MAKERERE UNIVERSITY

PROJECT: DESIGN AND CONSTRUCTION OF UDERU MOTORIZED PIPED WATER PROJECT AT PACHARA SUBCOUNTY IN ADJUMANI DISTRICT.

CMG7301 PROJECT/FIELD REPORT

BY

IZAKARE KAREODE RICHARD

Registration No.: 2020/HD08/17504U

REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF A POSTGRADUATE DIPLOMA IN CONSTRUCTION PROJECT MANAGEMENT OF MAKERERE UNIVERSITY

DECEMBER 2021

DECLARATION

I, Izakare Kareode Richard, hereby affirm that the content of this report is my bona fide work and has never been submitted to any University or Higher Institution of Learning for any academic award.

Signed: .....

Date: 25/01/2022

APPROVAL

This report has been submitted with the approval of the undersigned supervisor.

Signature..... Date.....31/01/2022

Eng. Dr. Dans Nshekanabo Naturinda
Senior Lecturer, School of Built Environment
Department of Construction Economics and Management
College of Engineering, Design, Art and Technology
Makerere University
P. O. Box 7062
KAMPALA

DEDICATION

I dedicate this report to my beloved family and the entire fraternity of Adjumani District Local Government.

ACKNOWLEDGEMENT

This course would not have been possible without the support of Adjumani District Local Government Council by permitting me as well as supporting me financially. Additionally, for lobbying for funds for the implementation of this project that has enhanced my skills in Construction Project Management

In gratitude, I salute Northern Uganda Resilience Initiative for earmarking funds for capacity building Program under the Support to Local Governments.

I am thankful to my field Supervisor and all the Lecturers of this course for their direct and indirect contributions in developing in my career and this report. I am further grateful to my friends in particular Akena Leonard and Komakech Henry for their sound counsel.

Last but not the least, I am indebted to my family for their understanding and continuing support which saw me through the course. The love of God is bestowed and to them.

ABSTRACT

The Government of Uganda, through the Ministry of Water and Environment (MoWE) using funding from the Donor Community, formulated a program, Government of Uganda UNICEF Country Program, to improve safe water infrastructure facilities in schools, Health centers and Communities in Twenty –nine (29) Districts of Adjumani, Arua, Moyo, Yumbe, Mbale, Koboko,Tororo, Maracha, Moroto, Kamwenge, Kiryandongo, Kyegegwa, Isingiro, Rakai,Luwero, Hoima, Lamwo, Kotido,Kaabong, Napak, Abim,Amudat, Nakapiripirit, Kyenjojo, Kampala, Kamuli, Ntungamo, Mayuge and Mbarara . The program is intended to be implemented over a period of 5 years with a projected budget of USD 150million.

This report is as a result of the project supervision of the Construction of a Motorized water project in Adjumani District implemented under the Government of Uganda UNICEF Country Program 2019-2021 program

The aim of this field attachment was to develop the student's skills to develop study issues in management of construction projects, collect data from various sources, analyze the data and present findings in a logical way.

This report gives a detail account of what transpired during the project right from inception to commissioning including design, Environmental Impacts Assessment, Occupational Health and safety, activities executed and Project management.

Any significant construction project will involve various stakeholders who arrive on the project at different stages as parties to the construction process. It's therefore very important to involve the different stakeholders from the initial stages of the project with a collective aim of delivering the project to meet the client's requirement of delivery on time, to the required quality and at a defined budget.

Considering the magnitude of the project and internal technical failures of the client's payment system, this time loss was quite reasonable. Overall, the project was completed outside the prescribed cost range and time.

The author learnt that project control was very essential in mitigating many of the management challenges that could arise during construction project execution process.

TABLE OF CONTENTS

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

%	Per cent
AfDB	African Development Bank
ATP	Ability to Pay
CUWS	Central Umbrella of Water and Sanitation
DI	Ductile Iron
DN	Nominal Diameter
DWD	Directorate of Water Development
EAP	Environmental Action Plan
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ESRI	Environmental Systems Research Institute
FGD	Focus Group Discussions
GIS	Geographical Information System
GI	Galvanized Iron
GoU	Government of Uganda
h	Hour
Ha	Hectares
HC	House Connections
HDPE	High Density Poly Ethylene
IWRM	Integrated Water Resources Management
IDA	International Development Association
IEC	Information, Education and Communication
IRR	Internal Rate of Return
KII	Key Informant Interviews
Km	Kilometer
l	Liter
LC	Local Council
m AMSL	Meters Above Mean Sea Level
m^3/d	Cubic meters per day
m^3/h	Cubic meters per hour
mg/l	Milligram per liter

MDG	Millennium Development Goals
MTN	Mobile Telecommunications Network
MWE	Ministry of Water and Environment
ND	Nominal Diameter
NEMA	National Environment Management Authority
NGO	Non-Governmental Organization
No	Number
NRW	Non-Revenue Water

