Republic of Uganda

Ministry of Water and Environment

Directorate of Water Development

Rural Water Supply and Sanitation Department

Consultancy Services for Feasibility Study and Detailed Engineering Design and Environmental Impact Assessments of Piped Water Supply and Sanitation Systems in Selected 30no Rural Growth Centres Across the Country

Lot 6: Kitenga RGC in Kaliro District, Bulange RGC in Namutumba District, Lugala RGC in Namayingo District, Bukizibu Bumwena and Nango RGCs in Mayuge District.

Contract No: **MWE/CONS/16-17/00081/6**

Detailed Design Report - Bukizibu Bumwena RGC

September 2020

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LIST OF ACRONYMS

AADD	Annual Average Daily Demand
CAD	Computer Aided Design
DoE	Directorate of Environment
DWD	Directorate of Water Development
DWRM	Directorate of Water Resource Management
EMP	Environmental Management Plan
ESIA	Environmental and Social Impact Assessment
FY	Financial Year
GI	Geotechnical Investigation
GIS	Geographical Information System
GoU	Government of Uganda
HEP	Hydro Electric Power
ISO	International Standards Organization
IT	Information Technology
LIDAR	Light Detection and Ranging
masl	Meters Above Sea Level
MWE	Ministry of Water and Environment
NDP	National Development Plan
NGOs	Non-Governmental Organisations
NRW	Non-Revenue Water
O&M	Operation and Maintenance
PACE	Performance, Autonomy and Creativity Enhancement Contract
PC	Performance Contract
PEA	Project Execution Agency
PIU	Project Implementation Unit
DIA	Diameter
SCT	Standard Conditions of Tender
ToR	Terms of Reference
UBOS	Uganda Bureau of Statistics
UWSSS	Urban Water Supply and Sanitation Sector
WATSAN	Water and Sanitation
WHO	World Health Organisation
WTP	Water Treatment Plant
EU	European Union
WSDF-E	Water and Sanitation Development Facility East

0 EXECUTIVE SUMMARY

The Ministry of Water and Environment through the Rural Water and Sanitation Department is responsible for carrying out planning and development of water supply facilities to cover communities or villages (LC1) with scattered population settlements up to 1,500 and Rural Growth Centres (RGCs) with populations between 1,500 and 5,000.

The Ministry of Water and Environment through the Rural Water Supply and Sanitation Department; **Support to Rural Water Supply and Sanitation Projec**t, intends to undertake feasibility study and detailed design of piped water supply schemes in selected 30 Rural Growth Centres across the country.

The Development objective of the project is “Sustainable safe water supply and sanitation facilities, based on management responsibility and ownership by the users, within easy reach of 77% of the rural population by the year 2019 with and 90%-95% effective use and functionality of facilities.

0.1 Objectives of the Consultancy Contract

The services to be provided will include carrying out feasibility studies, detailed engineering design, environmental impact assessments as well as a resettlement action plan for piped water supply systems to ensure the optimal provision of water to the defined project area.

0.2 The Contract

SGI-Studio Galli Ingegneria S.r.l submitted a successful bid for the consultancy services for Lot 6 and the project details are stated as seen below.

Procurement Reference No:	**MWE/CONS/16-17/00081/6**
Subject of Procurement:	**CONSULTANCY SERVICES FOR FEASIBILITY STUDY AND DETAILED ENGINEERING DESIGN AND ENVIRONMENTAL IMPACT ASSESSMENTS OF PIPED WATER SUPPLY AND SANITATION SYSTEMS IN SELECTED 30NO RURAL GROWTH CENTRES ACROSS THE COUNTRY:** **LOT 6: KITENGA RGC IN KALIRO DISTRICT, BULANGE RGC IN NAMUTUMBA DISTRICT, LUGALA RGC IN NAMAYINGO DISTRICT, BUKIZIBU BUMWENA AND NANGO RGCS IN MAYUGE DISTRICT.**

The project is being financed by World Bank and implemented by DWD through Rural Water Supply and Sanitation Department.

0.2.1 Scope of Work

The scope of services as outlined in the Statement of Requirements / Terms of Reference consisting of the following main tasks:

- Inception Report
- Feasibility Study and Preliminary Design Report,
- Final Design Report and Tender Documents
- Environmental Impact Assessment Report

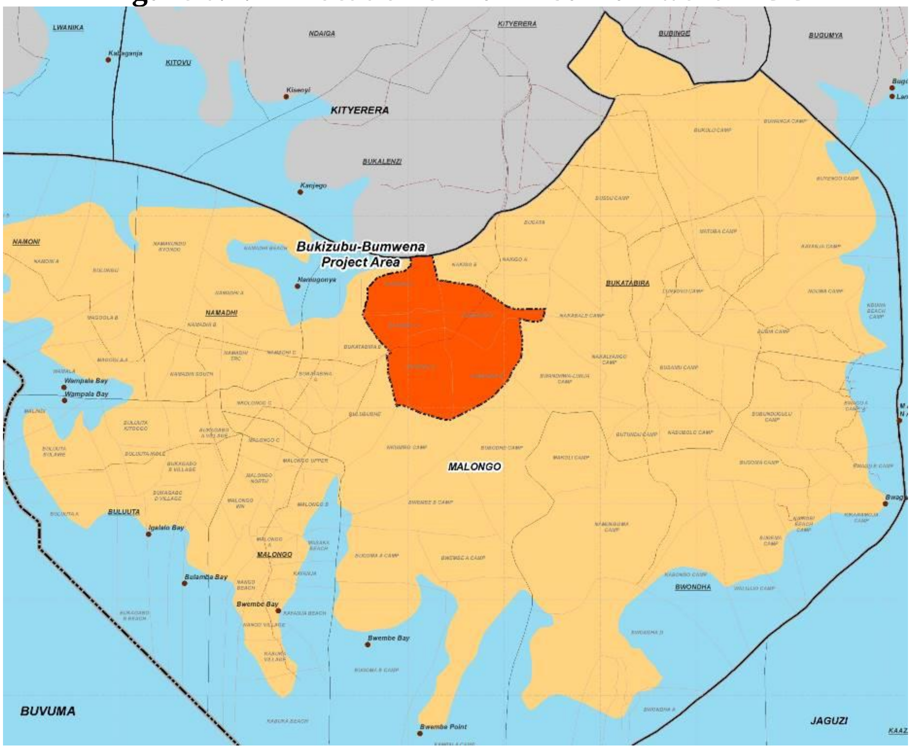
This is the design report for Bukizibu Bumwena RGC Water Supply and Sanitation System. This report is in three volumes namely:

- Volume 1– Basic Report,
- Volume 2– Engineer's Cost Estimate,
- Volume 3– Environmental Impact Assessment (will be submitted after the approval of the basic report and the scope of works.)

0.3 Description and Location of Project Area

Bukizibu Bumwena Center RGC is located in Malongo sub-county, Mayuge District. The sub-county is bordered by Kityerera sub-county to the North and Lake Victoria to the East, West and South thereby making the sub-county into sort of a Peninsula. The RGC is located approximately 40km by road from Mayuge District headquarters along the Mayuge-Bumwena-Malongo road. Figure 0.1 below shows the location of Bukizibu Bumwena.

Figure 0.1: Location of Bukizibu Bumwena RGC



0.4 Consumer Projection

The population for the Project Area was adopted from Uganda Bureau of Statistics based on The Uganda Population and Housing Census 2014. The adopted growth rate from UBOS based on Census, 2014 for Mayuge District is 3.24% p.a. and adopted for the domestic, institutional and commercial activity in the project area. The future domestic population in the project area has been projected as in Table 0.1: Population ProjectionsTable 0.1 overleaf.

Table 0.1: Population Projections

S/County	Parish	Village	Total Population					
			2019	2020	2025	2030	2035	2040
Malongo	Bumwena	Bukizibu A	1,219	1,258	1,475	1,730	2,029	2,380
		Bukizibu B	2,784	2,874	3,371	3,954	4,637	5,438
		Bukizibu C	745	769	902	1,058	1,241	1,455
		Bumwena B	1,516	1,565	1,835	2,152	2,524	2,960
	Parish Total		**6,264**	**6,466**	**7,583**	**8,894**	**10,431**	**12,233**
Bukizibu-Bumwena Water Supply Project Total			**6,264**	**6,466**	**7,583**	**8,894**	**10,431**	**12,233**
Source: UBOS, Mayuge District								

0.5 Summary of Feasibility Study Report

This study had been summarised as seen in Chapter 3 of this report which includes the socio economic household survey conducted, the design criteria used in the preliminary design of the system, the population projections, water demand assessment, water resources assessment, Risk assessment of the sources and the proposed institutional management analysis for the water supply project.

0.6 Detailed Design – Water Supply

The maximum day water demand for the entire system as per indicated in the feasibility study report is 848m^3/day. The water source for the piped water system is ground water in the form of production wells. Currently, one borehole of 27m^3/hr yield (DWD 60824) is already drilled. Due to the inadequate water resource to supply the entire project area, the system has been down sized to a maximum day demand of 397m^3/day which can be met by the available water resource (27m^3/hr BH). This demand serves the entire Bukizibu Villages (A, B &C) and a fraction of Bumwena as shown in Table 2.1. The water supply system infrastructure (storage and distribution network) has been designed for the ultimate year.

The water system will be designed as follows;

a) The submersible pump and chemical dosing equipment will be sized on the basis of the water demand of 397m^3/day.
b) The production well will deliver water into the reservoir tank.
c) Solar energy and HEP have been proposed as means of powering the submersible pumps.
d) A reservoir tank of 130m^3 representing 30% of MDD as placed on a 15m tower has been adopted.
e) A distribution network shall be of length 7.349km as shown in the Table 0.2 below.

Table 0.2: Distribution Network

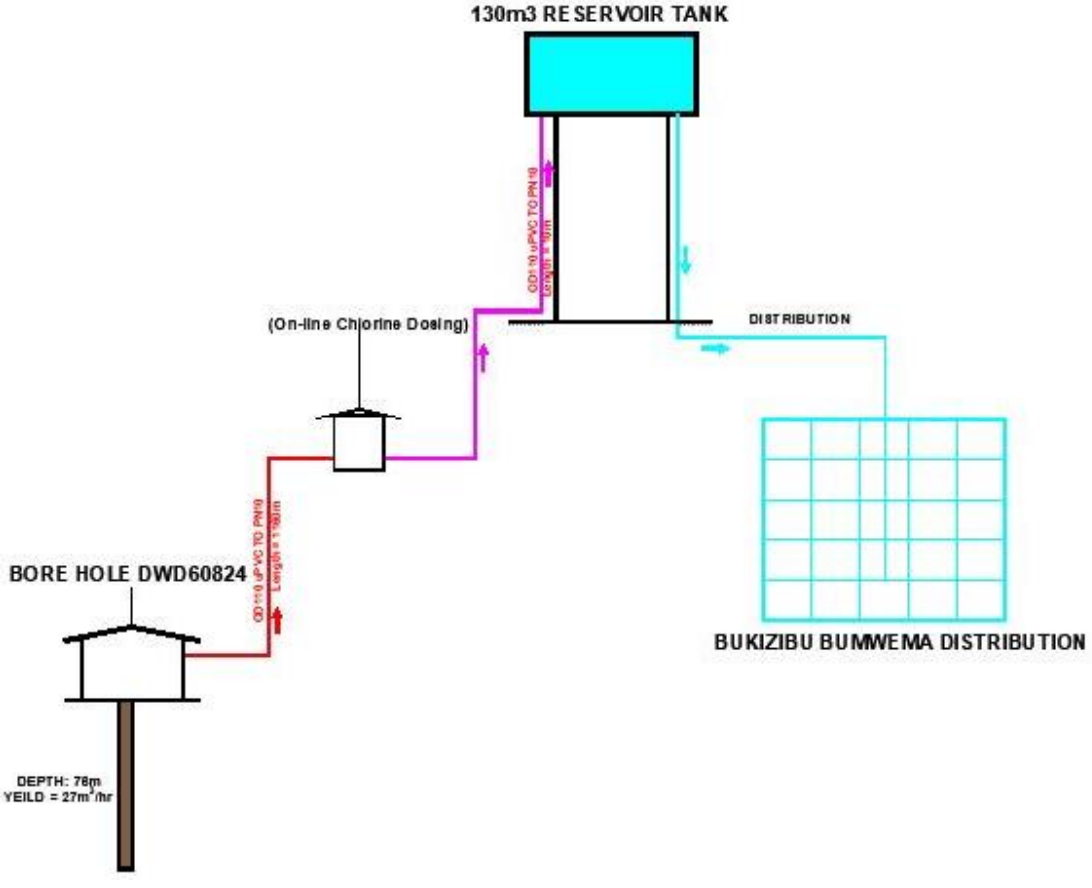
Pipe Details	Length (m)
OD160 uPVC PN6	139.6
OD110 uPVC PN6	320.3
OD90 HDPE PN6	497.0

Pipe Details	Length (m)
OD63 HDPE PN6	629.0
OD50 HDPE PN6	5,763.1
Total	**7,349.0**
Source: Project Estimates	

f) A total of 50 service connections shall be made in the initial year increasing to 355 in the ultimate year.

The schematic drawing illustrating the groundwater water development strategy is shown in Figure 0.2 below

Figure 0.2 Ground Water Schematics



0.7 Detailed Design – Sanitation

It is proposed to construct 1No. 6 stance water borne toilet for whose location will be proposed by the officials during construction.

0.8 Financial Analysis

0.8.1 Capital Cost Estimates

The capital investment cost estimates have been summarised in Table 0.3 overleaf.

Table 0.3 Summary of Capital Cost Estimates

Bill No	Description	Investment Costs UShs
	GENERAL	
BUK G-1	General Items	176,600,000
BUK G-2	Method Related Charges	41,000,000
BUK G-3	Dayworks	6,944,200
	WATER SUPPLY, SANITATION AND EQUIPMENT	
BUK W-1	Borehole Pump Station	73,511,691
BUK W-2	Borehole Pumping Mains	44,825,668
BUK W-3	Storage Reservoir and Site Works	262,217,237
BUK W-4	Distribution Network	147,532,765
BUK W-5	Intensification Network	287,087,470
BUK W-6	Borehole Guard House	20,433,080
BUK W-7	Chemical House	28,547,983
BUK W-8	Water Office	103,077,903
BUK ME-1	Mechanical & Electrical Works	369,523,820
BUK ME-2	Tools and Equipment	32,444,850
BUK S-1	6 Stance Waterborne Toilet (1No.)	61,723,800
	Sub-Total 1	**1,655,470,466**
	Allow for 10% contingency	165,547,047
	Sub-Total 2	**1,821,017,513**
	Allow for 18% VAT	327,783,152
	GRAND TOTAL	**2,148,800,665**

0.8.2 Per Capita Investment Costs

The per capita investments and re-investment costs for each scenario was calculated for the initial year (2020), intermediate year (2030), and the ultimate year (2040). The computations have been based on the served population. The results are given in Table 0.4 below.

Table 0.4 Per Capita Investment & Re-investment Costs

Per Capita Investment Cost	**Currency**	
	(USh)	(US $)
Resident population - Initial year (2020)	455,689	120
Resident population - Intermediate year (2030)	331,273	87
Resident population - Ultimate year (2040)	240,850	63
Per Capita Re-Investment Cost	**Currency**	
	(USh)	(US $)
	(USh)	(US $)
Resident population - Intermediate year (2030)	38,987	10
Resident population - Ultimate year (2040)	28,345	7
Source: Project estimates.		
Note 1US$ = 3800 ***Ush***		
Source: Project Estimates		

0.8.3 Summary of Financial Indicators

The results of the analyses are summarised in the Table 0.5 overleaf.

Table 0.5 Summary of Financial Indicators

Item	Discounted Totals				
	Discounted Rate (%/year)				
	0%	**5%**	**8%**	**10%**	**12%**
Net Present Value (in USh million)	173	-941	-1,237	-1,356	-1,435
Dynamic Prime Cost - O & M (USh/m^3)	1,420	1,477	1,509	1,530	1,550
Dynamic Prime Cost - Total (USh/m^3)	2,400	3,413	4,176	4,742	5,346
Internal Rate of Return	**0.5%**				
Source: Project Estimates					

0.9 Conclusions and Recommendations from the Financial Analysis

0.9.1 Conclusions

The main conclusions are as follows;

a) The Dynamic Prime Cost (DPC) covering the Operation & Maintenance costs at the discounted rate of 5% is USh 1,477 per m^3, which is less than the proposed tariff of USh 2,500 per m^3. If this tariff is charged, the project will cover its O & M costs. This is mainly due to low cost of water production due to the use of a hybrid system powered greatly by solar from the base year (2020) to the intermediate year (2030) and 50% of the production on HEP between the intermediate year (2030) to the ultimate year (2040).

b) The Internal Rate of Return (IRR) is (+0.5%). This means that at the tariff of USh 2,500 per m^3 the system will be able to generate a surplus.

c) As with all DWD implementation projects, investment and re-investment cost recovery is not considered. If the investment and re-investment costs are to be recovered, the tariffs, at the discounted rate of 5%, would have to be at least Ush 3,413.

d) The Net Present Values (NPV) is USh -941 million USh at 5% discounted rate. This means that the investment is not profitable at this (5%) discounted rate. However, it becomes profitable at 0% discount since the NPVs are USh +173 million.

e) The ultimate year 2040 per capita investment costs are US$ 63. According to the 2013 MWE manual, the average per capita investment cost for 12 towns implemented during the FY 2010/11 by MWE was US$ 40. The usually accepted MWE per capita investment costs range is US$ 60 – 120 and from the analysis made, this system falls in this bracket.

In summary therefore, the investments required Bukizibu Bumwena water supply system are justifiable as seen from the per capita investment costs and the IRR.

0.10 Institutional Analysis

Since Umbrella has been designated as the organisation in charge of operations and maintenance of all new systems being constructed directly by Ministry of Water and Environment, and due to the fact that umbrella does not have readily available personnel to run the systems after hand over, the following should be encouraged.

- Umbrella should select its proposed staff and forward their names to the contractor for hands on training during the commissioning of the works. This would normally be one month when both the construction supervision engineer and the contractor are present on site.

- Set up a stake holder's workshop to be attended by the major players as regards the project so as to appraise all parties of their roles in the management and operation of the water supply system.

- Ministry through DWD to conduct regular monitoring surveys to establish the performance of Umbrella, and where necessary render assistance to them.

0.11 Project summary sheet

The project details are summarised as in Table 0.6 below

Table 0.6 Project summary Sheet

Project Name	Bukizibu Bumwena
Project location	Mayuge district, Malongo Subcounty
Project duration	12months
Water sources	BH DWD 60824 (27m^3/hr)
Water treatment	Chlorination
Water demand	397m^3/day
Distribution system coverage	7.349Km
Implementation stage	Single phase
Annual cost	O&M varies yearly with increasing demands

1 INTRODUCTION

1.1 Background

The Ministry of Water and Environment through the Rural Water and Sanitation Department is responsible for carrying out planning and development of water supply facilities to cover communities or villages (LC1) with scattered population settlements up to 1,500 and Rural Growth Centres (RGCs) with populations between 1,500 and 5,000.

Water supply in rural communities is mainly via point sources, which consist of deep boreholes and shallow wells fitted with hand-pumps, springs, gravity flow schemes with public taps, and rain water harvesting tanks. The systems are community managed with support from the respective Local Governments and the Ministry of Water and Environment. The biggest challenge facing the sector is how to serve the water stressed areas where the traditional rural water supply sources cannot easily be implemented coupled with depletion of cheaper water resources in some areas. These districts / Sub-counties are lagging behind in coverage and require more expensive technological option which cannot easily be met. It is therefore important that permanent large ground water well fields are identified, developed and water transferred in bulk to the water stressed areas for multi-purpose use. Such sources should have yields able to meet water needs for sizeable areas/centres that have population beyond 18,000 persons and are therefore economically viable to develop piped water supply systems. This approach is a high cost intervention that will enable equity in coverage especially in water scarce areas.

