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**LAYIBI SWAMP**	DEPTHS	**3.00 (CH 57+000)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	22	%	BULK DENSITY	1.650	Mg/m^3
WT OF SAMPLE $ RING	253.5	g	DRY DENSITY (γ_D)	1.352	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.66	
WT OF WET SOIL	168.1	g	e_o	0.967	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0983	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY			
						Incremental Changes		$1+e_1$	m_v
						Viod ratio	*Pressure*		m^2/MN
0	0.0				0.966788	0	0		
30	0.0	67.40	0.1712	0.016835	0.949953	0.01684	30.0	1.967	0.285
50	0.0	256.30	0.6510	0.064019	0.902769	0.04718	20.0	1.950	1.210
108	0.0	304.20	0.7727	0.075984	0.890804	0.01196	58.0	1.903	0.108
225	0.0	321.40	0.8164	0.080280	0.886508	0.00430	117.0	1.891	0.019
432	0.0	346.50	0.8801	0.086549	0.880238	0.00627	207.0	1.887	0.016
Average									0.328

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT
CLIENT: M/s FICHTNER WATER & TRANSPORTATION
DATE: JUNE 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**LAYIBI SWAMP**	DEPTHS	**3.00 (CH 57+050)**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	17	%	BULK DENSITY	1.680	Mg/m^3
WT OF SAMPLE $ RING	252.5	g	DRY DENSITY (γ_D)	1.436	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.67	
WT OF WET SOIL	167.1	g	e_o	0.859	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0930	
RING CALIBRATION FACTOF	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes Viod ratio	Pressure	$1+e_1$	m_v m^2/MN
0	0.0				0.859464	0	0		
30	0.0	65.50	0.1664	0.015468	0.843996	0.01547	30.0	1.859	0.277
50	0.0	234.70	0.5961	0.055425	0.804039	0.03996	20.0	1.844	1.083
108	0.0	311.10	0.7902	0.073467	0.785997	0.01804	58.0	1.804	0.172
225	0.0	324.50	0.8242	0.076631	0.782833	0.00316	117.0	1.786	0.015
432	0.0	342.60	0.8702	0.080906	0.778559	0.00427	207.0	1.783	0.012
Average									0.312

Appendix 2j

Compaction Tests Results

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

COMPACTION RESULTS FOR BOREHOLE SAMPLES

Sample Label	Depth (m)	MDD (Mg/m^3)	OMC (%)	No. of Blows	DD (Mg/m^3)	MC at cast (%)	MC after soak (%)	CBR Value (%)
Karuma Intake BH1	1.50 - 3.45	1.68	16	30	1.55	16	19	9
Karuma Intake BH2	1.50 - 3.45	1.98	13	30	1.84	13	15	14
BH1 - Access to Intake	1.50 - 3.45	1.85	13	30	1.75	13	16	12
BH2 - Access to Intake	1.50 - 3.45	1.77	15	30	1.68	16	18	10
Clear Water Tank - BH1	1.50 - 3.45	2.00	12	30	1.87	13	17	18
Buffer Filter Wash Water - BH1	1.50 - 3.45	1.65	16	30	1.52	17	20	11
Filtration - BH1	1.50 - 3.45	1.70	15	30	1.63	15	18	11
Coagulation - BH1	1.50 - 3.45	1.60	17	30	1.52	18	21	10
Karuma Reservoir	1.50 - 3.45	1.69	17	30	1.53	17	19	11
Kamdini Tank Reservoir	1.50 - 3.45	1.93	14	30	1.87	15	18	14
Minakulu Reservoir	1.50 - 3.45	1.58	17	30	1.49	17	20	9
Bobi Pump station	1.50 - 3.45	1.67	16	30	1.58	16	19	13
Bobi Reservoir	1.50 - 3.45	1.95	13	30	1.83	14	16	15
Koro Abili Reservoir	1.50 - 3.45	1.52	18	30	1.45	18	21	10
New Customs Corner - BH1	1.50 - 3.45	1.80	15	30	1.72	16	18	12
New Customs Corner - BH2	1.50 - 3.45	1.48	20	30	1.39	20	22	6

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

COMPACTION RESULTS FOR HAND AUGER SAMPLES

Swamp Label	Chainage (Karuma - Gulu)	Depth (m)	MDD (Mg/m^3)	OMC (%)	No. of Blows	DD (Mg/m^3)	MC at cast (%)	MC after soak (%)	CBR Value (%)
Kankayi	3+270	3.0	1.56	17	30	1.48	18	20	8
Agengi	6+000	3.0	1.63	15	30	1.55	15	18	8
	6+050	3.0	1.69	16	30	1.58	16	18	9
Alenyi	9+000	3.0	1.50	19	30	1.45	19	21	7
	9+362	3.0	1.45	21	30	1.40	21	23	5
	9+393	3.0	1.56	18	30	1.50	19	21	7
Myene	12+000	3.0	1.54	22	30	1.45	22	24	9
	13+000	3.0	1.60	19	30	1.53	20	23	11
	13+100	3.0	1.63	18	30	1.55	19	21	12
	13+200	3.0	1.68	18	30	1.58	18	20	14
	13+500	3.0	1.70	17	30	1.62	17	19	16
Amwa - Otwe	14+500	3.0	1.64	18	30	1.56	18	20	13
	16+000	3.0	1.50	23	30	1.43	23	25	8
Ngaato	16+200	3.0	1.47	22	30	1.39	23	26	8
	16+250	3.0	1.51	19	30	1.45	20	22	10
	20+000	3.0	1.59	18	30	1.50	18	20	13
	20+300	3.0	1.52	19	30	1.46	19	21	10
	20+390	3.0	1.50	19	30	1.43	19	23	10

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

COMPACTION RESULTS FOR HAND AUGER SAMPLES

Swamp Label	Chainage (Karuma - Gulu)	Depth (m)	MDD (Mg/m^3)	OMC (%)	No. of Blows	DD (Mg/m^3)	MC at cast (%)	MC after soak (%)	CBR Value (%)
Atek	22+000	3.0	1.63	18	30	1.54	18	20	12
	22+100	3.0	1.51	19	30	1.43	19	21	10
Agada	25+000	3.0	1.58	18	30	1.49	18	21	11
Atego	29+050	3.0	1.55	19	30	1.46	20	22	9
	30+000	3.0	1.60	16	30	1.52	17	19	12
Minakulu	32+000	3.0	1.64	16	30	1.55	17	21	14
	32+100	3.0	1.58	19	30	1.51	20	23	12
	32+200	3.0	1.50	21	30	1.44	21	24	10
	32+300	3.0	1.68	17	30	1.57	18	21	13
	32+400	3.0	1.57	19	30	1.51	19	22	11
Lminango	42+200	3.0	1.63	17	30	1.55	17	19	13
	42+300	3.0	1.60	18	30	1.52	18	21	10
Palenga	45+000	3.0	1.47	22	30	1.40	22	24	5
	45+100	3.0	1.53	21	30	1.46	21	23	9
Tochi	47+000	3.0	1.58	20	30	1.50	22	24	10
	47+100	3.0	1.62	18	30	1.53	21	23	12
	47+200	3.0	1.49	23	30	1.38	25	27	4
	47+300	3.0	1.56	21	30	1.48	23	28	8
Tenakaya	53+000	3.0	1.61	19	30	1.53	24	26	12
	53+050	3.0	1.52	17	30	1.47	20	24	9
Koro Abili	55+050	3.0	1.58	18	30	1.49	21	23	9
	55+100	3.0	1.50	18	30	1.44	22	25	10
Layibi	57+000	3.0	1.64	16	30	1.52	19	23	14
	57+050	3.0	1.69	16	30	1.53	20	22	16

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

COMPACTION RESULTS FOR TRIAL PITS SAMPLES

TP Label/ Chainage (Karuma - Gulu)	Depth (m)	MDD (Mg/m^3)	OMC (%)	No. of Blows	DD (Mg/m^3)	MC at cast (%)	MC after soak (%)	CBR Value (%)
0+000	0.5	1.89	15	30	1.83	15	18	16
6+050	2.0	1.91	14	30	1.84	14	17	17
15+000	1.5	2.01	13	30	1.88	13	16	20
19+000	1.5	2.03	13	30	1.85	13	16	20
21+000	1.0	2.05	12	30	1.88	12	15	20
23+000	1.5	1.93	14	30	1.83	15	18	18
25+000	1.5	1.85	15	30	1.74	16	19	13
27+000	1.5	1.81	17	30	1.71	17	19	16
29+000	1.5	1.78	15	30	1.68	16	18	14
31+000	1.5	2.00	13	30	1.89	14	17	18
33+000	1.5	1.96	14	30	1.86	14	16	18
35+000	1.5	1.55	19	30	1.48	19	22	10
39+000	1.5	1.72	17	30	1.63	17	19	12
41+000	1.5	1.88	16	30	1.76	16	20	16
43+000	1.5	1.90	14	30	1.8	15	18	17
45+000	1.5	2.00	13	30	1.88	13	15	19

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

COMPACTION RESULTS FOR TRIAL PITS SAMPLES

TP Label/ Chainage (Karuma - Gulu)	Depth (m)	MDD (Mg/m^3)	OMC (%)	No. of Blows	DD (Mg/m^3)	MC at cast (%)	MC after soak (%)	CBR Value (%)
51+000	1.5	1.95	14	30	1.84	14	17	18
55+000	1.0	2.08	11	30	1.89	12	15	20
57+000	1.5	2.04	13	30	1.84	13	16	20
59+000	1.5	1.50	19	30	1.45	19	21	8
61+000	1.5	1.60	17	30	1.52	17	20	11
63+000	1.5	1.62	17	30	1.54	17	20	11
65+000	1.5	1.51	20	30	1.46	20	22	9
TP1 Gulu - Layibi Roundabout	1.5	1.84	14	30	1.75	15	17	13
TP2 Gulu - Layibi Roundabout	1.5	1.58	18	30	1.50	18	21	10

Appendix 2k

Chemical Test Results

Appendix 2k (1)

Chemical Test Results for Borehole Samples

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

CHEMICAL TESTS ON BOREHOLES SAMPLES

Label	**Depth (m)**	**TEST RESULTS**		
		pH	**Cl^- (%)**	**$SO_3^=$ (%)**
KARUMA INTAKE BH1	1.50-1.95	6.56	Traces	0.010
	3.00-3.45	6.64	0.002	0.008
KARUMA INTAKE BH2	1.50-1.95	6.54	Traces	0.014
	3.00-3.45	6.49	0.009	0.017
BH1 - ACCESS TO KARUMA INTAKE	1.50-1.95	6.47	0.012	0.024
	3.00-3.45	6.51	0.009	0.024
	4.50-4.95	6.58	Traces	0.028
BH2 - ACCESS TO KARUMA INTAKE	3.00-3.45	6.49	0.005	Traces
	4.50-4.95	6.53	Traces	"
BH1 - CLEAR WATER TANK	1.50-1.95	6.56	"	0.026
BH1 - FILTER WASH WATER	1.50-1.95	6.45	0.012	0.022
	3.00-3.45	6.56	Traces	0.021
	4.50-4.95	6.51	"	Traces
	6.00-6.45	6.63	"	0.017
	7.50-7.95	6.59	0.003	0.009
	9.00-9.45	6.61	0.001	0.013
	10.50-10.95	6.52	Traces	0.021
	12.00-12.45	6.58	"	Traces
	13.50-13.95	6.45	"	"
	15.00-15.45	6.53	"	"
BH1 - BUFFER FILTER WASH WATER	1.50-1.95	6.56	0.011	0.027
	3.00-3.45	6.49	Traces	0.028
	4.50-4.95	6.45	0.006	0.023
	6.00-6.45	6.53	Traces	0.018
	7.50-7.95	6.50	0.003	0.080
	9.00-9.45	6.48	Traces	Traces
	10.50-10.95	6.53	"	"
BH1 - FILTRATION	1.50-1.95	6.49	Traces	0.020
	3.00-3.45	6.53	0.003	0.016
	4.50-4.95	6.48	0.003	0.022
	6.00-6.45	6.57	0.005	0.019
	7.50-7.95	6.51	Traces	0.008
	9.00-9.45	6.48	"	Traces
	10.50-10.95	6.48	"	"
	12.00-12.45	6.46	"	"
	13.50-13.95	6.54	"	"
	15.00-15.45	6.49	"	"
BH1 - COAGULATION / FLOCCULATION	1.50-1.95	6.53	"	0.027
	3.00-3.45	6.55	"	0.021
	4.50-4.95	6.59	0.005	Traces
	6.00-6.45	6.56	Traces	0.017
	7.50-7.95	6.49	"	0.009
	9.00-9.45	6.53	"	Traces
	10.50-10.95	6.57	"	"
	12.00-12.45	6.48	"	"
	13.50-13.95	6.49	"	0.019
	15.00-15.45	6.49	"	0.024
KARUMA RESERVOIR	1.50-1.95	6.53	0.007	0.016
	3.00-3.45	6.51	0.003	0.008
	4.50-4.95	6.56	0.003	Traces
	6.00-6.45	6.49	Traces	0.005
	7.50-7.95	6.52	"	0.007
	9.00-9.45	6.49	"	0.002
	10.50-10.95	6.47	"	Traces
	12.00-12.45	6.62	"	"
	13.50-13.95	6.58	"	"
	15.00-15.45	6.55	"	"
Permissible Limits BS 1377		**4.5 Min.**	**0.05 Max.**	**0.2 Max.**

EPINEX ENGINEERING SERVICES LTD.

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CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

CHEMICAL TESTS ON BOREHOLES SAMPLES

Label	Depth (m)	TEST RESULTS		
		pH	Cl^- (%)	$SO_3^=$ (%)
KAMDINI TANK RESERVOIR	1.50-1.95	6.48	Traces	Traces
	3.00-3.45	6.53	"	"
	4.50-4.95	6.45	"	"
	6.00-6.45	6.57	"	"
	7.50-7.95	6.63	"	"
	9.00-9.45	6.57	"	"
	10.50-10.95	6.57	"	"
MINAKULU RESERVOIR	1.50-1.95	6.51	"	"
	3.00-3.45	6.54	0.001	"
	4.50-4.95	6.49	Traces	0.002
	6.00-6.45	6.56	"	Traces
	7.50-7.95	6.51	0.003	"
	9.00-9.45	6.58	"	"
	10.50-10.95	6.59	"	"
BOBI PUMP STATION	1.50-1.95	6.53	"	"
	3.00-3.45	6.62	"	"
	4.50-4.95	6.58	"	"
	6.00-6.45	6.58	"	"
	7.50-7.95	6.55	"	"
	9.00-9.45	6.62	"	"
	10.50-10.95	6.59	"	"
BOBI SUBCOUNTY/ RESERVOIR	1.50-1.95	6.54	"	"
	3.00-3.45	6.52	"	"
	4.50-4.95	6.52	0.005	"
	6.00-6.45	6.54	"	"
	7.50-7.95	6.49	"	"
	9.00-9.45	6.47	"	"
	10.50-10.95	6.51	"	"
BH1 - KORO ABILI RESERVOIR	1.50-1.95	6.57	"	"
	3.00-3.45	6.53	"	"
	4.50-4.95	6.62	"	"
	6.00-6.45	6.59	"	"
	7.50-7.95	6.60	"	"
	9.00-9.45	6.45	"	0.003
	10.50-10.95	6.49	Traces	0.006
BH 1 - NEW CUSTOMS CORNER TANK SITE	1.50-1.95	6.61	"	Traces
	3.00-3.45	6.49	"	"
	4.50-4.95	6.53	"	"
	6.00-6.45	6.59	"	"
	7.50-7.95	6.49	"	"
	9.00-9.45	6.49	"	"
	10.50-10.95	6.45	"	"
	12.00-12.45	6.53	"	"
	13.50-13.95	6.46	"	"
	15.00-15.45	6.49	"	"
BH 2 - NEW CUSTOMS CORNER TANK SITE	1.50-1.95	6.64	"	"
	3.00-3.45	6.62	"	"
	4.50-4.95	6.58	"	"
	6.00-6.45	6.48	"	"
	7.50-7.95	6.45	"	0.005
	9.00-9.45	6.46	"	Traces
	10.50-10.95	6.54	0.003	"
	12.00-12.45	6.57	0.002	"
	13.50-13.95	6.52	0.001	"
	15.00-15.45	6.56	Traces	"
Permissible Limits BS 1377		**4.5 Min.**	**0.05 Max.**	**0.2 Max.**

Appendix 2k (2)

Chemical Test Results for Hand Auger Samples

EPINEX ENGINEERING SERVICES LTD.

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CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

CHEMICAL TESTS ON HAND AUGER SAMPLES

Swamp Name	Label/ CH	Depth (m)	TEST RESULTS		
			pH	**Cl^- (%)**	**$SO_3^=$ (%)**
KANKAYI	Point 1 (CH 3+270LHS)	3.0	6.63	Traces	Traces
	Point 2 (CH:3+463 LHS)	3.0	6.59	"	"
AGENGI	Point 1 (CH 6+000LHS)	3.0	6.64	"	"
	Point 2 (CH 6+050LHS)	3.0	6.53	"	"
ALENYI	Point 1 (CH 9+000LHS)	3.0	6.72	"	"
	Point 2 (CH 9+150LHS)	3.0	6.77	0.003	"
	Point 3 (CH 9+362LHS)	3.0	6.78	0.005	0.003
	Point 4 (CH 9+393LHS)	3.0	6.74	Traces	Traces
MYENE	Point 1 (CH 12+000LHS)	3.0	6.71	"	"
	Point 2 (CH 13+000LHS)	3.0	6.73	"	"
	Point 3 (CH 13+100LHS)	3.0	6.70	"	"
	Point 4 (CH 13+200LHS)	3.0	6.75	"	"
	Point 5 (CH 13+500LHS)	3.0	6.71	"	"
AMWA, OTWE	Point 1 (CH 14+150LHS)	3.0	6.57	"	"
	Point 2 (CH 16+000LHS)	3.0	6.45	"	"
NGAATO	Point 1 (CH 16+200LHS)	3.0	6.64	0.003	"
	Point 2 (CH 16+250LHS)	3.0	6.62	Traces	"
	Point 3 (CH 20+000LHS)	3.0	6.65	"	"
	Point 4 (CH 20+300LHS)	3.0	6.59	"	"
	Point 5 (CH 20+390LHS)	3.0	6.63	"	"
Permissible Limits BS 1377			**4.5 Min.**	**0.05 Max.**	**0.2 Max.**

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

CHEMICAL TESTS ON HAND AUGER SAMPLES

Swamp Name	Label/ CH	Depth (m)	TEST RESULTS		
			pH	Cl^- (%)	$SO_3^=$ (%)
ATEK	Point 1 (CH 22+000LHS)	3.0	6.64	Traces	Traces
	Point 2 (CH 22+100LHS)	3.0	6.65	"	0.004
	Point 3 (CH 22+200LHS)	3.0	6.62	"	Traces
	Point 4 (CH 22+300LHS)	3.0	6.63	0.007	"
AGADA	Point 1 (CH 25+000LHS)	3.0	6.64	Traces	"
	Point 2 (CH 25+100LHS)	3.0	6.59	"	"
ATEGO	Point 1 (CH 29+050LHS)	3.0	6.56	"	"
	Point 2 (CH 30+000LHS)	3.0	6.62	"	"
MINAKULU	Point 1 (CH 32+000LHS)	3.0	6.62	"	"
	Point 2 (CH 32+100LHS)	3.0	6.45	"	"
	Point 3 (CH 32+200LHS)	3.0	6.62	"	"
	Point 4 (CH 32+300LHS)	3.0	6.65	"	"
	Point 5 (CH 32+400LHS)	3.0	6.59	"	"
LMINLANGO (BOBI)	Point 1 (CH 42+200LHS)	3.0	6.59	"	"
	Point 2 (CH 42+300LHS)	3.0	6.61	"	"
PALENGA	Point 1 (CH 45+000LHS)	3.0	6.57	"	"
	Point 2 (CH 45+100LHS)	3.0	6.64	"	"
Permissible Limits BS 1377			**4.5 Min.**	**0.05 Max.**	**0.2 Max.**

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CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

CHEMICAL TESTS ON HAND AUGER SAMPLES

Swamp Name	**Label/ CH**	**Depth (m)**	**TEST RESULTS**		
			pH	**Cl^- (%)**	**$SO_3^{=}$ (%)**
TOCHI	Point 1 (CH 47+000LHS)	3.0	6.60	Traces	Traces
	Point 2 (CH 47+100LHS)	3.0	6.63	"	"
	Point 3 (CH 47+200LHS)	3.0	6.56	"	"
	Point 4 (CH 47+300LHS)	3.0	6.56	"	"
TYENAKAYA	Point 1 (CH 53+000LHS)	3.0	6.45	"	"
	Point 2 (CH 53+050LHS)	3.0	6.56	"	0.006
KORO ABILI	Point 1 (CH 55+050LHS)	3.0	6.58	"	Traces
	Point 2 (CH 55+100LHS)	3.0	6.63	"	"
LAYIBI	Point 1 (CH 57+000LHS)	3.0	6.59	"	"
	Point 2 (CH 57+050LHS)	3.0	6.61	"	"
Permissible Limits BS 1377			**4.5 Min.**	**0.05 Max.**	**0.2 Max.**

Appendix 2l

Chemical Test Results for Water Samples

Appendix 2l (1)

Chemical Test Results for Water Samples from Boreholes

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

CHEMICAL TESTS ON WATER SAMPLES OBTAINED FROM BOREHOLES

BH location / Label	**Depth of Water Table (m)**	**TEST RESULTS**						
		pH	**Cl^- (mg/l)**	**SO_3 (mg/l)**	**TDS (mg/l)**	**Organic Matter (mg/l)**	**Colour**	**Odour**
BH1 - Karuma Intake	1.2	6.75	65	35	120	Nil	Colourless	Odourless
BH2 - Karuma Intake	1.0	6.81	70	20	110	"	"	"
Clear Water Tank (Reservoir Pumping Station) location - BH	2.0	6.74	75	40	135	"	"	"
Filter Wash Water/ Mineralisation/Chlorination dry chamber	3.5	6.72	75	30	125	"	"	"
Buffer Filter wash water	4.0	6.75	75	25	120	"	"	"
Filtration	0.8	6.75	65	30	125	"	"	"
Coagulation / flocculation	1.0	6.78	65	25	125	"	"	"
Permissible Limits BS 3148		**6 - 8**	**500 Max.**	**1000 Max.**	**500 Maximum**	**Nil**	**Colourless**	**Odourless**

Traces stand for insignificant amounts of chemicals in the soils

Appendix 2l (2)

Chemical Test Results for Water Samples from Swamps

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : JUNE 2018

CHEMICAL TESTS ON WATER SAMPLES OBTAINED FROM SWAMPS ALONG THE PROPOSED PIPELINE ALIGNMENT

Swamp Name / Label	**TEST RESULTS**						
	pH	**Cl^- (mg/l)**	**SO_3 (mg/l)**	**TDS (mg/l)**	**Organic Matter (mg/l)**	**Colour**	**Odour**
Aleny	6.80	70	10	180	Nil	Colourless	Odourless
Myene	6.73	60	Traces	100	"	"	"
Ngaato	6.64	65	"	120	"	Pale yellow	Peaty
Atek	6.66	60	"	130	"	"	"
Agada	6.67	50	"	150	"	Colourless	Odourless
Minakulu	6.65	65	"	140	"	Pale yellow	"
Lminlango/ Bobi	6.62	70	"	135	"	"	Peaty
Tochi	6.63	55	"	150	"	Yellowish	"
Swamp 49+000km from Kamdini	6.65	75	"	160	"	Colourless	"
Koro Abili	6.63	90	"	150	"	Colourless	"
Layibi	6.62	60	"	120	"	Colourless	Odourless
Permissible Limits BS 3148	**6 - 8**	**500 Max.**	**1000 Max.**	**500 Maximum**	**Nil**	**Colourless**	**Odourless**

Traces stand for insignificant amounts of chemicals in the soils

EPINEX ENGINEERING SERVICES LTD.