NS	Non-Piped Supply
NWSC	National Water and Sewerage Corporation
OD	Outside Diameter
O&M	Operation & Maintenance
PPDA	Public Procurement and Disposal Authority
PMU	Project Management Unit
PSP	Public Stand Posts (Water Points or Kiosks)
RGC	Rural Growth Centre
SEHS	Socio-Economic Household Survey
SP	Public Stand Posts (Water Points or Kiosks)
STWSP	Small Towns Water and Sanitation Project
ToR	Terms of Reference
UBOS	Uganda Bureau of Statistics
UfW	Unaccounted for Water
uPVC	unPlasticised Poly Vinyl Chloride
USh / UGX	Uganda Shilling
VAT	Value Added Tax
WSS	Water Supply System
WAP	Water Action Plan
WATSAN	Water and Sanitation
WSSP	Water Supply and Sanitation Program
WSDF-C	Water and Sanitation Development Facility- Central
WtP	Willingness to Pay

CHAPTER ONE: INTRODUCTION

1.1 Overview

This report is as a result of the project supervision of the Design and Construction of the Motorized water project at Uderu at Pachara Sub County in Adjumani District. As one of the requirements to attain a post graduate Diploma in Construction Project management in Makerere University, each student is required to submit a report on supervised short project/field attachment/industrial training carried out.

1.2 Background

The author was attached by the entity to supervise the Construction of a Motorized water supply project at Uderu at Pachara Sub county in Adjumani District.

The Government of Uganda, through the Ministry of Water and Environment(MoWE) using funding from the Donor Community, formulated a program, Government of Uganda UNICEF Country Program 2017-2021, to improve water supply infrastructure conditions in Twenty –nine (29) Districts of Adjumani, Arua, Moyo, Yumbe, Mbale, Koboko,Tororo, Maracha, Moroto, Kamwenge, Kiryandongo, Kyegegwa, Isingiro, Rakai,Luwero, Hoima, Lamwo, Kotido,Kaabong, Napak, Abim,Amudat, Nakapiripirit, Kyenjojo, Kampala, Kamuli, Ntungamo, Mayuge and Mbarara The program was implemented over a period of 5 years with a projected budget of USD 270million.

Adjumani District prioritized infrastructure investment for District Development Plan II which comprised of Construction of Motorized Water supply systems at Uderu in Pacara Sub county, Construction of a motorized System at Nyumazi in Dzaipi Sub county, Construction of a Motorized system at Ayilo in Dzaipi Sub county and construction of a motorized system at Ukusijoni Market in Ukusijoni Sub county.

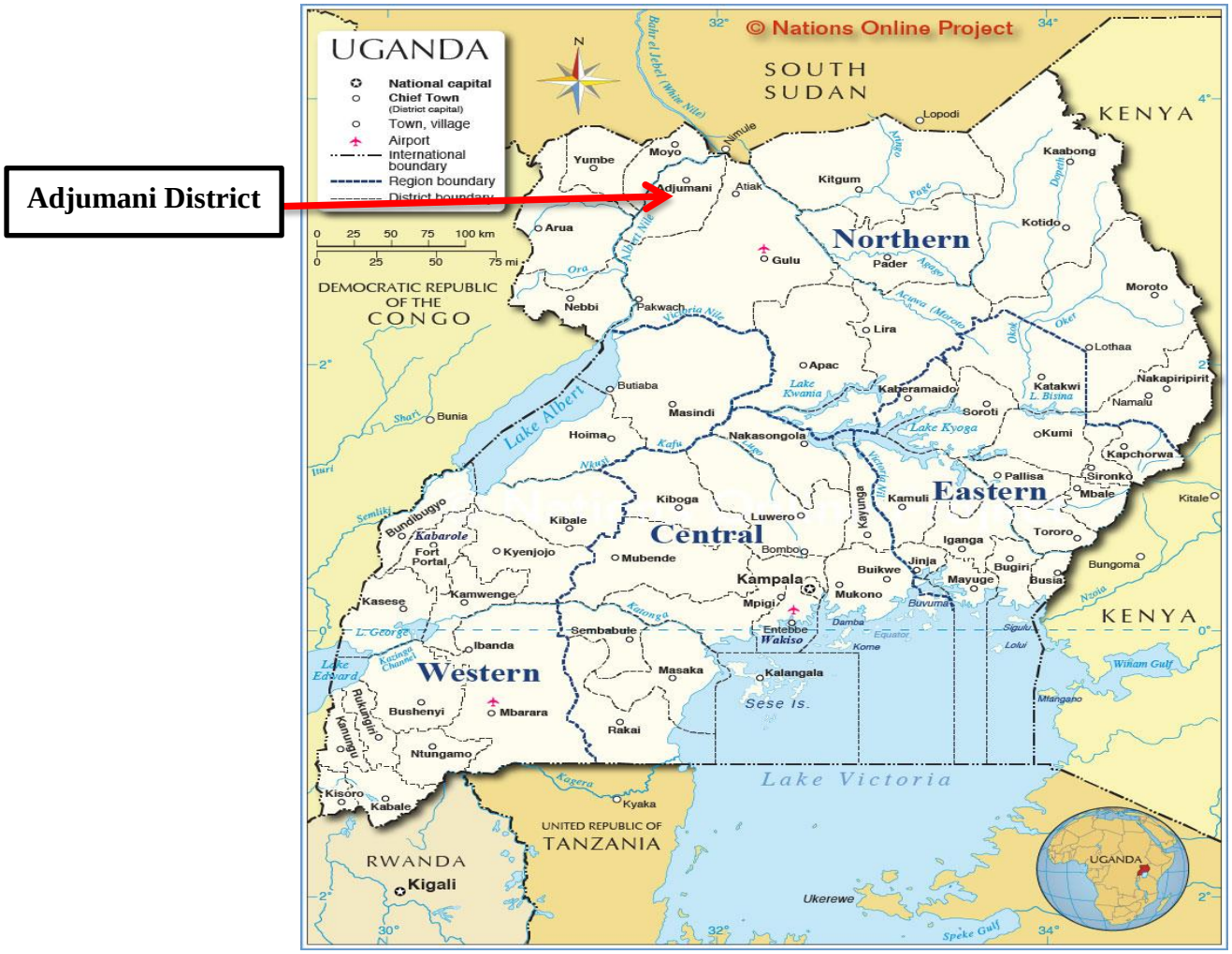
M/S Geobot Water Engineering Services Ltd was contracted by Adjumani District Local Government in 2018 to carry out the detailed engineering design, Environment assessment and resettlement action plan for Uderu Motorized water supply infrastructure at Pachara Sub county in Adjumani District. The design was completed in March 2018.