1.2 General

The Ministry of Water and Environment through the Rural Water Supply and Sanitation Department; **Support to Rural Water Supply and Sanitation Projec**t, intends to undertake feasibility study and detailed design of piped water supply schemes in selected 30 Rural Growth Centres across the country.

1.3 Development Objective

The Development objective of the project is "Sustainable safe water supply and sanitation facilities, based on management responsibility and ownership by the users, within easy reach of 77% of the rural population by the year 2019 with and 90%-95% effective use and functionality of facilities.

1.4 Specific Objectives

The specific objectives are:

- To assist the people in the project areas to obtain safe water supply and sanitation services.
- To provide a water supply system that will be sustainably operated and maintained by the operators,
- To promote better health through improved hygiene, excreta disposal and environmental management practices

1.5 Objectives of the Consultancy Contract

The services to be provided will include carrying out feasibility studies, detailed engineering design, environmental impact assessments as well as a resettlement action plan for piped water supply systems to ensure the optimal provision of water to the defined project area.

1.6 The Contract

SGI-Studio Galli Ingegneria S.r.l submitted a successful bid for the consultancy services for Lot 6 and the project details are stated as seen below.

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The project is being financed by World Bank and implemented by DWD through Rural Water Supply and Sanitation Department.

1.6.1 Scope of Work

1.6.1.1 Introduction

The scope of services as outlined in the Statement of Requirements / Terms of Reference consisting of the following main tasks:

- Inception Report
- Feasibility Study and Preliminary Design Report,
- Final Design Report and Tender Documents
- Environmental Impact Assessment Report

1.6.1.2 Summary of Tasks

The summary of the tasks and sub-tasks to be undertaken under the assignment is given below.

Table 1.1: Summary of Tasks

Component	Design
1	**Mobilisation / Inception Period**
1.1	Mobilisation of the project team
1.2	Project office installation
1.3	Establishment of contact with all parties
1.4	Kick-Off meeting
1.5	Initial site visits

Component	Design
1.6	Preparation and submission of the Inception Report
2	**Feasibility Study and Draft Engineering Design**
2.1	Carry out the feasibility study of water supply system to cover the selected rural growth centres.
2.2	Establish the existing population and settlement patterns particularly at the trading centres and institutions within the sub-counties in potential supply areas.
2.3	Determine the water demand for different areas (settlements patterns) within the sub-counties based on 20-year design horizon.
2.4	Conduct a detailed baseline survey to assess the socio-economic status of the beneficiaries with a view to assess the ability to operate and manage the piped water supply system given the different social-economic activities and cultural diversity.
2.5	Assess the existing sanitation and hygiene situation in the sub-counties and propose improvements. The consultant should note that each of the settlements (trading centres, institutions and rural communities) require different assessment and approach to improve the sanitation situation.
2.6	Carry out a water resources assessment of the of the potential water sources. The consultant should note and analyse all other problems that have of recent affected water supply sources located in the project area. Possibility of exploiting groundwater for localized water supply systems should be studied as an integral part of the water resources assessment.
2.7	Develop feasible options with corresponding institutional arrangement for operation and management of the piped water supply and sanitation system. Note that different management options may be required for different settlement patterns.
2.8	Carry out Environmental Impact Assessment for the proposed water supply project, where adverse conditions are envisaged, propose mitigation measures. The EIA should be conducted independently as per NEMA guidelines. Approved EIA should be submitted to the Ministry of Water and Environment. **COST MUST BE INCLUDED IN THE FINANCIAL BID**.
2.9	Prepare and present the feasibility report and preliminary designs to the district project stakeholders.
2.10	The Output of the feasibility study should include among others the best water supply option to the beneficiaries, the energy mix recommended and the necessary distribution network. It should also include the environmental impact assessment report. The consultant should get an approval of the feasibility report in writing before proceeding to the next stage.
3	**Detailed Engineering Design**
3.1	Carry out detailed topographic surveys for the proposed sites for intakes, storage facilities, transmission mains and agreed distribution networks.
3.2	Design and document the intake works including the treatment system for the piped water supply and sanitation systems with appropriate use of energy. This should include detailed drawings indicating site levels that can be used for construction.
3.3	Prepare detailed engineering hydraulic designs for the transmission mains and distribution networks including profiles and drawings for use during construction.

Component	Design
3.4	Design of hydraulic structures for specific location and site conditions including drawings for use during construction
3.5	Prepare bills of quantities for the intake works, storage facilities, transmission mains and agreed distribution networks. Provide Engineers cost estimate based on the prices of recent bids in Uganda.
3.6	Prepare particular and general technical specifications for all the engineering works including the intake works and structures, storage facilities, transmission and distribution systems.
3.7	Prepare tender documents for construction of the works including information to bidders.
3.8	Formulate a sanitation and hygiene improvement intervention strategy for the beneficiaries of the water supply project. Propose and cost the sanitation facilities to be provided in the project area based on the ministry policy and clearly indicating the possible locations.
3.9	Formulate and develop a sustainable operation, maintenance and management strategy for the proposed water supply system. This should indicate the probable tariffs to sustain the operations and management of the systems.
3.10	Formulate Environmental Impact Assessment for the proposed water supply projects, where adverse conditions are envisaged, propose mitigation measures and environmental management and monitoring plan. The EIA should be conducted as per NEMA guidelines. Approved EIA should be submitted to the Ministry of Water and Environment
3.11	Prepare and present the design reports to the district project stakeholders.

1.6.1.3 Other Tasks Undertaken

The hydrogeological/geophysical tests to site and drill production wells within the project area was carried out and compiled by the implementing authority (DWD) also acting as the client. However, all the reports regarding this activity in the project areas have not yet been submitted to the consultant to form part of the contract as indicated in the terms of reference.

1.7 Expected Outputs

The expected outputs from this assignment include the following:

a) Volume I Design Report,
b) Volume II Engineers Estimates
c) Volume III- Environmental Impact Assessment Report,

Bid documentation associated with this design report in regards to this Water Supply and Sanitation System is as follows:

i) Volume I- Bidding Document- Instructions To Bidders,
ii) Volume II- Bidding Forms and Bills of Quantities,
iii) Volume III- Works Requirements- Technical Specifications,
iv) Volume IV- Works Requirements- Detailed Design Drawings

This is the design report for Bukizibu Bumwena RGC Water Supply and Sanitation System

1.8 Design Report Contents

This is report and is made up of the following chapters:

Chapter 0 **Executive Summary** of all the crucial content in the Report.

Chapter 1 **Introduction:** detailing the project background, objectives, outputs, consultancy contract, and the report contents.

Chapter 2 **Profile of Project Area:** includes the Project Area location, climate, topography, administration and accessibility.

Chapter 3 **Summary of the Feasibility Study Report:** includes the summary of the feasibility report.

Chapter 4 **Design Criteria** involves the agreed criteria to be used in the design of the water supply system

Chapter 5 **Detailed Design** of the Water Supply and Sanitation System for the project area which shall include Consumer Projections, Water Demand Assessment

Chapter 6 **Financial Analysis** of the Water Supply System for the Project Area.

Chapter 7 **Institutional and Management Analysis** of the Water Supply System for the Project Area.

Chapter 8 **Annexes** of key attachments to the report.

2 PROFILE OF PROJECT AREA

2.1 Introduction

Bukizibu Bumwena Center RGC is located in Malongo sub-county, Mayuge District. The sub-county is bordered by Kityerera sub-county to the North and Lake Victoria to the East, West and South thereby making the sub-county into sort of a Peninsula. The district is also bordered by Iganga District to the North, Luuka and Jinja to the North West, Bugiri to the East and Lake Victoria to the South. The RGC is located approximately 40km by road from Mayuge District headquarters along the Mayuge-Bumwena-Malongo road. The coordinates of Bukizibu Bumwena Centre are, 557666.25 m E, 028583.77 m N. The aerial view of Bukizibu Bumwena is given in Picture 2.1 below.

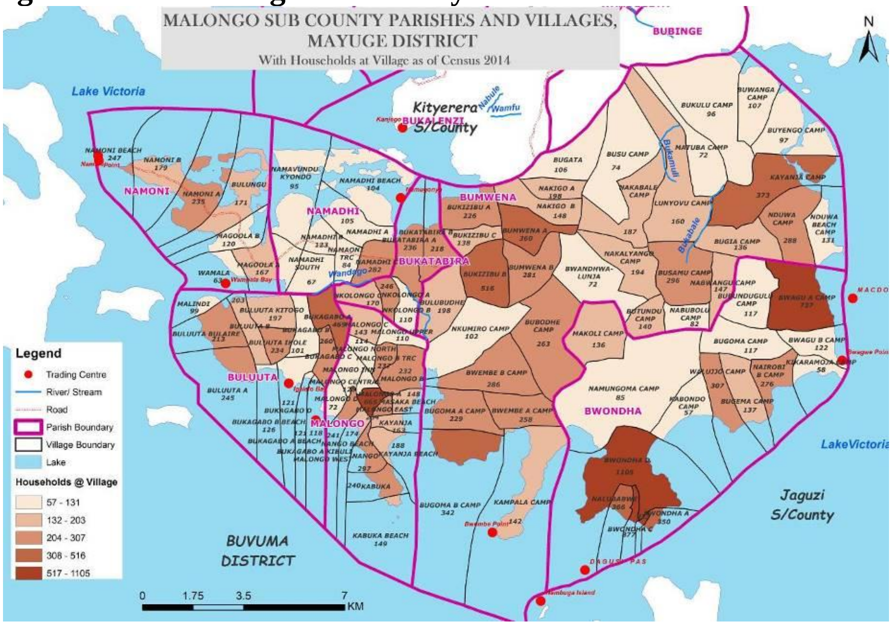
Picture 2.1: Bukizibu Bumwena RGC Project Area

2.2 Administrative Structure

Bukizibu Bumwena is located in Malongo parish, one of 7 parishes in Malongo sub-county as seen in Figure 2.1 overleaf. Bukizibu and Bumwena towns centres that form the project area are approximately 500m apart and separated by a swamp through which an access road connects both town centres. The RGC is currently headed by the Senior Assistant Secretary and consists mainly of shops, a weekly market, a police station, dry processing mills, schools, saloons and other commercial activities.

The RGC project area will comprise villages within the core of the RGC which are; Bumwena B, Bukizibu A, Bukizibu B and Bukizibu C, all located in Bumwena Parish.

Figure 2.1: Malongo Sub-county UBOS Statistical Abstract 2014



According to the National Population and Housing Census 2014, the annual population growth rate for Mayuge district is 3.24 with an average household size of 4.6 for Malongo sub-county. The number of Households (HH) and population in the project area is as given in Table 2.1 below.

Table 2.1: Population by Villages in the Project Area

Sub County	Parish/Ward	Village	UBOS HHs	HH size	Popn 2014	Base Year Popn 2018	Remarks Considered Popn
MALONGO	BUMWENA	BUKIZIBU A	226	4.6	1,040	1,181	100% of Population
		BUKIZIBU B	516	4.6	2,374	2,696	100% of Population
		BUKIZIBU C	138	4.6	635	721	100% of Population
		BUMWENA A	281	4.6	1,293	1,468	25% of Population
TOTAL PROJECT AREA			**1,161**	**4.6**	**5,341**	**6,067**	
Source: UBOS 2014 Mayuge District, Project Estimates							

2.3 Accessibility

The area is accessible off the Mayuge – Bumwena - Malongo gravel road as seen in the Picture 2.2 and Picture 2.3 below.

Picture 2.2: Bumwena Trading Centre

Picture 2.3: Bukizibu Trading Centre

2.4 Settlements

The structures in the core project area include permanent structures with semi-permanent structures being located mainly in the immediate fringe areas. There are typically rural spatial settlements in the fringe area with large open farmland outside the town fringes (see Picture 2.4 to Picture 2.6) below.

Picture 2.4: Structures in Bukizibu centre

Picture 2.5: Living Structure in Project centre

Picture 2.6: Structures in the Fringes of the centre

2.5 Power Source

Bukizibu Bumwena town centres are both connected to the national electricity grid which is the main source of power within and around the two project areas as seen in Picture 2.7 below

Picture 2.7: Electric poles in the Project Area

2.6 Telecommunications

Mobile telecommunications have eased the burden of communication significantly in Uganda since the communications sector was opened to private operator participation. All the major mobile telephone operators (MTN, Airtel and Orange) have services within the project area.

2.7 Commercial Activities

The main commercial activities are retail trade in general merchandise and agriculture (agricultural produce of crops such as Sugar cane, Maize, Coffee, Sweet potatoes, Beans), service industry (restaurants/eating places), petty trade and service provision including subsistence agriculture in the fringes of the project area. Despite being close to the lake, no commercial activity in which fresh fish was seen within the trading centre though at the lake shore. The Picture 2.8 to Picture 2.10 below show the commercial activities carried out within the project area.

Picture 2.8: Dry Milling Processing Plant

Picture 2.9: Food Staff Sold at Daily Road Side Market

Picture 2.10: Other activities within Trading Centre

2.8 Institutions

The main institutions within the project area are listed in Table 2.2 below and shown in Picture 2.11and Picture 2.12, shown below;

Table 2.2: Main Institutions within the Project Area

Type of Institution	Institution Name	Ownership
Market	Market (Daily)	Trading centre
Religious	Catholic Churches	Church
Religious	Protestant Churches	Church
Religious	Seventh Day Adventist	Church
Religious	Mosque	Moslems
School	Bukizibu Primary School	Gov.
Security	Police Station	Gov
NGO	Brac	Private
Source: Field Visits		

Picture 2.11: Mayuge District Local Government Offices

Picture 2.12: Malongo Sub-county Offices

2.9 Water Resources in the Project Area

2.10 Rainfall

Mayuge experiences extreme seasonal variations in monthly rainfall, falling throughout the year in the district. The most rain falls during the 31days centred around April 18 with an average total accumulation of 244mm. The least rain falls around July 10, with an average total accumulation of 57mm, as shown in Figure 2.2.

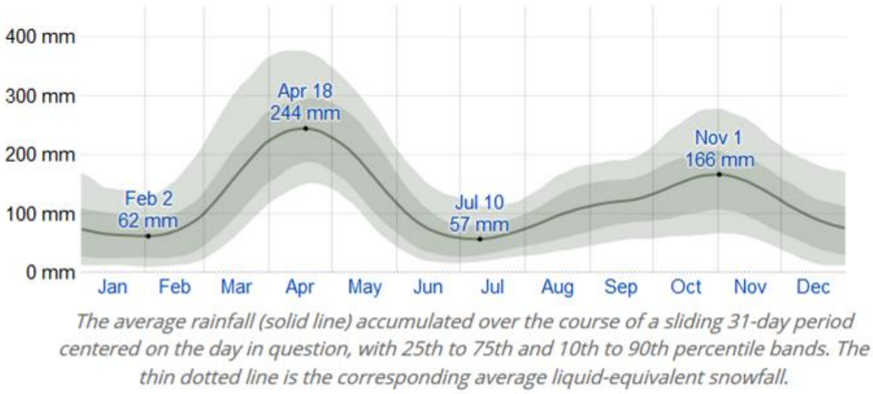


Figure 2.2: Average Monthly Rainfall for Mayuge District

In general, there are two peak rainfall seasons in a year that is April-June and August-November. These two are punctuated with a longer dry season from December-March and a short one from July-August. These seasons enable farmers to have at least two growing seasons. Average rainfall is estimated at 1200mm, with some spatial variation from about 1000mm in the south to 1110mm in southern areas.

2.11 Temperatures

The annual mean average temperature in Mayuge 28.4^{o}C with the lowest being 17^{o}C as shown in Figure 2.3.

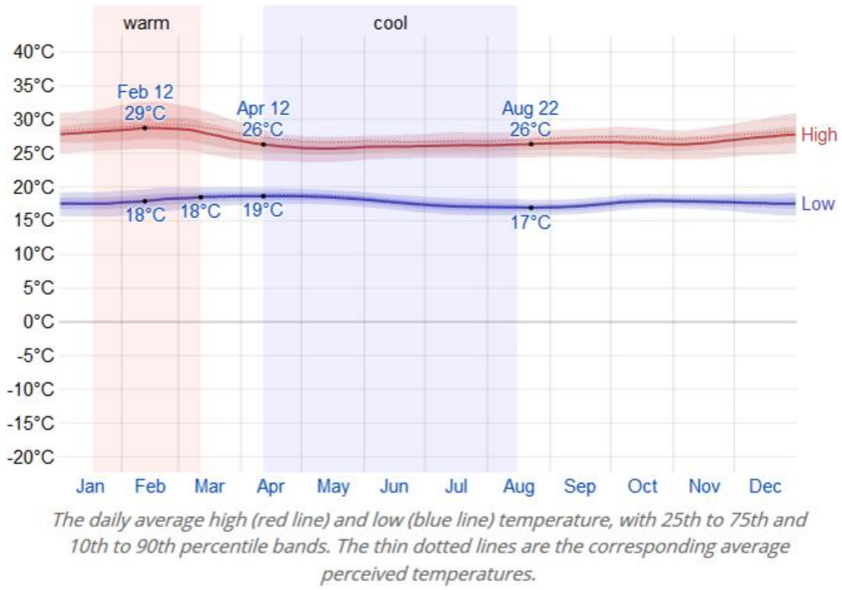


Figure 2.3: Average High and Low Temperatures for Mayuge District

2.12 Sun

The length of the day in Mayuge does not vary substantially over the course of the year, staying within 8 minutes of 12 hours throughout. In 2018, the shortest day is December 22, with 12 hours, 6 minutes of daylight; the longest day is June 21, with 12 hours, 9 minutes of daylight as seen in Figure 2.4 below.

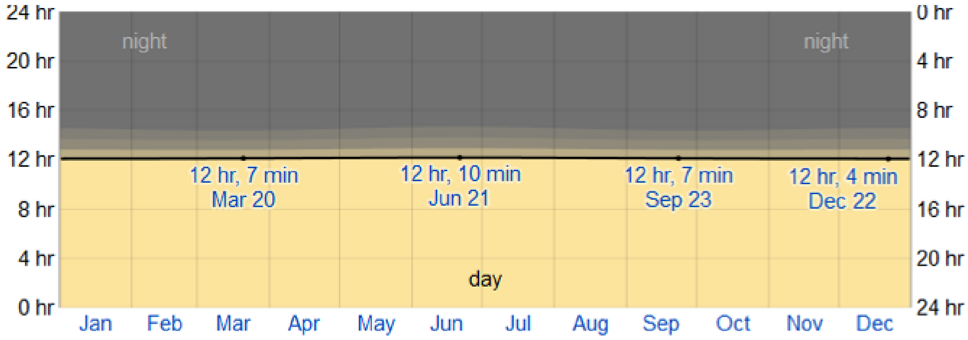


Figure 2.4: Hours of Daylight and Twilight

The earliest sunrise is on November 3, and the latest sunrise is on February 11. The earliest sunset is on November 4, and the latest sunset is on February 11 as seen in Figure 2.5 below.