REPORT ON GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

KARUMA WATER INTAKE & TREATMENT WORKS SITES

PREPARED FOR:
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SEPTEMBER 2018

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LIST OF ACRONYMS

BH	-	Borehole
BS	-	British Standard
CH	-	Fat clay
CL	-	Lean clay
CO_2	-	Carbon dioxide
GC	-	Clayey gravel
GL	-	Ground Level
HPP	-	Hydro Power Project
kg	-	Kilogram
kN	-	Kilo Newton
kPa	-	Kilo Pascal
Ltrs	-	Litres
LL	-	Liquid Limit
m	-	Meters
mm	-	Millimeter
m^2	-	Square meters
m^3	-	Cubic meters
MPa	-	Mega Pascal
M/s	-	Messrs
µm	-	Micro Meter
PI	-	Plasticity Index
PL	-	Plastic Limit
SC	-	Clayey sand
SP	-	Gravelly sand
SPT	-	Standard Penetration Test
TP	-	Trial Pit
UCS	-	Unconfined Compressive Strength
USCS	-	Unified Soil Classification System
WTP	-	Water Treatment Plant

1.0 INTRODUCTION

At the request of **M/s Fichtner Water & Transportation**, Epinex Engineering Services Ltd. conducted geotechnical investigations at the proposed **Nile Water Intake and Water Treatment Plant sites at Karuma** in the month of August 2018. These investigations are part of the proposed Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment (IPILC).

The exercise was intended to aid in the evaluation of the suitability of the in-situ strata in terms of the soils strata's bearing capacity and related soil parameters. This information will be utilized in appropriate foundation and embankment designs for the proposed construction.

In this report, the key outputs of the investigations and a documentation of the field and laboratory activities carried out, major findings and the recommendations are detailed.

1.1 Scope of Work

The geotechnical investigations were carried out at the proposed Karuma Intake and Water Treatment Plant sites situated in northern Uganda. Laboratory work was carried out at the Epinex engineering Services' home office in Kampala.

The scope of work for the geotechnical investigations as per the Client's requirement was:

1. Fieldwork:

   i. Rotary drilling of boreholes as follows:

   - Karuma Intake Site…….1No. borehole to 15.0m depth, and
   - Karuma Water Treatment Plant…… 5No. boreholes each to 15.0m depth.

   ii. Conducting Standard Penetration Tests (SPTs) and obtaining disturbed samples in each borehole at 1.5m depth intervals;

   iii. Retrieving undisturbed samples, 2Nos. in each borehole where the strata is found to be cohesive;

iv. Determination and monitoring of the ground water level for 24 hours in each borehole, where encountered.

2. Laboratory tests on the disturbed and undisturbed samples included:

   i. Particle size distribution / Sieve analysis
   ii. Classification (Unified Soil Classification System)
   ii. Natural Moisture content determination
   iii. Atterberg limits
   iv. Triaxial tests parameters
   v. Shear strength parameters
   vi. Oedometer consolidation
   vii. pH, Sulphates and Chlorides on Soils and Water Samples

3. Reporting

   The geotechnical investigation report includes the following:

   - Allowable soil bearing capacity at specific depths in the boreholes
   - Ground water level
   - Shear strength parameters
   - Triaxial strength parameters
   - Predicted settlement at depths where undisturbed samples were obtained
   - Site sub-surface geology

A site plan indicating borehole positions at the intake and water treatment sites is provided in **Appendix 1a.**

1.2 Structure of the report

The report is structured in the following chapters:

Chapter 1: Introduction

Chapter 2: Project and Site Description

Chapter 3: Methodology for Field and Laboratory Work

Chapter 4: Presentation and Discussion of Field and Laboratory results

Chapter 5: Conclusions and Recommendations

APPENDICES

APPENDIX 1: FIGURES

Figure 1a: Site Map indicating Boreholes Locations at the Karuma Intake & Water Treatment Sites

Figure 1b: Simplified Geology Map of Uganda

Figure 1c: Seismic Map of Uganda

APPENDIX 2: FIELD FINDINGS AND LABORATORY TESTS RESULTS

Appendix 2a: Photographic Representation of Geotechnical Work

Appendix 2b: Borehole Logs

Appendix 2c: Soil Index Properties

Appendix 2d: Bearing Capacity based on SPT – N Values

Appendix 2e: Shear Resistance in Shear Box

Appendix 2f: Tri-axial Strength Test

Appendix 2g: Unconfined Compressive Strength

Appendix 2h: Consolidation Test Results

Appendix 2i: Compaction Tests Results

Appendix 2j: Chemical Test Results on Soils & Water Samples

2.0 SITE DESCRIPTION

2.1 Site location, Nature and Current Land use

The proposed Karuma intake and water treatment sites are situated in Kiryandongo district in the vicinity of Karuma Village and Murchison.

By the time of geotechnical investigations, the intake site was characterized by thick bushes which in some areas, grew over rocky outcrops. The water treatment site was largely covered with thick bushes as well.

2.2 Tectonics and Seismology

2.2.1 Tectonics

The sites are located on a fairly stable geological unit. However, numerous faults exist within the country and tremors due to earthquakes do occur.

The sites area is located within the shield area, but only Approx. 50 – 100 km from the western rift and about 70 km south of the Aswa Fault Zone. It is therefore susceptible to the potential effect of major tectonic features of regional scale.

2.2.2 Seismology

As per Appendix 1c the site is in the main, located in Zone 2 of the Seismic Zoning of Uganda, implying a moderate (Earthquake hazards are not very high in the project area and not negligible either) likelihood of earthquake occurrence in the area. (Seismic Code of Practice for Structural designs; Uganda National Bureau of Standards, First Edition: June 2003).

According to baseline information in the **Main Report Vol. II (June 2012) of the Environmental and Social Impact Assessment of Karuma Hydro Power Project (600 MW)** which neighbors the proposed Karuma intake and water treatment sites, horizontal seismic coefficients for Karuma HPP preliminarily considered were 0.18g. The vertical seismic design coefficient considered was 2/3rd of the horizontal seismic design coefficient which was computed to be 0.12g. The above report was prepared by Energy Infratech Private Limited in association with WSS Service Uganda LTD., Uganda; Nelson and Associates Environment Consultants, Uganda

Furthermore, the following information has been extracted from **Uganda's Ministry of Works Bridge Design Manual (Part 2)** and may be used in the consideration of horizontal acceleration as a result of the subsoil conditions:

Earthquake Loads

Minimum Earthquake Forces for Structures

(1) Earthquake loads shall be those arising from the horizontal components of characteristic gravitational loads due to earthquake. Earthquake loads shall be used in the design of Structures if their application shall produce more unfavorable load combinations than the wind loads.

(2) Structures located in areas of expected seismic activity or in mining zones shall be designed for a minimum horizontal seismic loadings assumed to act non-concurrently in the direction of each of the main axes of the structures in accordance with:

$$F_{tot} = C_s\, G_{DL}$$

where C_s is the seismic base shear coefficient and is determined from

$$C_s = \alpha\beta\gamma$$

and G_{DL} is the permanent load (dead load)

(a) The coefficient α is the design bedrock acceleration ratio given by

$$\alpha = \alpha_o I$$

where,

α_o = the bed rock acceleration ratio from the site and depends on the seismic zone (in the case of Karuma Intake and WTP – Zone 2) as given in Table 1.0.

I = the importance factor which depends on the classification of the structure with respect to the economic value and post-disaster used as given in Table 2.0.

Table 1.0: Bedrock Acceleration Ratio, α_o

Zone	1	2	3
α_o	0.15	0.07	0.05

Table 2.0: Structure Importance Factor, *I*

Structure type	*I*
Structures and Structures to be used during or immediately after an earthquake, such as hospitals, fire stations, broadcasting Structures, power stations,	1.5
Structures and structures of occupancy	1.0
Single storey factory Structures not containing highly valuable equipment, small workshop Structure and the like	0.5
Structure and structures, if they were to fail, would not involve loss of life or destruction of valuable equipment. Farm Structures and structures not occupied for any length of time. Temporary Structures.	0.0

(b) The coefficient β is the elastic design factor for the site and is given by

$$\beta = \beta_o S < 2.5$$

where β_o is the elastic design response spectrum factor for bedrock foundation and standard damping of 5% as determined from

$$\beta = \frac{1.2S}{T^{2/3}} \leq 2.5$$

and S is the soil classification and site condition factor given in Table 3.0.

Table 3.0: Site Condition Factor, *S*

Subsoil class	A	B	C
C	1.0	1.25	1.5

The influence of local ground conditions on the seismic action shall be accounted for by considering the three subsoil classes *A*, *B* and *C* described by the following stratigraphic profiles:

Subsoil Class A:

- Rock or other geological formation characterized by a shear wave velocity v_s of at least 800m/s, including at most 5m of weaker material at the surface.

- Stiff deposits of sand, gravel or over consolidated clay, at least several tens of meters thick, characterized by a gradual increase of the mechanical properties with depth and by v_s–value of at least 400m/s at a depth of 10m.

Subsoil Class B

Deep deposits of medium dense sand, gravel or medium stiff clays with thickness from several tens to many hundreds of meter, characterized by v_s-values of at least 200m/s at a depth of 10m; increasing to at least 350m/s at a depth of 50m.

Subsoil Class C

- Loose cohesionelss soil with or without some soft cohesive layers, characterized by v_s-values below 200m/s in the uppermost 20m.
- Deposits with predominant soft-to-medium stiff cohesive soils, characterized by v_s-values below 200m/s in the uppermost 20m.

(c) The values γ are given as function of the type of structural system defined in Table 4.0. The values of γ for structural Types 1 and 2 in Table 4.0 are set on the assumption of compliance with sophisticated design, detailing and construction control requirements in accordance with the state of the art in earthquake and are therefore not recommended for general application.

Table 4.0: Structural Systems Types Factor, γ

Type	Type or arrangement of resisting elements	Value of γ
1	**<u>Structure with a ductile moment-resisting space frame with the capacity to resist the total required force.</u>** Structures with a dual structural system consisting of a complete ductile moment-resisting space frame and ductile flexural walls designed in accordance with the following criteria: The frame and ductile flexural walls shall resist the total lateral force in accordance with their relative rigidities considering the interaction of the flexural walls and frames. In this analysis the minimum shear in the frame must be at least 26% of the total base shear. **<u>Structures with a dual system consisting of a complete ductile moment resisting space frame and shear walls or steel bracing designed in accordance with the following criteria:</u>** The shear walls or steel bracing acting independently of the ductile moment-resisting space frame shall resist the total required lateral force. The ductile moment-resisting space frame shall have the capacity to resist not less than 25% of the required lateral force, but in no case shall the ductile moment-resisting space frame have a lower capacity than that required in accordance with the relative rigidities.	0.3
2	Structures with ductile flexural walls and Structures with ductile framing systems not otherwise classified in this Table	0.4
3	Structures with a dual structural system consisting of a complete ductile moment-resisting space frame with masonry infilling designed in accordance with the following criteria: The wall system comprising the infilling and the confining elements acting independently of the ductile moment-resisting space frames shall resist the total lateral force. The ductile moment-resisting space frame shall have the capacity to resist not less than 25% of the required lateral force.	0.5
4	Structures (other than Types 1, 2 and 3) or reinforced concrete, steel or reinforced masonry shear walls.	0.5

Table 4.0: Structural Systems Types Factor, γ

Type	Type or arrangement of resisting elements	Value of γ
5	Structures of unreinforced masonry and all other structural except Types 1 to 4 inclusive.	0.8
6	Elevated tanks plus contents on 4 or more cross-based legs and not supported by a Structure	1.0

Distribution of the Horizontal Seismic Forces

(1) The total lateral seismic force, F_{tot}, shall be distributed (in the absence of a more rigorous procedure) over the height of the structure in accordance with:

$$F_b = F_t + \sum_{j=1}^{n} F_j$$

(2) The concentrated force F_t at the top, which is in addition to F_n shall be determined from:

$$F_{no} = 0.07 T_1 F_b$$

(1) F_{no} need not exceed $0.25F_{tot}$ and may be considered a s zero where T is 0.7 second or less. The remaining portion of the base shear F_{tot} shall be distributed over the height of the structure including level n according to:

$$F_t = \frac{(F_{tot} - F_{no}) G_x h_x}{\sum_{i=1}^{n} G_i h_i}$$

where,

G_x, Gi = the portion of G_{eq} located at or assigned to level x or i

h_x, hi = the height above the base to level x or i.

At each level designated as x, the force F_x shall be applied over the area of the Structure in accordance with the mass distribution on that level.

2.3 Topography

Topographically, the sites are predominantly near flat terrain giving rise to peneplain topography. Small raised grounds forming hummocks and ridges are also noticed at different locations, giving rise to rolling topography.

2.4 Geology

Broadly the geological set up of Karuma Intake and Water treatment sites Project area can be subdivided into two categories: overburden and weathered rock/ bedrock.

2.5 Climate and Vegetation

The climate of the project area comprises dry and wet seasons with rainfall distributed in two wet seasons, namely: March to June and August to November. Average annual rainfall received is 1500 mm.

The project area has a bimodal rainfall pattern with a short dry spelt in July and one long dry season from late November to early March. Mean monthly rainfall ranges from 14 mm in January to 230 mm in August. The micro-climate of the area is hot and humid with an average relative humidity of 60%, mean maximum temperature of 29°C, mean minimum temperature of 22°C and wind speeds of 8 kmph.

3.0 METHODOLOGY FOR FIELD AND LABORATORY WORK

3.1 Field Investigations

Field investigations were carried out in accordance with BS 5930:1981 ‘‘Code of Practice for Site Investigations” and in association with Eurocode 7: “Geotechnical design Part 1”: General rules: BS EN 1997-1:2004 as described in this chapter.

3.1.1 Rotary Boring

A total of 6No. geotechnical investigations boreholes were investigated using a rotary drilling rig as follows:

- Karuma Intake Site…….1No. borehole to 9.45m depth, and
- Karuma Water Treatment Plant site…5No. boreholes investigated as follows:
  - Coagulation / Flocculation…. to 15.45m depth;
  - Filtration……………………...to 10.95m depth;
  - Filter Wash Water…………...to 15.45m depth;
  - Buffer Filter Wash Water……to 7.95m depth; and
  - Clear Water Tank…………....to 15.45m depth.

The main auger set-up comprised a continuous helix of blades on a central shaft, which rotated into the ground to remove subsoil materials and permit access for sampling.

Table 5.0 presents coordinates that indicate the locations for the boreholes.

Table 5.0: Locations of Boreholes Investigated

S.No.	BH Label	Coordinates (ARC 1960/ UTM 36N)	
		X (Easting)	Y (Northing)
1	BH1 - Karuma Intake	418917	248890
2	Coagulation / flocculation	418852	249269
3	Filtration	418846	249249
4	Filter Wash Water/ Mineralisation/Chlorination dry chamber	418839	249220
5	Buffer Filter wash water	418880	249244
6	Clear Water Tank (Reservoir Pumping Station) location - BH	418890	249173

3.1.2 Standard Penetration Tests

The Standard Penetration Test (SPT) which is a dynamic in-situ test used to determine the comparative strengths of underlying soils strata based on established penetration N-values was performed in all the boreholes. The tests were conducted at 1.5m depth intervals using a standard split-barrel in accordance with BS 1377:Part9:1990. The N-values obtained from this test were used in the computation of soils' allowable bearing capacity based on empirical relationships evolved by Terzaghi & peck (1948). In addition, the test was used to provide an indication of the density and consistency of the different soil layers encountered. During the exercise, a mechanism comprising a split spoon sampler of an internal diameter of 150mm was attached to SPT rods to reach the required depths. The complete assembly was driven into the ground by blows from a 65kg hammer falling freely through a height of 760mm. The blows for the first 150mm penetration were regarded as sitting blows, hence discarded. The blows for the subsequent 300mm in two sequences of 150mm were recorded and computed to derive N-values at various depths.

3.1.3 Strata Sampling

During the process of undertaking SPT tests, sampling of disturbed soil samples in the boreholes was carried out using the split sampler (D - 35 samples) at 1.5m depth intervals starting at the existing ground level. Undisturbed samples were recovered at depths were relatively cohesive strata was encountered. Rock cores and cobbles were recovered at the intake and water treatment sites.

Sampling from Hand augers and trial pits was undertaken at 1.5m depth intervals.

The strata recovered from the sites were visually inspected, identified, labeled and taken to the laboratory for testing. During borehole drilling and hand augering, profiling and logging were undertaken for each investigation location as per the logs in **Appendix 2b.**

3.1.4 Ground Water Table

The standard practice of determining water table was adopted whereby in the event that ground water was encountered in a borehole, the borehole location was left covered. The water level was allowed to stabilize for about 24 hours after which the actual level of the water table was measured using a tape measure.

3.2 Laboratory Testing

Laboratory testing was carried out on the samples obtained from the field to identify their physical properties, and establish parameters for predicting their strength characteristics. The tests were conducted according to the following standard methods:

Name of Test	Standard Test Method	Sample Status
Sieve Analysis	BS 1377: Part 2: 1990	Disturbed
Classification	BS 1377: Part 2: 1990	“
Natural Moisture Content	BS 1377: Part 2: 1990	“
Atterberg Limits that include:		
• Liquid Limit	BS 1377: Part 2: 1990	“
• Plastic Limit	BS 1377: Part 2: 1990	“
• Plasticity Index	BS 1377: Part 2: 1990	“
Shear Strength Tests	BS 1377: Part 7: 1990	Undisturbed
Triaxial tests parameters	BS 1377: 1990	“
Unconfined Compressive Strength (Soils Samples)	BS 1924: Part 2: 1990	“
Unconfined Compressive Strength (Rock Cores)	ASTM D 7012-07	Rock Cores
Oedometer Consolidation Tests	BS 1377: Part 5: 1990	“
pH, Sulphates and Chlorides	BS 1377: Part3: 1990	Disturbed

3.2.1 Sieve Analysis

The standard method of wet sieving which conforms to BS 1377: Part 2: 1990 was adopted. Representative specimens were taken from the samples and oven dried at temperatures between 105^o and 110^{o}C for 24 hours. The dried soils were later washed through a 0.075mm BS test sieve in accordance with the test method. The retained fractions were again oven-dried for 24 hours at the same temperature and then sieved through a nest of BS test sieves in a descending order of aperture sizes, using a mechanical sieve shaker. The fractions retained on each sieve were weighed and the proportions of the original samples passing given sieves were determined.

3.2.2 Natural Moisture Content

The test was carried out in accordance with BS 1377: Part 2: 1990. Representative specimens were obtained from the samples and their net weights taken. The specimens were then oven dried at temperatures between 105^{o}C and 110^{o}C for 24 hours, after which the dry weights of the specimens were taken. The ratio of moisture loss (wet mass – dry mass) to the mass of the dried soils specimens expressed as a percentage was taken as the moisture content of the specimen.

3.2.3 Atterberg Limits

3.2.3.1 Liquid Limit

Liquid limit tests were carried out using the BS cone penetrometer in accordance with BS 1377: Part 2: 1990. A BS cone penetrometer fitted with an automatic timing device that ensures 5 second penetration under an 80gm load was used. Oven-dried representative samples were ground in a mortar and sieved through a 0.425 mm BS test sieve. 200g of each of the samples passing the 0.425 mm BS test sieve were mixed thoroughly with distilled water and thereafter the water was allowed to permeate the samples overnight in an air tight container. The soils specimens were then remixed the following day with sufficient water to achieve two penetrations in the range between 15mm and 25mm. After each penetration the respective moisture contents of the specimens were determined. A moisture content penetration curve was drawn for each of the specimens from which the moisture content at 20mm penetration was taken as the liquid limit.

3.2.3.2 Plastic Limit

Plastic limit tests were carried out in accordance with BS 1377: Part 2: 1990. The samples used for the tests were prepared in the same manner as those for the liquid limit tests. The test specimens were first rolled into balls of soil pastes between the hands and then into threads between the palm and a glass plate. The plastic limits were taken as the moisture contents at which the threads develop transverse cracks when they were about 3mm diameter.

3.2.3.3 Plasticity Index (PI)

The plasticity Index was determined in conformity with BS 1377: Part 2: 1990. The plasticity index is the numerical difference between the LL and PL. PI = LL – PL.
A summary of the results of the soil index property tests is attached in **Appendix 2c.**

3.2.4 Shear Strength Tests

Direct Shear tests were performed on undisturbed samples in conformity with BS 1377: Part 7: 1990. Three specimens of sizes 60x60x20mm were prepared. The first specimen was given a fixed normal stress close to the respective overburden pressure and was sheared along its horizontal plane through its mid-depth to failure.

The same was done on the other two specimens but this time the fixed normal stresses were successively higher. The failure points were noted. A plot was made between the normal stress as the absicca and the shear stress as the ordinate. The slope of the graph was the angle of internal friction Ø and the intercept was the cohesion cu. Details of results are as indicated in **Appendix 2e.**

3.2.5 Triaxial Strength Tests (Un-drained Shear Strength Test)

The test was conducted on fine grained homogeneous soils, and involved determination of undrained shear strength, cohesion and angle of internal friction of soil specimens of cohesive soil strata when subjected to a constant confining pressure and to a strain controlled axial loading, when no change in total moisture content is allowed. It was essentially carried out to determine the shear strength parameters of the soil samples in terms of total stresses i.e. the angle of shear resistance and the cohesion. These values were then used to calculate the bearing capacity of a soil. The tests were undertaken on a set of three similar specimens subject to different confining pressures. The test procedure involved extruding soil samples from core cutters into the sampling tubes in undisturbed state, while protecting the samples from moisture loss. From the sampling tubes, the samples were driven into the 38mm diameter moulds, trimmed and removed. The length Lo, diameter and mass were measured to determine the bulk density. The specimen to be tested was first placed between end caps in the membrane quickly to prevent loss of moisture and sealed. The specimen was then centrally placed on the base of the tri-axial cell. The piston was allowed to slide down slowly until contact was made with the bearing surface. The cell was filled with water, to displace all the air and the water pressure noticed to rise and be equal to the overburden pressure. The loading ring was set to read zero as well as the axial deformation ring. The machine was switched on and force readings taken for every after 0.5mm of deformation.

For each specimen, the following parameters were determined:

- Axial force, P = reading on force measuring device * ring constant;
- Strain, e = change in length/original length;
- Initial cross sectional area, Ao;
- Area, A = Ao / (1-e); and the
- Deviator stress, (δ1-δ3) = 1000 P/A (Where P is the Force and A is the Area).