1.3 Location and description of the Project

Adjumani district is located in the north-western region of Uganda, between latitudes 31o 24" and 32o 4" east of Greenwich line; and longitudes 2o 53" and 3o 37" north of the Equator. The district lies on the eastern bank of the Albert Nile, which is its common border with Moyo District. It borders the districts of Amuru in the south and east, Arua and Yumbe in the west and Moyo in the North. Adjumani is one of the districts that form Uganda's common border with the Republic of South Sudan in the northeast. The total land area of the district is 3128 Sq. Kms, of which 46.8 Sq. Kms is covered by water. The area occupied by forest is estimated at 37.44 Sq. Kms. Of the 1455 Sq. Kms of arable land, only 120.8 Sq. Kms is under cultivation.

Adjumani District lies at an approximate altitude ranging from 900 to 1500 metres above sea level. It is principally gentle undulating land merging into rock outcrops. The southern part of the district, especially the area occupied by Ciforo Sub-county comprises of highlands dropping into broad flat-bottomed valleys while the north stands at a low slope gradient. The district is mainly underlain by a complex formation consisting of highly weathered and exposed hard-core rocks, quartzite sandstones, and clay. Hard-core rock and sand are used in construction work; murram is mined and used for road works while clay is for pottery and brick industry. Open water bodies comprise 2.5% of total land area with River Nile (Albert Nile) being the major feature of the district. Other prominent rivers include Itirikwa, Esia, Ayugi, Tete, Adidi and Zoka. In Adropi sub-county there are prominent seasonal streams like Assisi, Adropi, Robidire, Oliji, Ariwa, Minia, Surumu, Ura eyi that drain into river Nile. The district is also endowed with a hot spring, located at Amuru in Pakelle sub-county. Adjumani is endowed with considerable vegetation cover. Permanent wetlands with a variety of vegetation particularly papyrus occupy the banks of River Nile (Albert Nile). Seasonal swamps also occupy a sizeable area of the district. The Arawa highlands and the equatorial forest of Zoka, in Ofua sub-county, dominate the southern part of the district. Other areas are predominantly savannah woodland and grassland with grasses ranging from 0.5-2.0 meters' high.