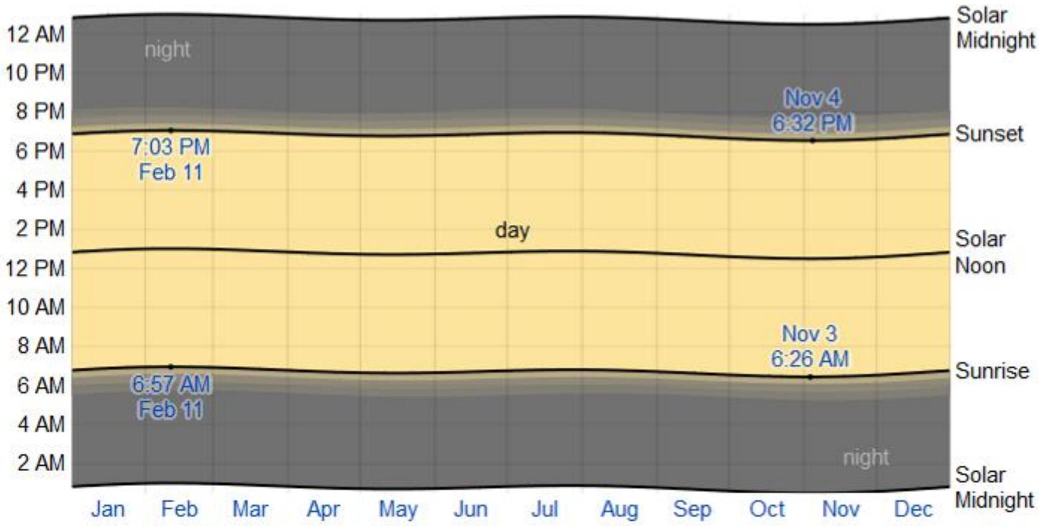


Figure 2.5: Sunrise and Sunset with Twilight

The solar day over the course of the year 2018. From bottom to top, the black lines are the previous solar midnight, sunrise, solar noon, sunset, and the next solar midnight. The day, twilights (civil, nautical, and astronomical), and night are indicated by the colour bands from yellow to grey.

2.13 Humidity

Mayuge experiences extreme seasonal variation in the perceived humidity. The muggier period of the year lasts for 9.4 months, from September to June, during which time the comfort level is muggy, oppressive, or miserable at least 44% of the time. The muggiest month of the year is May, with muggy conditions 90% of the time. The least muggy month of the year is July, with muggy conditions 29% of the time as seen in Figure 2.6 overleaf.

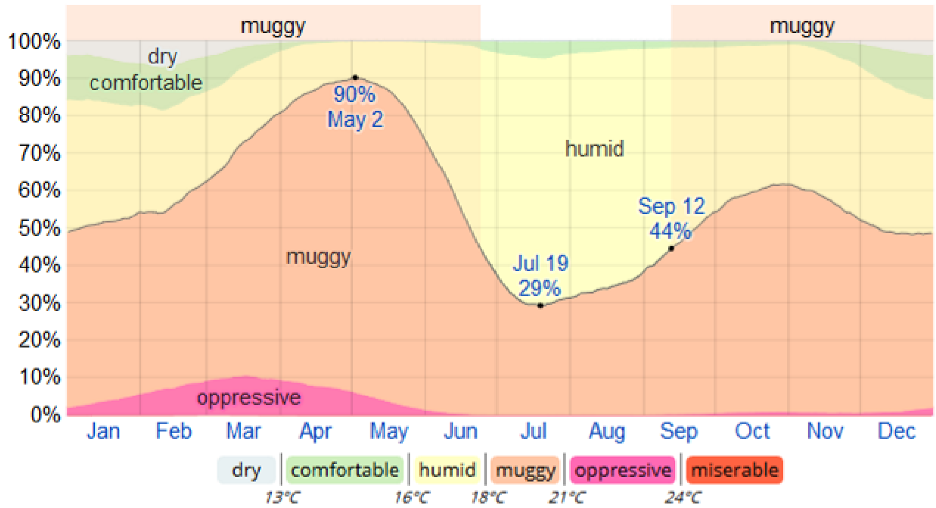
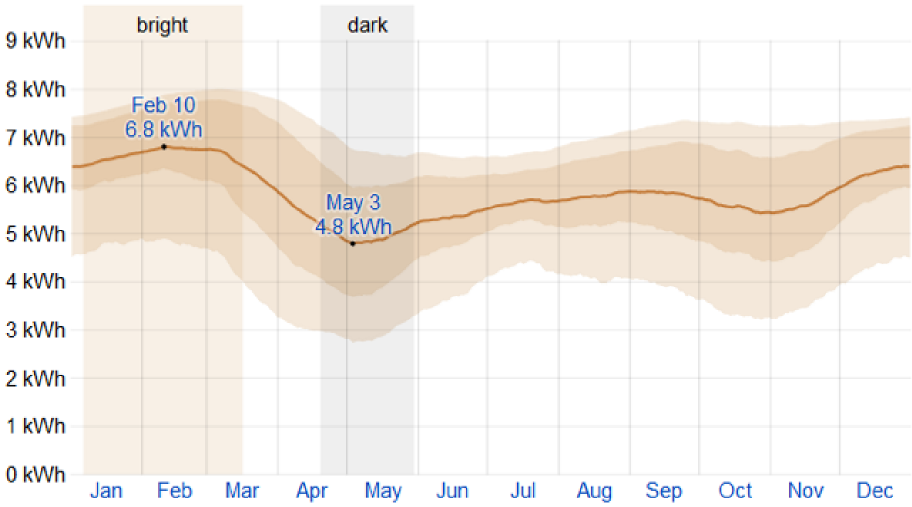


Figure 2.6: Humidity for Mayuge

2.14 Solar Energy

The average daily incident shortwave solar energy experiences some seasonal variation over the course of the year. The brighter period of the year lasts for 2.3 months, from January 6 to March 16, with an average daily incident shortwave energy per square meter above 6.4 kWh. The brightest day of the year is February 10, with an average of 6.8 kWh. The darker period of the year lasts for 1.3 months, from April 19 to May 30, with an average daily incident shortwave energy per square meter below 5.2 kWh. The darkest day of the year is May 3, with an average of 4.8 kWh. Figure 2.7 below best illustrates the solar energy trend in Mayuge district.



The average daily shortwave solar energy reaching the ground per square meter (orange line), with 25th to 75th and 10th to 90th percentile bands.

Figure 2.7: Average Incident Shortwave Solar Energy for Bukizibu Bumwena

2.15 Topography and Vegetation

The topography of Mayuge contains only modest variations in elevation, with a maximum elevation change of 69 meters and an average elevation above sea level of 1,184 meters. The area within district is covered by cropland (69%) and trees (22%), and water (28%).

2.16 Geology

The largest part of the District is underlain by un-differential gneisses formerly seen as part of basement complex. Rhodi, Ferralitic and Nitisol are the predominant soil types with patches of Epi/Endo petricplinthsols superimposed on the Nitsols in isolated and very small areas. This soil type is of relatively high to moderate fertility, they are permeable, with a stable structure, and low erodibility, hence less prone top erosion.

2.17 Soils

Generally, all soil types in Mayuge District are of moderate stable structure, low in erodibility and high fertility, with ability to support a wide range of activities such as settlement, farming and forest establishment.

2.18 Hydrogeology

The project area generally stands at a low slope gradient running into seasonal swamps which form water collection points. Ground water has been taped mainly in form of hand dug wells (20 No.) and boreholes (5No.). Picture 2.13 to Picture 2.16 below show some of the boreholes and hand dug wells being used.

Picture 2.13: Hand dug well in the Bukizibu trading Centre

Picture 2.14: Children Fetching Water from a Hand dug well in the Bumwena trading Centre

Picture 2.15: Hand dug well being dug

Picture 2.16: A Borehole in the Bukizibu

2.19 Surface Water

The major surface water bodies within or close to the project area is Lake Victoria and the swamp which separates Bumwena from Bukizibu. Picture 2.17 overleaf shows local residents collecting water from a culvert placed on the swampy road section of the Bumwena-Bukizibu road within the project area.

Picture 2.17: Bumwena residents Fetching water from Culvert

3 SUMMARY OF FEASIBILITY STUDY REPORT

3.1 Socio-Economic Household Survey

The socio-economic household survey (SEHS) was conducted by the Consultant as part of the community consultation process. The consultation process consisted of the following activities:

- Socio-Economic Household Survey (SEHS),
- Focus Group Discussions (FGDs),
- Key Informant Interviews (KIIs).

This survey was quantitative in nature and explored the household structure, composition and economy, water supply and use, willingness-to-pay and affordability. The overriding objective of the SEHS was to assess the existing socio-economic situation of the project area and the willingness to pay for improved water supply and sanitation services.

The study adopted a mixed method approach. The mixed-method combined the detailed insights and understanding obtained from using qualitative approaches with the ability to generalise to a wider population offered by quantitative data collection. The study involved three key steps which include preparation, Data collection and Data analysis.

3.2 Existing Water Supply and Sanitation Situation

There is no piped water supply system within Bukizibu Bumwena and the residents depend on the lake and hand dug wells and sometimes the culverts for their everyday water needs.

The Ministry of Water and Environment through the Rural Water Supply and Sanitation Department carried out borehole siting and drilling of a proposed production well within the project area.

Bukizibu Bumwena Centres currently has no central piped sewerage facilities. The population in the centre is mainly served by pit latrines as there is no public toilet within any of the trading centres.

As regards solid waste management, there is a designated solid waste dump site in Bukizibu located within the town centre itself where waste is collected at household level and dumped at this site indiscriminately. As for Bumwena centre, the locals collect and dump their rubbish in the swamp nearby.

3.3 Design Criteria

The design criteria and standards for the water supply system are as follows:

a) A design horizon of 20 years with the initial year being 2020, and ultimate year 2040.
b) To allow for increased demands during the dry season, a maximum day peak factor of 1.3 has been proposed. The Transient Population is allowed for within this maximum day factor.
c) To accommodate the peak hourly flow in the major distribution mains from the reservoir(s) to the project area, a peak hour factor of 2.0 will be considered.
d) To limit water hammer effects, the maximum flow velocities in the pipes will be maintained within the range 0.75 -2.5 m/s. For water pumping mains the flow velocities at the optimum pipe diameter shall apply.

e) The pressures in the distribution system will, as far as possible, be kept below PN6 and above PN 1.0.
f) Non-Revenue Water (NRW) / Un-accounted for Water (UfW) has been taken as 20%.
g) It is proposed to size the storage at 30% of the maximum day's demand.
h) The treatment works are assumed to operate for 24 hours per day. The distribution system is assumed to operate 24 hours per day. The pumping stations will however operate for a maximum of 16 h/d.
i) The water quality to be met is the Uganda Drinking Water Standard (US - 201: 1994).

3.4 Consumer Projections

The population for the Project Area was adopted from Uganda Bureau of Statistics based on The Uganda Population and Housing Census 2014. The adopted growth rate from UBOS based on Census, 2014 for Mayuge District is 3.24% p.a. and adopted for the domestic, institutional and commercial activity in the project area. The future domestic population in the project area has been projected as in Table 3.1 below.

Table 3.1: Population Projections

S/County	Parish	Village	Total Population					
			2019	**2020**	**2025**	**2030**	**2035**	**2040**
Malongo	Bumwena	Bumwena A	1,942	2,005	2,352	2,759	3,236	3,795
		Bumwena B	1,516	1,565	1,835	2,152	2,524	2,960
		Bukizibu A	1,219	1,258	1,475	1,730	2,029	2,380
		Bukizibu B	2,784	2,874	3,371	3,954	4,637	5,438
		Bukizibu C	745	769	902	1,058	1,241	1,455
		Nakigo A	1,068	1,103	1,294	1,518	1,780	2,088
		Nakigo B	798	824	966	1,133	1,329	1,559
		Parish Total	**10,072**	**10,398**	**12,195**	**14,304**	**16,776**	**19,675**
Bukizibu-Bumwena Water Supply Project Total			**10,072**	**10,398**	**12,195**	**14,304**	**16,776**	**19,675**
Source: UBOS and Project Estimates								

3.5 Water Demand Assessment

The unit consumption rates are related to the level of service being offered. Three services levels have been used and these include:

- House Connection (HC) - individual house connection with internal plumbing, kitchen, toilet and bathroom with shower;
- Yard Tap (YT) connection - no internal plumbing, no water borne sanitation;
- Stand Post Supply (SP) - usually offsite supply, either from a stand post or purchasing from a neighbour;

In determining the rates of consumption for the domestic water demand, a review was carried out of the rates in current use in the country. The adopted unit consumption rates are as follows.

i) House Connection (HC) - 50 l/c/d;
ii) Yard Tap (YT) connection - 40 l/c/d;
iii) Stand Post Supply (SP) - 20 l/c/d;

For the commercial, institutional and industrial demand these, rates have been adopted from the DWD design manual, 2nd Edition 2013.

The unit consumption rates, the levels of service and the consumer population figures have been used to calculate the water demand at the various tariff levels. The water demand computation has been made based on the ability to pay (5% of Income), with the consumption based on the adopted unit rates, and for the different tariffs of Ush 36, 50 and 83 per 20 litres.

A tariff of Ush 50/20 litres has been adopted. This is the proposed tariff to be charged by the operator of the system. The demands at tariffs of USh 36 and 83 have been calculated for comparative purposes only.

The ranges of the maximum day total demands are given in Table 3.2 below. This is inclusive of 20% un-accounted for water. A maximum day factor of 1.3 has been applied to the average day demands.

Table 3.2: Summary of Maximum Day Demands

Basis of Computation	Demand at Given Tariff (m^3/day)		
	NWSC 2018 (PSP-Urban Poor)	Umbrella Tariff (Proposed Tariff)	NWSC 2018 (Domestic)
	USh 36 / 20L	USh 50/ 20L	USh 83 / 20L
ATP (5% Income)	882	848	824
Source: Project Estimates			

In the design, the system will be sized on the basis of the Ability to Pay (ATP) the tariff of USh 50 per 20 litres. The design demand is therefore 848m^3/day.

3.6 Water Resources Assessment

3.6.1 Groundwater Assessment

A borehole (DWD 60824) has been drilled within the project area. According to data provided by the Client, the borehole has a yield of 27m^3/hr.

The ultimate year (2040) maximum day demand is 848m^3/day. An analysis was carried of the borehole yield required for 16-hour pumping regime in Table 3.3 below.

Table 3.3: Available Borehole Capacity

Bukizibu Bumwena	Maximum Day Demand at Given Tariff (m^3/day)		
	USh 36/ 20L	USh 50/ 20L	USh 83/ 20L
Demand- m^3/hr	55.12	53.02	51.53
1 No Borehole	55.1	53.0	51.5
2 No Boreholes	27.6	26.5	25.8
3 No Boreholes	18.4	17.7	17.2
4 No Boreholes	13.8	13.3	12.9
Source: Project Estimates			

For the proposed tariff of USh 50 / 20L, the borehole yields required are as shown. Considering the safe yield of the DWD 60824 (27m^3/hr), it will be sufficient to meet the demand in the ultimate year over a 16hr pumping regime.

3.6.2 Surface Water Assessment

The reliable surface water source near Bukizibu Bumwena RGC is Lake Victoria. Lake Victoria can meet the water demands of Bukizibu Bumwena RGC.

3.6.3 Conclusion

Lake Victoria can meet the water demands of Bukizibu Bumwena RGC. The challenge is one of designing an intake that can continue operating efficiently given the known large variations in Lake level. Additionally, the capital cost and maintenance costs or the water treatment processes might be prohibitive.

Groundwater sources in the form of production wells are viable sources of water for the piped water supply system. The existing borehole (DWD 60824) can supply the piped water supply system. Though there will be a need for drilling of a 27m3/hr borehole in order to meet the demand in the ultimate year (2040)

3.7 Risk Assessment and Source Protection

The vulnerability of all potential water resources regarding different hazards and conflicts is assessed. If possible, mitigation or protection measures are indicated accordingly.

3.8 Preliminary Design – Water Supply

In the design, the system will be sized basing on the maximum day water demand of 848m^3/day in the year 2040.

3.8.1 Ground Water Scenario I – Production Boreholes (2No.)

Currently, one borehole of 27m^3/hr yield is already drilled. The consultant has assumed that the deficit of 26.02m^3/hr shall be met by drilling one well of 26.02m^3/hr average yield.

This development scenario will consist of the following aspects

a) Siting and Drilling of 1No. New production well of capacity 26.02m^3/hr.
b) Construction of 2No. new borehole pumping houses
c) Installation of 2No. submersible pumps
d) Construction of transmission mains from the boreholes to the reservoir
e) Construction of a new Storage Reservoir.
f) Construction of a distribution network for the project area.
g) Making New Consumer Connections

3.8.2 Surface Water Supply Development Scenario

This development scenario consists of Lake Victoria as the source of water and contains the following aspects:

a) Construction of an intake on Lake Victoria in Bukizibu A village (555906.52E, 30115.78N)
b) Construction of semi conventional Water Treatment Plant nearby.

c) Pumping of treated water from the treatment plant to a storage reservoir located on the hill in the Project area.
d) Construction of a new Storage Reservoir for the project area.
e) Construction of a distribution network in the project area.
f) Making new Consumer Connections.

3.8.3 Comparison of the two Scenarios

The components of the different water supply scenarios are summarised in Table 3.4 below

Table 3.4: Different Water Supply Scenario Components

Component	**Ground Water (MDD 847.39m³/day)**	**Surface Water (MDD 847.39m³/day)**
	Scenario I (2No. Boreholes)	**Scenario II (Lake Victoria)**
Intake Capacity (m^3/day)	848	889.76
Raw Water Pump House / Intake Structure	2No. (1No. Existing, 1No. To be Drilled)	1No.
Raw Water Riser Main (m)		
OD110 HDPE PN16	150	
Raw Water Pumping Main (m)		
OD160 uPVC PN10		400
OD100 uPVC PN10	4618	
Raw Water Pumps (Submersible)		
Head 157m, Flow 26.5m^3/hr	1No.	
Head 152m, Flow 26.5m^3/hr	1No.	
Head 21m, Flow 55.61m^3/hr		2No. (1No. Duty, 1No. Standby)
Water Treatment Plant Capacity (m^3/day)		847.39
Alum Dosing Unit and House		1No.
Rapid Hydraulic Mixing Tank		1No.
Aerator		1No.
Flocculator - Horizontal Flow Type		1No. Channel with 5No. Compartments 9.1mx2.0mx1.2m deep with 5 Baffels
Sedimentation Tanks		2No. Rectangular 12mx3.5mx2.0m deep
Rapid Gravity Sand Filters		4No. Rectangular 10.8mx2.0mx2.0m deep
Clear Water / Contact Tank		2No. Rectangular 9.2mx4.2mx2.0m deep
Sludge Drying Beds		1No.
Sump, Chlorine Dosing Unit and Pump House	1No.	1No.
Clear Water Pumps		
Head 88m, Flow 52.96m^3/hr		2No. (1No. Duty, 1No. Standby)
Backwash Pumps		
Head 12m, Flow 2.65m^3/hr		2No. (1No. Duty, 1No. Standby)
Backwash Tank		
		1No. 30m^3 elevated on 10m tower
Air Blowers		
		2No. (1No. Duty, 1No. Standby)

Component	**Ground Water (MDD 847.39m³/day)**	**Surface Water (MDD 847.39m³/day)**
	Scenario I (2No. Boreholes)	**Scenario II (Lake Victoria)**
Clear Water Pumping Mains (m)		
OD160 uPVC PN10		4,021
Storage Tank	254m³ Cold Pressed Steel Tank Elevated on 10m steel tower	
Distribution Network (m)	12,783	
Source: Project Estimates		

3.9 Preliminary Design - Sanitation

The proposed interventions in sanitation are centred on the construction of 1No. 6 stance water borne toilet facility; whose location will be proposed by the officials during construction.

3.10 Financial Analysis of the Water Supply Scenarios

3.10.1 Capital Cost Estimates

The preliminary capital investment costs determined for the proposed water supply and sanitation interventions as summarised in Table 3.5 below.