The values at failure were tabulated, and a graph of $(\delta_1 - \delta_3)/2$ against $(\delta_1 + \delta_3)/2$ plotted to determine the Cohesion (C) and Angle of friction (Φ); Where δ_1 is the deviator stress minus cell pressure and, δ_3 is the cell pressure. Details of results are as indicated in **Appendix 2f.**

3.2.6 Unconfined Compressive Strength

3.2.6.1 UCS for Soils Samples

To perform the unconfined compression test on the undisturbed samples, a sample was extruded from the sampling tube. A cylindrical sample of soil was trimmed such that the ends were reasonably smooth and the length-to-diameter ratio was on the order of two; where feasible. The soil sample was then placed in a loading frame on a metal plate; by turning a crank, the level of the bottom plate being raised.

The top of the soil sample was restrained by the top plate, which was attached to a calibrated proving ring. As the bottom plate was raised, an axial load was applied to the sample. The crank was turned at a specified rate so that there was a constant strain rate. The load was gradually increased to shear the sample, and readings were taken periodically of the force applied to the sample and the resulting deformation. The loading was continued until the soil developed an obvious shearing plane or the deformations became excessive.

The measured data were used to determine the strength of the soil specimen and the stress-strain characteristics. Finally, the sample was oven dried to determine its water content. The maximum load per unit area was taken to be the unconfined compressive strength, q_u.

In the unconfined compression test, it was assumed that no pore water was lost from the sample during set-up or during the shearing process. A saturated sample thus remained saturated during the test with no change in the sample volume, water content, or void ratio.

More significantly, the sample was held together by an effective confining stress that resulted from negative pore water pressures (generated by menisci forming between particles on the sample surface). Pore pressures were not measured in an unconfined compression test; consequently, the effective stress was undetermined. Hence, the undrained shear strength measured in an unconfined test was expressed in terms of the total stress. Detailed results are as indicated in **Appendix 2g.**

3.2.6.2 UCS for Rock Core Samples

The rock core specimen shall be tested at moisture content close to field condition as possible. The Length / Diameter ratio was preferably kept to be 2 to 3. The diameter of the specimen was noted to be greater than 10 times the diameter of largest grain size. The diameter of the samples was 100mm.

The Specimen was prepared in such a manner that the cylindrical surface was kept smooth and free from abrupt and irregularities. The surfaces of the test specimen and the two bearing discs were cleaned thereafter; the specimen was placed on the lower disc.

The axis of the specimen was carefully aligned with the center of thrust of the spherical seat. A load was continuously applied at a constant stress rate within the limits of 0.5MPa/s to 1.0MPa/s. The maximum load on the specimen at failure was recorded in N within 1% accuracy.

The UCS of the specimen was calculated by dividing the maximum load carried by the specimen during the test, by the average cross sectional area. Detailed results are as indicated in **Appendix 2g.**

3.2.7 Oedometer Consolidation Tests

The tests were performed in accordance with BS 1377: Part 5: 1990. A specimen of 76mm diameter and 20mm height was cut from the undisturbed sample and placed in the floating ring of the oedometer cell. Soaking of the sample was done after which the sample was loaded and readings of compression were noted at regular time intervals 0 min, ½, 1, 2, 4, 8,15,30, 1 h…..24h.

Successively higher loads were applied each after 24 hours until 7 cycles were completed. In the meantime the specific gravity of the same sample was determined. A plot was made between the cell pressure and the void ratio from which the coefficient of volume compressibility (m_v) and the preconsolidation pressure (p_c) were determined. Detailed results are as indicated in **Appendix 2h.**

3.2.8 Standard Compaction Tests (BS Light)

Five representative samples each weighing 2.5kg of material passing BS 20mm test sieve were prepared. Each specimen was thoroughly mixed with different amounts of water to give a suitable range of moisture contents i.e. two values from either side of the optimum moisture content. The five specimens were allowed to cure for at least four hours. The weight of the mould whose volume is 944m^3, together with the attached base plate was determined to the nearest 1g and taken to be M1. The extension collar was attached to the mould and the mould placed on the concrete floor. Each specimen was compacted in the mould in three layers giving each layer 25 blows (free fall) of a 2.5kg rammer. The collar was removed and excess soil removed using a straight edge so as to remain with a sample that only flushes with the mould edge. The soil sample and the mould with the attached base plate were weighed to the nearest 1g (M2). The compacted specimen was extruded from the mould and a representative portion of about 300g was used to determine the moisture content (W) at 105 ± 5°C for 24 hours. The bulk density and dry densities of each of the compacted samples was calculated. The dry densities versus moisture contents of the five specimens were plotted; a curve of best fit was drawn from which the Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) were read off at the peak of the curves. Detailed results are as indicated in **Appendix 2i.**

3.2.9 pH, Sulphates and Chlorides

3.2.9.1 Sulphate Test

The test was performed in accordance with BS: 1377: Part 3: 1990. The gravimetric method was used. A barium chloride solution was added to the water and the precipitate of barium sulphate was collected, dried and weighed. The sulphate content was then calculated in accordance with the analytical procedures – BS 1377: Part 3: 1990 (Acid – soluble sulphate content of the soil) that involved a consideration of the mass of the water used in the analysis and the mass of barium sulphate precipitated. Results are presented in **Appendix 2j**.

3.2.9.2 Chloride Test

This test was conducted in accordance with BS: 1377: Part 3: 1990. 5g of material passing 0.150mm BS test sieve was put in a beaker of 500ml volume. 50ml of distilled water was added followed by 15ml of concentrated nitric acid. The mixture was then heated to near boiling point, cooled and filtered through coarse graded filter paper. The residue was washed with distilled water and all the filtrate collected. Silver nitrate was then added to the filtrate from a burette until all the chlorides were precipitate. Titration was done with standard potassium thiocynate using ferric alum as an indicator. 3,5-5 trimethylhexan-l-ol was used to coagulate the precipitate. Results are presented in **Appendix 2j**.

3.2.9.3 pH Test on Soil Samples

Alkalinity / acidity were expressed as pH. The test was performed in accordance with BS: 1377: Part 3: 1990 and the electrometric method of pH determination were adopted. For every specimen, 10g of soil sample was dissolved in distilled water sample and placed in 100ml beaker and stirred for a few minutes then covered with a cover glass and allowed to stand for 8hours. Initially the pH meter was calibrated using a standard buffer solution. The electrode was then washed with distilled water and immersed in the dissolved sample. The corresponding readings were then taken with brief stirring between each reading. Results are presented in **Appendix 2j**.

3.2.9.4 Chemical Tests on Water Samples

Chemical tests on ground water were carried out in accordance with BS: 1377: Part 3: 1990. Ground water samples were filtered and analyzed gravimetrically by precipitating the sulphates with $Bacl_2$ and reported in mg/l (parts per million).

Tests to ascertain the chloride content in water samples were performed titrimetrically with a standard solution of potassium thiocyanate with ferric alum indicator solution (BS: 1377: Part 3: Section 7:1990). The pH value Acidity / Alkalinity in water samples was determined electrometrically in accordance with BS 1377: Part 3: Section 9: 1990. Results are presented in **Appendix 2j**.

4.0 PRESENTATION AND DISCUSSION OF FIELD AND LABORATORY RESULTS

4.1 Field Findings

Based on visual inspection, the in-situ soils strata at the intake site were generally granite rocks from a depth of 6.0m. The strata from the intake and water treatment sites were to a large extent; non-cohesive.

4.1.1 Photographic Presentation

A photographic representation of field work is provided in **Appendix 2a**. However, below are some photos presenting site investigation works.

Plate 1 ***Plate 2***

Plates 1&2: Rotary Drilling Works at the Sites

Plate 3 ***Plate 4***

Plates 3&4: The Conduct of Standard Penetration Tests in the Boreholes

4.1.2 Ground Water Table

Ground water table was encountered at the boreholes investigation locations as per Table 6.0.

Table 6.0: Depths of Water Table in Boreholes

No.	BH Label	Water Table (m) From Existing GL
1	BH1 - Karuma Intake	7.30
2	Coagulation / flocculation	7.50
3	Filtration	5.00
4	Filter Wash Water/ Mineralisation/Chlorination dry chamber	3.60
5	Buffer Filter wash water	5.10
6	Clear Water Tank	1.35

4.1.3 Standard Penetration Tests

Standard penetration tests were carried out where penetration could be achieved. SPT tests were not feasible for very hard strata. In circumstance where rocky strata were encountered, rock core samples were extracted. These were notably obtained in the lower depths of the intake site.

The SPT- N values from the intake and water treatment sites ranged from 11 (Filtration 1.50-1.95m depth) to 76 (Buffer Filter Wash Water 7.50-7.95m depth. Details are presented in **Appendix 2d**.

4.2 Laboratory Findings

4.2.1 Classification Test Results

Laboratory classification tests were carried out for each of the soil samples recovered from the site. A summary of the index properties is presented in Table 7.0.

Table 7.0: Summary of Soil Index Properties for Intake & Water Treatment Sites

Location	Range of Index Properties			Range of NMC (%)
	LL (%)	PL (%)	PI (%)	
Karuma Intake	39 - 42	21 - 28	11 - 21	16 - 17
Karuma Water Treatment	36 - 71	NP - 34	Nil - 43	5 - 32

4.2.2 Evaluation of the Soil Bearing Capacity

4.2.2.1 Bearing Capacity Based on SPT-N Values

The maximum pressures the soils from the site are capable of resisting have been estimated from the laboratory and field N-values based on empirical relations. A summary of the range of allowable bearing capacities is presented in **Table 8.0** (See details in **Appendix 2d**). For purposes of computing the soils' bearing capacity, the following assumptions were made:

- The maximum allowable settlement in non-cohesive soils is 25mm;
- The design N-values are derived from the statistical average of all values within a depth zone equal to the footing width below the founding depth; and
- The foundation base assumed is a 2m square footing.

Table 8.0: Range of Bearing Capacities of the Sub Soils Based on SPT – N Values

Site Label	Allowable bearing capacity (kPa)	
	From (Lowest Value)	To (Highest Value)
Karuma Intake	337	>700
Karuma Water Treatment	115 (Coagulation; 1.50 – 1.95m)	>700 (Filtration; 9.00 – 10.95m & Buffer Filter Wash Water; 4.50 – 7.95m)

4.2.2.2 Shear Box Test

The maximum pressures the soils are capable of resisting have been estimated from the shear strength parameters from the laboratory tests on undisturbed samples obtained from the boreholes at depths specified in **Table 9.0.** A 1.0m square footing was assumed along with the following additional considerations:

- Terzaghi's bearing capacity equations are valid for laboratory test results,
- Failure mechanism is by general shear;
- The factor of safety against shear failure is 3.0; the evaluations are presented in Tables of **Appendix 2e.**

Table 9.0: Range of Allowable Bearing Capacities based on Shear Strength

Investigation Location	**Allowable bearing capacity (kPa)**	
	From (Lowest Value)	**To (Highest Value)**
a) Boreholes (General Shear Failure)		
Karuma Intake	93	
Water Treatment site	92 (Buffer Filter Wash-1.50m)	294 (Coagulation -7.50m)

4.2.2.3 Triaxial Tests

Table 10.0 presents a summary of Triaxial test results performed on undisturbed soils samples. Detailed results are presented in **Appendix 2f.**

Table 10.0: Summary of Allowable Bearing Capacities based on Triaxial Tests

Investigation Location	**Allowable bearing capacity (kPa)**	
	From (Lowest Value)	**To (Highest Value)**
a) Boreholes (General Shear Failure)		
Karuma Intake	146	
Water Treatment site	144 (Buffer Filter Wash-1.50m)	368 (Coagulation -7.50m)

4.2.3 Unconfined Compressive Strength Tests

4.2.3.1 UCS Tests Results on Undisturbed Soils Samples

i) Boreholes Samples

Table 11.0 presents a summary of unconfined compressive strength performed on undisturbed soils samples obtained from boreholes. Detailed results are presented in **Appendix 2g.**

Table 11.0: Summary Results for Unconfined Compressive Strength on U- Samples

BH Label	Coordinates (ARC 1960/ UTM 36N)		Depth (m)	Sample Diameter, Ø (mm)	Area (mm²)	Breaking Load (kN)	UCS (MPa)
	X (Easting)	Y (Northing)					
Intake Site	418917	248890	1.5	100	7855	0.145	0.145
Coagulation / Flocculation	418852	249269	7.5	100	7855	0.151	0.151
Filtration	418846	249249	3.0	100	7855	0.146	0.146
			4.5	100	7855	0.146	0.146
Filter Wash Water	418839	249220	3.0	100	7855	0.125	0.125
			4.5	100	7855	0.143	0.143
Buffer Filter Wash Water	418880	249244	1.5	100	7855	0.144	0.144

4.2.3.2 UCS Tests Results on Rock Core Samples

The tests performed in accordance with ASTM D 7012-07, were conducted on the core specimens that had been trimmed using a mechanical grinder to secure a flat and smooth surface at the ends. The specimens obtained from the boreholes at the Karuma intake and water treatment had their length-to-diameter ratio ranging from 1.50 to 2.00. Results from the unconfined compressive strength tests are presented in **Table 12.0.** Details are presented in **Appendix 2g.**

Table 12.0: Summary Results for Unconfined Compressive Strength Tests on Rock Core Samples

S. No.	BH Label	Depth range	Core Diameter, Ø (mm)	Area (mm²)	Breaking Load (kN)	Unconfined Compressive Strength (MPa)
1	BH1 - INTAKE	3.00-3.45	100	7855	519	66.1
		6.00-6.45	100	7855	523	66.6
		7.50-7.95	100	7855	546	69.5
		9.00 -9.45	100	7855	612	77.9
2	Buffer Filter Wash Water	6.00-6.45	100	7855	412	52.5

From the above results it can be deduced that the unconfined compressive strength of the rock core samples at the intake site ranged from 66.1MPa to 77.9MPa taking on the maximum value at 9.45m. The buffer filter wash borehole's core sample had a UCS result of 52.5MPa.

4.2.4 Consolidation Tests Results

4.2.4.1 U- Samples from Boreholes

Parameters used to estimate the magnitude and rate of compressibility of the sub soils were obtained from one dimensional consolidation tests on undisturbed samples. The results obtained are tabulated in **Table 13.0** (Details are attached in **Appendix 2h**).

Table 13.0: Summary of One-dimensional Consolidation Test Results on BHs Samples

Test Location	Depth (m)	Coefficient of Volume Compressibility (Mv) in m^2/MN	Range of Mv	Remarks
Intake site	1.5	0.433	0.3 - 1.5	High Compressibility
Coagulation / Flocculation	7.5	0.186	0.1 - 0.3	Medium Compressibility
Filtration - BH1	3.0	0.225	0.1 - 0.3	"
Filtration - BH2	4.5	0.185	0.1 - 0.3	"
Filter Wash Water - BH1	3.0	0.178	0.1 - 0.3	"
Filter Wash Water - BH2	4.5	0.231	0.1 - 0.3	"
Buffer Filter Wash Water	1.5	0.268	0.1 - 0.3	"

The Coefficient of Volume Compressibility was computed using the following formula:
$Mv = (\delta e/\delta p) \times 1000/ (1+e1)$ m²/MN (Bowles, 1997:401).

From the above remarks, consolidation is generally classified as medium when it ranges from 0.1 - 0.3m²/MN and high when M_v ranges from 0.3 - 1.5 m²/MN.

4.2.5 Compaction Tests Results (BS Light)

CBR values for boreholes samples obtained from 1.50 – 3.45m depth from compaction tests ranged from 8% (Filter Wash Water – BH1 at 3.45m) to 16% (Filtration – BH2 at 4.5m depth). Detailed results are presented in **Appendix 2i.**

4.2.6 Chemical Tests

4.2.6.1 Chemical Tests on Soils Samples

Chemical tests on soil samples retrieved from the boreholes yielded pH values ranging from 6.48 to 6.63. All the samples obtained had negligible quantities of chlorides and sulphates that may not have any adverse effect on the construction materials likely to be used **(Appendix 2j)**.

4.2.6.2 Chemical Tests on Water Samples

i) Water Samples from Boreholes

The water samples from boreholes had pH values ranging from 6.70 (Coagulation) to 6.78 (Filtration). Chlorides ranged from 65mg/l (Filtration site & Clear Water Tank site) to 80mg/l (Buffer Filter Water site) whereas the sulphates were also of very low values. All these parameters including the organic matter, colour and odour are within permissible limits as provided for in BS: 1377: Part 3: 1990. Results in **Appendix 2j.**

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

i) Geotechnical investigations for Karuma Intake & Water Treatment Plant as a part of Improvement Programme to the Living Conditions in Gulu and Small Towns en Route in the Victoria Nile Catchment comprised:

- Rotary Drilling of 6No. boreholes to depths ranging from 7.50m to 15.0m;
- Conducting Standard Penetration Tests (SPTs) and obtaining disturbed samples in each borehole at 1.5m depth intervals, and 2No. undisturbed samples wherever he strata was found to be cohesive, all for laboratory testing;

ii) The soils' consistency varied from firm to hard for the cohesive strata and from medium dense to very dense for the non-cohesive strata. The specific gravity of the undisturbed soil samples ranged from 2.61 to 2.67.

iii) In terms of seismicity, the site geographically falls within Zone 2 of the Seismic Zoning of Uganda, implying there is a moderate likelihood of earthquake occurrence in the area.

iv) Ground water table was encountered in the boreholes at depths ranging from 1.35m (Clear Water Tank) to 7.5m (Coagulation).

v) The **obtained allowable bearing capacities** from field SPT N-values in the boreholes ranged from 115 (Coagulation; 1.50 – 1.95m) to >700 (Filtration; 9.00 –10.95m & Buffer Filter Wash Water; 4.50 – 7.95m); **See Appendix 2d**.

vi) Shear strength results based on **General Shear Failure** on undisturbed samples obtained from the sites ranged from 92 (Buffer Filter Wash- 1.50m) to 294 (Coagulation -7.50m).

vii) Triaxial compression test results carried out on undisturbed samples obtained from the sites ranged from 144 (Buffer Filter Wash- 1.50m) to 368 (Coagulation -7.50m).

viii) Unconfined compressive strength on boreholes samples from intake site ranged from 66.1MPa to 77.9MPa; with the maximum value being registered at 9.45m. The buffer filter wash borehole's core sample posted UCS result of 52.5MPa.

ix) Consolidation tests performed on the undisturbed samples obtained from the intake site at 1.5m depth posted a value of $0.433m^2/MN$ signifying high compressibility. The water treatment site boreholes exhibited values ranging from $0.178m^2/MN$ (Filter Wash Water at 3.0m depth) to $0.268m^2/MN$ (Buffer filter Wash Water) ; all representing medium compressibility.

x) Standard Compaction (BS Light) posted CBR values for boreholes samples obtained from 1.50 – 4.45m depth ranging from 8% (Filter Wash Water: 3.00-3.45m depth) to 16% (Filtration: 4.50 – 4.95m depth)

xi) Chemical tests on soil samples retrieved from the boreholes yielded pH values ranging from 6.48 to 6.63. All the samples obtained had negligible quantities of chlorides and sulphates that may not have any adverse effect on the construction materials likely to be used (Appendix 2j).

xii) Chemical tests on water samples from boreholes exhibited pH values ranging from 6.70 (Coagulation) to 6.78 (Filtration). Chlorides ranged from 65mg/l (Filtration site & Clear Water Tank site) to 80mg/l (Buffer Filter Water site) whereas the sulphates were also of very low values. All these parameters including the organic matter, colour and odour are within permissible limits as provided for in BS: 1377: Part 3: 1990. Results presented in Appendix 2j.

5.2 Recommendations

i) Designs should be undertaken on the basis of the allowable bearing capacities obtained from field SPT-N values together with a consideration of shear strength, triaxial strength, unconfined compressive strength; and compressibility characteristics of the soils strata.

ii) In the event that foundations are to be constructed below the ground water table for particular locations (notably at the clear water tank site), the allowable bearing capacity to be considered in the design should be a half of the obtained allowable bearing capacity; thus catering for the effect of the high water table.

iii) The strata at the proposed sites are within acceptable limits of alkalinity. Therefore no special cement is required to be used during the construction of the foundations. In all cases therefore, readily available Portland cement, 42.5N is recommended for use for the construction works owing to its ability to ensure the achievement of good early strength for concrete. Water proof cement may also be used as necessary.

However since the foundations are likely to be constructed at depths below the ground water level in some cases, rapid hardening cement is recommended to be used for achievement of early strength of concrete for those particular locations.

iv) Appropriate design seismic acceleration values consistent with Contract Technical Specifications and Uganda Seismic Code US319:2003 must be adopted during foundation design due to the high likelihood of earthquake occurrence in the area. Reference may also be done to subsection 2.2.2 of this report.

v) Design considerations may also appropriately allow for: the impact or vibrations due to plant producing significant dynamic loads; lifting or handling equipment such as forklifts, trolleys or cranes operating on the floors of Structures; lateral and uplift forces due to retained soils or ground water inertia sway forces.