Figure 1.1: Location Map-Adjumani District



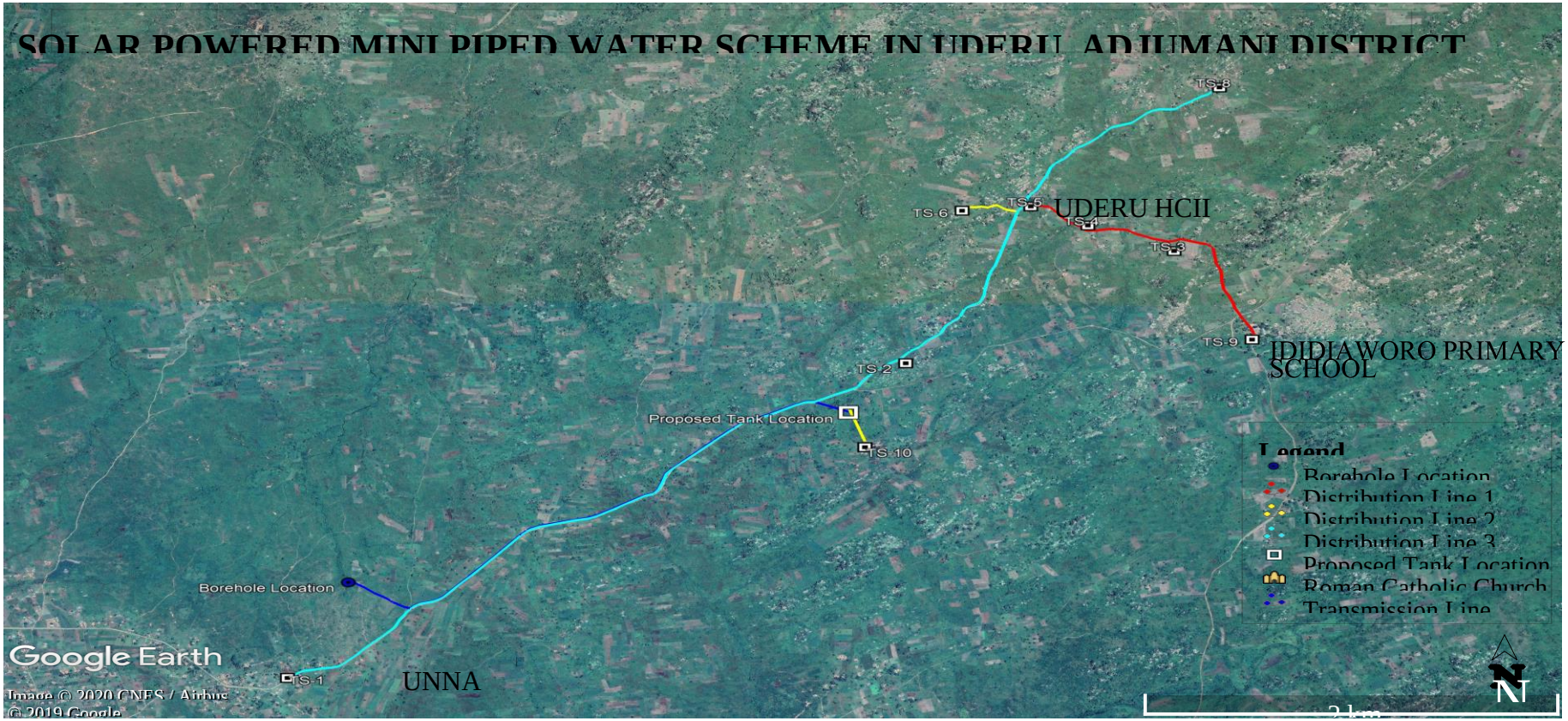
1.4 Project Area Description

Adjumani District covers an area of 10 sq. km and is the major town in Uganda's West Nile region. It lies approximately 446km from the Country's capital Kampala. The project originally comprised of construction of Alere Piped water system and Ayilo piped water supply system but this has since been put to halt and Uderu piped water system proposed to be first handled due to lack of safe water at the location in question. The detailed description of each of the infrastructure is provided in the proceeding sections.

Project Location

The Water project, Uderu is located in Unna Parish Pachara Subcounty. It has a direct benefit for the people at Unna central village and Ibibiaworo village where there is also poor ground water potential link. The detailed locations are highlighted in Figure 1-2.

Figure 1.2 Site location map


SOLAR POWERED MINI PIPED WATER SCHEME IN UDERU ADJUMANI DISTRICT
TS-8
TS-6
TS-5
UDERU HCII
TS-4
TS-3
TS-9
IDIDIAWORO PRIMARY SCHOOL
TS-2
Proposed Tank Location
TS-10
Borehole Location
TS-1
UNNA
Google Earth
Image © 2020 CNES / Airbus
© 2019 Google
Legend
Borehole Location
Distribution Line 1
Distribution Line 2
Distribution Line 3
Proposed Tank Location
Roman Catholic Church
Transmission Line
N
2 km

1.5 Tasks carried out by the entity & its role to society

Adjumani District Council, like any other authority, is tasked with the role of providing social services for all the communities. The types of social services provided by the Adjumani District council include community sensitization on government programs in sectors such as health, education, wealth creation; provision and maintenance of infrastructure such as roads, buildings, drainage facilities, water etc., as well as control of development.

1.6 Structure of Organisation

Adjumani District is one of the old 45 Districts of Uganda. The District has a political leadership that is headed by a Chairperson. The Chairpersons executive committee has 5 councillors - including the Vice Chairperson and secretaries for production, finance/planning as well as works/social services. On the other hand, the technical arm of governance is headed by the Chief Administrative Officer who is deputized by a Deputy Chief Administrative Officer. There are also heads of department for production, finance/planning, works/technical services, health, community development and education

1.7 Main objective of the field attachment

The aim of this field attachment was to develop the student's skills to develop study issues in management of construction projects, collect data from various sources, analyze the data and present findings in a logical way.

1.8 Brief Description of Project Components

The works initially comprised of two components, Construction of a Modern Out Patient Department and Construction of the Motorized water supply system both for Uderu Health Centre II. The existing hand pump or borehole dried up that pre-empted construction of a new water sources. However, following the several joint inspections and meeting where all stakeholders were represented, the proposed location of the Outpatient Department was halted and priority was given to construction of the water system.

Adjumani District Local Government then took on the overall role of locating another site, however, due to the difficulties encountered in securing land to suitably locate the Water source, a meeting held on June 1st 2017 resolved that the drilling of the water source(borehole) be sited

in Unna central Village and subsequently transmitted to Uderu from the appropriately drilled water source.