Table 3.5 Summary of Combined Capital Cost Estimates

Item	**Description**	**Capital Investment Costs**	
		Ground Water Supply	**Surface Water Supply**
		Scenario I	**Scenario II**
1.0	Preliminary and General Items	281,137,431	479,568,347
2.0	Intakes / Pump House	115,877,378	448,836,450
3.0	Treatment Plant Works	150,000,000	1,635,000,000
4.0	Raw Water Transmission Mains	167,605,715	17,256,403
5.0	Clear Water Transmission Mains	0	229,941,552
6.0	Storage Reservoir	320,390,000	320,390,000
7.0	Distribution Network and Service Connections	856,401,214	856,401,214
8.0	Water Office	120,000,000	120,000,000
9.0	Mechanical and Electrical for Raw Water	990,100,000	272,985,950
10.0	Mechanical and Electrical for Clear Water	91,000,000	894,871,900
	Sub Total 1	**3,092,511,738**	**5,275,251,817**
	Allow 10% Contingency	309,251,174	527,525,182
	Sub Total 2	**3,401,762,911**	**5,802,776,998**
	Allow 18% VAT	612,317,324	1,044,499,860
	Grand Total	**4,014,080,235**	**6,847,276,858**
Source: Project Estimates			

3.10.2 Per Capita Investment Costs

The per capita investments and re-investment costs for each scenario was calculated for the initial year (2020), intermediate year (2030), and the ultimate year (2040). The computations have been based on the served population. The results are given in Table 3.6 overleaf.

Table 3.6 Per Capita Investment & Re-investment Costs

Per Capita Investment Cost	Scenario I		Scenario II	
	Currency		Currency	
	(USh)	(US $)	(USh)	(US $)
Resident population - Initial year (2020)	386,043	102	658,519	173
Resident population - Intermediate year (2030)	280,626	74	478,697	126
Resident population - Ultimate year (2040)	204,019	54	348,019	92
Per Capita Re-Investment Cost	**Currency**		**Currency**	
	(USh)	(US $)	(USh)	(US $)
Resident population - Intermediate year (2030)	44,837	12	79,515	21
Resident population - Ultimate year (2040)	32,597	9	57,809	15
Source: Project estimates.				
Note 1US$ = 3800 ***Ush***				
Source: Project Estimates				

3.10.3 Summary of Financial Indicators

The results of the analyses are summarised in the Table 3.7 below.

Table 3.7 Summary of Financial Indicators

Item	Discounted Totals				
	Discounted Rate (%/year)				
	0%	**5%**	**8%**	**10%**	**12%**
Scenario I (Ground Water)					
Net Present Value (in USh million)	742	-1,512	-2,124	-2,376	-2,548
Dynamic Prime Cost - O & M (USh/m^3)	2,043	2,080	2,102	2,115	2,128
Dynamic Prime Cost - Total (USh/m^3)	2,999	3,919	4,620	5,143	5,703
Internal Rate of Return	**1.2%**				
Scenario II (Lake Victoria)					
Net Present Value (in USh million)	-2,031	-4,588	-5,158	-5,351	-5,455
Dynamic Prime Cost - O & M (USh/m^3)	1,518	1,565	1,592	1,610	1,626
Dynamic Prime Cost - Total (USh/m^3)	2,798	4,354	5,559	6,461	7,432
Internal Rate of Return	**-1.9%**				
Source: Project Estimates					

3.10.4 Conclusions and Recommendations from the Financial Analysis

The main conclusions are as follows:

1) The Dynamic Prime Cost (DPC) covering the Operation & Maintenance costs only is lowest for the Surface Water Supply Scenario II (Utilisation of Lake Victoria). The DPC at the discounted rate of 5% is USh 1,565 per m^3, which is less than the proposed tariff of Ush 2,500 per m^3. If this tariff is charged, the project will cover its O & M costs and will generate a surplus. The DPC, at the discounted rate of 5%, for the Ground Water Supply Scenario I (Utilisation 2 No. boreholes) is USh 2,080 per m^3, which is less than the proposed tariff of Ush 2,500 per m^3. If this tariff is charged, the project will cover its O & M costs and will generate a surplus. In summary, the both Scenarios can cover their O&M costs from the tariff

of USh 2,500 per m^3. This is mainly due to low Energy Costs of Water Production due to the use of solar as the power source.

2) The best Internal Rate of Return (IRR) is got from the Ground Water Supply Scenario (+1.2%) with the Surface Water Scenario having an IRR of -1.9%. This means that at the tariff of USh 2,500 per m^3 the Ground Water Scenario provides a surplus hence can break even while the Surface Water Scenario will not break even.

3) As with all DWD implementation projects, investment and re-investment cost recovery is not considered. If the investment and re-investment costs are to be recovered, the tariffs, at the discounted rate of 5%, would have to be at least USh 3,919 and USh 4,354 per cubic metre for the Ground and Surface Water Scenarios respectively.

4) The Net Present Values (NPV) are USh -1,512 million and USh -4,588 million (at 5% discounted rate) for the Ground and Surface Water Scenarios respectively. This means that the investment is not profitable for both the Water Scenarios at 5% discounted rate however it becomes profitable at 0% discount for the Ground Water Scenario since the NPV is USh +742 million.

5) The ultimate year 2040 per capita investment costs are US$ 54, and 92 for the Ground and Surface Water Scenarios respectively. According to the 2013 MWE manual, the average per capita investment cost for 12 towns implemented during the FY 2010/11 by MWE was US$ 40. The usually accepted MWE per capita investment costs range is US$ 60 - 120. All scenarios fall in this bracket.

The ground water option is thus recommended for the supply of water to the Bukizibu Bumwena RGC piped water supply system on condition that when the proposed production well is sited and drilled, the yields obtained are able to meet the demand.

3.10.5 Combined Preliminary Capital Cost Estimates

The preliminary capital investment costs determined for the proposed water supply and sanitation interventions as summarised in Table 3.8 below.

Table 3.8 Summary of Combined Capital Cost Estimates

No.	Proposed Intervention	Cost Estimates
1	Water Supply Investments	4,014,080,235
2	Sanitation Investments	271,100,000
	Total	**4,285,180,235**
Source: Project Estimates		

3.11 Environmental Impact Assessment

The environmental impact assessment will be submitted as a stand-alone report once the proposed source has been approved by the client, hence will not be elaborated upon from this point forward.

3.12 Institutional Analysis

3.12.1 Introduction

Management of the GFS s will follow standard DWD management procedures. A private operator (PO) under the supervision of the DWD will run the system. The modalities for engaging the private operators are embedded in the policies of the directorate and have been applied in various projects with reasonable success. This chapter reviews these experiences and discusses the way forward for Bukizibu Bumwena RGC Water Supply and Sanitation System.

3.12.2 Private Sector Participation (PSP) in Water Supply Systems

Water schemes require formal management arrangements, a legal basis for ownership and supervision as well as the ability to expand services to meet the growing demand for services.

Management of small water schemes evolved in Uganda over the years from traditional public sector models through demand-driven community approaches in the 1990's to private sector participatory arrangements in recent years since 2001.

The concept of private sector participation (PSP) was initiated by the Water and Sanitation Program-Africa and developed by the DWD. The urban water sector reform study of 2002 re-affirmed the need for PSP in the management of urban water services. On the basis of these initiatives, private sector participation in the management of water schemes was introduced in the urban water services in Uganda.

POs were selected on basis of competitive bidding following a pre-qualification phase. Successful bidders later negotiated and signed contracts with the Water Authorities of the respective schemes they had applied for. The contracts are performance-oriented and they run for two or three years upon which the parties are required to negotiate renewal.

The organizational arrangements for PSP in Water Schemes essentially follow a semi-decentralised policy framework whereby the POs have considerable autonomy in operational decision-making on all aspects of engineering and commercial matters. However, the DWD retains full powers for procurement of water meters, chemicals and spare parts. In centralising procurement of these essential service inputs, DWD might perhaps be undermining the operational functioning of the schemes. The likely impact of these arrangements is that overall progress in performance may be hampered by financial constraints unless revenues accruing can supersede the costs of achieving the 'set targets' and POs are permitted more flexibility in operational expenditure. But financial control objectives can be achieved without necessarily undermining operational efficiency. One way is implementing procedures that compel transparency and accountability but preserve operational autonomy.

Generally, before the incoming of the umbrella organisations to operate and maintain the systems, the Water Authorities (Councils) adequately carried out the functions in relation to the supervision of the POs. POs were paid from the joint bank account in time and good cooperation was established between the Councils and POs in most of the cases.

3.12.3 Umbrella Organisations

The Umbrella organisation (Eastern, Western, Central and Northern) was gazzeted by the Ministry of water and Environment to operate and maintain all the water supply and sanitation systems within their regions of operation.

For the case of Bukizibu Bumwena water supply and sanitation system, Eastern Umbrella is designated as the Water Authority and Operator of this System due to the fact that the project lies in its area of jurisdiction.

The roles of the stakeholder as regards this system are as follows

3.12.4 The Operator (Eastern Umbrella)

The Operator (Eastern Umbrella) manages the water supply and sanitation, including:

- Operating the system in accordance with the set guidelines
- Maintaining the system,
- Developing the system,
- Billing the consumers,
- Collecting revenue,
- Receiving applications for and making new connections,
- Making extensions to the system or assets,
- Attend to all customers,
- Prepare draft business plans for the authority,
- Prepare regular status reports for the operations of the system,
- Maintain regular accounts for submission to the Ministry.
- To operate a Management Information System (MIS) as provided by the Ministry.
- Keep records of the operation of the water supply system - both physical and technical,
- Ensures that all accounts are audited,
- Set and publish Tariff & Charges

3.12.5 The Consumer

The consumer has the following obligations:

- Pay on time for the water used, services provided, and penalties imposed,
- Ensure the security of the meter.

3.12.6 Recommendations

Since the Umbrella has been designated as the organisation in charge of operations and maintenance of all new systems being constructed directly by Ministry of Water and Environment, and due to the fact that umbrella does not have readily available personnel to run the systems after hand over, the following should be encouraged.

- Umbrella should select its proposed staff and forward their names to the contractor for hands on training during the commissioning of the works. This would normally be one month when both the construction supervision engineer and the contractor are present on site.

- Set up a stake holder’s workshop to be attended by the major players as regards the project so as to appraise all parties of their roles in the management and operation of the water supply system.

- Ministry through DWD to conduct regular monitoring surveys to establish the performance of Umbrella, and where necessary render assistance to them.

4 DESIGN CRITERIA

4.1 Introduction

This section is concerned with the establishment of design parameters and standards, for water supply and sanitation, to be used in the design of the project interventions. The criteria has been adopted from the Ministry of Water and Environment Water Supply Design Manual, 2nd Edition (2013).

4.2 Design Criteria- Water Supply

The proposed design criteria is detailed as follows and summarized in Table 4.5 overleaf.

4.2.1 Design Horizon.

The DWD Water Supply Design Manual (2013) gives the following timeline for the determination of the design Horizon:

1) Initial Year- Year of Commissioning Water Supply System taken to be 5 years after commencement of Feasibility Studies.

2) Ultimate Year- 20 years Design Horizon from Initial Year.

Based on the above, the Initial Year is 2020 with the Ultimate Year 2040 Government of Uganda which is in tandem with the government's Vision 2040[1] by the National Planning Authority.

Furthermore, in order to cater for any water supply system improvement Immediate measures which may be undertaken prior to the long-term measures being commissioned in the Initial year, a Base Year of 2019 has been taken for planning purposes. Therefore, in summary, the design is based on:

a) Base Year- 2019.
b) Initial Year- 2020.
c) Ultimate Year- 2040.

4.2.2 Hydraulic Peak Factors

The Average Day Demand which depicts the daily water consumption by domestic and non-domestic consumers is subject to seasonal climatic variations, harvest seasons, and other factors such as transient population, and religious and cultural festivals. To allow for increased demands during these seasons, a maximum day peak factor of 1.3 is proposed.

[1] **Uganda Vision 2040** provides development paths and strategies to operationalize Uganda's Vision statement which is "**A Transformed Ugandan Society from a Peasant to a Modern and Prosperous Country within 30 years**". The Vision 2040 is conceptualized around strengthening the fundamentals of the economy to harness the abundant opportunities around the country. The identified opportunities include: oil and gas, tourism, minerals, ICT business, abundant labour force, geographical location and trade, water resources, industrialisation, and agriculture among others that are to date considerably under-exploited. Achieving the transformational goal will thus depend on the country's capacity to strengthen the fundamentals including: infrastructure (energy, transport, water, oil and gas, and ICT); Science, Technology, Engineering and Innovation (STEI); land use and management; urbanisation; human resource; and peace, security and defence. (Ref: http://gov.ug/content/uganda-vision-2040)

Application of this factor to the Average Day Demand gives us the Maximum Day Demand which will be used to design the capacities of the water source works, raw and treated water transmission mains, pumping stations, water treatment plants, and reservoirs.

Hourly fluctuations in demand vary depending on water usage. These fluctuations are catered for by peak hour factors which tend to be high for small rural communities and lower for larger communities. Distribution mains have to be designed with adequate capacity to meet the peak hour demands of the consumers being supplied. To accommodate the peak hourly flow in the major distribution mains from the reservoir(s) to the system a peak hour factor of 2.0 is proposed.

4.2.3 Transient Population

This population is allowed for within the maximum day factor of 1.3.

4.2.4 Pipe Flow Velocities

In order to limit hydraulic forces on bends in the distribution networks and to limit water hammer effects, it is proposed that the maximum flow velocities should not exceed 0.75 – 2.5 m/s. For water pumping mains the flow velocities at the optimum pipe diameter shall apply. Head losses in the main pipelines will be limited to maximum of 10 m/km.

4.2.5 Operating Pressures

In line with the MWE Water Manual 2013, the pressures in the distribution system will, as far as possible, be kept below PN 6 (60m of Water Head) and above PN 1 (10m of Water Head).

4.2.6 Un-accounted for Water

Allowance must be made for losses, and other unaccounted for water use. This is also known as Non-Revenue Water (NRW). According to IWA[2], this is the difference between System Input Volume and Billed Authorized Consumption. This NRW is a result of Unbilled Authorised Consumption, Apparent, and Real (Physical Water) Losses which include:

3) Unbilled Metered and Unbilled Unmetered Consumption (Unbilled Authorised Consumption);

4) Unauthorised Consumption (Apparent Losses). This includes meter bye passes, illegal connections, meter reversals, etc.

5) Metering Inaccuracies and Systematic Data Handling Errors (Apparent Losses);

6) Water Pipe leakages and bursts on Transmission and Distribution mains, and service connection pipes up to the consumer meter (Real Losses);

7) Storage Reservoir leakages and overflows (Real Losses).

NRW can be given either as a percentage of the average daily water consumption or of water production (System Input volume). The latter ratio has been selected. In this approach, the UfW is assumed to be constant and not subject to seasonal variations.

[2] The International Water Association, 2014

According to Scheme Water Supply records for selected towns and/or RGCs in the country, they indicate that the Non-Revenue Water is on average 18%, with a monthly maximum of 25%. It is therefore proposed that a figure of 20% UfW is used in the determination of the water demand.

4.2.7 Raw Water Intake / Treatment Plant Water Usage

Water losses also occur at the Intake and water treatment plant where water is used for cleaning screens, backwashing the rapid gravity filters, cleaning the water structures, general intake and treatment plant water usage e.g. laboratory and sanitation facilities, etc. It is proposed to use 10% of the Maximum Day Demand to cater for these losses.

4.2.8 Selection of Pipe Materials

Choice of material for the laying of pipes and replacement of old pipework installations will be based on commonly used pipe material sizes in the country as follows:

- Large diameter (>250mm ND) – Ductile Iron or Steel
- Medium size diameter (110 – 250mm ND) – uPVC
- Small size diameter (< 90mm OD) – HDPE

4.2.9 Storage Capacity

Storage reservoirs are designed to fulfil the following functions:

a) To provide for fluctuations in consumer demand during the day (e.g. the peak hour flow), without having to design the treatment plant and pumping mains to match this peak flow. It thus provides a balance between the demand rate of transmission (at maximum day demand) and consumption rate (peak hour flow). This is the balancing storage. Additionally, the storage reservoir provides for a fairly constant residual pressure and flow to the consumers.

b) The storage reservoir also provides a reserve capacity for fire-fighting, power interruptions, and allows time for system repairs and essential maintenance upstream of the storage to be made without interrupting flow to the consumers. This is the Emergency Storage.

It is proposed to size the storage at 30% of the maximum day’s demand inclusive of emergency storage.

4.2.10 System Operation Time

The distribution system is assumed to operate 24 hours per day. The pumping stations will however operate for a maximum of 16 hours/day.

4.2.11 Water Treatment and Quality

The World Health Organization’s Guidelines for Drinking Water Quality, set up in Geneva in 1993, and lately revised in the 4th Edition, 2011; are the international reference point for the establishment of national regulations and standards for drinking water. It should be mentioned that though WHO recognises that drinking water should be acceptable to consumers in appearance, taste, and odour, no guideline values have been set for constituents influencing water quality that have no direct link to adverse health impacts.

In the case of the Water and Sanitation Programme, the quality of water to be delivered to the end consumer should conform to Uganda Drinking Water Standard (US-201: 2008, 2nd Edition). The Uganda Standard US-201 was first declared a National Standard in 1994 and revised in 2008 in line with the WHO guidelines and other market requirements. This is given in Table 4.1 below along with the WHO 2011 standards for comparison purposes.

Table 4.1 Drinking Water Quality Standards Uganda (2008) & WHO (2011)

Characteristic	Unit	US-201: 2008 Requirement	WHO 2011 Requirement	Uganda Standard (US EAS 12)-2014
Physical Requirements				
Colour	Hazen units, max. Pt scale	15	No Guideline	15
Odour		Acceptable to consumers and no abnormal changes	No Guideline	Acceptable to consumers and no abnormal changes
Taste		Acceptable to consumers and no abnormal changes	No Guideline	Acceptable to consumers and no abnormal changes
Turbidity	NTU	5	1	5
Dissolved Solids	mg/l	700	No Guideline	700
Suspended Solids	mg/l	0	No Guideline	0
Electrical Conductivity (EC)	µS/cm	1500	250	1500
Chemical Requirements				
pH		6.5 - 8.5	6.5 – 8.5	6.5 - 8.5
Total Hardness (as $CaCO_3$)	mg/l	500	No Guideline	300
Calcium (as Ca)	mg/l	75	No Guideline	150
Sodium (as Na)	mg/l	200	200	200
Magnesium	mg/l	50	No Guideline	100
Arsenic (as As)	mg/l	0.05	0.01	0.01
Copper (as Cu)	mg/l	1.0	2.0	1.0
Chloride (as Cl)	mg/l	250	250	250
Chromium (as Cr 6+)	mg/l	0.05	0.05	0.05
Fluoride (as Fl)	mg/l	1.0	1.5	1.5
Iron (as Fe)	mg/l	<0.30	No Guideline	<0.30
Manganese (as Mn)	mg/l	0.1	0.1	0.1
Nitrates (as NO_3)	mg/l	5	50 (Total Nitrogen)	No Guideline
Barium	mg/l	1.0	0.7	0.7
Aluminum (as Al)	mg/l	0.1	0.2	No Guideline
Sulphates	mg/l	200	250	400
Zinc (as Zn)	mg/l	5.0	3.0	5.0
Lead (as Pb)	mg/l	0.05	0.01	0.01
Selenium (as Se)	mg/l	0.01	0.01	0.01
Cadmium (as Cd)	mg/l	0.01	0.003	0.003
Phenolic substances (C_6H_5OH)	mg/l	0.001	No Guideline	No Guideline
Mercury (as Hg)	mg/l	0.001	0.001	0.001
Cyanide	mg/l	0.01	0.07	0.01
Poly nuclear aromatic substances	mg/l	nil	No Guideline	No Guideline
Residual free chlorine	mg/l	0.2	0.2	0.2-0.5
Mineral oil	mg/l	0.01	No Guideline	0.01

Characteristic	**Unit**	**US-201: 2008 Requirement**	**WHO 2011 Requirement**	**Uganda Standard (US EAS 12)-2014**
Anionic detergents	mg/l	0.2	No Guideline	No Guideline
Pesticides		Trace	Trace	Trace
Carbon chloroform extracts (CCE, organic pollutants)	mg/l	0.2	No Guideline	No Guideline
Source: Uganda Bureau of Standards, WHO Guidelines, 2011				

4.2.12 Specific Water Demand

4.2.12.1 Domestic Consumption Rates

The per capita domestic consumption rates are based on the level of service being offered. In determining the rates of consumption for the water demand, a comparison of the rates used in previous studies in the country with those in the DWD Water Manual 2013 was carried out.