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APPENDIX 1: FIGURES

Appendix 1: Figure 1a

Site Map indicating Boreholes Locations at the Karuma Intake & Water Treatment Sites

Legend

- WTP Buildings
- Nile water intake
- Clear water transmission main (to Gulu)
- Raw water pipeline
- Access Road
- Power line Karuma-Lira (30m reserve area)

Coordinate Reference System: WGS 84 / UTM zone 36N

Index	Description of amendment	Date	Name

Client: GOVERNMENT OF UGANDA

NATIONAL WATER AND SEWERAGE CORPORATION (NWSC)

Co-financed by : The Government of Uganda and KFW

Consultants: FICHTNER WATER & TRANSPORTATION *In association with* GOPA Infra, M&E, Governance Systems International

Project: INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN ROUTE IN THE VICTORIA NILE CATCHMENT (IPILC)

ENGINEERING AND INSTITUTIONAL CONSULTANCY (EIDC) SERVICES

Drawing title:

Package 1.2 - Water supply physical measures
Nile water treatment plant
Location for geotechnical investigation at intake site

Drawn by :	J. von Vogt	
Checked by :	J. von Vogt	
Approved by :	J. von Vogt	
Scale :	1:1.000	Drawing no.: XXXXXXXX
Date :	25.4.2018	

Legend

- WTP Buildings
- Clear water transmission main (to Gulu)
- Raw water pipeline

Coordinate Reference System: WGS 84 / UTM zone 36N

Index	Description of amendment	Date	Name

Client: GOVERNMENT OF UGANDA

NATIONAL WATER AND SEWERAGE CORPORATION (NWSC)

Co-financed by :

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Project:

INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN ROUTE IN THE VICTORIA NILE CATCHMENT (IPILC)

ENGINEERING AND INSTITUTIONAL CONSULTANCY (EIDC) SERVICES

Drawing title:

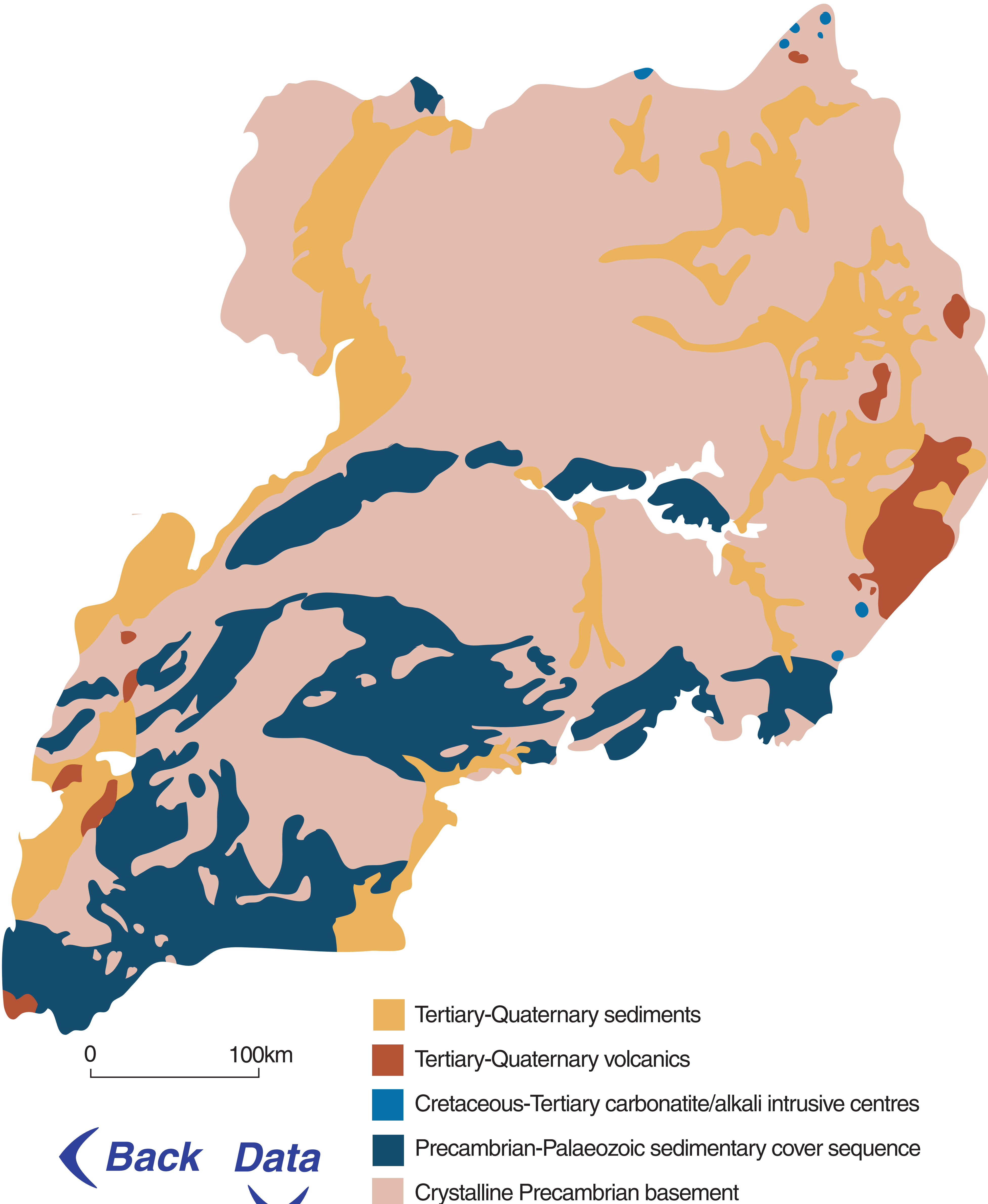
Package 1.2 - Water supply physical measures
Nile water treatment plant
Locations for geotechnical investigations

Drawned by :	J. von Vogt
Checked by :	J. von Vogt
Approved by :	J. von Vogt
Scale :	1:1.000
Date :	20.4.2018
Drawing no.:	XXXXXXXX

Appendix 1: Figure 1b

Simplified Geology Map of Uganda

Simplified Geology of Uganda



Back Data

Extracts from Mining Journal Uganda Supplement April 1996

Economic Geology

Uganda lies within the borders of the African Plate, one of the largest known regions of continental crust that contains Archaean cratons that date to at least 2,500 Ma. The Plate extends through much of eastern and central Africa, and has been modified by subsequent geological events such as high-grade metamorphism along mobile belts, the deposition of several generations of sedimentary cover, granitic and other intrusions, and the development of rift faulting.

Much of Uganda's geology has been studied in broad outline only and detailed work remains to be done. The geochronology is as yet incomplete. Two-thirds of the country is underlain for the most part by Precambrian rocks, comprised of Archaean, and Lower and Middle Proterozoic Groups of varied lithology. Tertiary and Cretaceous carbonatite, syenite and alkaline volcanic rocks are also found, and there are Pleistocene and Recent sediments and volcanics in the Rift Valley.

Archaean

The Archaean shield covers much of the southern half of Uganda, to the east of Lake Victoria, forming an extension of the Tanzanian shield. The shield here is composed chiefly of granites and gneisses. Several gold-bearing greenstone belts, comprising Nyanzian volcanics and overlying Kavirondian sediments, extend into Uganda from Kenya and Tanzania, but appear not to be as well developed as in the neighbouring countries.

The granitic metamorphic rocks in the Ugandan portion of the Tanzanian shield have commonly been described by the term "basement complex". This simplification is being replaced by more specific terms as additional information is gathered. Reconnaissance mapping indicates that much of central Uganda, and perhaps two-thirds of the country as a whole, is underlain by basement complex rocks that are interpreted as being predominantly of sedimentary origin.

The Archaean Nyanzian system comprises a sequence of dominantly mafic volcanic rocks and sediments that form greenstone belts within the basement complex in the east of the country. Also occurring in neighbouring countries, these greenstones are estimated to reach thicknesses of 5,000 m in Tanzania. The Nyanzian greenstones both host precious metals deposits and have the potential for base metals, a feature of the unit being the occurrence of steeply dipping fold axes along an east-west orientation.

Rocks of the Kavirondian system occur in association with the Nyanzian greenstones in eastern Uganda; these comprise conglomerates, coarse arkosic and feldspathic grits and quartzite resting unconformably on the Nyanzian rocks from which they are at least partly derived.

Proterozoic

Uganda's Proterozoic systems require more work on age dating and field mapping to allow better cross-border correlations. Three systems of this geological period have been identified; the Buganda-Toro, Karagwe-Ankolean and Bukoban systems.

The Lower Proterozoic Toro (or Buganda-Toro) system consists mainly of non-calcareous sediments and is found in three areas: along the north shore of Lake Victoria in the east, in the central region and as the core of the Rwenzori mountains in the southwest. A distinguishing feature is that metamorphism is higher in the central and southwestern regions than in eastern Uganda. This system contains the copper-cobalt ores found at Kilembe, and is thus of considerable economic significance to the country.

The Karagwe-Ankolean system lies within the Middle Proterozoic Kibaran Fold Belt that extends southwest from Uganda into Zaire and Zambia. Younger than the Toro system, its sedimentary features reflect shallow-water deposition with argillites, shales and sandstones in a uniform succession. The thinner sandstones and quartzites are lenticular. The rocks are deformed along north-south axes with circular intrusives of porphyritic granites lying at the cores of the anticlines. Resistant quartzite ridges surround the granite intrusives. The economic importance of this system lies in its veins of tin, tungsten and niobium-tantalum that are found around the periphery of the granites.

The Bukoban system is thought to extend across the Proterozoic-Palaeozoic boundary but there are insufficient age dates as yet to be certain. The rocks are of little economic interest. They are hardly deformed and not metamorphosed, consisting mostly of sandstones, quartzite, shales, some dolomitic limestones, red beds, cherts and lava flows.

Palaeozoic To Cainozoic

Small outliers of Karroo system sediments, ranging in age from Upper Carboniferous to Upper Jurassic or possibly Cretaceous, outcrop in a few locations in Uganda. Although this system hosts major coalfields to the south, these outliers represent the northernmost extent of Karroo sediments, and there are no commercial coal resources in Uganda.

Miocene volcanics outcrop in several areas of eastern Uganda, close to the Kenyan border and are denoted topographically by the prominent mountains of southern Karamoja region. Carbonatite ring complexes, possibly as early as Cretaceous and representing the eroded remnants of volcanoes of a similar geological suite, occur in several eastern locations.

Cainozoic rocks are either of sedimentary or volcanic origin and are found in the western Rift Valley adjoining Rwanda and Zaire. The sediments are thick, exceeding 4,000 m in fault-lined basins. Volcanics have been ejected from vents and there are hot springs in the district.

Major Structures

The major structural controls within Uganda include orogenic fold belts and shear zones in the Precambrian, and the processes of formation of the Rift Valley and later volcanic centres, followed by crustal warping during the Pleistocene that resulted in the formation of Lake Victoria. The orogenic fold belts usually follow fairly consistent trends.

Shear belts occur in the Precambrian in several areas of the country. The Aswa shear belt is the most extensive, following a northwesterly trend for over 300 km through northern Uganda and into southern Sudan. Other belts, probably of Late Precambrian age, run through the Karamoja region, Acholi and the West Nile district.

The Rift Valley extends along the western border with Zaire and encompasses Lake Albert, Lake George, Lake Edward, and the Rwenzori Mountains horst block. Sediment thicknesses of 1,800 to 4,000 m are estimated to lie within the Rift Valley, which is still locally active.

Mineral Occurrences

Extensive portions of Uganda have been exposed to prolonged and intense weathering. These processes have led to some materials being concentrated into ores, most notably gold, tin, pyrochlore (niobium, tantalum and rare earths), and apatite.

Mineral occurrences include gold in Busia in the southeast, hosted by an Archaean greenstone belt (Nyanzian-Kavirondian), whilst in the southwest at Buhweju and Kigezi, gold occurs in Lower to Middle Proterozoic metasediments.

Gold mining has taken place at Busia in both alluvial and quartz vein occurrences. However, it appears that much of the so-called alluvials are actually lateritic formations formed by weathering of huge volumes of the underlying Archaean greenstones. The lateritic profile in many areas approaches 20 m and extends over tens of square kilometres. This lateritic gold may lead to the discovery of primary sources in the greenstones beneath.

Recent exploration in the southwest in the Buhweju-Mashonga area indicates that much of the gold being extracted by artisans derives from lateritic gravel lying on kaolinised bedrock. The weathering profile in most parts of this area is 10 to 20 m thick. Quartz veins have also been noted and some are being worked.

In addition to Busia and Buhweju-Mashonga, other potential gold areas include Kigezi, Mubende and Karamoja. Karamoja, in the northeast, is of particular interest since favourable gold potential may exist in the intrusive and volcano-sedimentary rocks of Proterozoic and possibly Archaean age.

The most prospective district for base metals is in the Kilembe belt, where the volcano-sedimentary Lower Proterozoic series extends for over 90 km. The stratabound massive sulphides at Kilembe, containing copper and cobalt mineralisation, are hosted in rocks of the important Buganda-Toro system.

Apart from Kilembe, there are copper showings in the northeast at Bobong and Kaabong in Karamoja region, occurring within Karasuk Group rocks. There are also chromite occurrences in ultramafic rocks at Nakiloro, in the Karamoja district. An ultramafic rock assemblage identified at Moroto by the DGSM for further study may represent a Lower Proterozoic or Archaean layered intrusion, and in consequence holds potential as a new target area for nickel, chromium, copper and platinum-group metals mineralisation.

Other base metals have been noted. Lead, zinc and gold have been found in the Buganda-Toro Complex at Kitaka, within the Buhweju gold district. The Muko iron ore deposit occurs in Middle Proterozoic Kibaran rocks, whilst magnetite occurrences in the east, such as at Sukulu, are found in Tertiary carbonatites. Most of the cassiterite, tungsten, columbo-tantalites, beryl and lithium mineralisation is hosted by pegmatites and granites of the Buganda-Toro and Kibaran Complexes.

Amongst industrial minerals, phosphates are found in the east in Tertiary carbonatites that also host limestone, titanium and rare-earth elements. There is also limestone at Hima in the southwest, in a secondary deposit derived from calcareous tuffs and hot springs. Other industrial minerals include clay, kaolin, feldspar, diatomite, silica sand and various types of dimension stone.

Geophysical Interpretation

Geophysical surveying has revealed the potential for a number of significant features that may prove of interest in the search for further mineral resources in Uganda. Some of this information has been extrapolated from regional airborne surveying, and evidence for some of the features suggested has yet to be confirmed on the ground.

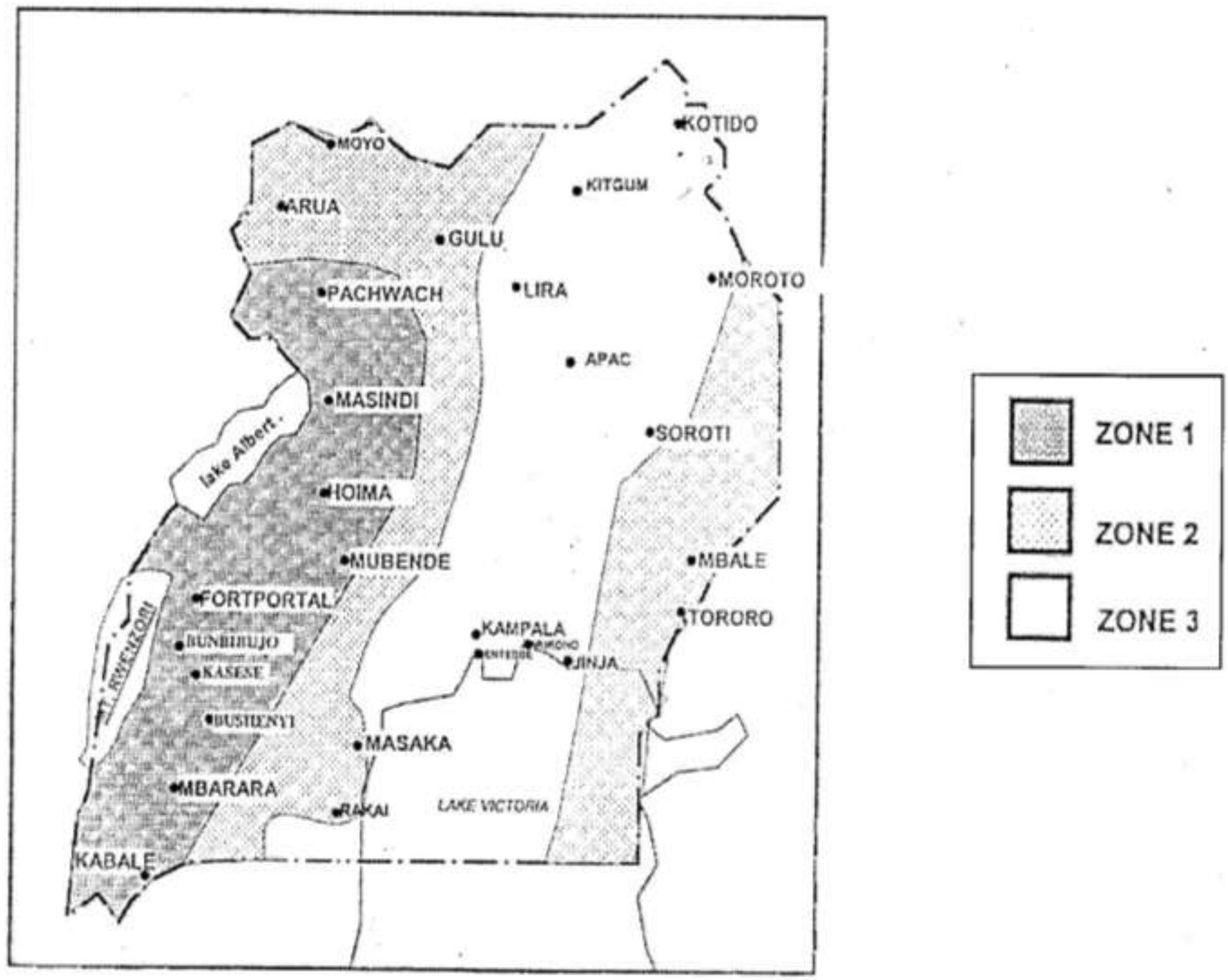
Amongst these potential targets are a regionally extensive dyke swarm hypothesised as running from Tanzania into Uganda and lying in a series of semicircular arcs through the south of the country. Aeromagnetic data suggest the presence of this feature, which has a diameter of some 600 km. Also running northwards from Tanzania are two arcuate belts of magnetic anomalies that may be related to the nickel- and cobalt-rich ultramafic bodies that occur in the border region between Tanzania and Rwanda.

Interpretation of aeromagnetics also suggests that there is potential for further copper and other base metal discoveries to the east of the Kilembe district, while other features are considered to represent the tantalum, tin, tungsten and gold mineral belt on the Uganda-Rwanda border. Furthermore, it is also possible that the gold-bearing Nyanzian greenstones are more extensive than currently known, with large areas being overlain by superficial cover.

Appendix 1: Figure 1c

Seismic Map of Uganda

SEISMIC MAP OF UGANDA (Seismic Code of Practice for Structural designs; Uganda National Bureau of Standards, First Edition: June 2003).



Seismic zoning of Uganda

APPENDIX 2: FIELD FINDINGS AND LABORATORY TESTS RESULTS

Appendix 2a

Photographic Representation of Geotechnical Work

Plate 1.0

Plate 2.0

Plate 3.0

Plates 1.0 – 3.0: Views of the Intake Site

Plate 4.0

Plate 5.0

Plate 6.0

Plates 4.0 & 5.0: Rotary Drilling works in progress at the site

Plate 6.0: Samples obtained from the intake site

Plate 7.0

Plate 8.0

Plate 9.0

Plates 7.0-9.0: Rotary Drilling works in progress at the water treatment plant site

Plate 10.0

Plate 11.0

Plate 12.0

Plates 10.0-12.0: The conduct of Standard Penetration Tests (SPT) at the site

Plate 13.0: Coagulation Site Samples

Plate 14.0: Filtration Site Samples

Plate 15.0: Filter Wash Water Samples

Plate 16.0: Buffer Filter Wash Water Samples

Plate 17.0: Clear Water Tank Samples

Appendix 2b

Borehole Logs

EPINEX ENGINEERING SERVICES LTD

RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile Catchment

Position of BH: Easting (X) 418917, Northing (Y) 248890 (ARC 1960/ UTM 36N)

Hole/Pit No.: BH1 - INTAKE SITE

Depth of Water Table: 7.3m below EGL

Date Started: 09.08.18

Drilling Method used: Rotary

Date Completed: 09.08.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95	= x = x= x = = x = x = x = =x = =x = x=	√	√	10 14 16	30	Dark brown silty clay	Stiff
3.00 3.45		-	-	_ _ _	_	Whitish grey sedimentary rock	Moderately strong rock
4.50 4.95		√	-	66 _ _	_	Dark grey-brownish clayey weathered rock	Dense
6.00 6.45		-	-	_ _ _	_	Blackish rock	Moderately strong rock
7.50 7.95		-	-	_ _ _	_	Light grey rock	"
9.00 9.45		-	-	_ _ _	_	Dark grey-blackish rock	Strong rock

EPINEX ENGINEERING SERVICES LTD

RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile

Position of BH: Easting (X) 418852, Northing (Y) 249269 (ARC 1960/ UTM 36N)

Hole/Pit No.: BH1 - COAGULATION / FLOCCULATION

Depth of Water Table: 7.5m from EGL

Date Started: 10.08.18

Drilling Method used: Rotary

Date Completed: 10.08.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50	=x =x = x			4			
1.95	= x = x = x	√	-	6	13	Yellowish brown clayey sand with silt	Medium dense
	= x = x = x			7			
3.00	= = = =			8			
3.45	= = = =	√	-	9	20	Yellowish brown gravelly clayey sand	"
	= = = =			11			
4.50	= oo = oo			10			
4.95	ooo = ooo	√	-	12	26	Yellowish brown clayey sand with gravel	"
	oo = ooo			14			
6.00	= oo = oo			13			
6.45	ooo = ooo	√	-	13	28	"	"
	oo = ooo			15			
7.50	= oo = oo			23			
7.95	ooo = ooo	√	√	28	53	Greyish brown gravelly clay	Very stiff
	oo = ooo			25			
9.00	= oo = oo			26			
9.45	ooo = ooo	√	-	26	54	"	"
	oo = ooo			28			
10.50	= oo = oo			11			
10.95	ooo = ooo	√	-	13	27	Light brown clayey sand with gravel	Medium dense
	oo = ooo			14			
12.00	= oo = oo			13			
12.45	ooo = ooo	√	-	14	32	"	Dense
	oo = ooo			18			
13.50	= oo = oo			16			
13.95	ooo = ooo	√	-	14	35	"	"
	oo = ooo			21			
15.00	= =o = o=			17			
15.45	=o= = ooo	√	-	21	43	Light brown gravelly inorganic clay	Very stiff
	=o = o=o			22			

EPINEX ENGINEERING SERVICES LTD

RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile

Position of BH: Easting (X) 418846, Northing (Y) 249249 (ARC 1960/ UTM 36N)

Hole/Pit No.: BH1 - FILTRATION

Depth of Water Table: 5.0m from EGL

Date Started: 11.08.18

Drilling Method used: Rotary

Date Completed: 11.08.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95	= oo = oo ==o = ooo oo = o==	√	-	4 5 6	11	Brownish yellow clay with gravel	Firm
3.00 3.45	= oo = oo ==o = ooo oo = o==	√	√	15 17 20	37	"	Very stiff
4.50 4.95	= oo = oo ==o = ooo oo = o==	√	√	18 22 21	43	Brownish grey clay with gravel	"
6.00 6.45	= oo = oo ooo = ooo oo = ooo	√	-	26 23 31	54	Light brown clayey gravel	Very dense
7.50 7.95	= oo = oo ooo = ooo oo = ooo	√	-	14 24 26	50	Brownish grey clayey gravel	"
9.00 9.45	= oo = oo ooo = ooo oo = ooo	√	-	36 32 34	66	Yellowish brown clayey gravel	"
10.50 10.95	= oo = oo ooo = ooo oo = ooo	√	-	33 35 35	70	Reddish brown clayey gravel	"

EPINEX ENGINEERING SERVICES LTD

RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile

Position of BH: Easting (X) 418839, Northing (Y) 249220 (ARC 1960/ UTM 36N)

Hole/Pit No.: BH1 - FILTER WASH WATER

Depth of Water Table: 3.6m from EGL

Date Started: 13.08.18

Drilling Method used: Rotary

Date Completed: 13.08.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50 1.95	= oo = oo ==o = ooo oo = o== =	√	-	17 15 14	29	Dark brown gravelly clay	Stiff
3.00 3.45	= oo = oo ==o = ooo oo = o== =	√	√	23 21 21	42	Yellowish brown gravelly clay	Very stiff
4.50 4.95	=xxx = xxx xxx = xx= xx = xxx =	√	√	37 33 17	50	Yellowish brown silty clay	Very stiff - hard
6.00 6.45	=xxx = xxx xxx = xx= xx = xxx =	√	-	7 8 11	19	Pinkish brown silty/chalky clay	Stiff
7.50 7.95	===== = == === = === === = ====	√	-	16 17 19	36	Brownish pink chalky clay	Very stiff
9.00 9.45	== = = == = = =	√	-	18 18 22	40	Greyish brown weathered sandstone	Dense
10.50 10.95	== = = == = = =	√	-	9 17 24	41	"	"
12.00 12.45	== = = == = = =	√	-	11 21 24	45	"	"
13.50 13.95	= ======== = ======== = = =======	√	-	8 20 19	39	Greyish brown sandy clay	Very stiff
15.00 15.45	oo oo oo oo ooo oo ooooooooo	√	-	13 18 22	40	Brown gravelly sand	Dense