1.9 Construction of Uderu Motorized piped water system

Uderu Piped water system is a Mini piped water scheme that has a source yielding 25m3/h and transmitted over a distance of about 2.5Km and distributed to about 5Km with a pressed steel tank reservoir and twelve Public stand posts serving Uderu Health Centre II, Ibibiaworo Primary school and the surrounding community, a total population of about 2500 people

1.10 Author's Involvement

The writer was attached by the entity to the project manager's team to work with the supervising consultant in order to deliver the required output (finished Water system). During this process, the author played key roles during project identification, design supervision, procurement process for contractor and supervision consultant, resettlement of project affected persons (PAPs), relocation of utilities and project execution including: -

- Linkage with local utility organizations such as National Water & Sewerage Corporation (NWSC) to ensure timely relocation of utilities along the existing distribution and transmission mains
- Preparation of monthly, quarterly and other periodic project reports
- Verification of interim payment certificates
- Verification of project items for possible variations
- Examination of contractor's claims and quotations
- Identification of snags and verification of snag lists prepared by contractor.

CHAPTER TWO: DESIGN

2.1 Introduction

The Government of Uganda is committed to a policy for the increased provision of safe water supply and adequate sanitation to the whole population. The current water supply coverage for Uganda is estimated to 64 %, whereas the coverage of sanitation service, mostly on-site sanitation is about 33 %. According to the Millennium Development Goals 100% of urban population and 62% of rural population should have had access to safe water sources by 2015.

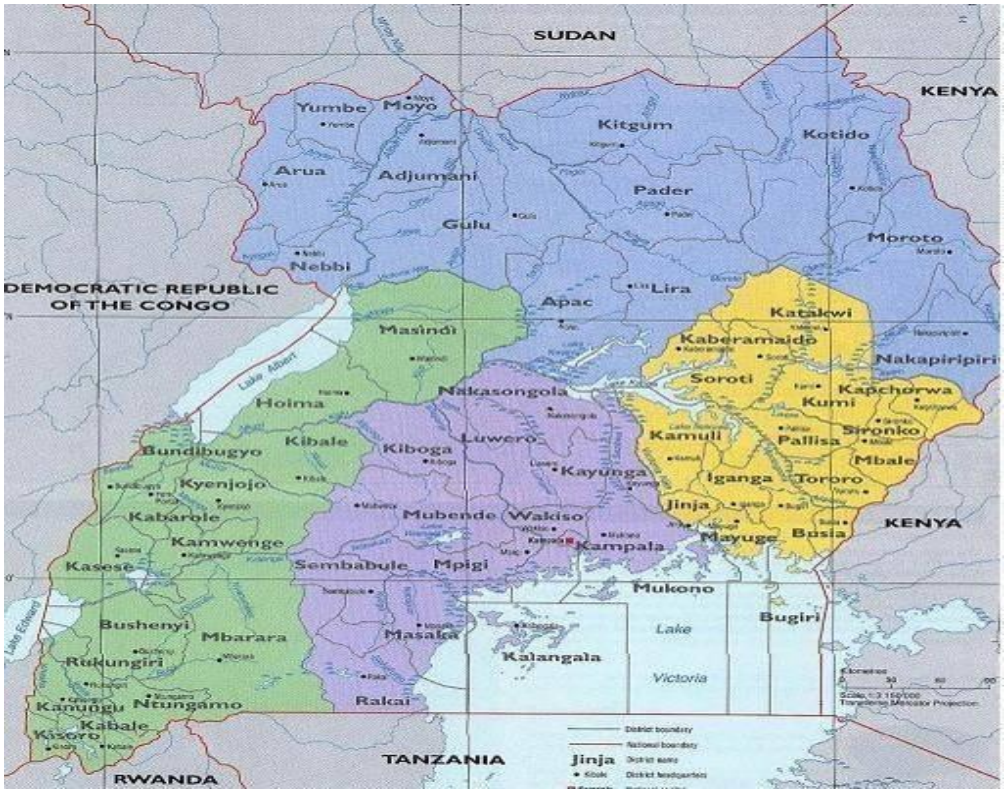
Adjumani District Local government is desirous to support the planning, design, construction supervision of a water supply system. This assignment is therefore aimed at fulfilling this goal. This is the Detailed Design Report for Uderu Town water supply system.

2.2 Description of the Village

Uderu village is located in Unna Parish, Pachara Sub County, and Adjumani District. It is one of the villages that have been water stressed for a while. Preparation of priority needs of the population is identified through bottom up Participatory planning conducted right from Village, Parish, Sub County and District

Location of the town is given in **Figure 0.1** below.

Figure 1.3: Location of Adjumani District



2.3 Detailed Design of Water Supply Interventions

Design has been carried out of the intervention required under the ground water supply scenario. The components of the system are Storage Reservoir, Distribution Network, Service Connections, Production Borehole, Raw Water Transmission Main.