Table 4.2 Comparison of Unit Demands for Domestic Consumption

Source	**House Connections (l/c/d)**	**Yard Tap (l/c/d)**	**Stand Post (l/c/d)**
MWE Design Manual, 2013	50	40	20
Source: Design Manual			

Three levels of service and corresponding per capita consumption rates are proposed and these are summarized below and in **Table 4.3**.

- For House Connections in the project area, medium income housing is predominant therefore the rate of 50 l/c/d from the DWD Water Manual 2013 has been adopted.
- The rate of consumption at the yard tap shows little variation across the refugee camp and host communities. A Single household figure of 40 l/c/d from the DWD Water Manual 2013 has been adopted.
- The stand post consumption of 20 l/c/d is considered the minimum to sustain healthy existence, and is therefore adopted.

Table 4.3 Per Capita Domestic Consumption Rates

No	**Domestic Consumer Category**	**Description**	**Per Capita Consumption (l/c/d)**
1	House Connection (HC);	Low income consumers- single household using yard tap. This connection has no internal plumbing or water borne sanitation.	50
2	Yard Tap (YT)	Low income consumers-single and multiple households using yard taps. This connection has no internal plumbing or water borne sanitation.	40
3	Public Stand Post (SP)	Low Income Users- usually offsite supply, either from a stand post or purchase from a neighbour.	20
Source: Project Estimates, DWD Water Manual 2013			

4.2.13 Non-Domestic Consumption Rates

This category covers the institutional, commercial, and industrial consumers. The proposed rates have been adopted from the DWD design manual (2013) and rates used in other similar schemes designed recently. They have been determined from within the specified ranges to suit the socio economic and socio-cultural conditions in the project areas.

4.2.14 Design Economic Life

Annual maintenance cost factors and Design Economic life of the various design components have been adopted from the DWD Design Manual, 2013. The relevant factors are summarized in Table 4.4 below.

Table 4.4 Annual Maintenance and Economic life of Design components

Component	Economic Life (Years)	Annual Maintenance Cost (% of Construction Cost)
Intake Works, Treatment Works	40, 30	1%
Boreholes and Wells	25	1%
Mechanical and Electrical Items	15	5%
Pipelines, Water Meters	30, 15	1%
Masonry / Concrete Storage reservoirs	30	1%
Steel storage reservoirs including Towers	25	2%
Masonry Buildings	30	1%
Gantries, Water Kiosks, Latrines	25	2%
Site Works- Roads, Fences	30, 25	1%
Source: MWE Water Supply Design Manual 2013, Project Estimates		

4.2.15 Formula for Design of Transmission Mains

The transmission mains will be designed using the Hazen-Williams Formula using an excel spread sheets to design the main requirements in the ultimate design year. The formula is as follows:

$Q = K*C*A*R\wedge^{0.63}*S\wedge^{0.54}$

Where: Q = Discharge in the section (m^3/s)

C = Hazen Williams roughness coefficient (unit less)
120 for Steel Pipes, 140 for HDPE and uPVC

A = Flow area m^2

S = Friction slope (m /m)

K = Constant (0.85 for SI)

R = Hydraulic radius (m)

D = 4R

Where: R = Hydraulic radius (m)

D = Diameter (m)

4.3 Summary of Design Criteria

The summary of the water supply design criteria along with comparison details from the DWD Manual (2013) and previous studies criteria is also given in Table 4.5 overleaf.

Table 4.5: Summary of Water Supply Design Criteria

Design Criteria	Abbreviations and Dimensions	DWD Design Manual (2013)	Adopted Design Criteria
Baseline Data- Population			
Design Period	Years	NA	20
Design Horizon	Year	NA	2040
Population at Design Horizon	P [inh.]	NA	8,922
Maximum Day Demand	m^3/day	NA	397
Hydraulic Criteria			
Max Day Factor		1.1 - 1.3	1.3
Peak Hour Factor		2.0	2.0
Maximum flow velocities in the pipes	m/s	-	0.75 - 2.5
Maximum Head losses in the main pipes	m/km	-	10
Operating Pressures			
Minimum in Distribution Network	bar	-	1.0
Maximum in Distribution Network	bar	-	6.0
Water Losses			
In Distribution System (UfW)	% of Total Average Day Demand	20 – 25%	20%
Intake & Treatment Plant Use	% of Maximum Day Demand	10%	10%
Pipe Material Selection			
Large Diameter (>250mm ND)			Ductile Iron or Steel
Medium Size Diameter (100-250mm ND)			uPVC
Small Size Diameter (< 90mm OD)			HDPE
Minimum Pipe Cover			
General Pipe Laying	m	0.6 -3.0	~ 0.9
Pipes laid below roads and reserves	m	0.9	1.2
Storage Capacity			
Sizing of Reservoirs- Balancing Storage	% of Maximum Day Demand	50%	30%
Sizing of Reservoirs- Emergency Storage (Firefighting)	% of Maximum Day Demand	50%	10%
Other Design Criteria			
Water Treatment Plant Operation Time	hour/day	-	16
Pumping Stations Operation Time	hour/day	-	16
Distribution System Operation Time	hour/day	-	24
Water Treatment Quality Standards- Drinking Water		Uganda (US - 201: 1994)	Uganda (US - 201: 1994)
Specific Water Demand			
Domestic Consumption			
House Connection			
High Income Housing	l/c/d	200	50
Medium Income Housing	l/c/d	100	
Yard Tap			
Multiple Households	l/c/d	50	40
Single Household	l/c/d	40	
Public Stand Post	l/c/d	20	20
Part Time Users (Urban Poor)	l/c/d		5

Design Criteria	Abbreviations and Dimensions	DWD Design Manual (2013)	Adopted Design Criteria
Institutional Consumption			
Schools			
Day			
With pit latrine	l/std/d	10	5
With water closet	l/std/d	20	10
Boarding	l/std/d	100	20
Hospitals / Health Centers			
Health Care Dispensaries	l/visitor/d	50	20
Health Centre I- No modern facilities			
In patients	l/bed/d	50	50
Out patients	l/c/d	NA	5
Non-Resident staff	l/c/d	NA	10
Resident staff	l/c/d	NA	10
Health Centre II- with maternity and pit latrine			
In patients	l/bed/d	70	70
Out patients	l/c/d	NA	10
Non-Resident staff	l/c/d	NA	10
Resident staff	l/c/d	NA	20
Health Centre III- with maternity and pit latrine			
In patients	l/bed/d	100	70
Out patients	l/c/d	NA	5
Non-Resident staff	l/c/d	NA	5
Resident staff	l/c/d	NA	20
Health Centre IV- with maternity and water closet			
In patients	l/bed/d	150	100
Out patients	l/c/d	NA	10
Non-Resident staff	l/c/d	NA	10
Resident staff	l/c/d	NA	40
Hospital, District- with surgery unit			
In patients	l/bed/d	200	100
Out patients	l/c/d	NA	10
Non-Resident staff	l/c/d	NA	10
Resident staff	l/c/d	NA	100
Hospital, Regional Referral- with surgery unit			
In patients	l/bed/d	400	150
Out patients	l/c/d	NA	10
Non-Resident staff	l/c/d	NA	10
Resident staff	l/c/d	NA	100
Administrative Offices			
With pit latrine	l/worker/d	-	5
With water closet	l/worker/d	70	40
Mosque	l/c/d	NA	20
Church	l/c/d	NA	5
Prisons	l/inmate/d	NA	50
Commercial / Industrial Consumption			
Hotels / Lodges			
High class	l/bed/d	600	600

Design Criteria	Abbreviations and Dimensions	DWD Design Manual (2013)	Adopted Design Criteria
Medium class	l/bed/d	300	300
Low class	l/bed/d	50	50
Bars / Restaurants			
High class	l/bar/d	1000	1000
Low class	l/bar/d	700	700
Shops			
Small Town	l/shop/d	150	50
Fuel Station/Washing Bays			
Small Town	Station/d	5000	5000
Markets	l/ha/d	20000	2000 l/market/day
Public Sanitation			
Small Town	l/person/d	50	20
Food Industry			
Dairy	Milk received (m^3)	2 - 5	200 l/d
Abattoir	Animals slaughtered (ton)	5 -10	200 l/abattoir/day
Butchery	l/d	NA	50
Grain millers (Dry processing mills)	Grain received (ton)	2 - 5	30 l/d
Other Industries			
Tannery	Raw skins (ton)	50 - 150	50
Cotton mill	Cotton thread (tufi)	50 - 150	50
Medium Scale (water intensive)	m^3/ha/d	40	40
Medium Scale (medium water intensive)	m^3/ha/d	15	15
Small Scale (dry)	m^3/ha/d	5	5

4.4 Design Criteria- Sanitation

4.4.1 Sanitation Needs

This section covers the design criteria and standards for Sanitation Works. Human waste consists of two basic elements – excreta and sullage. Excreta has a high solid content and is highly infected with pathogenic organisms. Sullage is wastewater from kitchens, baths, wash tubs, etc. and has a lower pathogenic content. Both excreta and sullage require satisfactory treatment and disposal.

The type of sanitation facilities will depend on the level of service for water supply as follows:

i) High water consumption (e.g. house connections) – water borne sanitation in the form of septic tank systems or central sewerage.

ii) Low water consumption (e.g. yard tap or stand tap users) – non-water borne on site sanitation facilities.

4.4.2 Water Borne Sanitation

Wastewater is closely related to the water consumption. To calculate potential wastewater flows, factors are applied to the water consumption. The following factors in **Table 4.6** overleaf have been adopted.

Table 4.6 Sanitation Technology

No.	Description of Water Consumer Category	Waste Water Production	Possible Wastewater Disposal
1	House Connection (HC)	80%	Water borne
2	Yard Tap (YT)	20%	Usually Non-Water borne
3	Public Stand Post (SP)	0%	Non-Water borne
4	Part Time Users (NS)	0%	Normally Non-Water borne
5	Institutional (Inst)	85%	Water borne
8	Commercial/Industrial (Com/Ind)	90%	Water borne
Source: Previous Studies- Sanitation Strategy and Master Plan for Kampala City			

4.4.3 On-Site Sanitation

The options for appropriate on-site sanitation are given in **Table 4.7** below.

Table 4.7 On-Site Sanitation Options

No.	On-Site Sanitation System	Household Water Service Level	Water required for Operation (l/c/d)	Operation & Maintenance
1	Simple Pit Latrine (Unlined)	Yard Tap / Stand Post	Nil	Cleaning only
2	VIP Latrine (Lined)	Yard Tap / Stand Post	nil	Cleaning only
3	Twin-Pit VIP (Lined)	Yard Tap / Stand Post	nil	Changing and emptying pit every two years
4	Latrine with Vault	Yard Tap / Stand Post	nil	Periodic tank emptying- similar to cesspit
5	Eco-San (Dehydrating Type)	Yard Tap / Stand Post	nil	Removal of faeces and Urine on regular basis
6	Pour-Flush	Yard Tap / Stand Post	5-25	Cleaning only
7	Twin-Pit Pour Flush	Yard Tap / Stand Post	20-30	Changing and emptying every 2 yrs.
8	Cesspit*	House Connection / Yard Tap	5-40	Periodic tank emptying – more frequent than for septic tanks
9	On-Site Septic Tank*	House Connection / Yard Tap	5-40	Periodic tank emptying
Source: Previous Studies				

The main improved on-site sanitation technologies, which have been separated into 2 groups: Non-Water and Water toilets.

4.4.3.1 Non-Water Toilets

Table 4.8 Single Pit Latrine

Advantages	Disadvantages
Relatively low capital cost. Relatively simple construction so some or all can be built by the householder. Does not need water for operation. Easily understood– residents are familiar with this solution. Can accept common degradable and non-degradable anal cleansing materials.	Flies and odours are usually noticeable. Emptying costs may be significant compared to capital costs. Sludge requires secondary treatment and/or appropriate discharge. Can contribute to pollution of surface water and ground water sources. Low pathogen and BOD reduction.

Advantages	Disadvantages
Small land requirement (<1.5m^2) – possible on most plots	
Source: Previous Studies / Compendium EAWAG[3]	

Table 4.9 Ventilated Improved Pit Latrines (VIP)

Advantages	Disadvantages
Low capital cost (though higher than for simple pit latrines) Relatively simple construction so some or all can be built by the householder Does not need water for operation Generally, easily understood – many residents familiar with this solution Effective control of flies (if kept dark) and odours Can accept common degradable and non-degradable anal cleansing materials Small land requirement (<1.5m^2) – possible on most plots.	Emptying costs may be significant compared to capital costs. Sludge requires secondary treatment and/or appropriate discharge. Can contribute to pollution of surface water and ground water sources. Low pathogen and BOD reduction.
Source: Previous Studies / Compendium EAWAG	

Table 4.10 Double Ventilated Improved Pit Latrines (Double VIP)

Advantages	Disadvantages
Longer life than single VIP (if maintained, indefinite) i.e. reduced reinvestment costs. Low capital cost (though higher than for simple pit latrines) Relatively simple construction so some or all can be built by the householder Does not need water for operation Generally, easily understood – many residents familiar with this solution Effective control of flies (if kept dark) and odours Can accept common degradable and non-degradable anal cleansing materials Small land requirement – possible on most plots.	Emptying costs may be significant compared to capital costs. Sludge requires secondary treatment and/or appropriate discharge. Can contribute to pollution of surface water and ground water sources. Higher capital costs than single pit latrines. Low pathogen and BOD reduction.
Source: Previous Studies / Compendium EAWAG	

Table 4.11 Fossa Alterna

Advantages	Disadvantages
Longer life than single VIP (if maintained, indefinite) i.e. reduced reinvestment costs. Low capital cost (cheaper than double VIP but more expensive than simple pit latrines). Emptying can be made manually with simple precautions (low or no operation cost). Potential for use of stored faecal material as soil conditioner. Relatively simple construction so some or all can be built by the householder. Does not need water for operation. Generally, easily understood – many residents familiar with this solution. Effective control of flies (if kept dark) and odours (better than VIP because of the addition of soil, ash and/or leaves). Can accept common degradable anal cleansing materials.	Emptying costs may be significant compared to capital costs. Sludge requires secondary treatment and/or appropriate discharge. Can contribute to pollution of surface water and ground water sources. Higher capital costs than single pit latrines. Requires constant source of cover material (soil, ash, leaves, etc.). Garbage may ruin reuse opportunities of Compost

[3] Compendium of Sanitation Systems and Technologies, EAWAG 2008

Advantages	**Disadvantages**
Small land requirement – possible on most plots. Significant reduction of pathogen.	
Source: Previous Studies / Compendium EAWAG	

Table 4.12 Urine Diverting Dry Toilet (Eco-San toilet)

Advantages	**Disadvantages**
Longer life than single VIP (if maintained, indefinite) i.e. reduced reinvestment costs. Low capital cost (cheaper than double VIP but usually more expensive than simple pit latrines). Good for poor soils, high groundwater or rocky ground. Effective control of flies (if kept dark) and odours (better than VIP). Emptying can be made manually with simple precautions (low or no operation cost). Urine and treated faeces can be recycled for agricultural purposes if desired. Small land requirement – possible on most plots. Significant reduction of pathogen.	**Requires acceptance!** Requires education. Use requires practice and/or skills. Careful slab washing required if faeces to remain dry. Urine may cause odour problems Moslems and others who use water for anal cleansing may find dehydrating eco-sans more complicated to use due to the need to keep water away from the faeces (however, variations of eco-sans have been traditional used in both the Yemen and Zanzibar and suitable designs exist for use by water-washing households). Requires a constant source of ash, sand or lime.
Source: Previous Studies / Compendium EAWAG	

4.4.3.2 Water Toilets

Table 4.13 Full Flush Toilet + Septic Tank + Soak Pit

Advantages	**Disadvantages**
No odour problems if used correctly. Cheaper than sewerage for medium to low population density. Septic tank can be built and repaired with locally available materials. Long service life.	Requires a constant and important source of water (usually piped water supply). High capital and operating cost compared to other on-site sanitation options. Requires sufficient area on plot for drainage field or soak pit and hence will not be suitable for high density settlements. Relatively complex construction so usually requires skilled builder. Seat cannot uneasily be built or repaired locally. Regular de-sludging required and seepage needs to be handled and treated safely. Sludge requires treatment. Requires construction of a pit – which may be difficult in areas of hard ground or high groundwater. Can contribute to pollution of surface water and ground water sources.
Source: Previous Studies / Compendium EAWAG	

Table 4.14 Pour Flush + Double Pit

Advantages	**Disadvantages**
Because of the alternating pit design, their life is virtually unlimited. i.e. reduced reinvestment costs.	Even if limited, a constant source of water must be available.

Advantages	Disadvantages
Low cost (though higher than for simple pit latrines). Excavation of humus is easier than faecal sludge (low or no operation cost). Potential use of stored material as soil conditioner. Moderate reduction in pathogens. Relatively simple construction so some or all can be built by the householder. No flies or odour problems. Lower water use.	Clogging is frequent when bulky cleansing materials are used. Requires construction of a pit – which may be difficult in areas of hard ground or high groundwater. Can contribute to pollution of surface water and ground water sources.
Source: Previous Studies / Compendium EAWAG	

5 DETAILED DESIGN

5.1 Water Supply System Capacity

The maximum day water demand for the entire system as per indicated in the feasibility study report is 848m^3/day. The water source for the piped water system is ground water in the form of production wells. Currently, one borehole of 27m^3/hr yield (DWD 60824) is already drilled. Due to the inadequate water resource to supply the entire project area, the system has been down sized to a maximum day demand of 397m^3/day which can be met by the available water resource (27m^3/hr BH). This demand serves the entire Bukizibu Villages (A, B &C) and a fraction of Bumwena as shown in Table 2.1. The water supply system infrastructure (storage and distribution network) has been designed for the ultimate year.

The development scenario will consist of the following aspects

a) Construction of 1No new borehole pumping house
b) Installation of 1No. submersible pump
c) Construction of transmission mains from the borehole to the reservoir
d) Construction of a new Storage Reservoir in Bukizibu A village.
e) Construction of a distribution network for the project area.
f) Making New Consumer Connections.
g) Construction of a Chemical House
h) Construction of a Water office block

5.2 Design demand

In the design, the system will be sized on the basis of the maximum day water demand of 397m^3/day. The design demand determination was varied from that reflected in the feasibility report due to the limitation in the water resource requirement. The calculations have been put in **Annex** Error! Reference source not found.**.1**, and summarized in Table 5.1 below.

Table 5.1: Summary of Demand Calculation

Bukizibu-Bumwena						
Served	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**
Popn.	4,568	4,716	5,530	6,487	7,607	8,922
Domestic	*102*	*106*	*124*	*145*	*171*	*200*
Govt/Inst	*23*	*23*	*27*	*32*	*38*	*44*
Ind/Com	*0*	*0*	*0*	*0*	*0*	*0*
UFW	*31*	*32*	*38*	*44*	*52*	*61*
ADD	*156*	*161*	*189*	*222*	*260*	*305*
MDD	***203***	***210***	***246***	***288***	***338***	***397***

5.3 Development Strategy

The water supply system will be based on ground water. Water will be pumped from the boreholes to a storage reservoir. Distribution from the reservoir tanks will be by gravity to the consumers.

5.4 Borehole Development

A borehole (DWD 60824) has been drilled within the project area. According to data provided by the Client, the borehole has a yield of 27m^3/hr.