EPINEX ENGINEERING SERVICES LTD

RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile

Position of BH: Easting (X) 418880, Northing (Y) 249244 (ARC 1960/ UTM 36N)

Hole/Pit No.: BH1 - BUFFER FILTER WASH WATER

Depth of Water Table: 5.1m from EGL

Date Started: 12.08.18

Drilling Method used: Rotary

Date Completed: 12.08.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50	= oo oo			8			
1.95	= oo = oo	√	√	22	45	Yellowish brown gravelly clay	Very stiff - Hard
	= oo = o			23			
3.00	oo oo oo			24			
3.45	o oo oo	√	-	26	50	Yellowish brown gravelly sand	Dense
	o oo o o			24			
4.50	= oo oo			31			
4.95	= oo = oo	√	-	35	73	Yellowish brown gravelly clay	Hard
	= oo = o			38			
6.00				57			
6.45		√	-	-	-	Dark brown lateritic rock	Moderately strong
				-			
7.50				37			
7.95		√	-	33	76	Yellowish brown weathered lateritic rock	"
				43			

EPINEX ENGINEERING SERVICES LTD

RECORD OF BOREHOLE INVESTIGATIONS

Project: Integrated Programme to Improve the Living Conditions in Gulu and Small Towns en-Route in the Victoria Nile

Position of BH: Easting (X) 418890, Northing (Y) 249173 (ARC 1960/ UTM 36N)

Hole/Pit No.: BH1 - CLEAR WATER TANK

Depth of Water Table: 1.35m from EGL

Date Started: 14.08.18

Drilling Method used: Rotary

Date Completed: 14.08.18

Size of hole/pit: 100mm

Foreman: Robert Owori

Diameter of Core: N/A

Weather Condition/ Temperature: Sunny

Sample				Field Test		Description	Remarks
Depth (m)	Material Symbol	Disturbed	Undisturbed (U-100)	SPT Blows	SPT-N Value		
1.50	= oo = oo			8			
1.95	ooo = ooo	√	-	13	37	Yellowish grey clayey gravel	Dense
	oo = ooo			24			
3.00	ooooooooo			11			
3.45	ooooooooo	√	-	8	18	Brownish grey schist / clayey weathered rock	Medium dense
	ooooooooo			10			
4.50	ooooooooo			5			
4.95	ooooooooo	√	-	8	19	Greyish brown schist weathered rock	"
	ooooooooo			11			
6.00	ooooooooo			7			
6.45	ooooooooo	√	-	9	21	"	"
	ooooooooo			12			
7.50	ooooooooo			8			
7.95	ooooooooo	√	-	22	47	Whitish brown schist weathered rock	Dense
	ooooooooo			25			
9.00	ooooooooo			6			
9.45	ooooooooo	√	-	10	44	"	"
	ooooooooo			34			
10.50	ooooooooo			9			
10.95	ooooooooo	√	-	17	53	Greyish brown schist weathered rock	Very dense
	ooooooooo			36			
12.00	ooooooooo			9			
12.45	ooooooooo	√	-	10	31	Whitish brown schist clayey weathered rock	Dense
	ooooooooo			21			
13.50	ooooooooo			13			
13.95	ooooooooo	√	-	13	27	"	Medium dense
	ooooooooo			14			
15.00	ooooooooo			14			
15.45	ooooooooo	√	-	16	37	"	Dense
	ooooooooo			21			

Appendix 2c

Soil Index Properties

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : SEPTEMBER 2018

SOIL CLASSIFICATION FOR BOREHOLES SAMPLES

Label	Depth range (m)	20.0 mm	10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.15 mm	0.075 mm	Atterberg limits LL %	PL %	PI %	NMC (%)	USCS	REMARKS
KARUMA INTAKE BH1	1.50-1.95			100	96	91	84	80	72	67	62	56	42	21	21	17	CL	Silty Lean Clay
	4.50-4.95			100	64	55	46	33	30	26	21	19	39	28	11	16	GC	Clayey gravel with weathered rock
BH1 - COAGULATION / FLOCCULATION	1.50-1.95	100	84	64	57	46	42	42	41	39	38	36	41	18	23	17	SC	Clayey sand with silt
	3.00-3.45		100	76	71	62	56	55	52	47	42	37	42	17	25	20	SC	Gravelly clayey sand
	4.50-4.95	100	94	85	80	60	50	48	45	42	40	38	39	20	19	10	SC	Clayey sand with gravel
	6.00-6.45						100	80	67	64	55	49	41	10	31	12	SC	"
	7.50-7.95	100	98	89	82	68	64	61	59	56	54	52	39	12	27	11	CL	Gravelly inorganic clay
	9.00-9.45		100	99	98	95	79	73	63	58	56	53	41	16	25	13	CL	"
	10.50-10.95	100	80	68	64	56	50	49	47	45	43	40	41	15	26	11	SC	Clayey sand with gravel
	12.00-12.45		100	85	70	65	56	50	49	47	45	43	42	15	27	13	SC	"
	13.50-13.95				100	99	84	78	61	54	51	48	46	16	30	11	SC	"
	15.00-15.45				100	99	96	95	87	83	80	78	45	17	28	14	CL	Gravelly inorganic clay
BH1 - FILTRATION	1.50-1.95			100	76	72	69	56	54	51	50	50	48	28	20	23	CL	Lean clay with gravel
	3.00-3.45			100	72	68	58	55	53	51	50	50	45	22	23	18	CL	"
	4.50-4.95				100	94	70	65	61	56	52	50	43	34	9	24	CL	"
	6.00-6.45			100	69	56	48	37	31	25	20	18	49	25	24	21	GC	Clayey gravel
	7.50-7.95				100	85	74	68	65	62	56	48	45	28	17	17	GC	"
	9.00-9.45				100	90	82	76	70	62	60	56	42	29	13	16	GC	"
	10.50-10.95			100	90	85	75	64	60	53	50	49	48	34	14	14	GC	"

LL: Liquid Limit **NMC:** Natural Moisture Content

PL: Plastic Limit **USCS:** Unified Soil Classification System

PI: Plasticity Index

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : SEPTEMBER 2018

SOIL CLASSIFICATION FOR BOREHOLES SAMPLES

Label	Depth range (m)	20.0 mm	10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.15 mm	0.075 mm	Atterberg limits LL %	PL %	PI %	NMC (%)	USCS	REMARKS
BH1 - FILTER WASH WATER	1.50-1.95				100	98	86	82	73	67	64	62	42	17	25	19	CL	Gravelly inorganic clay
	3.00-3.45			100	97	94	90	79	76	71	67	66	43	14	29	14	CL	"
	4.50-4.95				100	99	84	80	67	61	58	56	39	10	29	8	CL	Silty inorganic clay
	6.00-6.45	100	99	87	83	77	72	71	68	65	63	61	36	16	20	31	CL	"
	7.50-7.95	100	98	94	91	89	85	81	70	65	61	58	59	20	39	17	CH	High plasticity fat clay
	9.00-9.45			100	96	78	73	60	51	46	41	37	71	28	43	19	SP	Gravelly sand
	10.50-10.95		100	88	76	71	57	50	49	45	43	40	56	NP	-	19	SP	"
	12.00-12.45				100	95	73	68	61	57	53	49	57	NP	-	24	SP	"
	13.50-13.95	100	91	84	81	72	66	64	61	59	57	55	48	17	31	14	CL	Sandy inorganic clay
	15.00-15.45				100	98	81	77	62	56	52	48	38	20	18	17	SP	Gravelly sand
BH1 - BUFFER FILTER WASH WATER	1.50-1.95		100	89	84	77	70	68	66	61	56	51	40	17	23	20	CL	Gravelly lean clay
	3.00-3.45		100	90	73	64	52	47	46	44	43	41	33	13	20	5	SP	Gravelly sand
	4.50-4.95	100	97	87	84	79	75	74	71	68	68	65	35	13	22	9	CL	Gravelly lean clay
BH1 - CLEAR WATER TANK	1.50-1.95			100	63	56	43	32	28	25	19	15	48	23	25	22	GC	Clayey gravel
	3.00-3.45				100	92	64	61	53	48	45	41	52	NP	-	24	-	Weathered rock
	4.50-4.95				100	95	69	64	55	50	46	42	57	NP	-	29	-	"
	6.00-6.45				100	96	91	85	76	73	68	66	60	NP	-	32	-	"
	7.50-7.95				100	99	86	84	81	76	71	69	55	NP	-	25	-	"
	9.00-9.45					100	91	88	84	71	68	64	58	NP	-	24	-	Schist weathered rock
	10.50-10.95				100	99	97	86	80	76	74	71	56	NP	-	31	-	"
	12.00-12.45				100	98	91	89	84	75	69	66	49	NP	-	26	-	Schist clayey weathered rock
	13.50-13.95				100	91	84	78	70	66	61	58	51	NP	-	28	-	"
	15.00-15.45				100	93	89	82	73	69	64	62	53	NP	-	29	-	"

LL: Liquid Limit **NMC:** Natural Moisture Content

PL: Plastic Limit **USCS:** Unified Soil Classification System

PI: Plasticity Index

Appendix 2d

Bearing Capacity based on SPT – N Values

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : SEPTEMBER 2018

EVALUATION OF BEARING CAPACITY OF THE SOIL BASED ON FIELD SPT-N VALUES

BH Label	Depth range (m)	Predominant Material Fraction	Design N-Value	Unconfined Compressive Strength, qu (kPa)	Undrained Cohesion, Cu (kPa)	Ultimate Bearing Capacity, qult (kPa)	Allowable Bearing Capacity, qall (kPa)
Karuma Intake BH 1	1.50-1.95	Silty clay	30	393	197	1010	337
	4.50-4.95	Clayey weathered rock	-	-	-	-	>700
Coagulation / Flocculation - BH1	1.50-1.95	Clayey sand with silt	13	-	-	-	115
	3.00-3.45	Clayey sand	20	-	-	-	235
	4.50-4.95	Clayey sand with gravel	26	-	-	-	300
	6.00-6.45	"	28	-	-	-	330
	7.50-7.95	Gravelly clay	53	694	347	1784	595
	9.00-9.45	"	54	707	354	1818	606
	10.50-10.95	Clayey sand with gravel	27	-	-	-	310
	12.00-12.45	"	32	-	-	-	380
	13.50-13.95	"	35	-	-	-	410
	15.00-15.45	Gravelly clay	43	563	282	1448	483
Filtration - BH1	1.50-1.95	Clay with gravel	11	144	72	370	123
	3.00-3.45	"	37	485	242	1246	415
	4.50-4.95	"	43	563	282	1448	483
	6.00-6.45	Clayey gravel	54	-	-	-	685
	7.50-7.95	"	50	-	-	-	595
	9.00-9.45	"	66	-	-	-	>700
	10.50-10.95	"	70	-	-	-	>700

Note:

For cohesive soils, the relationship qu = 13.1 x Design N-value is used for evaluation of the Unconfined Compressive Strength qu, the cohesion Cu = qu/2 and qult = 5.14 x Cu. qall is evaluated using a factor of safety of 3

**Allowable Bearing capacity with settlement limited to approximately 25mm for cohesionless soils read off directly from the Chart (Published by Terzaghi and Peck 1967)*

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : SEPTEMBER 2018

EVALUATION OF BEARING CAPACITY OF THE SOIL BASED ON FIELD SPT-N VALUES

BH Label	Depth range (m)	Predominant Material Fraction	Design N-Value	Unconfined Compressive Strength, qu (kPa)	Undrained Cohesion, Cu (kPa)	Ultimate Bearing Capacity, qult (kPa)	Allowable Bearing Capacity, qall (kPa)
Filter Wash Water - BH1	1.50-1.95	Gravelly clay	29	380	190	976	325
	3.00-3.45	"	42	550	275	1414	471
	4.50-4.95	Silty clay	50	655	328	1683	561
	6.00-6.45	"	19	249	124	640	213
	7.50-7.95	"	36	472	236	1212	404
	9.00-9.45	Weathered sandstone	40	-	-	-	470
	10.50-10.95	"	41	-	-	-	485
	12.00-12.45	"	45	-	-	-	540
	13.50-13.95	Sandy clay	39	511	255	1313	438
	15.00-15.45	Gravelly sand	40	-	-	-	470
Buffer Filter Wash Water - BH1	1.50-1.95	Gravelly clay	45	590	295	1515	505
	3.00-3.45	Gravelly sand	50	-	-	-	595
	4.50-4.95	Gravelly clay	73	-	-	-	>700
	7.50-7.95	Weathered rock	76	-	-	-	>700
Clear Water Tank - BH1	1.50-1.95	Clayey gravel	37	-	-	-	450
	3.00-3.45	Weathered rock	18	-	-	-	220
	4.50-4.95	"	19	-	-	-	230
	6.00-6.45	"	21	-	-	-	250
	7.50-7.95	"	47	-	-	-	575
	9.00-9.45	"	44	-	-	-	535
	10.50-10.95	"	53	-	-	-	670
	12.00-12.45	"	31	-	-	-	365
	13.50-13.95	"	27	-	-	-	310
	15.00-15.45	"	37	-	-	-	450

Note:

For cohesive soils, the relationship qu = 13.1 x Design N-value is used for evaluation of the Unconfined Compressive Strength qu, the cohesion Cu = qu/2 and qult = 5.14 x Cu. qall is evaluated using a factor of safety of 3

**Allowable Bearing capacity with settlement limited to approximately 25mm for cohesionless soils read off directly from the Chart (Published by Terzaghi and Peck 1967)*

Appendix 2e

Shear Resistance in Shear Box

EPINEX ENGINEERING SERVICES LTD.

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : SEPTEMBER 2018

EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL (GENERAL SHEAR FAILURE)

BOREHOLE LABEL	DEPTH, D (m)	WIDTH, B (m)	BULK DENSITY, γ (Mg/m^3)x10	COHESION C (KPa)	ANGLE OF FRICTION ϕ (Degrees)	BEARING CAPACITY FACTORS			ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLEBEARING CAPACITY q_{all} (KPa)
						Nc	Nq	N_γ			
Intake Site	1.5	1.0	17.6	35	23	22.1	10.6	7.8	280	3	93
Coagulation / Flocculation	7.5	1.0	17.3	29	19	16.7	6.8	4.5	882	3	294
Filtration	3.0	1.0	17.1	43	27	30.0	16.6	13.7	853	3	284
	4.5	1.0	17.5	23	23	22.1	10.6	7.8	835	3	278
Filter Wash Water	3.0	1.0	17.4	35	23	22.1	10.6	7.8	553	3	184
	4.5	1.0	17.6	26	20	17.7	7.4	5.0	586	3	195
Buffer Filter Wash Water	1.5	1.0	17.3	32	23	22.1	10.6	7.8	275	3	92

$$q_{ult} = CN_C sc + q_o N_q + \tfrac{1}{2}\gamma B N_\gamma s\gamma$$

Where: $q_o = \gamma D$

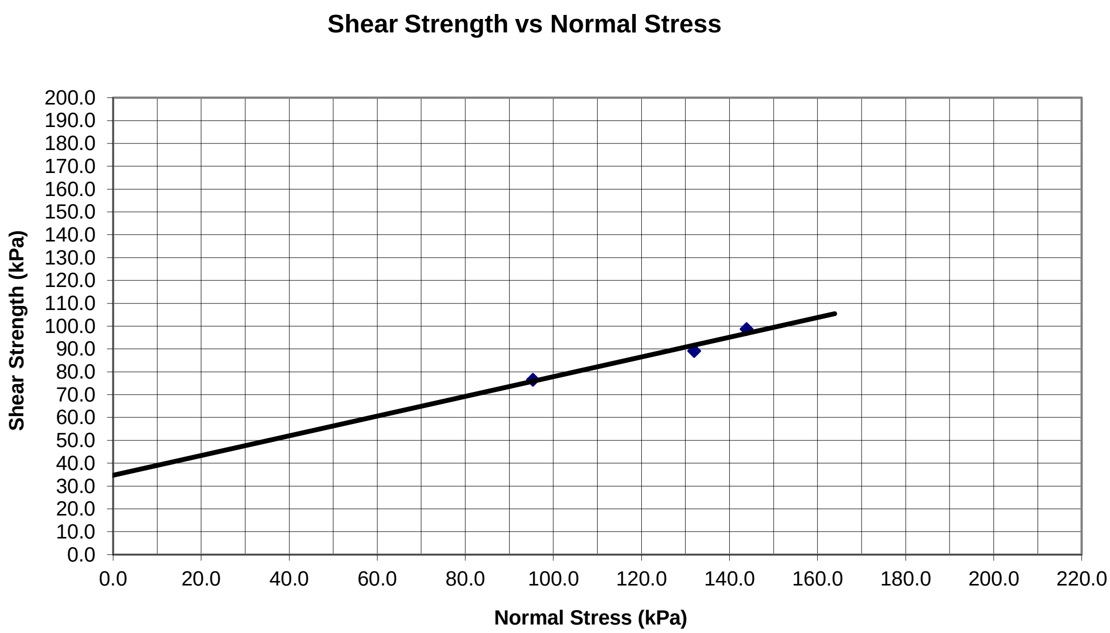
$q_{all} = q_{ult}/F$

For :	strip	square
sc	1	1.3
sγ	1	0.8

SHEAR BOX TEST OF SOILS

Project : Proposed Gulu Water Supply Project	**SAMPLE No: Karuma Intake**
Client : M/s Fichtner Water & Transportation	
Date : September 2018	**DEPTH (m): 1.5**

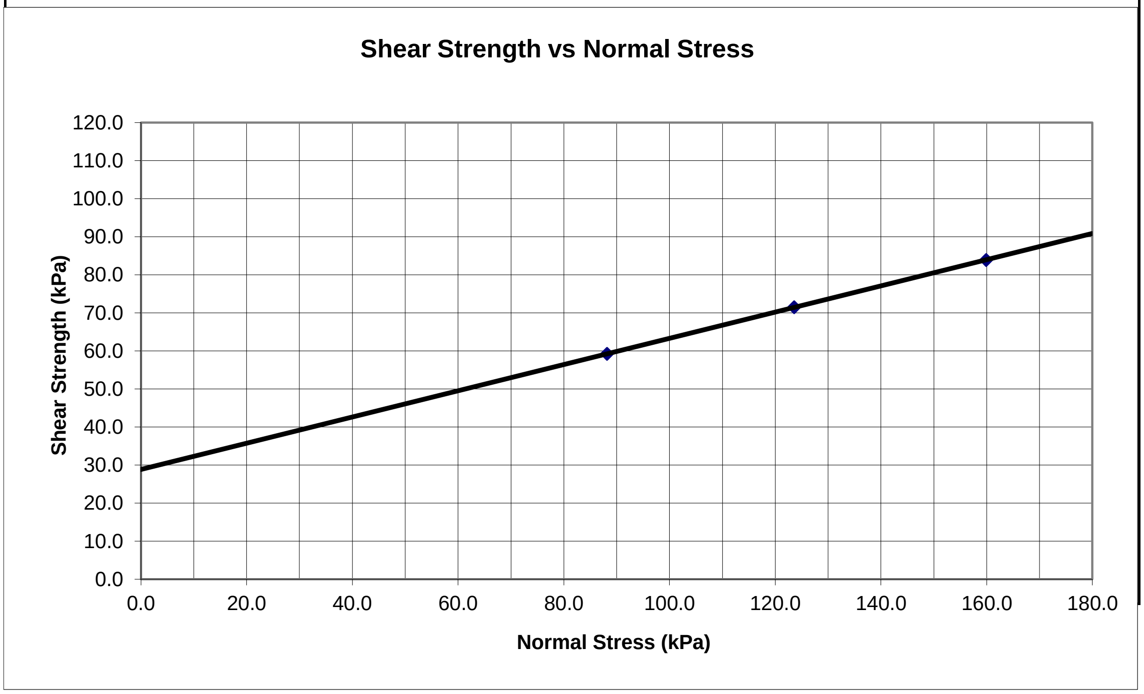
Bulk Density	**Normal Stress**	**Shear Strength**	**Cohesion**	**Angle of Internal Friction**
γ_b	δ_n	τ_s	C	ϕ
Mg/m^3	kPa	kPa	kPa	(Degree)
1.76	95.4	76.5	35	23
	132.0	89.1		
	143.9	98.7		



SHEAR BOX TEST OF SOILS

Project : Proposed Gulu Water Supply Project	**SAMPLE No: Coagulation / Flocculation**
Client : M/s Fichtner Water & Transportation	
Date : September 2018	**DEPTH (m): 7.5**

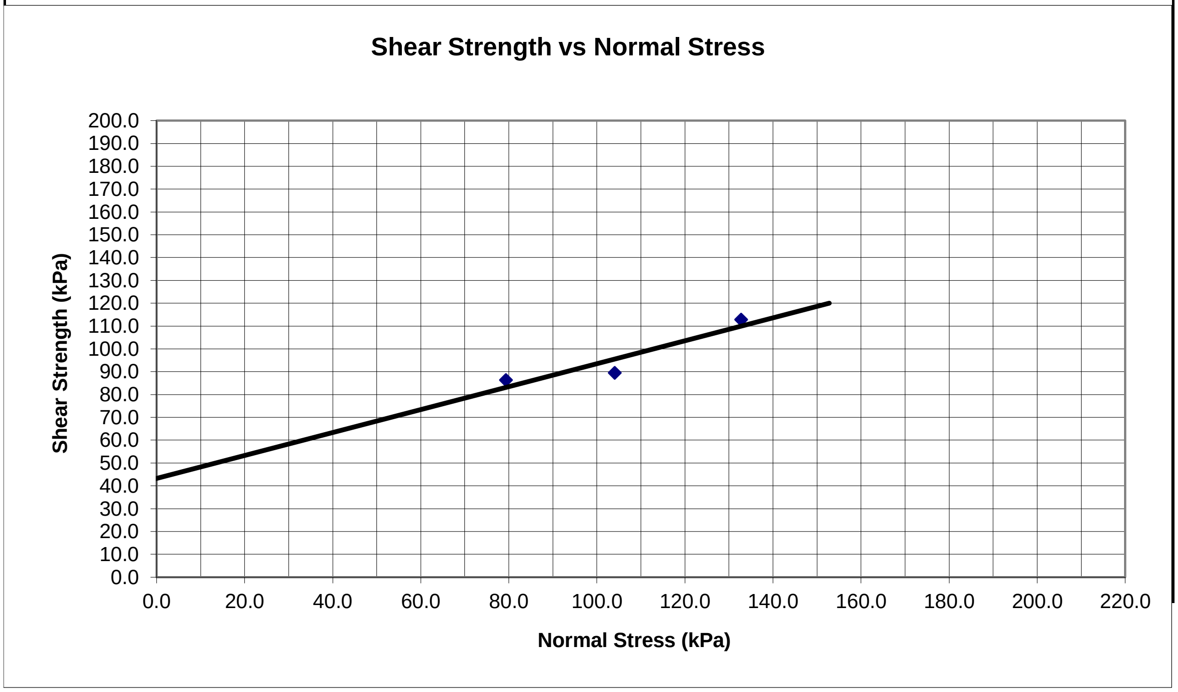
Bulk Density γ_b Mg/m^3	**Normal Stress** δ_n kPa	**Shear Strength** τ_s kPa	**Cohesion** C kPa	**Angle of Internal Friction** ϕ (Degree)
1.73	88.2	59.2	29	19
	123.6	71.5		
	159.9	83.9		