The components are summarized in **Table 0.1** below

Table 0.1: Different Water Supply Components

Description	**Unit**	**Ground Water Supply**
		Quantity
Distribution Network		
OD 90 HDPE PN 6	m	3,315
OD 63 HDPE PN 6	m	2,264
Service Connections		
OD 32 Public Stand Posts	No.	12
Storage Reservoir		
60m^3 Pressed Steel Reservoir	No.	1
12 m High Steel Tower	No.	1
Production Borehole		
Uderu: yield 20m3/hr. (Drilled & Test Pumped)	No.	1
New Risers/Pumping Mains No.1		
DN 40 steel pipe PN 16	m	85
OD 50 HDPE PN 16	m	2,367
Mechanical and Electrical Items		
Multi crystalline PV Solar panels rated at 280pW 24 Volts DC, 72 Cells.	No.	20
PV Solar Panels Control Unit including high/low pressure and dry run protection.	No.	76
M&E Items for Borehole House	No.	1

Mechanical Tools and Equipment	No.	1
20KVA Generator	No.	1
Pump House	No.	1
Ecosan Toilet	No.	1

1.1 Background

The Government of Uganda is committed to a policy for the increased provision of safe water supply and adequate sanitation to the whole population. The current water supply coverage for Uganda is estimated to 64 %, whereas the coverage of sanitation service, mostly on-site sanitation is about 33 %. According to the Millennium Development Goals 100% of urban population and 62% of rural population should have had access to safe water sources by 2015.

Adjumani District Local government is desirous to support the planning, design, construction supervision of a water supply system. This assignment is therefore aimed at fulfilling this goal. This is the Detailed Design Report for Uderu village water supply system.

1.2 The Consultancy Contract and Scope of Services

A contract was signed between the Government of Uganda and M/s GeoBot Water Engineering Services Ltd, for the Design of a piped Water Supply System for Uderu town in Pachara Sub County.

1.3 Mobilization and Staff Assignment

1.3.1 Mobilization

The following staff commenced their activities;

- Project Manager/Design Engineer,
- Water Resources Expert,
- Sociologist,
- Topographic Surveyor.

For the fieldwork, the consultant's staff were divided into teams as follows:

- Socio-Economic team headed by the Sociologist,
- Engineering team headed by the Design Engineer,

The teams carried out visits to the towns at different times. Various field work activities were carried out as described below.

1.3.2 Socio-Economic Household Surveys

The Socio-Economist concentrated on the following aspects of fieldwork:

- Selecting people to administer questionnaires on socio-economic activities in the respective project areas.
- Training the selected local research assistants in the use of the survey instrument.
- Supervising the socio-economic survey exercise.
- Collecting data on institutions, commerce, and local administration.
- Focus group discussions with various interests' groups, such as women's representatives, water point committees and traders.

1.3.3 Engineering Surveys

The Design Engineering Team consisted of a Design Engineer assisted by a GIS AutoCAD expert / Junior Engineer. It concentrated on the following aspects of fieldwork:

- Delineation and mapping of the layout of the towns in order to develop water supply configuration for each project area.
- Identification and mapping of existing facilities including water supply sources, schools, and health facilities.
- Assessing the general soil and ground conditions.
- Liaison with the District Water Officers, District Authorities, and Town Authorities to access data on water, sanitation, institutional and commercial activities.

1.3.4 Water Resources Surveys

The Water Resources Team conducted an assessment of the ground / surface water resources, i.e. streams, swamps, lakes, boreholes, shallow wells, springs, etc., in and adjacent to the towns and collected data, from the District Water Offices and Directorate of Water Resources Management, on the existing ground / surface water sources in the project areas. It coordinated with the Design Engineering Team in the identification and mapping of the water resources.

1.4 Reporting Obligations

The major deliverables under this consultancy contract are:

- Inception Report;
- Feasibility Study Reports;
- Detailed Design Reports;

This is the Detailed Design Report for Uderu Water supply system.

2 DESIGN CRITERIA

2.1 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. It includes a comparison with criteria used in the design of interventions according to:

1) Previous Studies / Projects i.e. Zirobwe Water Supply and Sanitation Project, 2012; and

2) DWD Water Supply Design Manual (2013).

2.2 Design Criteria- Water Supply

The proposed design criteria are detailed as follows and summarized in **Table 2.5** overleaf.

2.2.1 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- 25 years Design Horizon from Initial Year.

Based on the above, the Initial Year is 2022 with the Ultimate Year 2041, which is also in line with the Government of Uganda's Vision 2040[1].

[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, industrialization, 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);

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 2016 has been taken for planning purposes. Therefore, in summary, the design is based on:

a) Base Year- 2017.

b) Initial Year- 2022.

c) Ultimate Year- 2041.

2.2.2 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 1.2 is proposed.

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 this parish a peak hour factor of 2.0 is proposed.

2.2.3 Transient Population

This population is allowed for within the maximum day factor of 1.2.

2.2.4 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

---

land use and management; urbanization; human resource; and peace, security and defense. (Ref: http://gov.ug/content/uganda-vision-2040)

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.

2.2.5 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).