The ultimate year (2040) maximum day demand is 397m^3/day. An analysis was carried of the borehole yield required for 16-hour pumping regime as summarized in Table 5.2 below.

Table 5.2: Borehole Requirements

Town	Maximum Day Demand at Given Tariff (m^3/day)		
	USh 36/ 20L	USh 50/ 20L	USh 83/ 20L
Demand- m^3/hr	25.18	24.29	23.66
1 No Borehole	25.2	24.3	23.7
2 No Boreholes	12.6	12.1	11.8
3 No Boreholes	8.4	8.1	7.9
4 No Boreholes	6.3	6.1	5.9

Only one borehole DWD60824 is to be used for the new supply system. An analysis regarding the ability of this well to supply the project area with sufficient water was conducted as seen in Table 5.3 below was carried out.

Table 5.3 Available Ground Water Supply in Bukizibu Bumwena Project Area

Borehole No.	Location	Well Status	Borehole Yield (m^3/hr)	Pumping Duration (hrs)	Groundwater Supply (m^3/day)	Groundwater Supply Vs. Maximum Day Demand					
						2019	2020	2025	2030	2035	2040
						Water Demand (m^3/day) per Year					
						203	210	246	288	338	397
Supply Vs Demand											
12hr Pumping Duration (2020-2030 Maximum Duration Pumping)											
Existing Borehole	Bukizibu	BH DWD 60824	25.2	12	302.1	149%	144%	123%	105%	89%	76%
Total for Available Wells			**25.2**	**12**	**302.1**	**149%**	**144%**	**123%**	**105%**	**89%**	**76%**
Supply Shortfall (m^3/day)						***99***	***92***	***56***	***14***	***-36***	***-95***
Supply Shortfall (m^3/hr)						***8.3***	***7.7***	***4.7***	***1.1***	***-3.0***	***-7.9***
16hr Alternative Pumping Duration (2030-2040 Maximum Duration Pumping)											
Existing Borehole	Bukizibu	BH DWD 60824	25.2	16	402.8	198%	192%	164%	140%	119%	102%
Total for Available Wells			**25.2**	**16**	**402.8**	**198%**	**192%**	**164%**	**140%**	**119%**	**102%**
Supply Shortfall (m^3/day)						***200***	***193***	***157***	***114***	***65***	***6***
Supply Shortfall (m^3/hr)						***16.6***	***16.1***	***13.1***	***9.5***	***5.4***	***0.5***
Source: Field Study Estimates											

From Table 5.3 above, the following should be noted:

a) The proposed newly drilled borehole in will be able to supply the project area until the ultimate design period (2040) at an average of 16hr pumping regime.

b) Considering a 12hrs pumping regime to the intermediate year (2030) will be able to meet the project area demand as shown in Table 5.3 Available Ground Water Supply in Bukizibu Bumwena Project AreaTable 5.3. Through this, the energy cost is reduced since the 16hrs pumping regime is considered only between the intermediate year to the ultimate year (2040)

5.5 Detailed Design of Water Works

5.5.1 Borehole Design Elements

The design of the production boreholes includes:

a) Construction of borehole pump house, installation of submersible pump and pipework.
b) Pumping main from the borehole to the storage reservoir.
c) Supply and installation of power requirements for the pump house.
d) Associated Borehole Pump House site works.

5.5.2 Borehole Pump and Pumping Transmission Mains

The pumps for the production wells and size of the transmission main were designed using Hazen-Williams Formula and a spread sheet was used to design the main requirements in the design year 2040. The formula is given in **Section 4.2.15**. The details of the calculation for the design of the borehole pumps and the main sizing is summarised in Table 5.4 below.

Table 5.4: Raw Water Pump Details

Borehole Number	BH DWD 60824
Supply Area Demand (m^3/d)	**397**
Test Pump Yield (m^3/hr)	**26.50**
Borehole Yield to be Used (m^3/hr)	**25.2**
Hours of Pumping (hr)	16.0
Efficiency Pump (%)	60.0%
Efficiency Motor (%)	80.0%
Total Daily Delivery (m^3/day)	403
Pumping Main Section No. 01 (From Pump Installation Point to Ground Level at Borehole)	
Ground Level at Borehole (m AMSL)	1146.39
Pump Installation Depth in Borehole (m BGL)	75.000
Cwh	140
Pipe Details	**OD110 HDPE PN16**
Pipe Diameter ND (mm)	90.00
Pipe Diameter ND (m)	0.090
Flow in Pipe (m^3/hr)	25.175
Flow in Pipe (m^3/s)	0.007
Velocity (m/s)	1.10
Length of Pipe Section No. 01 (m)	**75.00**
Friction Loss (m)	1.07
Fittings losses - 10% (m)	0.11
Total Headloss in Section 01 (m)	**1**
Pumping Main Section No. 02 (From Ground Level at Borehole to Ground Level at Reservoir)	
Ground Level at Tank (m AMSL)	1179.520
Ground Level at Borehole (m AMSL)	1146.390
Static Lift (m)	**33.130**
Cwh	140
Pipe Details	**OD110 uPVC PN10**
Pipe Diameter ND (mm)	99.40
Pipe Diameter ND (m)	0.099
Flow through pipe section 02 (m^3/hr)	25.175
Flow through pipe section 02 (m^3/s)	0.007
Velocity (m/s)	0.90
Chainage at Reservoir	1+160
Chainage at Borehole	0+000
Length of Pipe Section No. 02 (m)	**1,160.00**

Borehole Number	**BH DWD 60824**
Friction Loss (m)	10.24
Fittings losses - 10% (m)	1.02
Total Headloss in Section 02 (m)	**11**
Total Pumping Head from Borehole to Reservoir	
Total Static Head from Borehole Installation Point to Reservoir	108
Total Headloss from Borehole Installation Point to Reservoir	12
Total Pumping Head from Borehole to Reservoir	**121**
Summary of the Design	
Total Length of Transmission	
OD110 HDPE PN16 (m)	75
OD110 uPVC PN10 (m)	1160
Capacity of pump in the borehole	
Head (m)	121
Flow (m^3/hr)	25.2
Power (kW)	**17.2**
Source: Project estimates.	

The drilled borehole (DWD 60824) will have a pump and transmission main with the following characteristics:

a) Flow of 25.0m^3/h at 120m head;

b) Borehole riser pipe of OD110 HDPE PN16, 75m long; and pumping main of OD110 uPVC PN10, 1,160m long up to the storage reservoir.

The borehole pump houses will be the standard 3.5m X 3.0m floor area, pump house with a semi-detached office/store room giving a total floor area of 7.2m X 3.0m. The pump house will contain the associated pipework, fittings and electrical switch gear. A single roomed 3.0m X 3.0m floor area pump attendant and guard house with an Eco-San toilet will also be constructed at the borehole site.

5.5.2.1 Energy and Power Provision Costs

From the feasibility study report, the power supply option to the borehole is by use of solar power and it will be augmented by HEP.

The characteristics of the power requirement of the pump has been calculated using the formula seen in Table 5.5 below.

Table 5.5: Pump Power Requirement Equation

P= [ρ x g x h x Q/3600]/ (e1 x e2)

Where;

P is required input power (Watts)

ρ is water density (kg/m^3) = 1000

g is gravity constant (m/s^2) = 9.81

h is pump head (m)

Q is pump capacity (m^3/hr)

e1 is efficiency of pump = taken from selected pump details

e2 is efficiency of pump motor = taken from selected pump details

The pump power requirement is summarized in Table 5.6 overleaf.

Table 5.6: Pumps and Power Requirements

Location	Head (m)	Flow (m^3/hr)	Required Motor Size KW	Available Motor (kW)	duty	kva	Total power (KVA)	Amperage (A)	Starting KVA	Solar Panels No. (1x280pW)	Solar Panels area (m2)
DWD 60824	121	25.2	19.8	20.0	1	25.00	25.00	34.78	25.00	79	47.88
Source: Project Estimates											

The power requirement for the borehole includes the supply of and installation of 79No. of mono crystalline PV Solar panels rated at 280pW 12 Volts DC, including: PV solar panel support structure (solar array) for mounting solar panels; all electrical accessories; complete as per specifications.

Since 16hrs pumping is required to meet the demand in the ultimate year, Hydro Electric Power has been considered into the design in order to provide the necessary power requirements. This is due to the limitation of solar working hours which is considered to be 8hrs at maximum per day. The energy cost has been optimised by taking into the account the power requirements to meet the demand at the intermediate year(2030) and at the ultimate year.(2040) To the intermediate year, the HEP is used for 4hrs which takes the total pumping hours to 12hrs and then between the intermediate year to the ultimate year, the system runs on HEP for 8hrs, this takes the pumping hrs to 16hrs. Through this, the energy cost for running the system is optimised without compromising pumping delivery to the tank.

5.5.3 Disinfection Facilities

The chemical storage, mixing and dosing will be performed at the borehole source sites in separate rooms. A set of DOSATRON inline proportional chemical dozers to dose chlorine solution from the mixing tanks directly into the pumping main and in response to a pressure differential device installed in the pumping main. The pressure differential device shall be an orifice plate or a venturi meter.

5.5.4 Storage Reservoir

As detailed under **Section 4.2.9 "Storage Capacity",** the required storage capacity has been computed as 30% of the maximum day demand. The required storage capacity is therefore 130m^3. A 130m^3 main reservoir has been adopted. This new tank represents a storage capacity of 30% in the ultimate year maximum day demand. The reservoir's storage capacity at various stages of the design period is reflected in Table 5.7 below.

Table 5.7: Reservoir Storage Capacity

Item	Bukizibu-Bumwena RGC Storage					
	2019	2020	2025	2030	2035	2040
MD Demand- m^3/day	203	210	246	288	338	397
Storage Capacity (m^3)	130	130	130	130	130	130
Hours of Storage	15	15	13	11	9	8
Storage Capacity (%)	64%	62%	53%	45%	38%	33%
Source: Project Estimates						

Due to the topography of the project area and the high pressures experienced in the far reaches of the distribution network, it is recommended to place the reservoir tank on a 15m high steel tower.

The reservoir will be made of square cold pressed steel panels of length 1.22m. The reservoir shall be provided with inlet, overflow, outlet, and drain pipe work. The following fittings shall also be provided for the reservoir;

a) Internal ladder of galvanised steel,
b) Wall mounted level indicator,
c) Vents on the tank roof,
d) Roof level access cover of galvanised steel.

The access covers shall be at least 100 mm above the finished level of the roof and shall be lockable. The roof vents shall be similarly set out and shall be fitted with vermin proofing and mosquito proofing fabric.

The overall internal dimensions of the reservoir (130m^3) are as follows: -

- Length - 6.10m,
- Width - 6.10m,
- Depth - 3.66m.

The pipe work (rated PN10) of the reservoir shall be in Epoxy Coated Steel Pipe work as follows;

- Inlet - DN 100,
- Outlet - DN 150,
- Overflow - DN 200,
- Drain - DN 50.

5.5.5 Main Reservoir Site Works

The site works at the reservoir consists of the following:

a) The general earthworks,
b) The site pipe work,
c) The site drainage,
d) Miscellaneous works.

The outlet from the main reservoir shall be fitted with new bulk flow meters. The site layout drawings for the respective reservoir is given in drawing BUK-3.0.0, in Annex 8.4

5.5.6 Distribution Network

The downstream of the distribution system reservoirs has been modelled using EPANET 2.0. A peak hour factor of 2.0 was used.

The smallest size of pipe chosen is OD 50 HDPE. Pipes smaller than OD50, will be laid as Network Intensification lines. Table 5.8 below shows the estimated sizes and length of the distribution pipes while Figure 5.1 below shows the Epanet Model whose details are attached in Annex 8.3.

Figure 5.1: Bukizibu Bumwena RGC Epanet Distribution Network Model

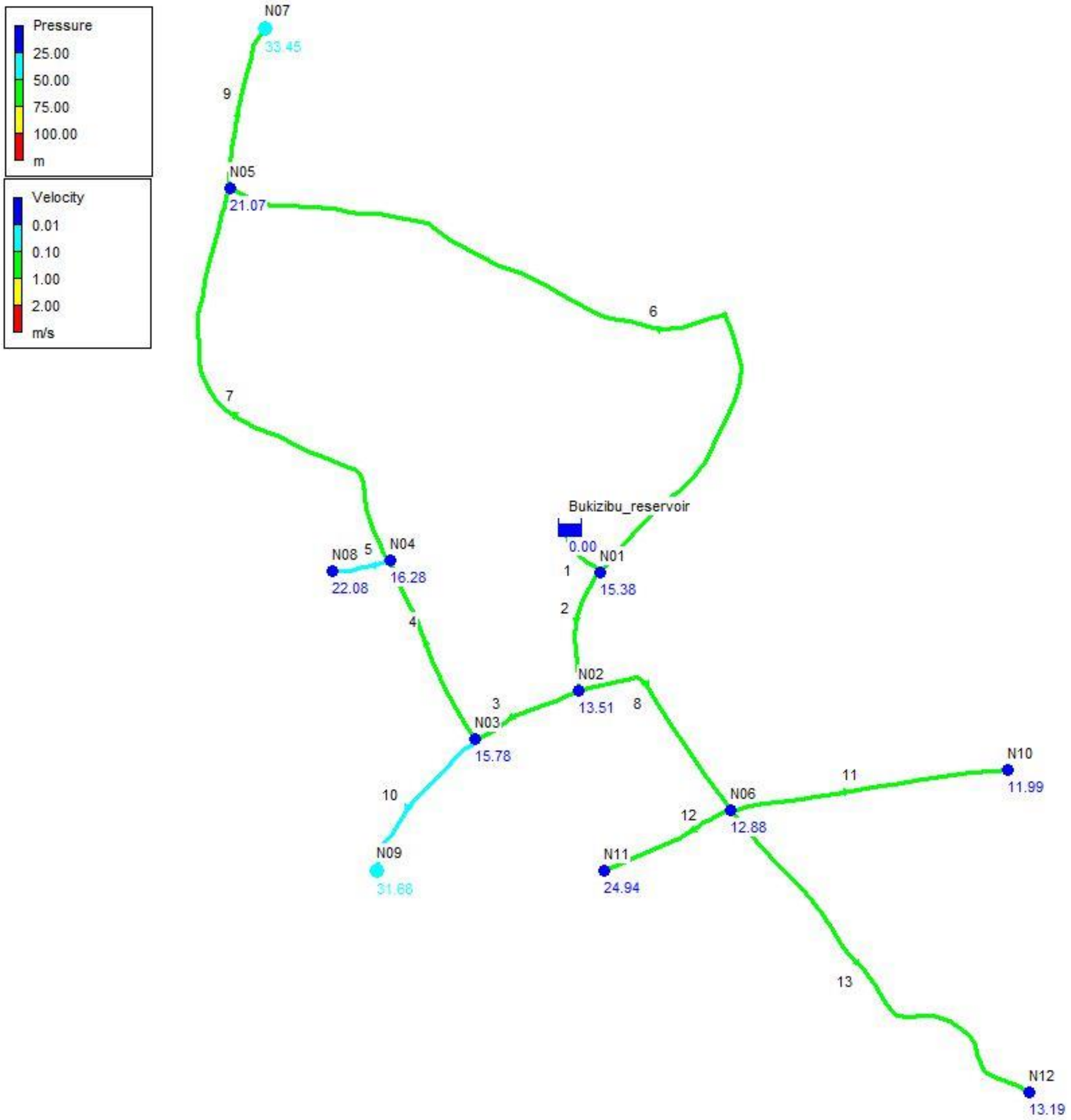


Table 5.8: Distribution Mains

Pipe Details	Length (m)
OD160 uPVC PN6	139.6
OD110 uPVC PN6	320.3
OD90 HDPE PN6	497.0
OD63 HDPE PN6	629.0
OD50 HDPE PN6	5,763.1
Total	**7,349.0**
Source: Project Estimates	

5.5.7 Service Connections

The location of the service pipes will not be known until applications for connections are received. At this stage, only an estimate of the sizes, quantities and costs can be given. On the basis of the population to be served at the tariff of USh 50/20 litres, the total number of connections required in the ultimate 2040 has been estimated as in Table 5.9 overleaf. The criteria used to determine the number of service connections for each served population category is as follows.

Table 5.9: Population per Category Criteria

Category	Population Served	Source of Criteria
House Connection	5 persons per household	Socio-Economic Study Data
Yard Taps	2 Households per yard tap	Project Estimates
Standpipes	250 persons Per Standpipe	Maximum Number- DWD Water Manual 2013
Urban Poor	250 persons per Standpipe	Standpipe coverage

The required number of service connections is given below.

Table 5.10: Required Service Connections

Bukizibu-Bumwena	House Conn	Yard Tap	Stand Pipe	No Supply	Total
2020	33	0	17	0	**50**
2025	39	0	20	0	**59**
2030	45	0	24	0	**69**
2035	53	1	28	0	**82**
2040	62	1	32	0	**95**
Total	**232**	**2**	**121**	**0**	**355**

A total of 355 no. service connections comprising of house connections and stand pipes are to be made in Bukizibu-Bumwena in the ultimate year 2040 as seen in Table 5.10 above while a total of 50 will be made in the initial year 2020. However according to the MWE requirements, the minimum connections for a system is considered at 400 no. which is to take into account the un-expected increase in the demand for connections during implementation as is the norm and these have been catered for in the bills of quantities. It has been assumed that the connection materials will be supplied by the project on the payment of the connection fees. The number and location of the public stand posts will be determined during the construction period

5.5.8 Network Intensification

There are some parts of the proposed water supply areas where the trunk mains are adequate but the mains are too far away for the customers to be able to connect at reasonable cost. As a measure to increase the densification of the distribution networks as a drive to increase the customer base, and allow a neater layout of the service connection pipes, some pipe work intensification will be required.

The intensification lines will be demand-driven, and installed where there are adequate applications for connections. Estimated quantities for this item have thus been included in the Bills of Quantities to cater for this.

5.5.9 O&M Tools and Equipment

Part of the investment will be used to supply new O & M tools and equipment. Equipment will be supplied for the running the water supply system and well as equipping the water office. These will include;

i) Plumbing Tools and Equipment,

ii) Mechanical Tools and Equipment,

iii) Electrical Tools and Equipment,

iv) Miscellaneous Tools,

v) Chemical Equipment and Chemicals.