SHEAR BOX TEST OF SOILS

Project : Proposed Gulu Water Supply Project	**SAMPLE No: Filtration**
Client : M/s Fichtner Water & Transportation	
Date : September 2018	**DEPTH (m): 3.0**

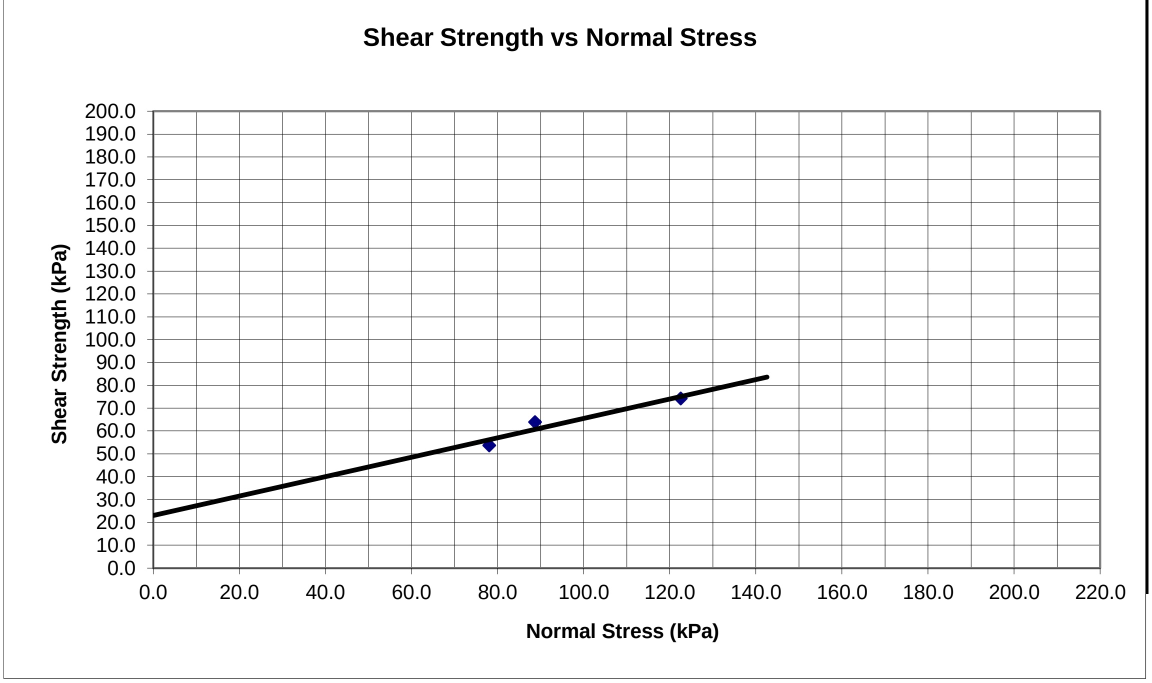
Bulk Density	**Normal Stress**	**Shear Strength**	**Cohesion**	**Angle of Internal Friction**
γ_b	δ_n	τ_s	C	ϕ
Mg/m^3	kPa	kPa	kPa	(Degree)
1.71	79.4	86.4	43	27
	104.1	89.5		
	132.8	112.8		



SHEAR BOX TEST OF SOILS

Project : Proposed Gulu Water Supply Project	**SAMPLE No: Filtration**
Client : M/s Fichtner Water & Transportation	
Date : September 2018	**DEPTH (m): 4.5m**

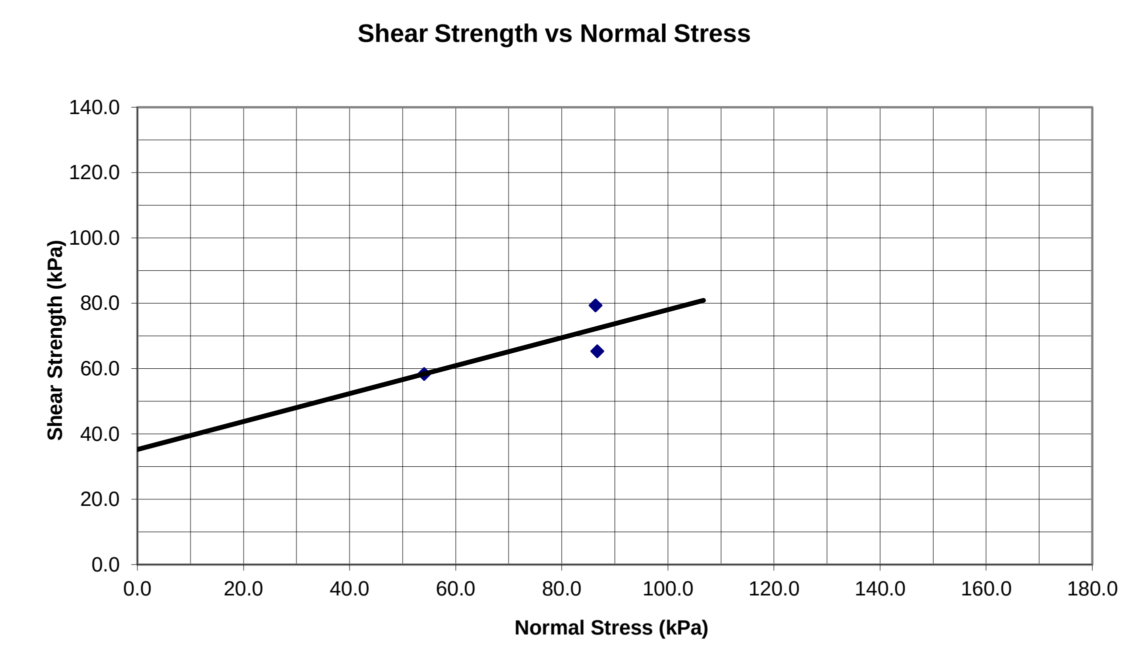
Bulk Density γ_b Mg/m^3	**Normal Stress** δ_n kPa	**Shear Strength** τ_s kPa	**Cohesion** C kPa	**Angle of Internal Friction** ϕ (Degree)
1.75	122.6	74.3	23	23
	88.7	63.9		
	78.1	53.7		



SHEAR BOX TEST OF SOILS

Project : Proposed Gulu Water Supply Project	**SAMPLE No: Filter Wash Water**
Client : M/s Fichtner Water & Transportation	
Date : September 2018	**DEPTH (m): 3.0**

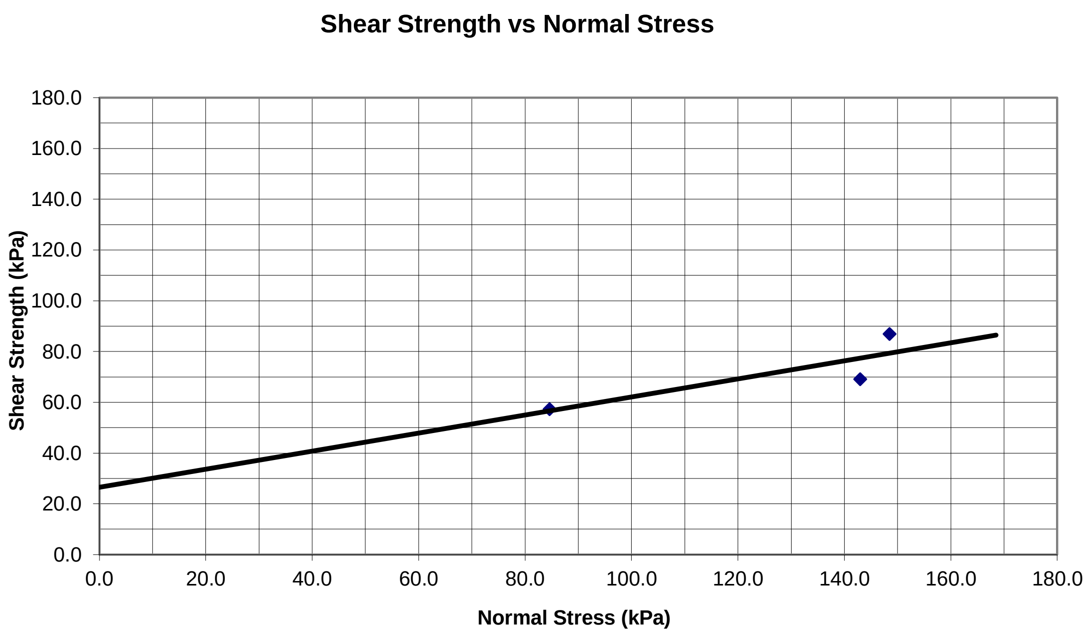
Bulk Density γ_b Mg/m^3	**Normal Stress** δ_n kPa	**Shear Strength** τ_s kPa	**Cohesion** C kPa	**Angle of Internal Friction** ϕ (Degree)
1.74	86.4	79.3	35	23
	86.7	65.3		
	54.1	58.3		



SHEAR BOX TEST OF SOILS

Project : Proposed Gulu Water Supply Project	**SAMPLE No: Filter Wash Water**
Client : M/s Fichtner Water & Transportation	
Date : September 2018	**DEPTH (m): 4.5**

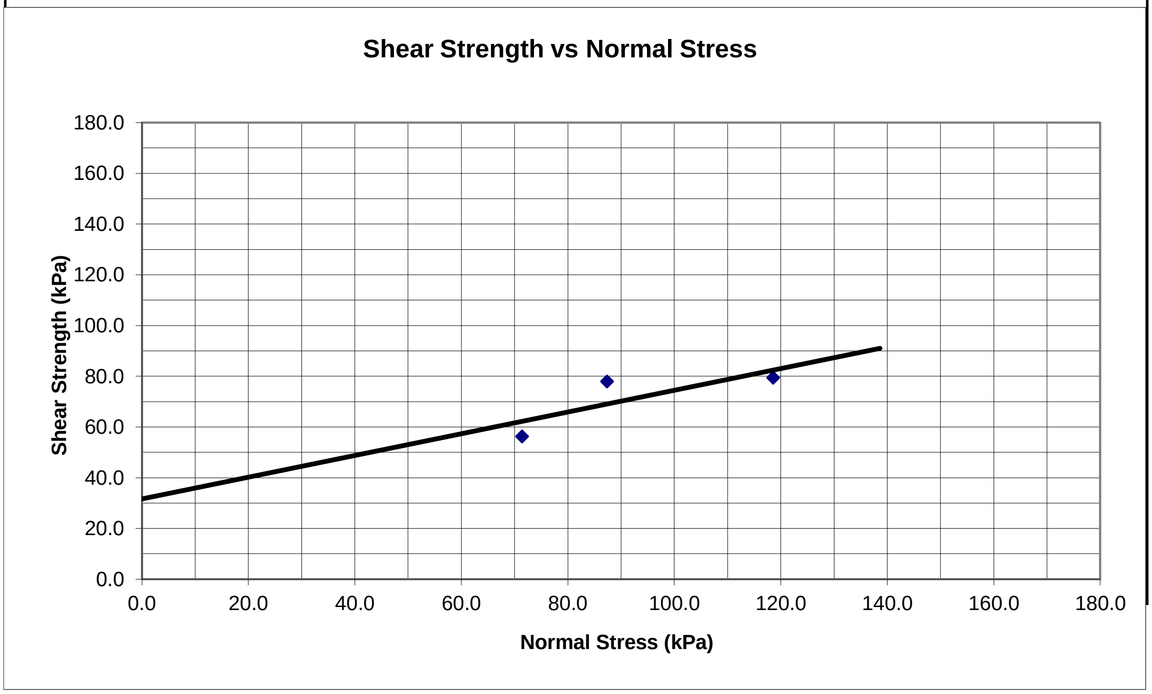
Bulk Density γ_b Mg/m^3	**Normal Stress** δ_n kPa	**Shear Strength** τ_s kPa	**Cohesion** C kPa	**Angle of Internal Friction** ϕ (Degree)
1.76	84.6	57.3	26	20
	143.0	69.1		
	148.5	86.9		



SHEAR BOX TEST OF SOILS

Project : Proposed Gulu Water Supply Project	**SAMPLE No: Buffer Filter Wash Water**
Client : M/s Fichtner Water & Transportation	
Date : September 2018	**DEPTH (m): 1.5**

Bulk Density γ_b Mg/m^3	**Normal Stress** δ_n kPa	**Shear Strength** τ_s kPa	**Cohesion** C kPa	**Angle of Internal Friction** ϕ (Degree)
1.73	118.6	79.4	32	23
	87.4	78.0		
	71.4	56.3		



Appendix 2f

Triaxial Strength Tests Results

EPINEX ENGINEERING SERVICES LTD.

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : SEPTEMBER 2018

TRIAXIAL STRENGTH TESTS - EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL

BOREHOLE LABEL	DEPTH, D (m)	WIDTH, B (m)	BULK DENSITY, γ (Mg/m^3)x10	COHESION C (KPa)	ANGLE OF FRICTION ϕ (Degrees)	BEARING CAPACITY FACTORS			ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLEBEARING CAPACITY q_{all} (KPa)
						Nc	Nq	N_γ			
Intake Site	1.5	1.0	17.6	28	27	30.0	16.6	13.7	439	3	146
Coagulation / Flocculation	7.5	1.0	17.3	26	21	19.1	8.5	5.9	1103	3	368
Filtration	3.0	1.0	17.1	41	29	34.8	20.5	17.7	1052	3	351
	4.5	1.0	17.5	21	25	25.1	12.7	9.7	1000	3	333
Filter Wash Water	3.0	1.0	17.4	35	22	20.7	9.5	6.9	496	3	165
	4.5	1.0	17.6	23	20	17.7	7.4	5.0	586	3	195
Buffer Filter Wash Water	1.5	1.0	17.3	26	27	30.0	16.6	13.7	432	3	144

$$q_{ult} = CN_C sc + q_o N_q + \tfrac{1}{2}\gamma B N_\gamma s\gamma$$

Where: $q_o = \gamma D$

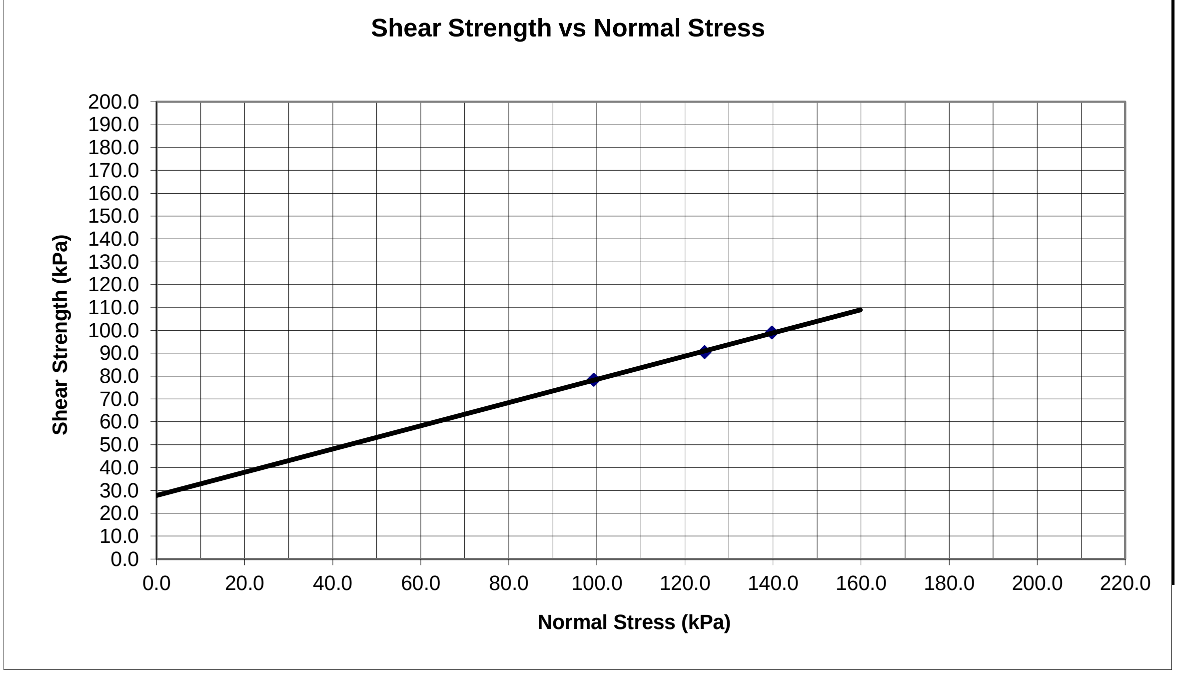
$q_{all} = q_{ult}/F$

For :	strip	square
sc	1	1.3
sγ	1	0.8

TRIAXIAL STRENGTH TEST OF SOILS

Project : Proposed Gulu Water Supply Project	**SAMPLE No: Karuma Intake**
Client : M/s Fichtner Water & Transportation	
Date : September 2018	**DEPTH (m): 1.5**

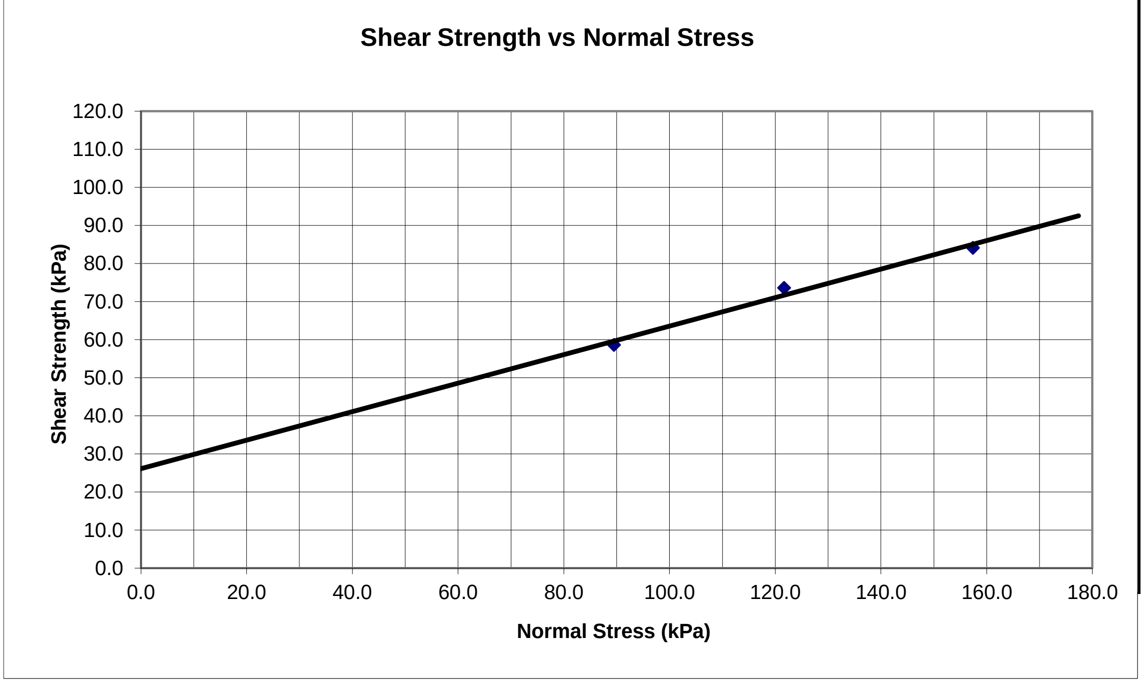
Bulk Density γ_b Mg/m^3	**$(\delta_1 + \delta_3)/2$** δ_n kPa	**$(\delta_1 - \delta_3)/2$** τ_s kPa	**Cohesion** C kPa	**Angle of Internal Friction** ϕ (Degree)
1.76	99.3	78.4	28	27
	124.5	90.5		
	139.8	99.1		



TRIAXIAL STRENGTH TEST OF SOILS

Project : Proposed Gulu Water Supply Project	**SAMPLE No: Coagulation / Flocculation**
Client : M/s Fichtner Water & Transportation	
Date : September 2018	**DEPTH (m): 7.5**

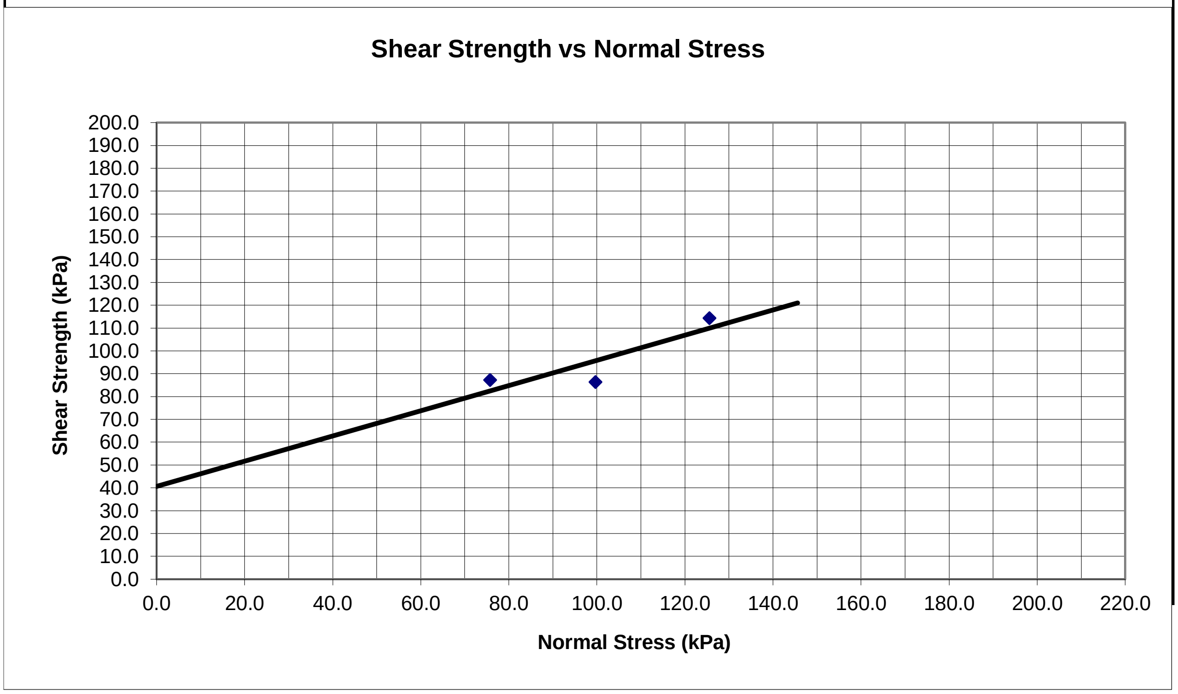
Bulk Density γ_b Mg/m^3	**$(\delta_1 + \delta_3)/2$** δ_n kPa	**$(\delta_1 - \delta_3)/2$** τ_s kPa	**Cohesion** C kPa	**Angle of Internal Friction** ϕ (Degree)
1.73	89.5	58.6	26	21
	121.7	73.6		
	157.4	84.1		