2.2.6 Un-accounted for Water

Allowance must be made in the feasibility study and detailed design 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 Authorized Consumption, Apparent, and Real (Physical Water) Losses which include:

1) Unbilled Metered and Unbilled Unmetered Consumption (Unbilled Authorized Consumption);

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

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

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

5) 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.

It is proposed that a figure of 20% UfW is used in the determination of the water demand.

2.2.7 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:

[2] The International Water Association, 2014

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

2.2.8 Storage Capacity

Storage reservoirs are designed to fulfill 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.

A selected design practice with respect to provision of storage capacity in the country is as given below:

- Zirobwe Water Supply and Sanitation System (2012) - 30% of maximum day demand.
- Lake Victoria Water and Sanitation Program II (2012) - Mayuge, Buwama - Kayabwe, Ntungamo and Bukakata Water Supply and Sanitation Systems- 30% of maximum day demand.
- Small Towns Water and Sanitation Project- BADEA (Soroti, Sironko and Kaberamaido) - 50% of maximum day demand.
- Water Management and Development Project: - Arua Water and Sanitation Project (2012) - 30% of maximum day demand.
- DWD Design manual 2013- 50% of maximum design demand for balancing purposes, and 12 hours of maximum day demand (50%) for emergency storage.

It is proposed to size the storage at 30% of the maximum day's demand for balancing purposes, plus 10% of maximum day's demand for emergency storage.

2.2.9 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.

2.2.10 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 recognizes that drinking water should be acceptable to consumers in appearance, taste, and odor, 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 Program, 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 2.1** overleaf along with the WHO 2011 standards for comparison purposes.

Table 2.1 Drinking Water Quality Standards Uganda (2008) & WHO (2011)

Characteristic	**Unit**	**US-201: 2008 Requirement**	**WHO 2011 Requirement**
Physical Requirements			
Colour	Hazen units, max. Pt scale	15	No Guideline
Odour		Acceptable to consumers and no abnormal changes	No Guideline
Taste		Acceptable to consumers and no abnormal changes	No Guideline
Turbidity	NTU	5	1

Dissolved Solids	mg/l	700	No Guideline
Suspended Solids	mg/l	0	No Guideline
Electrical Conductivity (EC)	µS/cm	1500	250
Chemical Requirements			
pH		6.5 - 8.5	6.5 – 8.5
Total Hardness (as $CaCO_3$)	mg/l	500	No Guideline
Calcium (as Ca)	mg/l	75	No Guideline
Sodium (as Na)	mg/l	200	200
Magnesium	mg/l	50	No Guideline
Arsenic (as As)	mg/l	0.05	0.01
Copper (as Cu)	mg/l	1.0	2.0
Chloride (as Cl)	mg/l	250	250
Chromium (as Cr 6+)	mg/l	0.05	0.05
Fluoride (as Fl)	mg/l	1.0	1.5
Iron (as Fe)	mg/l	<0.30	No Guideline
Manganese (as Mn)	mg/l	0.1	0.1
Nitrates (as NO_3)	mg/l	5	50 (Total Nitrogen)
Barium	mg/l	1.0	0.7
Aluminum (as Al)	mg/l	0.1	0.2
Sulphates	mg/l	200	250
Zinc (as Zn)	mg/l	5.0	3.0
Lead (as Pb)	mg/l	0.05	0.01
Selenium (as Se)	mg/l	0.01	0.01
Cadmium (as Cd)	mg/l	0.01	0.003
Phenolic substances (C_6H_5OH)	mg/l	0.001	No Guideline
Mercury (as Hg)	mg/l	0.001	0.001
Cyanide	mg/l	0.01	0.07
Poly nuclear aromatic substances	mg/l	nil	No Guideline
Residual free chlorine	mg/l	0.2	0.2
Mineral oil	mg/l	0.01	No Guideline
Anionic detergents	mg/l	0.2	No Guideline

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

2.2.11 Specific Water Demand

2.2.11.1 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 2.2 Comparison of Unit Demands for Domestic Consumption

Source	**House Connections (l/c/d)**	**Yard Tap (l/c/d)**	**Stand Post (l/c/d)**	**Urban Poor (l/c/d)**
DWD Design Manual, 2013	100 - 200	40 - 50	20	0
Zirobwe Town WSP, 2012	100	40	20	5
Buwama- Kayabwe WSP, 2012	100	40	20	5
Mayuge Town WSP, 2012	100	40	20	0
Rwimi Town Water Supply, 2005	80	30	20	0
Kaberamaido & Sironko (STWSPBADEA, 2005)	100	40	20	5
Eastern Centres WSP, 2000	100	40	20	0
Source: Projects undertaken and Published Studies				

Four levels of service and corresponding per capita consumption rates are proposed and these are summarized below and in **Table 2.3**.

- For House Connections in the town, medium income housing is predominant therefore the rate of 100 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 various towns. 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.
- The final category are the households who draw piped water for limited use, and depend mainly on non-piped sources of supply (Point water Sources). This category is provided with 5 l/c/d.