The proposed tools and equipment are listed in Table 5.11 below

Table 5.11: Tools and Equipment

ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY
	PLUMBING TOOLS AND EQUIPMENT		
PE 2.1	Blowlamp: pump action, pressure type, approx. 0.5 litre capacity, complete with wind proof nozzle and one set of replacement parts	No.	1
PE 2.2	Brushes, wire type for cleaning parts, 300 mm long, 3 rows of approximately15 tufts with 25 mm long steel bristles	No.	2
PE 2.3	File, flat machinist's, length 250 mm, second cut	No.	1
PE 2.4	File, flat machinist's, length 250 mm, smooth cut	No.	1
PE 2.5	File, flat machinist's, length 250 mm, bastard cut	No.	1
PE 2.6	File, half-round machinist's, length 250 mm, smooth cut	No.	1
PE 2.7	File, half-round machinist's, length 250 mm, but bastard cut	No.	1
PE 2.8	File handles, 100 x 27 mm	No.	2
PE 2.9	Hammer, mechanic's, 200 & tempered forged steel head, ash or white hickory handle, polished face	No.	1
PE 2.10	Mattocks	No.	2
PE 2.11	Pliers, arc joint, minimum 5 adjustments, 240 mm long	No.	2
PE 2.12	Saw, Plumbers, 400 mm, fine tooth edge for cutting metal and coarse teeth for cutting wood, complete with 5No. blades	No.	2
PE 2.13	Screw drivers, assorted, hammer-proof, non-inflammable plastic handle	Set	2
PE 2.14	Shovels	No.	2
PE 2.15	Tape measure, Stanley type steel, metric units, 5 m	No.	2
PE 2.16	Tapping machine, furnished with ratchet crank for manual operation, for making tappings from DN 15 (1/2") to DN 50 (2") on mains of DN 25 (1") to DN 300 (12")	No.	1
PE 2.17	Die set with stock, for threading from DN 15 to DN 150	No.	1
PE 2.18	Vice with parallel jaw 100 mm as Peddinghaus, Matador 10203, portable type, with tripod stand	No.	1
	WATER QUALITY TESTING KIT		
QE 3.1	Portable analysis kit such as Potalab 1 (Wag-WE10010) of M/s Wagtech International or similar with reagents to carry out 300 tests for microbiological and physico-chemical testing	Set	
	MISCELLANEOUS TOOLS		
MT 4.1	Contractor's pick axe with point and chisel steel end, length 800 mm	No.	2
MT 4.2	Steel hoe, blade width 200 mm, 1.5 kg complete with good wooden handle	No.	2
MT 4.3	Seamless pressed tray wheelbarrow, steel frame, with pneumatic wheels, 80 litres	No.	2
MT 4.4	33CC 2-Cycle Petrol-Powered engine Straight Shaft Attachment Capable String Lawn Trimmer with 17-inch cutting path (including 10No. replacement trimmer lines)	No.	1
MT 4.5	Steel rakes	No.	3
	CHEMICAL EQUIPMENT AND CHEMICALS		
CE 5.1	Stainless steel graduated (metric) buckets (10 litres)	No.	2
CE 5.2	Stainless steel scoops for scooping chemicals - 1 kg capacity	No.	2
CE 5.3	Food Quality Common Salt (NaCl) in 50Kg Sacks	No.	4

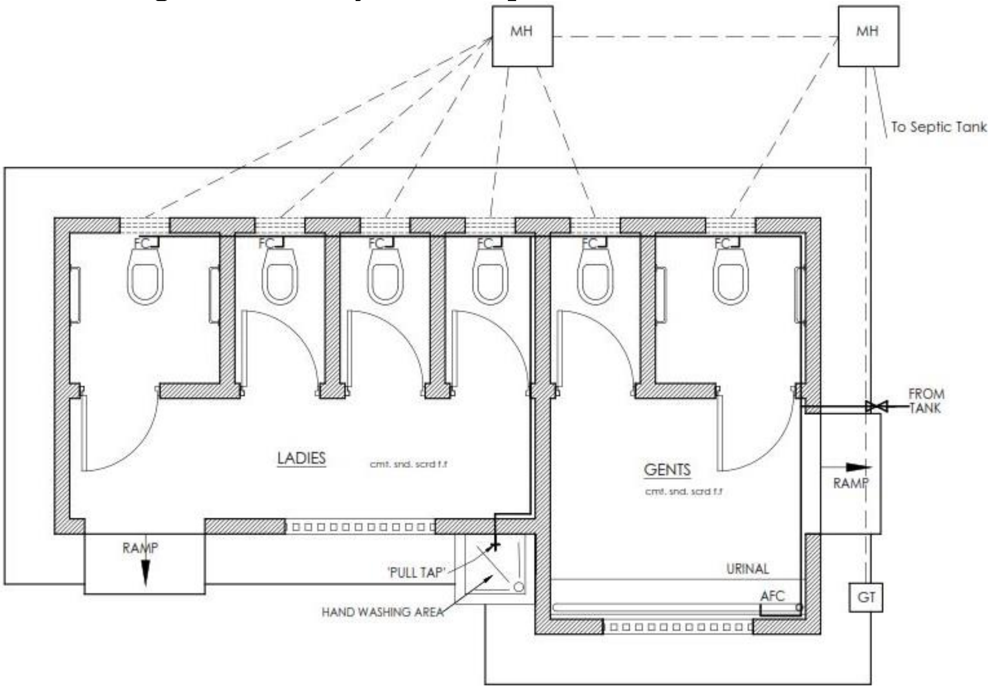
5.6 Detailed Design of Sanitation Works

5.6.1 Proposed Interventions

The Consultant proposes construction of 1No. public water borne sanitation facilities. It is proposed to construct 1No. 6 stance water borne toilet for whose location will be proposed by the officials during construction.

A layout out of the toilet facility is shown in Figure 5.2 below.

Figure 5.2: Layout of Proposed Water Borne Toilet



5.6.2 Operation and Maintenance of the Proposed Toilets

The public toilet can only be properly maintained when the users are paying a fee set by the local authorities. This can be in the form of;

- A monthly fee being charged to the residents within the locality of the public toilet who would wish to use it, while the non-residents paying and fee for every time, they use the toilet or,

- A standard user fee is charged for using the toilet at any one time.

6 FINANCIAL ANALYSIS

6.1 Introduction

The objective of the financial analysis is to show to what extent the cost regarding the implementation and operation of the water supply system, accruing to the operating entity, will be covered by the commercial revenues. The Water Supply system was subjected to a financial analysis to determine their financial viability for Bukizibu Bumwena RGC water supply.

The following parameters have been used to evaluate the financial viability of the project:

a) Dynamic Prime Cost (DPC),
b) Internal Rate of Return (IRR),
c) Net Present Value (NPV),
d) Per Capita Investment Costs.

The proposed water supply tariff, of USh 2,500 per cubic metre (US 50/ 20 litres consumed), has been used for the financial analysis of the water supply system and the main inputs into the financial analysis are as follows:

i) Capital Investment Costs.
ii) Capital Reinvestment Costs.
iii) Operation & Maintenance Costs which include: Personnel, Office Running, Energy, Chemical, and Maintenance Costs.
iv) Residual Values of the Assets.

6.2 Capital Investment Cost Estimates

The capital costs are detailed in the Engineer's Estimates in a separate volume (Basis Design Report-Volume 2). They are summarized in Table 6.1 below. All the costs are entirely in Uganda Shillings.

Table 6.1: Capital Investment Cost Estimates

Bill No	Description	Investment Costs UShs
	GENERAL	
BUK G-1	General Items	176,600,000
BUK G-2	Method Related Charges	41,000,000
BUK G-3	Dayworks	6,944,200
	WATER SUPPLY, SANITATION AND EQUIPMENT	
BUK W-1	Borehole Pump Station	73,511,691
BUK W-2	Borehole Pumping Mains	44,825,668
BUK W-3	Storage Reservoir and Site Works	262,217,237
BUK W-4	Distribution Network	147,532,765
BUK W-5	Intensification Network	287,087,470
BUK W-6	Borehole Guard House	20,433,080
BUK W-7	Chemical House	28,547,983
BUK W-8	Water Office	103,077,903
BUK ME-1	Mechanical & Electrical Works	369,523,820
BUK ME-2	Tools and Equipment	32,444,850
BUK S-1	6 Stance Waterborne Toilet (1No.)	61,723,800
	Sub-Total 1	**1,655,470,466**

Bill No	Description	Investment Costs UShs
	Allow for 10% contingency	165,547,047
	Sub-Total 2	**1,821,017,513**
	Allow for 18% VAT	327,783,152
	GRAND TOTAL	**2,148,800,665**

6.3 Capital Reinvestment Cost Estimates

The M&E equipment has a usage life of 12 years after which they will need replacing. Re-investment costs for the project have thus been calculated for the replacement of the borehole pumps, MCC Panels, chemical dozers, and mixers in the year 2030. The re-investment costs, are presented in Table 6.2 below.

Table 6.2 Capital Reinvestment Cost Estimates

Bill No	Description	Re-Investment Costs UShs
BUK ME-1	Mechanical & Electrical Works	162,382,670
BUK ME-2	Tools and Equipment	32,444,850
	Sub-Total 1	**194,827,520**
	Allow for 10% contingency	19,482,752
	Sub-Total 2	**214,310,272**
	Allow for 18% VAT	38,575,849
	GRAND TOTAL	**252,886,121**

6.4 Operation & Maintenance Costs

6.4.1 Personnel Costs

Personnel are required in the project area to operate the water supply system by.

- Operating the system in accordance with the service standards.
- Maintaining the system.
- Developing the system.
- Billing the consumers.
- Collecting revenue.
- Receiving applications for and making new connections.
- Making extensions to the system or assets.
- Attending to all customers.
- Keeping records of the operations of the system.
- Writing status reports for the operations of the system.

The level of personnel and personnel costs are presented in Table 6.3 below.

Table 6.3 Personnel Schedule and Costs

Position	Total Salary ('000 USh/month)	Staff Required (No.)	Total Staff Costs (Mio. USh /year)
Manager	1,000	1	12.0
Accounts Officer	650	1	7.8
Secretary	500	1	6.0
Plumber / Technician	600	3	21.6

Position	Total Salary ('000 USh/month)	Staff Required (No.)	Total Staff Costs (Mio. USh /year)
Meter Readers	200	4	9.6
Attendant / Guard	180	6	13.0
Total		**16**	**70**
Source: Project Estimates			

6.4.2 Running Costs

The office running costs include stationary, utilities, cleaning and general office costs. They are summarised in Table 6.4 below. These are derived from the levels and costs in similar small towns.

Table 6.4 Office Running Costs

Item	Amount (USh '000/month)	Amount (USh '000/year)
Stationary	50	600
Office Supplies	100	1,200
Transport Costs	50	600
Office and Utilities	100	1,200
Cleaning Services	50	600
Total		**4,200**
Source: Project Estimates.		

6.4.3 Chemical Costs

The chemical costs include the cost of chlorine. Since ground water normally has good bacteriological quality, it is anticipated that the disinfection of the water will be minimal. The unit chemical costs are given in Table 6.5 while the annual chemical costs are given in Table 6.6 below. The unit costs are the costs of dosing hypochlorite per m^3 of water produced. These are calculated from the selected dosing rates and market prices of the chemicals.

Table 6.5 Chemical Costs

Chemical	Dosage rate per litre (mg/l)	Dosage rate per cubic metre (g/m^3)	Actual dosage rate per cubic metre (g/m^3)	Cost of chemical per kg (USh)	Cost of chemical for kg/m^3 (USh)
Chlorine	4	4	5.7	6,000	34.3
Source: Project Estimates					

6.4.4 Energy Costs

Since 16hrs pumping is required to meet the demand in the ultimate year, Hydro Electric Power has been considered into the design in order to provide the necessary power requirements. This is due to the limitation of solar working hours which is considered to be 8hrs at maximum per day. The energy cost has been optimised by taking into the account the power requirements to meet the demand at the intermediate year(2030) and at the ultimate year.(2040) To the intermediate year, the HEP is used for 4hrs which takes the total pumping hours to 12hrs and then between the intermediate year to the ultimate year, the system runs on HEP for 8hrs, this takes the pumping hrs to 16hrs. Through this, the energy cost for running the system is optimised without compromising pumping delivery to the tank.
The energy costs incurred while running the system on solar is Zero (0) however only the cost of maintaining the system are incurred. The summary of the annual energy cost incurred while operating on HEP and chemical costs are given in Table 6.6 below. These are derived from the unit costs above and the annual water production.

Table 6.6 Water Volumes (In '000 m3), Annual Energy & Chemical Costs

Item	2020	2025	2030	2035	2040
Water Produced (in '000 m^3 / year)	76.5	89.8	105.3	123.5	144.8
Losses (in '000 m^3 / year)	15.3	18.0	21.1	24.7	29.0
Water Sold (in '000 m^3 / year)	61.2	71.8	84.2	98.8	115.8
Energy Costs (USh mio. / year)	7.5	8.8	10.4	18.2	21.4
Chemical Costs (USh mio. / year)	2.6	3.1	3.6	4.2	5.0
Maximum Day Demand (in m^3/day)	209.7	245.9	288.4	338.3	396.7
Pumping hours per day	8.5	9.9	11.6	13.6	16.0
Cost of Water Produced (in USh/m^3)	0.0	1,314	1,140	1,041	914
Source: Project Estimates					

6.4.5 Maintenance Costs

The annual maintenance costs are taken as a percentage of the investment costs as given in Table 4.4 above. Since the reinvestment costs include item replacement, their maintenance costs are covered in the maintenance costs derived from the investment costs. The categorized capital investment and reinvestment cost estimates are given in Table 6.7 below.

Table 6.7 Investment & Reinvestment Cost Categories

	Cost Estimates (million USh)
Item	**Estimates (million Ush)**
Civil Works	
Structures and Siteworks	825.19
Pipelines	719.98
Subtotal	**1,545.17**
Mechanical and Electrical Works	
Mechanical and Electrical Works	316.36
Solar Items	287.27
Subtotal	**603.63**
Total	**2,148.80**
Preliminaries, Contingencies and VAT	0.00
Total	**2,148.80**
Re-Investment Cost Estimates	
Mechanical and Electrical Works	252.89
Total Re-investment Costs	**252.89**
Notes: Preliminaries and Contingencies has been distributed *pro rata* across all items. M&E Re-investment is after 10 years for Pumps	
Source: Project Estimates	

The annual maintenance costs would therefore be as given in the **Table 6.8** below.

Table 6.8 Annual Maintenance Costs

Item	**Maintenance Cost** (% of Capital Cost)	**Annual Maintenance Costs** (million USh)
Structures and Site works	1.0%	8.25
Pipe work	1.0%	7.20
Mechanical and Electrical Works	5.0%	15.82
Solar Power	1.0%	2.87
Total		**34.14**
Source: Project Estimates		

6.5 Residual Values of the Assets

Residual values for the capital investment and reinvestment cost assets were calculated on the basis of the estimated technical-economic service lifetime of each cost item. They are accounted for as negative investment cost occurring in the ultimate design year, 2040.

Residual values are the expected sale value of an asset at the end of its estimated service lifetime. For the M&E items replaced after 12 years a salvage value of 10% was considered as the residual value even though they had reached the end of their estimated service lifetime. Table 6.9 contains residual values of the assets for the three water supply scenarios. Table 6.10 contains a recapitulation of the investment capital, re-investment, and operation costs. The cash flows that have been used for the financial analysis are given in Table 6.11 overleaf.

Table 6.9: Residual Value of Assets

Item	As-New Value year 2020 (million USh)	As-New Value year 2030 (million USh)	Theoretical Life span (years)	Year of Construction	Remaining Value in year 2040 (million USh)
Civil Works					
Structures and Siteworks	825.2	-	50	2020	495.1
Pipelines	720.0	-	50	2020	432.0
Subtotal	**1,545.2**	**-**			**927.1**
Mechanical and Electrical Works					
Mechanical and Electrical Works [a, b]	316.4	-	10	2020	-316.4
Solar Items	287.3	0.0			0.0
Mechanical and Electrical Works Re-Investment	-	252.9	10	2030	84.3
Subtotal	**603.6**	**252.9**			**-232.1**
Total	**2,148.8**	**252.9**			**695.0**

Notes

a] The mechanical and electrical items have been given a lifespan of 10 years after which re-Investment in their replacement will be carried out

b] Although the mechanical and electrical items will have attained their theoretical lifespan in 2030, they have been given a salvage value of 10% of their Initial cost.

Source: Project Estimates

Table 6.10: Recapitulation of Capital & Maintenance Costs (USh million)

10.	2020	2025	2030	2035	2040	Total
Capital Costs						
Civil Works	1,545.2					1,545.2
Mechanical / Electrical Items	603.6					603.6
Total Project Costs	**2,148.8**					**2,148.8**
Reinvestment Costs						
Mechanical / Electrical Items			252.9			253
Total Reinvestment Costs			**252.9**			**253**
Operation Costs						
Energy Costs		8.8	10.4	18.2	21.4	**276.0**
Chemical Costs		3.1	3.6	4.2	5.0	**74.6**
Maintenance Costs		31.3	31.3	31.3	31.3	**625.4**
Personnel Costs		70.0	70.0	70.0	70.0	**1,399.2**
Office Running Costs		4.8	4.8	4.8	4.8	**96.0**
Total Operation Costs		**117.9**	**120.0**	**128.5**	**132.4**	**2,471.2**
Residual Values					**-695.0**	**-695.0**
Grand Total	**2,148.8**	**117.9**	**372.9**	**128.5**	**-562.7**	**4,177.8**
Source: Project Estimates						

6.6 Results of the Analyses

6.6.1 Dynamic Prime Cost

The Dynamic Prime Cost (DPC) of the water supply services has been used as a basis for determining the financial viability of the project. The DPC of a water supply or sanitation project are obtained by dividing the sum of discounted project investment, re-investment and operation costs by the sum of discounted project outputs both considered over the length of the evaluation period. This in effect gives the tariff necessary for the system to operate without subsidy.

In keeping with the practice in DWD, the water supply undertaking is only expected to meet its operation and maintenance costs. In this analysis, both the total DPC (i.e. with both investment, re-investment, and O & M costs considered) and the operation and maintenance DPC have been calculated. Only the latter will be used for project evaluation.

The objective of the Dynamic Unit Cost analysis is to determine the average tariff level necessary in order to recover cost over the evaluation period. According to standard practice, the calculation of Dynamic Unit Cost is based on a present value analysis, according to which the present value of the cost cash flow of the project is to be divided by the present value of the corresponding flow of water consumption over the determined evaluation period.

The main assumptions underlying the calculation of the DPC are:

i) Evaluation period of 12 years of full system operation with the base year 2019,

ii) Main discount rate applied is 5%, which is generally assumed as investment return for social infrastructure projects. In addition, rates of 0%, 8% and 12% are applied.

iii) Unit rates are in USh,

iv) VAT and taxes are excluded,

v) Physical contingencies of 10% are included, and

vi) Cost categories considered are investment cost, reinvestment cost, residual cost, as well as operation and maintenance cost.

The sequence of work steps for the calculation of the Dynamic Prime Cost are as follows:

i) Allocation of project investment cost, respective re-investment cost, indicating a tentative split between civil works, M&E and other equipment;

ii) Estimation and allocation of annual recurrent operation and maintenance costs,

iii) Present value analysis, i.e. calculation of dynamic prime cost per m³ of water consumed adequate to recover costs.

The detailed values of the Dynamic Prime Cost are given in Table 6.11 below.

Table 6.11 Dynamic Prime Costs

Item	Discounted Totals				Dynamic Prime Costs (USh/m^3 consumed)			
	Discounted Rate (%/year)				Discounted Rate (%/year)			
	5%	8%	10%	12%	5%	8%	10%	12%
Total Water Consumed ('000 m^3/year)	**981.1**	**730.4**	**610.9**	**517.9**				
<u>**Capital Costs**</u> (USh million)								
Project Investments	2,046.5	1,989.6	1,953.5	1,918.6	2,085.8	2,724.1	3,197.5	3,704.8
Project Re-investments	240.8	234.2	229.9	225.8	245.5	320.6	376.3	436.0
Residual Values	-387.0	-276.0	-221.5	-178.4	-394.5	-377.9	-362.5	-344.5
Total	**1,900.3**	**1,947.8**	**1,961.9**	**1,966.0**	**1,936.8**	**2,666.8**	**3,211.3**	**3,796.3**
<u>**Operation Costs**</u> (USh million)								
Pumping Costs	148.3	107.3	88.2	73.5	151.1	146.9	144.3	141.9
Chemical Costs	42.0	31.3	26.2	22.2	42.9	42.9	42.9	42.9
Maintenance Costs	371.1	284.3	242.0	208.5	378.3	389.2	396.1	402.7
Personnel Costs	830.3	636.0	541.5	466.6	846.3	870.8	886.3	901.0
Office Running Costs	57.0	43.6	37.2	32.0	58.1	59.7	60.8	61.8
Total	**1,448.8**	**1,102.5**	**935.0**	**802.8**	**1,476.6**	**1,509.5**	**1,530.4**	**1,550.2**
Grand Total	**3,349.1**	**3,050.3**	**2,896.9**	**2,768.7**	**3,413.4**	**4,176.3**	**4,741.6**	**5,346.5**
Source: Project Estimates								

6.6.2 Net Present Value

Net present value (NPV) is the present value of an investment's expected cash inflows (water sale revenues and residual values of assets) minus the costs of acquiring and operating the investment (Investment and reinvestment costs, and O&M costs). It compares the present value of money in the initial year 2020 to the present value of money in the ultimate year 2040, taking inflation and returns into account.