TRIAXIAL STRENGTH TEST OF SOILS

Project : Proposed Gulu Water Supply Project	**SAMPLE No: Filtration**
Client : M/s Fichtner Water & Transportation	
Date : September 2018	**DEPTH (m): 3.0**

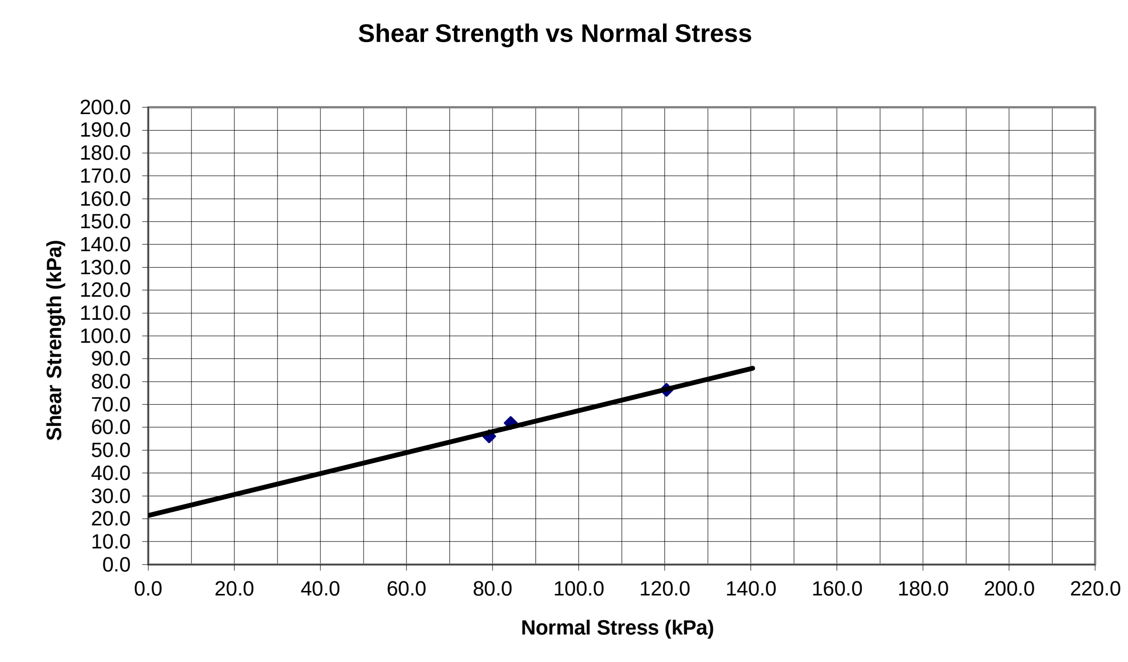
Bulk Density γ_b Mg/m^3	**$(\delta_1 + \delta_3)/2$** δ_n kPa	**$(\delta_1 - \delta_3)/2$** τ_s kPa	**Cohesion** C kPa	**Angle of Internal Friction** ϕ (Degree)
1.71	75.8	87.3	41	29
	99.7	86.3		
	125.6	114.4		



TRIAXIAL STRENGTH TEST OF SOILS

Project : Proposed Gulu Water Supply Project	**SAMPLE No: Filtration**
Client : M/s Fichtner Water & Transportation	
Date : September 2018	**DEPTH (m): 4.5m**

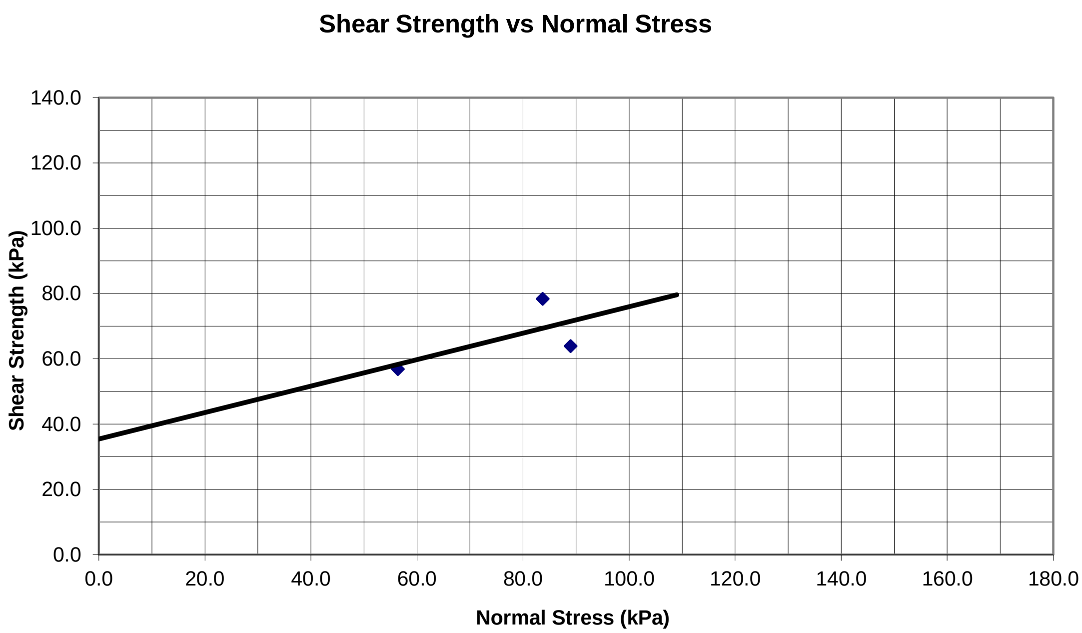
Bulk Density	**$(\delta_1 + \delta_3)/2$**	**$(\delta_1 - \delta_3)/2$**	**Cohesion**	**Angle of Internal Friction**
γ_b	δ_n	τ_s	C	ϕ
Mg/m^3	kPa	kPa	kPa	(Degree)
1.75	120.4	76.4	21	25
	84.2	61.9		
	79.2	56.1		



TRIAXIAL STRENGTH TEST OF SOILS

Project : Proposed Gulu Water Supply Project	**SAMPLE No: Filter Wash Water**
Client : M/s Fichtner Water & Transportation	
Date : September 2018	**DEPTH (m): 3.0**

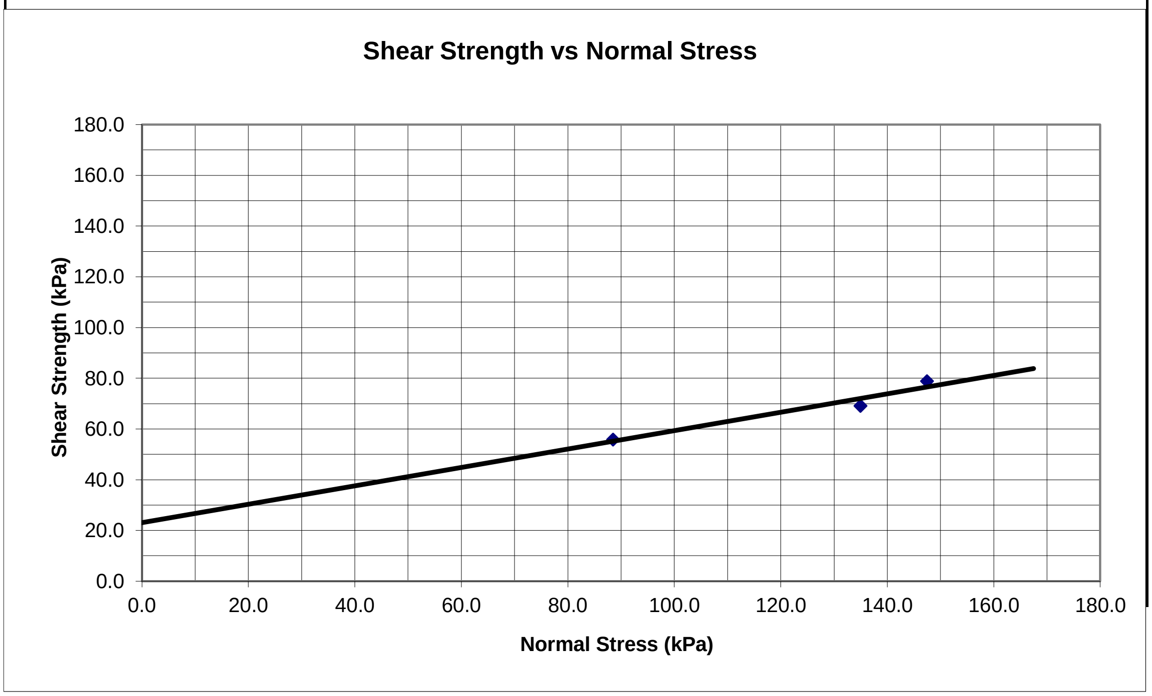
Bulk Density γ_b Mg/m^3	**$(\delta_1 + \delta_3)/2$** δ_n kPa	**$(\delta_1 - \delta_3)/2$** τ_s kPa	**Cohesion** C kPa	**Angle of Internal Friction** ϕ (Degree)
1.74	83.7	78.4	35	22
	89.0	63.9		
	56.4	56.8		



TRIAXIAL STRENGTH TEST OF SOILS

Project : Proposed Gulu Water Supply Project	**SAMPLE No: Filter Wash Water**
Client : M/s Fichtner Water & Transportation	
Date : September 2018	**DEPTH (m): 4.5**

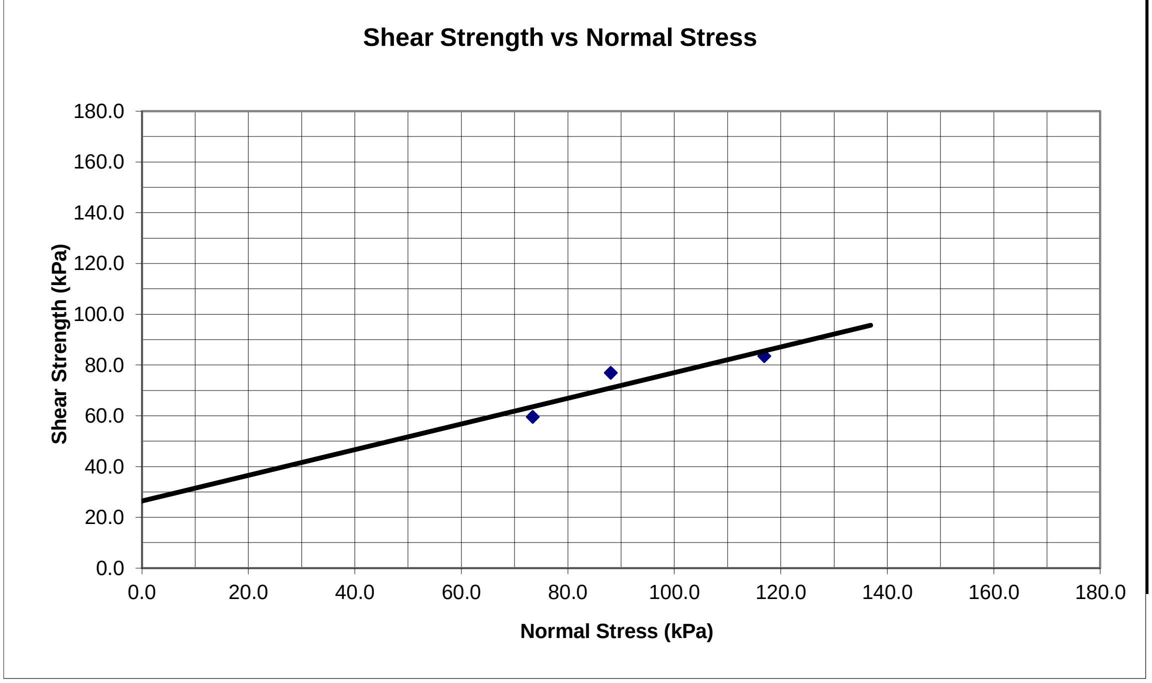
Bulk Density γ_b Mg/m^3	**$(\delta_1 + \delta_3)/2$** δ_n kPa	**$(\delta_1 - \delta_3)/2$** τ_s kPa	**Cohesion** C kPa	**Angle of Internal Friction** ϕ (Degree)
1.76	88.5	55.8	23	20
	135.0	69.1		
	147.5	78.9		



TRIAXIAL STRENGTH TEST OF SOILS

Project : Proposed Gulu Water Supply Project	**SAMPLE No: Buffer Filter Wash Water**
Client : M/s Fichtner Water & Transportation	
Date : September 2018	**DEPTH (m): 1.5**

Bulk Density	**$(\delta_1 + \delta_3)/2$**	**$(\delta_1 - \delta_3)/2$**	**Cohesion**	**Angle of Internal Friction**
γ_b	δ_n	τ_s	C	ϕ
Mg/m^3	kPa	kPa	kPa	(Degree)
1.73	116.9	83.5	26	27
	88.1	76.9		
	73.4	59.6		



Appendix 2g

Unconfined Compressive Strength

Appendix 2g (1)

Unconfined Compressive Strength for Soils Samples

EPINEX ENGINEERING SERVICES LTD.

GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

DETERMINATION OF UNCONFINED COMPRESSIVE STRENGTH FOR THE COHESIVE SOILS SAMPLES OBTAINED FROM SITE

(Tested in Accordance with ASTM D 7012-07)

DATE: SEPTEMBER 2018

COHESIVE SAMPLES FROM KARUMA WATER INTAKE & TREATMENT PLANT BOREHOLES

BH Label	Coordinates (ARC 1960/ UTM 36N)		Depth (m)	Sample Diameter, Ø (mm)	Area (mm²)	Trimmed Length,l (mm)	Length/Diameter Ratio (l/Ø)	Weight, w (Kg)	Density (Kg/m³)	Specific Gravity	Moisture content at test (%)	Breaking Load (kN)	Unconfined Compressive Strength (MPa)
	X (Easting)	Y (Northing)											
Intake Site	418917	248890	1.5	100	7855	200.0	2.00	2.95	1877.7849	2.61	15	1.14	0.145
Coagulation / Flocculation	418852	249269	7.5	100	7855	200.0	2.00	2.90	1845.958	2.63	8	1.19	0.151
Filtration	418846	249249	3.0	100	7855	200.0	2.10	2.86	1820.4965	2.63	15	1.15	0.146
			4.5	100	7855	200.0	2.05	2.84	1807.7658	2.67	22	1.15	0.146
Filter Wash Water	418839	249220	3.0	100	7855	200.0	2.00	3.03	1928.7078	2.66	18	0.98	0.125
			4.5	100	7855	200.0	2.15	2.89	1839.5926	2.62	11	1.12	0.143
Buffer Filter Wash Water	418880	249244	1.5	100	7855	200.0	2.00	2.78	1769.5735	2.64	17	1.13	0.144

Notes: -Temperature at which test was performed 25°C

-All the specimens failed longitudinally

Appendix 2g (2)

Unconfined Compressive Strength for Rock Core Samples

EPINEX ENGINEERING SERVICES LTD.

GEOTECHNICAL INVESTIGATIONS FOR THE PROPOSED INTEGRATED PROGRAMME TO IMPROVE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

DETERMINATION OF UNCONFINED COMPRESSIVE STRENGTH FOR THE DIFFERENT ROCK CORE LAYERS OBTAINED FROM THE BOREHOLES

(Tested in Accordance with ASTM D 7012-07)

DATE: SEPTEMBER 2018

S.No.	BH Label	Depth range	Core Diameter, Ø (mm)	Area (mm²)	Trimmed Length,l (mm)	Length/Dia. Ratio (l/Ø)	Weight, w (Kg)	Density (Kg/m³)	Specific Gravity	Moisture content at test	Breaking Load (kN)	Unconfined Compressive Strength (MPa)
1	BH1 - INTAKE	3.00-3.45	100	7855	150	1.50	4.85	4116	4.23	0.07	519	66.1
		6.00-6.45	100	7855	150	1.50	4.80	4074	4.32	0.08	523	66.6
		7.50-7.95	100	7855	150	1.50	5.20	4413	4.36	0.08	546	69.5
		9.00 -9.45	100	7855	200	2.00	5.70	3628	4.87	0.05	612	77.9
2	Buffer Filter Wash Water	6.00-6.45	100	7855	150	1.50	4.95	4201	4.28	0.09	412	52.5

Notes: -Rate of Loading is 0.65 MPa/s

-Temperature at which test was performed 25°C

* Failure along cleavage

-All the rest of the specimens failed longitudinally

Appendix 2h

Consolidation Test Results

EPINEX ENGIINEERING SERVICES LTD.

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT: M/s FICHTNER WATER & TRANSPORTATION

DATE: SEPTEMBER 2018

SUMMARY OF CONSOLIDATION TEST RESULTS

Test Location	Depth (m)	Coefficient of Volume Compressibility (Mv) in m^2/MN	Range of Mv	Remarks
Intake site	1.5	0.433	0.3 - 1.5	High Compressibility
Coagulation / Flocculation	7.5	0.186	0.1 - 0.3	Medium Compressibility
Filtration - BH1	3.0	0.225	0.1 - 0.3	"
Filtration - BH2	4.5	0.185	0.1 - 0.3	"
Filter Wash Water - BH1	3.0	0.178	0.1 - 0.3	"
Filter Wash Water - BH2	4.5	0.231	0.1 - 0.3	"
Buffer Filter Wash Water	1.5	0.268	0.1 - 0.3	"

EPINEX ENGINEERING SERVICES LTD.

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT: M/s FICHTNER WATER & TRANSPORTATION

DATE: SEPTEMBER 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-1**	DEPTHS	**1.5m**		**INTAKE SITE**
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)		0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3				
MC BEFORE TEST	15	%	BULK DENSITY		1.760	Mg/m^3
WT OF SAMPLE $ RING	252.3	g	DRY DENSITY (γ_D)		1.530	Mg/m^3
WT OF EMPTY RING	85.5	g	SPECIFIC GRAVITY		2.61	
WT OF WET SOIL	166.8	g	e_o		0.705	
WT OF DRY SOIL		g				
			VOID RATIO FACTOR (F)		0.0853	
RING CALIBRATION FACTOR	0.00254					

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY — Incremental Changes: *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.705398	0	0		
30	0.0	98.50	0.2502	0.021334	0.684064	0.02133	30.0	1.705	0.417
50	0.0	235.10	0.5972	0.050919	0.654478	0.02959	20.0	1.684	0.878
108	0.0	453.90	1.1529	0.098308	0.607090	0.04739	58.0	1.654	0.494
225	0.0	647.00	1.6434	0.140131	0.565267	0.04182	117.0	1.607	0.222
432	0.0	876.50	2.2263	0.189837	0.515561	0.04971	207.0	1.565	0.153
Average									0.433

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CLIENT: M/s FICHTNER WATER & TRANSPORTATION

DATE: SEPTEMBER 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-1**	DEPTHS **7.50m**		**COAGULATION/ FLOCCULATION**
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	8	%	BULK DENSITY	1.730	Mg/m^3
WT OF SAMPLE $ RING	251.6	g	DRY DENSITY (γ_D)	1.602	Mg/m^3
WT OF EMPTY RING	86	g	SPECIFIC GRAVITY	2.63	
WT OF WET SOIL	165.6	g	e_o	0.642	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0821	
RING CALIBRATION FACTOR	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.641850	0	0		
30	0.0	86.30	0.2192	0.017995	0.623855	0.01799	30.0	1.642	0.365
50	0.0	145.70	0.3701	0.030381	0.611469	0.01239	20.0	1.624	0.381
108	0.0	193.20	0.4907	0.040285	0.601565	0.00990	58.0	1.611	0.106
225	0.0	232.50	0.5906	0.048480	0.593370	0.00819	117.0	1.602	0.044
432	0.0	289.30	0.7348	0.060323	0.581526	0.01184	207.0	1.593	0.036

Average 0.186

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CLIENT: M/s FICHTNER WATER & TRANSPORTATION

DATE: SEPTEMBER 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-1**	DEPTHS **3.0m**	**FILTRATION**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	15	%	BULK DENSITY	1.710	Mg/m^3
WT OF SAMPLE $ RING	251.6	g	DRY DENSITY (γ_D)	1.487	Mg/m^3
WT OF EMPTY RING	85.2	g	SPECIFIC GRAVITY	2.63	
WT OF WET SOIL	166.4	g	e_o	0.769	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0884	
RING CALIBRATION FACTOR	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.768713	0	0		
30	0.0	95.20	0.2418	0.021384	0.747329	0.02138	30.0	1.769	0.403
50	0.0	134.80	0.3424	0.030280	0.738434	0.00890	20.0	1.747	0.255
108	0.0	246.50	0.6261	0.055370	0.713343	0.02509	58.0	1.738	0.249
225	0.0	389.50	0.9893	0.087492	0.681221	0.03212	117.0	1.713	0.160
432	0.0	476.90	1.2113	0.107124	0.661589	0.01963	207.0	1.681	0.056
Average									0.225

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CLIENT: M/s FICHTNER WATER & TRANSPORTATION

DATE: SEPTEMBER 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-2**	DEPTHS **4.5m**	**FILTRATION**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	22	%	BULK DENSITY	1.750	Mg/m^3
WT OF SAMPLE $ RING	252.3	g	DRY DENSITY (γ_D)	1.434	Mg/m^3
WT OF EMPTY RING	85.4	g	SPECIFIC GRAVITY	2.67	
WT OF WET SOIL	166.9	g	e_o	0.861	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0931	
RING CALIBRATION FACTOR	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY: Incremental Changes Viod ratio	Incremental Changes Pressure	$1+e_1$	m_v m^2/MN
0	0.0				0.861371	0	0		
30	0.0	97.40	0.2474	0.023025	0.838347	0.02302	30.0	1.861	0.412
50	0.0	146.00	0.3708	0.034514	0.826858	0.01149	20.0	1.838	0.312
108	0.0	167.80	0.4262	0.039667	0.821704	0.00515	58.0	1.827	0.049
225	0.0	243.80	0.6193	0.057633	0.803739	0.01797	117.0	1.822	0.084
432	0.0	349.00	0.8865	0.082502	0.778870	0.02487	207.0	1.804	0.067
Average									0.185

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CLIENT: M/s FICHTNER WATER & TRANSPORTATION

DATE: SEPTEMBER 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-1**	DEPTHS	**3.0m**	**FILTER WASH WATER**
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	18	%	BULK DENSITY	1.740	Mg/m^3
WT OF SAMPLE $ RING	252.4	g	DRY DENSITY (γ_D)	1.475	Mg/m^3
WT OF EMPTY RING	85.5	g	SPECIFIC GRAVITY	2.66	
WT OF WET SOIL	166.9	g	e_o	0.804	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0902	
RING CALIBRATION FACTOR	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.803908	0	0		
30	0.0	93.60	0.2377	0.021443	0.782465	0.02144	30.0	1.804	0.396
50	0.0	138.40	0.3515	0.031707	0.772201	0.01026	20.0	1.782	0.288
108	0.0	197.30	0.5011	0.045201	0.758707	0.01349	58.0	1.772	0.131
225	0.0	246.00	0.6248	0.056358	0.747550	0.01116	117.0	1.759	0.054
432	0.0	279.40	0.7097	0.064010	0.739899	0.00765	207.0	1.748	0.021
Average									0.178

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CLIENT: M/s FICHTNER WATER & TRANSPORTATION

DATE: SEPTEMBER 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-2**	DEPTHS	**4.5m**	**FILTER WASH WATER**
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	11	%	BULK DENSITY	1.760	Mg/m^3
WT OF SAMPLE $ RING	252.6	g	DRY DENSITY (γ_D)	1.586	Mg/m^3
WT OF EMPTY RING	85.6	g	SPECIFIC GRAVITY	2.62	
WT OF WET SOIL	167	g	e_o	0.652	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0826	
RING CALIBRATION FACTOR	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0				0.652386	0	0		
30	0.0	96.50	0.2451	0.020251	0.632136	0.02025	30.0	1.652	0.409
50	0.0	134.80	0.3424	0.028288	0.624098	0.00804	20.0	1.632	0.246
108	0.0	259.20	0.6584	0.054394	0.597992	0.02611	58.0	1.624	0.277
225	0.0	387.90	0.9853	0.081402	0.570984	0.02701	117.0	1.598	0.144
432	0.0	511.00	1.2979	0.107235	0.545151	0.02583	207.0	1.571	0.079
Average									0.231

EPINEX ENGINEERING SERVICES LTD.