If NPV > 0; It means the investment is profitable.

NPV < 0; It means the investment is not profitable.

NPV = 0; It means the investment is neither profitable nor unprofitable.

The detailed values of the Net Present Value are given in Table 6.12 overleaf.

6.6.3 Internal Rate of Return

Internal rate of return (IRR) is the discount/interest rate at which the net present value of an investment becomes zero. In other words, IRR is the discount rate which equates the present value of the future cash flows (positive and negative) of an investment with the initial investment. Using IRR to obtain net present value is known as the discounted cash flow method of financial analysis.
The detailed values of the Internal Rate of Return are given in Table 6.12 below.

Table 6.12: Cash Flow Projections, Net Present Values, and Internal Rate of Return

Cash Flows (in USh million)	**2020**	**2025**	**2030**	**2035**	**2040**	**Net Present Values (USh mio.)**				
Scenario I (Groundwater)						0%	5%	8%	10%	12%
Investment	-2,148.8									
Total Operation and Maintenance Costs		-118	-120	-128	-132					
Re-Investment			-253							
Residual Value					695					
Revenues (Water)		180	211	247	290					
Net Cash Flows	**-2,148.8**	**62**	**-162**	**118**	**852**	**173**	**-941**	**-1,237**	**-1,356**	**-1,435**
IRR	**0.5%**									
Source: Project Estimates										

6.6.4 Per Capita Investment Costs

The per capita investments and re-investment costs were calculated for the initial year (2020), intermediate year (2030), and the ultimate year (2040). The computations have been based on the served population. The results are given in Table 6.13 below.

Table 6.13 Per Capita Investment & Re-investment Costs

Per Capita Investment Cost	**Currency**	
	(USh)	(US $)
Resident population - Initial year (2020)	455,689	120
Resident population - Intermediate year (2030)	331,273	87
Resident population - Ultimate year (2040)	240,850	63
Per Capita Re-Investment Cost	**Currency**	
	(USh)	(US $)
	(USh)	(US $)
Resident population - Intermediate year (2030)	38,987	10
Resident population - Ultimate year (2040)	28,345	7
Source: Project estimates.		
Note 1US$ = 3800 ***Ush***		
Source: Project Estimates		

6.6.5 Summary of Financial Indicators

The results of the analyses are summarised in the Table 6.14 below.

Table 6.14 Summary of Financial Indicators

Item	**Discounted Totals**				
	Discounted Rate (%/year)				
	0%	**5%**	**8%**	**10%**	**12%**
Net Present Value (in USh million)	173	-941	-1,237	-1,356	-1,435
Dynamic Prime Cost - O & M (USh/m^3)	1,420	1,477	1,509	1,530	1,550
Dynamic Prime Cost - Total (USh/m^3)	2,400	3,413	4,176	4,742	5,346
Internal Rate of Return	**0.5%**				
Source: Project Estimates					

6.7 Conclusions and Recommendations from the Financial Analysis

6.7.1 Conclusions

The main conclusions are as follows;

a) The Dynamic Prime Cost (DPC) covering the Operation & Maintenance costs at the discounted rate of 5% is USh 1,477 per m^3, which is less than the proposed tariff of USh 2,500 per m^3. If this tariff is charged, the project will cover its O & M costs. This is mainly due to low cost of water production due to the use of a hybrid system powered greatly by solar from the base year (2020) to the intermediate year (2030) and 50% of the production on HEP between the intermediate year (2030) to the ultimate year (2040).

b) The Internal Rate of Return (IRR) is (+0.5%). This means that at the tariff of USh 2,500 per m^3 the system will be able to generate a surplus.

c) As with all DWD implementation projects, investment and re-investment cost recovery is not considered. If the investment and re-investment costs are to be recovered, the tariffs, at the discounted rate of 5%, would have to be at least Ush 3,413.

d) The Net Present Values (NPV) is USh -941 million USh at 5% discounted rate. This means that the investment is not profitable at this (5%) discounted rate. However, it becomes profitable at 0% discount since the NPVs are USh +173 million.

e) The ultimate year 2040 per capita investment costs are US$ 63. According to the 2013 MWE manual, the average per capita investment cost for 12 towns implemented during the FY 2010/11 by MWE was US$ 40. The usually accepted MWE per capita investment costs range is US$ 60 – 120 and from the analysis made, this system falls in this bracket.

In summary therefore, the investments required to Improve Bukizibu Bumwena water supply system are justifiable as seen from the per capita investment costs and the IRR.

7 INSTITUTIONAL AND MANAGEMENT ANALYSIS

7.1 Introduction

Management of the system will follow standard DWD management procedures. A private operator (PO) under the supervision of the DWD will run the system. The modalities for engaging the private operators are embedded in the policies of the directorate and have been applied in various projects with reasonable success. This chapter reviews these experiences and discusses the way forward for Bukizibu Bumwena RGC Water Supply and Sanitation System.

7.2 Private Sector Participation (PSP) in Water Supply Systems

Water schemes require formal management arrangements, a legal basis for ownership and supervision as well as the ability to expand services to meet the growing demand for services. Management of small water schemes evolved in Uganda over the years from traditional public sector models through demand-driven community approaches in the 1990’s to private sector participatory arrangements in recent years since 2001.

The concept of private sector participation (PSP) was initiated by the Water and Sanitation Program-Africa and developed by the DWD. The urban water sector reform study of 2002 re-affirmed the need for PSP in the management of urban water services. On the basis of these initiatives, private sector participation in the management of water schemes was introduced in the urban water services in Uganda.

POs were selected on basis of competitive bidding following a pre-qualification phase. Successful bidders later negotiated and signed contracts with the Water Authorities of the respective schemes they had applied for. The contracts are performance-oriented and they run for two or three years upon which the parties are required to negotiate renewal.

The organizational arrangements for PSP in Water Schemes essentially follow a semi-decentralised policy framework whereby the POs have considerable autonomy in operational decision-making on all aspects of engineering and commercial matters. However, the DWD retains full powers for procurement of water meters, chemicals and spare parts. In centralising procurement of these essential service inputs, DWD might perhaps be undermining the operational functioning of the schemes. The likely impact of these arrangements is that overall progress in performance may be hampered by financial constraints unless revenues accruing can supersede the costs of achieving the ‘set targets’ and POs are permitted more flexibility in operational expenditure. But financial control objectives can be achieved without necessarily undermining operational efficiency. One way is implementing procedures that compel transparency and accountability but preserve operational autonomy.

Generally, before the incoming of the umbrella organisations to operate and maintain the systems, the Water Authorities (Councils) adequately carried out the functions in relation to the supervision of the POs. POs were paid from the joint bank account in time and good cooperation was established between the Councils and POs in most of the cases.

7.3 Umbrella Organisations

The Umbrella organisation (Eastern, Western, Central and Northern) was gazetted by the Ministry of water and Environment to operate and maintain all the water supply and sanitation systems within their regions of operation.

For the case of Bukizibu Bumwena water supply and sanitation system, Eastern Umbrella is designated as the Water Authority and Operator of this System due to the fact that the project lies in its area of jurisdiction.

The roles of the stakeholder as regards this system are as follows

7.3.1 The Operator (Eastern Umbrella)

The Operator (Eastern Umbrella) manages the water supply and sanitation, including:

- Operating the system in accordance with the set guidelines
- Maintaining the system,
- Developing the system,
- Billing the consumers,
- Collecting revenue,
- Receiving applications for and making new connections,
- Making extensions to the system or assets,
- Attend to all customers,
- Prepare draft business plans for the authority,
- Prepare regular status reports for the operations of the system,
- Maintain regular accounts for submission to the Ministry.
- To operate a Management Information System (MIS) as provided by the Ministry.
- Keep records of the operation of the water supply system - both physical and technical,
- Ensures that all accounts are audited,
- Set and publish Tariff & Charges

7.3.2 The Consumer

The consumer has the following obligations:

- Pay on time for the water used, services provided, and penalties imposed,
- Ensure the security of the meter.

7.3.3 Recommendations

Since the Umbrella has been designated as the organisation in charge of operations and maintenance of all new systems being constructed directly by Ministry of Water and Environment, and due to the fact that umbrella does not have readily available personnel to run the systems after hand over, the following should be encouraged.

- Umbrella should select its proposed staff and forward their names to the contractor for hands on training during the commissioning of the works. This would normally be one month when both the construction supervision engineer and the contractor are present on site.

- Set up a stake holder’s workshop to be attended by the major players as regards the project so as to appraise all parties of their roles in the management and operation of the water supply system.

- Ministry through DWD to conduct regular monitoring surveys to establish the performance of Umbrella, and where necessary render assistance to them.

8 ANNEXES

Annex 8.1: Demography
Annex 8.2: Water Demand Calculations
Annex 8.3: Water Supply Design Calculations
Annex 8.4: Design Drawings

Annex 8.1

Demography

Table 8.1: Population Projections

S/County	Parish	Village	Base Population	Population Growth Rates			Total Population					
			2014	2014-2020	2020-2030	2030-2040	2019	2020	2025	2030	2035	2040
Malongo	Bumwena	Bukizibu A	1,040	3.2%	3.2%	3.2%	1,219	1,258	1,475	1,730	2,029	2,380
		Bukizibu B	2,374	3.2%	3.2%	3.2%	2,784	2,874	3,371	3,954	4,637	5,438
		Bukizibu C	635	3.2%	3.2%	3.2%	745	769	902	1,058	1,241	1,455
		Bumwena B	1,293	3.2%	3.2%	3.2%	1,516	1,565	1,835	2,152	2,524	2,960
	Parish Total		**5,341**	**3.2%**	**3.2%**	**3.2%**	**6,264**	**6,466**	**7,583**	**8,894**	**10,431**	**12,233**
Bukizibu-Bumwena Water Supply Project Total			**5,341**	**3.2%**	**3.2%**	**3.2%**	**6,264**	**6,466**	**7,583**	**8,894**	**10,431**	**12,233**
Source: UBOS, Mayuge District												

Table 8.2: Served Population

S/County	Parish	Village	% Population Served	Served Population					
				2019	2020	2025	2030	2035	2040
Malongo	Bumwena	Bukizibu A	100%	1,219	1,258	1,475	1,730	2,029	2,380
		Bukizibu B	100%	2,784	2,874	3,371	3,954	4,637	5,438
		Bukizibu C	100%	186	192	226	265	310	364
		Bumwena B	25%	379	391	459	538	631	740
	Parish Total		**73%**	**4,568**	**4,716**	**5,530**	**6,487**	**7,607**	**8,922**
Bukizibu-Bumwena Water Supply Project Total			**73%**	**4,568**	**4,716**	**5,530**	**6,487**	**7,607**	**8,922**
Source: Project Estimates									

Table 8.3: Institutional Population

Demand Category	Unit	Population					
		2019	2020	2025	2030	2035	2040
Institutions							
Education							
Day Scholars	No.	6,397	6,604	7,745	9,084	10,654	12,496
Boarding Scholars	No.	0	0	0	0	0	0
Hospitals / Health Centres							
In-Patients	Beds	0	0	0	0	0	0
Out-Patients	No.	10	10	12	14	17	20
Non-Resident Staff	No.	4	4	5	6	7	8
Resident Staff	No.	0	0	0	0	0	0
Commercial / Industrial							
Restaurants/Eating Places	No.	10	10	12	14	17	20
Shops	No.	75	77	91	107	125	147
Dry Processing Mills	No.	3	3	4	4	5	6
Markets	No.	1	1	1	1	2	2
Offices	No.	15	15	18	21	25	29
Police Posts	No.	1	1	1	1	2	2
Churches	No.	11	11	13	16	18	21
Mosques	No.	7	7	8	10	12	14
Source: Field Surveys and Project Estimates							

Annex 8.2

Water Demand Calculations

Table 8.4: Demand by Enumeration (2019 & 2040)

S/County	Parish	Village	Demand Year 2019 (m^3/d)						Demand Year 2040 (m^3/d)					
			Domestic	Institutions	Industrial / Commercial	UFW	Total Demand	Max Day Demand	Domestic	Institutions	Industrial / Commercial	UFW	Total Demand	Max Day Demand
Malongo	Bumwena	Bukizibu A	27.3	5.6	0.0	8.2	41.2	53.6	53.4	11.0	0.0	16.1	80.5	104.6
		Bukizibu B	62.4	5.6	0.0	17.0	85.1	110.6	122.0	11.0	0.0	33.2	166.2	216.1
		Bukizibu C	4.2	5.6	0.0	2.5	12.3	15.9	8.2	11.0	0.0	4.8	24.0	31.1
		Bumwena B	8.5	5.6	0.0	3.5	17.7	23.0	16.6	11.0	0.0	6.9	34.5	44.9
		Parish Total	**102**	**23**	**0**	**31**	**156**	**203**	**200**	**44**	**0**	**61**	**305**	**397**
Bukizibu-Bumwena Water Supply Project Total			**102**	**23**	**0**	**31**	**156**	**203**	**200**	**44**	**0**	**61**	**305**	**397**
Source: Field Surveys and Project Estimates														

Annex 8.3

Water Supply Design Calculations

Table 8.5: Borehole Pumping Main

Borehole Number	BH DWD 60824
Supply Area Demand (m^3/d)	**397**
Test Pump Yield (m^3/hr)	**26.50**
Borehole Yield to be Used (m^3/hr)	**25.2**
Hours of Pumping (hr)	16.0
Efficiency Pump (%)	60.0%
Efficiency Motor (%)	80.0%
Total Daily Delivery (m^3/day)	403
Pumping Main Section No. 01 (From Pump Installation Point to Ground Level at Borehole)	
Ground Level at Borehole (m AMSL)	1146.39
Pump Installation Depth in Borehole (m BGL)	75.000
Cwh	140
Pipe Details	**OD110 HDPE PN16**
Pipe Diameter ND (mm)	90.00
Pipe Diameter ND (m)	0.090
Flow in Pipe (m^3/hr)	25.175
Flow in Pipe (m^3/s)	0.007
Velocity (m/s)	1.10
Length of Pipe Section No. 01 (m)	**75.00**
Friction Loss (m)	1.07
Fittings losses - 10% (m)	0.11
Total Headloss in Section 01 (m)	**1**
Pumping Main Section No. 02 (From Ground Level at Borehole to Ground Level at Reservoir)	
Ground Level at Tank (m AMSL)	1179.520
Ground Level at Borehole (m AMSL)	1146.390
Static Lift (m)	**33.130**
Cwh	140
Pipe Details	**OD110 uPVC PN10**
Pipe Diameter ND (mm)	99.40
Pipe Diameter ND (m)	0.099
Flow through pipe section 02 (m^3/hr)	25.175
Flow through pipe section 02 (m^3/s)	0.007
Velocity (m/s)	0.90
Chainage at Reservoir	1+160
Chainage at Borehole	0+000
Length of Pipe Section No. 02 (m)	**1,160.00**
Friction Loss (m)	10.24
Fittings losses - 10% (m)	1.02
Total Headloss in Section 02 (m)	**11**
Total Pumping Head from Borehole to Reservoir	
Total Static Head from Borehole Installation Point to Reservoir	108
Total Headloss from Borehole Installation Point to Reservoir	12
Total Pumping Head from Borehole to Reservoir	**121**
Summary of the Design	
Total Length of Transmission	
OD110 HDPE PN16 (m)	75
OD110 uPVC PN10 (m)	1160
Capacity of pump in the borehole	
Head (m)	121
Flow (m^3/hr)	25.2
Power (kW)	**17.2**
Source: Project estimates.	

Table 8.6: Distribution Network Node Details

Node ID	Elevation (m.a.s.l)	Base Demand (lps)	Off Peak Flows (Peak Factor=0.5)			Normal Peak Flows (Peak Factor=1.0)			Peak Flows (Peak Factor=2.0)		
			Demand (lps)	Hydraulic Gradient (m.a.s.l)	Residual Pressure (m)	Demand (lps)	Hydraulic Gradient (m.a.s.l)	Residual Pressure (m)	Demand (lps)	Hydraulic Gradient (m.a.s.l)	Residual Pressure (m)
Junc N01	1160.21	1.23	0.63	1175.84	15.63	1.25	1175.78	15.57	2.5	1175.59	15.38
Junc N02	1160.26	0.93	0.48	1175.7	15.44	0.96	1175.28	15.02	1.92	1173.77	13.51
Junc N03	1155.88	0.11	0.06	1175.54	19.66	0.12	1174.7	18.82	0.24	1171.66	15.78
Junc N04	1153.79	0.08	0.05	1175.42	21.63	0.09	1174.26	20.47	0.18	1170.07	16.28
Junc N05	1147.63	0.3	0.15	1175.31	27.68	0.3	1173.88	26.25	0.6	1168.7	21.07
Junc N06	1158.21	0.82	0.41	1175.49	17.28	0.83	1174.54	16.33	1.66	1171.09	12.88
Junc N07	1134.84	0.15	0.08	1175.28	40.44	0.15	1173.76	38.92	0.3	1168.29	33.45
Junc N08	1147.98	0.02	0.01	1175.42	27.44	0.03	1174.25	26.27	0.06	1170.06	22.08
Junc N09	1139.94	0.03	0.02	1175.53	35.59	0.04	1174.69	34.75	0.08	1171.62	31.68
Junc N10	1157.31	0.45	0.23	1175.36	18.05	0.46	1174.04	16.73	0.92	1169.3	11.99
Junc N11	1145.88	0.12	0.07	1175.47	29.59	0.13	1174.46	28.58	0.26	1170.82	24.94
Junc N12	1155.15	0.25	0.12	1175.28	20.13	0.25	1173.78	18.63	0.5	1168.34	13.19
Resvr Bukizibu-Bumwena_Rsvr	1175.66	#N/A	-2.31	1175.86	0	-4.61	1175.86	0	-9.22	1175.86	0
Source: Project Estimates											

Table 8.7: Distribution Network Pipe Details

Pipe ID	Nodes	Length (m)	Pipe Details	Internal Diameter (mm)	Roughness	Velocity at Peak Flow (m/s)
Pipe 1	Bukizibu-Bumwena_Rsvr to N01	139.6	OD160 uPVC PN6	150.6	140	0.52
Pipe 2	N01 to N02	320.3	OD110 uPVC PN6	103.6	140	0.73
Pipe 3	N02 to N06	497.0	OD90 HDPE PN6	83.0	140	0.62
Pipe 4	N06 to N10	629.0	OD63 HDPE PN6	58.0	140	0.35
Pipe 5	N02 to N03	257.6	OD50 HDPE PN6	46.0	140	0.53
Pipe 6	N03 to N04	444.1	OD50 HDPE PN6	46.0	140	0.34
Pipe 7	N04 to N05	1,063.2	OD50 HDPE PN6	46.0	140	0.2
Pipe 8	N01 to N05	1,837.5	OD50 HDPE PN6	46.0	140	0.35
Pipe 9	N03 to N09	379.0	OD50 HDPE PN6	46.0	140	0.05
Pipe 10	N04 to N08	128.1	OD50 HDPE PN6	46.0	140	0.04
Pipe 11	N05 to N07	371.6	OD50 HDPE PN6	46.0	140	0.18
Pipe 12	N06 to N11	315.0	OD50 HDPE PN6	46.0	140	0.16
Pipe 13	N06 to N12	967.0	OD50 HDPE PN6	46.0	140	0.3
Source: Project Estimates						

Annex 8.4

Design Drawings

Drawings List

SGI-MWE-BUK-0.0.0	General Layout (Entire Project Area)
SGI-MWE-BUK-1.0.0	Typical Borehole Layout
SGI-MWE-BUK-3.0.0	130m^3 Tank Plan Layout