PROJECT: GEOTECHNICAL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT: M/s FICHTNER WATER & TRANSPORTATION

DATE: SEPTEMBER 2018

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF:	**BH-1**	DEPTHS **1.5m**	**BUFFER FILTER WASH WATER**	
DIAMETER OF SPECIMEN	0.075	m	THICKNESS ($2H_1$)	0.02	m
VOLUME OF SPECIMEN	0.0000884	m^3			
MC BEFORE TEST	17	%	BULK DENSITY	1.730	Mg/m^3
WT OF SAMPLE $ RING	253.5	g	DRY DENSITY (γ_D)	1.479	Mg/m^3
WT OF EMPTY RING	86.5	g	SPECIFIC GRAVITY	2.64	
WT OF WET SOIL	167	g	e_o	0.785	
WT OF DRY SOIL		g			
			VOID RATIO FACTOR (F)	0.0893	
RING CALIBRATION FACTOR	0.00254				

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY: Incremental Changes *Viod ratio*	*Pressure*	$1+e_1$	m_v m^2/MN
0	0.0	0.00			0.785434	0	0		
30	0.0	96.80	0.2459	0.021949	0.763484	0.02195	30.0	1.785	0.410
50	0.0	198.50	0.5042	0.045010	0.740424	0.02306	20.0	1.763	0.654
108	0.0	267.90	0.6805	0.060746	0.724687	0.01574	58.0	1.740	0.156
225	0.0	347.10	0.8816	0.078705	0.706729	0.01796	117.0	1.725	0.089
432	0.0	396.40	1.0069	0.089884	0.695550	0.01118	207.0	1.707	0.032

Average 0.268

Appendix 2i

Compaction Tests Results

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROGRAMME TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : SEPTEMBER 2018

COMPACTION RESULTS FOR BOREHOLE SAMPLES

Location	BH Label	Depth (m)	MDD (Mg/m^3)	OMC (%)	No. of Blows	DD (Mg/m^3)	MC at cast (%)	MC after soak (%)	CBR Value (%)
Karuma Intake	BH1	1.50 - 1.95	1.74	16	30	1.55	16	17	10
Filtration	BH1	3.00 - 3.45	1.75	13	30	1.52	13	16	13
		4.50 - 4.45	1.73	23	30	1.63	23	25	16
Filter Wash Water	BH1	3.00 - 3.45	1.69	19	30	1.52	19	23	8
		4.50 - 4.45	1.72	13	30	1.53	13	16	13
Buffer Filter Wash Water	BH1	1.50 - 3.45	1.84	18	30	1.87	18	20	11

Appendix 2j

Chemical Test Results on Soils and Water Samples

Appendix 2j (1)

Chemical Test Results on Soils Samples

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : SEPTEMBER 2018

CHEMICAL TESTS ON WATER INTAKE & TREATMENT PLANT GEOTECHNICAL BOREHOLES SAMPLES

BH Label	Depth range (m)	Test Results		
		pH	Cl^- (%)	$SO_3^=$ (%)
Karuma Intake BH 1	1.50-1.95	6.52	Traces	Traces
	4.50-4.95	6.53	"	"
Coagulation / Flocculation - BH1	1.50-1.95	6.61	0.004	0.001
	3.00-3.45	6.57	Traces	Traces
	4.50-4.95	6.49	"	"
	6.00-6.45	6.52	"	"
	7.50-7.95	6.56	"	"
	9.00-9.45	6.51	0.005	"
	10.50-10.95	6.54	0.003	"
	12.00-12.45	6.57	0.001	0.002
	13.50-13.95	6.61	Traces	0.003
	15.00-15.45	6.51	"	Traces
Filtration - BH1	1.50-1.95	6.52	0.003	0.002
	3.00-3.45	6.56	0.005	Traces
	4.50-4.95	6.63	Traces	"
	6.00-6.45	6.59	0.001	"
	7.50-7.95	6.53	Traces	"
	9.00-9.45	6.48	"	"
	10.50-10.95	6.55	"	"
Permissible Limits BS 1377		**4.5 Min.**	**0.05 Max.**	**0.2 Max.**

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : SEPTEMBER 2018

CHEMICAL TESTS ON WATER INTAKE & TREATMENT PLANT GEOTECHNICAL BOREHOLES SAMPLES

BH Label	Depth range (m)	Test Results		
		pH	Cl^{-} (%)	$SO_3^{=}$ (%)
Filter Wash Water - BH1	1.50-1.95	6.54	Traces	Traces
	3.00-3.45	6.62	"	"
	4.50-4.95	6.58	"	"
	6.00-6.45	6.55	"	"
	7.50-7.95	6.53	"	"
	9.00-9.45	6.49	0.002	"
	10.50-10.95	6.52	Traces	"
	12.00-12.45	6.51	"	"
	13.50-13.95	6.47	"	"
	15.00-15.45	6.53	0.003	0.002
Buffer Filter Wash Water - BH1	1.50-1.95	6.54	0.001	Traces
	3.00-3.45	6.49	0.004	0.001
	4.50-4.95	6.59	0.002	0.001
	7.50-7.95	6.53	Traces	Traces
Clear Water Tank - BH1	1.50-1.95	6.54	"	"
	3.00-3.45	6.49	0.003	"
	4.50-4.95	6.53	Traces	"
	6.00-6.45	6.61	"	"
	7.50-7.95	6.57	"	"
	9.00-9.45	6.60	"	"
	10.50-10.95	6.56	"	"
	12.00-12.45	6.54	0.002	"
	13.50-13.95	6.53	0.004	0.002
	15.00-15.45	6.58	0.001	Traces
Permissible Limits BS 1377		**4.5 Min.**	**0.05 Max.**	**0.2 Max.**

Appendix 2j (2)

Chemical Test Results on Water Samples

EPINEX ENGINEERING SERVICES LTD.

PROJECT : SOIL INVESTIGATIONS FOR THE INTEGRATED PROJECT TO IMPROVE THE LIVING CONDITIONS IN GULU AND SMALL TOWNS EN-ROUTE IN THE VICTORIA NILE CATCHMENT

CLIENT : M/s FICHTNER WATER & TRANSPORTATION

DATE : SEPTEMBER 2018

CHEMICAL TESTS ON WATER SAMPLES OBTAINED FROM BOREHOLES

BH location / Label	Depth of Water Table (m)	TEST RESULTS						
		pH	Cl^- (mg/l)	SO_3 (mg/l)	TDS (mg/l)	Organic Matter (mg/l)	Colour	Odour
BH1 - Karuma Intake	7.30	6.74	75	35	130	Nil	Colourless	Odourless
Coagulation / flocculation	7.50	6.70	75	55	145	"	"	"
Filtration	5.00	6.78	65	45	135	"	"	"
Filter Wash Water/ Mineralisation/Chlorination dry chamber	3.60	6.75	75	50	130	"	"	"
Buffer Filter wash water	5.10	6.76	80	50	140	"	"	"
Clear Water Tank (Reservoir Pumping Station) location - BH	1.35	6.75	65	40	155	"	"	"
Permissible Limits BS 3148		**6 - 8**	**500 Max.**	**1000 Max.**	**500 Maximum**	**Nil**	**Colourless**	**Odourless**

Traces stand for insignificant amounts of chemicals in the soils

APPENDIX J: PROJECT LAYOUT DRAWINGS

APPENDIX K: CENSUS QUESTIONNAIRE

RESETTLEMENT ACTION PLAN (RAP) QUESTIONNAIRE FOR

KARUMA- GULU WATER SUPPLY PROJECT

Census Questionnaire

RAP conducted by:

AIR WATER EARTH (AWE) LIMITED
Environmental, Civil Engineers & Project Management Consultants
M1, 27 Binayomba Road, Bugolobi
PO Box 22428, Kampala
Office Tel. +256-41-4268466
C: +256-78-2580480/077-2496451
E: mail@awe-engineers.com
W: www.awe-engineers.com

November, 2018

AFFECTED HOUSEHOLD: SOCIO-ECONOMIC SURVEY FORM

Name of interviewer: ______________
Date of interview: ____/______/2018

Village: ______________________________
District ______________________________
Sub-County: ______________________________

SECTION 1: FAMILY INFORMATION

1. **Household Head** (Surname, First Name)______________________________

2. Gender __________________ (M/F)   Nationality______________________

3. Age of respondent: ________

1. (15-25)	☐	4. (46-55)	☐
2. (26-35)	☐	5. (56 and above)	☐
3. (36-45)	☐		

4. Tribe: ______________________________

1. Acholi	4. Lugbara
2. Langi	5. Other (specify)...
3. Alur	

5. How long have you lived in this village? ______________

1. since childhood *go to question 8*	4. 5 – 9 years *go to question 7*
2. over 25 years *go to question 8*	5. 5 years – 3 months *go to question 7*
3. 10 – 24 years *go to question 8*	6. just here for a season *go to question 7*

6. a. What was your reason for moving here?

1 = Marriage	5 = For education
2 = Grazing land	6 = Internal Displacement
3 = Farming	7 = Trade
4 = To find a job	8 = Other (specify)

b. Where did you move from (district, country)______________________________

7. Marital status (tick appropriate response):

1. Single ☐
2. Married (No. of spouses): ☐
3. Divorced ☐
4. Widowed ☐

8. Of what religious affiliation is your HH?

1. Catholic	☐	4. Pentecostal	
2. Protestant	☐	5. SDA	☐
3. Islam	☐	6. Others (specify)	☐

9. Have you ever attended any form of school?
    1. Yes ☐ (If Yes, go to 11)
    2. No ☐ (If No, go to 12)

10. What is the highest level of education you/ attained/currently in?
    1. Primary Education ☐
    2. Ordinary level ☐
    3. A' level ☐
    4. Vocational ☐
    5. University ☐
    6. None ☐

11a. Main occupation of head of household: ____________________________
    1. Private formal/manufacturing ☐
    2. Private formal/service ☐
    3. Private informal retail ☐
    4. Private Agriculture ☐
    5. Public Government ☐
    6. Student ☐
    7. others ☐

12. How far is your workplace (or school for students) from here?
    1. Record as stated_________
    2. Not Applicable________

13. How do you get to work?
    1. No need to travel (I work at home) ☐
    2. By public means ☐
    3. By personal vehicle ☐
    4. By Bicycle/motorcycle ☐
    5. By foot ☐
    6. Others (specify) ☐

14. In what capacity do you live on this land? *(Tick appropriate response)*
    1. Landowner ☐
    2. Tenant (Kibanja) ☐
    3. Co-owner ☐
    4. Squatter ☐
    5. Licensee ☐

15. How long have you lived on / used this land? .... (Years)

16. How did you acquire this land?
    1. Bought ☐
    2. Inherited from parents ☐
    3. Renting ☐

17. Describe tenureship of this land:
    1. Public land ☐
    2. Private *mailo* land ☐
    3. Freehold ☐
    4. Customary ☐
    5. Communal land ☐

18. If your land was to be acquired/taken from you: What mode of compensation would you want?
    - Cash ☐
    - Another similar property ☐

19. OTHER HOUSEHOLD MEMBERS:

How many people live within this HH?____________

How many children above 18 years live within the HH?_______________

How many children below 18 years live within the HH?_______________

				QUESTIONS ABOUT HOUSEHOLD (HH) AND FAMILY MEMBERS AT PERMANENT/HOME ADDRESS	
		How many people stay at your homestead? (permanent and temporary, however excluding visitors)		PLEASE LIST THE DETAILS OF THESE PEOPLE BELOW:	

1. First name	2. Relationship to household head	3. Residential status	4. Marital Status	5. Gender	6. Age	7. Disabled	8. Chronic illness	9. Highest education	10. Literacy (Can he /she read)	11. Skills	12. Employed	13. Cash income	14. Economic activity (Primary)	15. Economic activity (Secondary)
	Head of HH													
Children (under six years)														

Codes specific to this table: codes.....

1. First name – begin with a code and then the code name throughout....
2. Relationship to Household: Household Head = 1 ; Spouse of Household Head; = 2; Child of Household Head = 3; Parent of Household Head = 4; Grandchild of Household Head =5; Other RELATIVES of Household Head = 6; NOT RELATED to Household Head (7)
3. Residential status: Permanent (under normal circumstances sleep 4 nights (or more) a week at this homestead) = 1; Temporary (under normal circumstances sleep less than 4 nights a week at this homestead) = 2
4. Marital status: Single =1; Married =2; Divorced = 3; Widowed=4; Not married but Living Together =5
5. Gender: _______ Male = 1; Female = 2
6. Age (write age in absolute numbers)
7. Disabled ______ Yes=1 Go to a, b, c ,d; No=2
    a. Physical disability
    b. Hearing impairment
    c. Visual impairment
    d. Mental impairment
8. Chronic illness: ___Yes=1 Go to a, b, c ,d; No=2
    a. Diabetes
    b. Heart disease
    c. Sickle cell anaemia
    d. Other, specify
9. Highest education: Never attended school = 1; Kindergarten = 2; Lower primary(p1-4) = 3; Upper primary = (p5-7); O Level = 5; A Level = 6; University Degree 7, Other = 8; Does not know = 9
10. Literacy: Easily =1; with difficulty =2; can't read =3; Don't know =4
11. Skills: Carpentry = 1; Construction =2; Brick making =3; Lumberjack & Board making = 4; Drivers licence (light vehicle) = 5; Drivers licence (heavy vehicle) = 6, Mechanic = 7, Welding & Ironworks = 8; Fishnet Weaver = 9; Arts & Crafts = 10; Canoe & boat makers = 11; Hunter = ______________________ none= 13 ....
12. Employed: Yes = 1; No = 2; Not fit for employment = 3
13. Cash income: Yes = 1; No = 2
14. Economic activity primary:
    1. Going to school
    2. Subsistence farming
    3. Housework
    4. Regular paid public employee
    5. Regular paid private employee
    6. Own account worker e.g., petty trade, business (not subsistence farming)
    7. Casual labourer
    8. Others (specify)................................
    9. Unemployed
    10. Don't know
15. Economic activity secondary:
    1. Going to school
    2. Subsistence farming
    3. Housework
    4. Regular paid public employee
    5. Regular paid private employee
    6. Own account worker e.g., petty trade, business (not subsistence farming)
    7. Casual labourer
    8. Others (specify)................................
    9. Unemployed
    10= None

20. Information on Education

How many children are going to school? Girls_________ Boys_________

Do you have any school age children not going to school? Y / N

If yes how many are they? Boys ______ Girls _________

If children do not go to school, give reason why?

1. Lack school fees ☐
2. Schools very far from home ☐
3. Not interested in school ☐
4. Others *(specify)* ☐

If some or all members of your household dropped out of school, what was the most common reason for this?

1. Unwanted pregnancy/early pregnancy ☐
2. Preferred looking for jobs ☐
3. There was no money for school fees ☐
4. Distance of the school from homestead ☐
5. Other__________________________ ☐

How many Primary schools do you have in your village?_______

What is the distance to the nearest Primary school? _______

1. 100 metres ☐
2. 100-500 metres ☐
3. 1-1.5km ☐
4. Over 5km ☐

How many Secondary schools do you have in your village?________

What is the distance to the nearest secondary school? ______

1. 100 metres ☐
2. 100-500 metres ☐
3. 1-1.5km ☐
4. Over 5km ☐

By what means do the children go to school?

1. Walk ☐
2. By public means ☐
3. By private means ☐
4. others ☐

21. Nature of impact on household

How is your household going to be impacted? (Tick appropriate)

Description of Impact	Yes	No	Description of loss (*e.g. dwelling, shop, fence*).	Permanent (P) / temporary loss (T)
Loss of structures				
Loss of land				
Loss of annual crops				
Loss of perennial crops				
Loss of income				

22. Business owners

State nature of business activity you own that will be affected by the project____________________

1. When did your business start?______________________________
2. Nature of business:______________________________________
3. Informal or formal? Circle answer (*informal*= no permit/ licence; *formal* = has permit/license)
4. Average daily income (hence monthly income: ....shs/month)

Does your business employ workers?

1. Yes ☐
2. No ☐

If yes, are they permanent (P) or temporary (T): P ☐ T ☐ Both ☐

If permanent, fill in table below

Name of worker	Sex	Age	Work done	Monthly/weekly income	Education level

23. Information about structures on land that will be affected by the project.

a) Is this structure/building yours? Yes ☐ No ☐

b) What is the use of the affected building?

Use of Building (e.g. *commercial/ residential*)	Materials (Bricks, clay, wood etc)	Condition (Good,fair poor)	No. of storeys	No. of rooms	Has grid power supply? (Y/N)	Has piped water supply? (Y/N)

24. Information about crops grown

What are common types of food crops grown in the h/h?

____________________ _______________

____________________ _______________

____________________ _______________

____________________ _______________

What crops have you grown that will be affected?

____________________ _______________

____________________ _______________

____________________ _______________

What is the approximate distance to the market from your homestead?

1. Less than 5km ☐
2. 5-10km ☐
3. 10 or more ☐

Do you fertilize your land to improve yields? Yes ☐ No ☐

If yes, indicate what kind of fertilizer used: 1. Organic manure 2. Artificial fertilizers

Does the household keep any animals? 1. Yes ☐ 2. No ☐

If yes, how many of the following animals does the household have?

Animals	Nos.
1) Cattle	
2) Goats	
3) Sheep	
4) Chicken	
5) Ducks	
6) Pigs	
7) Others (specify)	

How does the household graze their animals?

1. Free range (common property)
2. Grazing on private/household property,
3. Others (specify)……………………………

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SECTIONS 2: LIVELIHOOD IN AFFECTED HOUSEHOLDS

Item Description	Cash for year 2014 (Ug. Shillings)	In kind/ barter* e.g. Cow/Labor/Grain
Income from household enterprises *(Note: Together with a PAP, you can make calculations from a person's description of sold goods)*		
Crop farming (name key crops):		
Other agricultural income (e.g. livestock, poultry)		
Non-agricultural income		
Property income		
Rent received from rented property (land, housing)		
Benefits		
Family allowances/social security benefits		
Remittances and assistance received from others		
Other (inheritance, alimony, scholarships, etc)		
Employment		
Formal employment income		
TOTAL	________	________

Do you have a bank account? Yes/No

If yes, where? (E.g. bank name, location, distance): ____________________

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SECTIONS 3: Income of Targeted Household

AWE Engineers
www.awe-engineers.com

What is the main source of Income of HH?

1. Salary
2. Husbands salary
3. Business on land
4. Business located elsewhere
5. Rent collected from affected land
6. Rent collected elsewhere
7. Agriculture activity on affected land
8. Agriculture activity on land elsewhere
9. Fishing
10. Others specify

What other activities generate income from this HH?

1. Fishing
2. Poultry
3. Retail shop
4. Other (specify) ______________________

How much is your monthly income? (Specify amount)…………………………

1. Below 100,000
2. 100,001-200,000
3. 200,001 - 300,000
4. 300,001 - 400,000
5. 400,001 - 500,000
6. 500,001 - 1,000,000
7. 1,000,001 - 1,500,000
8. Over 1,500,00

What is your monthly expenditure levels? (Specify amount)------------------------------

1. Below 100,000
2. 100,001-200,000
3. 200,001 - 300,000
4. 300,001 - 400,000
5. 400,001 - 500,000
6. 500,001 - 1,000,000
7. 1,000,001 - 1,500,000
8. Over 1,500,000

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SECTION 4: HEALTH, INFANT MORTALITY & VULNERABILITY

Are there chronically ill people in the household? YES ☐ NO ☐

If YES: Type of illness: ____________________

Number of births and deaths in the household over the last 12 months:

Births: ____________________

Deaths: ____________________ Cause: ______________

Has a child under age of 5 died in the household in last 3 years? YES ☐ NO ☐

If YES, Cause: ______________

What are the 3 commonest diseases that affect the household?

____

____

____

How much do you spend on treating the above commonest diseases? :______________

Where do you usually seek medical attention from?

1. Home treatment
2. Pharmacy/drug shop
3. Clinic
4. Health Centre
5. Hospital
6. Traditional doctor (including traditional birth attendants)
7. Others (specify)

SECTION 5: SOURCES OF WATER &ELECTRICITY

What are the sources of water for domestic use? *(Tick appropriate response)*

1. Communal borehole, ☐
2. Protected spring ☐
3. Unprotected spring ☐
4. River ☐
5. Piped water in house ☐
6. Open stand pipes ☐
7. Piped water ☐
8. Rain water ☐

What is the distance to the nearest source of safe drinking water?

1. 100 metres ☐
2. 100-500 metres ☐
3. 1-1.5km ☐
4. Over 5km ☐

What fuel do you use in the household for cooking?

1. Firewood ☐
2. Gas ☐
3. Charcoal ☐
4. Solar ☐
5. Kerosene ☐
6. Biogas ☐
7. Electricity ☐
8. Other ☐

What fuel do you use in the household for lighting?

1. Firewood ☐
2. Gas ☐
3. Charcoal ☐
4. Solar ☐
5. Kerosene ☐
6. Biogas ☐
7. Electricity ☐
8. Other ☐

Where does the household disposes of refuse?

1. In a landfill
2. In a dumpsite
3. Burn
4. Dig a compost pit
5.

What is the common facility of disposing human waste by household members?

1. Toilet ☐
2. Pit latrine ☐
3. Community Latrine ☐
4. Bush ☐
5. others ☐

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SECTION 6: Community ties, Cultural/ religious resources:

Are there graves on the land to be affected? YES ☐ NO ☐

If Yes, how many______________

Are there any areas of spiritual significance on your affected property? YES NO

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SECTION 7: EXPENDITURE PATTERNS

Rank the following items according to which you spend most money on per month (1= Most spent on; 7= least spent on)

Item	Amount (shs)	Rank
School fees (per term)		
Healthcare/medical expenses		
Food		
Clothing		
Transport		
Dependants		

Rent		
Airtime		

THANK YOU