Table 2.3 Per Capita Domestic Consumption Rates

No	Domestic Consumer Category	Description	Per Capita Consumption (l/c/d)
1	House Connection (HC);	High/Medium income consumers- Medium Income Housing: - single house connection with internal plumbing, kitchen, toilet and bathroom with shower.	100
2	Yard Tap (YT)	Medium income consumers- single / multiple households using yard taps. This connection with no internal plumbing or water borne sanitation.	40
3	Public Stand Post (PSP)	Low Income Users- usually offsite supply, either from a stand post or purchase from a neighbor.	20
4	Part Time Users (NS)	Urban Poor Category- part time users who draw piped water for limited use; possibly drinking and cooking only, and depend mainly on non-piped sources of supply for other domestic consumption.	5
Source: Project Estimates, DWD Water Manual 2013			

2.2.12 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 town.

2.2.13 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 2.4** below.

Table 2.4 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		

2.2.14 Formula for Design of Transmission Mains

The transmission mains will be designed using the Hazen-Williams Formula using an excel spread sheet 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)

2.3 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 2.5** overleaf.

Table 2.5 Summary of Water Supply Design Criteria

Design Criteria	Abbreviations and Dimensions	DWD Design Manual (2013)	Zirobwe Water Supply Project (2012)	Adopted Design Criteria
Baseline Data- Population				
Design Period	Years	NA	15	24
Design Horizon	Year	NA	2030	2040
Population at Design Horizon	P [inh.]	NA	18,584	17,881
Maximum Day Demand	m^3/day	NA	598	-
Hydraulic Criteria				
Max Day Factor		1.1 - 1.3	1.2	1.2
Peak Hour Factor		2.0	2.0	2.0
Maximum flow velocities in the pipes	m/s	-	0.75 - 2.5	0.75 - 2.5
Maximum Head losses in the main pipes	m/km	-	10	10
Operating Pressures				
Minimum in Distribution Network	bar	-	0.5	0.5
Maximum in Distribution Network	bar	-	6.0	6.0
Water Losses				
In Distribution System (UfW)	% of Total Average Day Demand	20 – 25%	20%	20%
Intake & Treatment Plant Use	% of Maximum Day Demand	10%	NA	10%
Pipe Material Selection				
Large Diameter (>250mm ND)			Ductile Iron or Steel	Ductile Iron or Steel

Medium Size Diameter (100-250mm ND)			uPVC	uPVC
Small Size Diameter (< 90mm OD)			HDPE	HDPE
Minimum Pipe Cover				
General Pipe Laying	m	0.6 -3.0	~ 0.9	~ 0.9
Pipes laid below roads and reserves	m	0.9	1.2	1.2
Storage Capacity				
Sizing of Reservoirs- Balancing Storage	% of Maximum Day Demand	50%	30%	30%
Sizing of Reservoirs- Emergency Storage (Firefighting)	% of Maximum Day Demand	50%	10%	10%
Other Design Criteria				
Water Treatment Plant Operation Time	hour/day	-	-	16
Pumping Stations Operation Time	hour/day	-	16	16
Distribution System Operation Time	hour/day	-	24	24
Water Treatment Quality Standards- Drinking Water		Uganda (US - 201: 1994)	Uganda (US - 201: 1994)	Uganda (US - 201: 1994)
Specific Water Demand				

Design Criteria	Abbreviations and Dimensions	DWD Design Manual (2013)	Zirobwe Water Supply Project (2012)	Adopted Design Criteria
Domestic Consumption				
House Connection				
High Income Housing	l/c/d	200	100	100
Medium Income Housing	l/c/d	100		
Yard Tap				
Multiple Households	l/c/d	50	40	40
Single Household	l/c/d	40		
Public Stand Post	l/c/d	20	20	20
Part Time Users (Urban Poor)	l/c/d		5	5
Institutional Consumption				
Schools				
Day				
With pit latrine	l/std/d	10	5	5
With water closet	l/std/d	20		10
Boarding	l/std/d	100	20	20
Hospitals / Health Centers				
Health Care Dispensaries	l/visitor/d	50	NA	20
Health Centre I- No modern facilities In patients	l/bed/d	50	100	50
Out patients	l/c/d	NA	5	5
Non-Resident staff	l/c/d	NA	10	10
Resident staff	l/c/d	NA	-	10
Health Centre II- with maternity and pit latrine In patients	l/bed/d	70	100	70
Out patients	l/c/d	NA	5	10

Non-Resident staff	l/c/d	NA	10	10
Resident staff	l/c/d	NA	-	20
Health Centre III- with maternity and pit latrine	l/bed/d	100	100	100
In patients				
Out patients	l/c/d	NA	5	10
Non-Resident staff	l/c/d	NA	10	10
Resident staff	l/c/d	NA	-	20
Health Centre IV- with maternity and water closet	l/bed/d	150	100	100
In patients				
Out patients	l/c/d	NA	5	10
Non-Resident staff	l/c/d	NA	10	10
Resident staff	l/c/d	NA	-	40
Hospital, District- with surgery unit In patients	l/bed/d	200	100	100
Out patients	l/c/d	NA	5	10
Non-Resident staff	l/c/d	NA	10	10
Resident staff	l/c/d	NA	-	100
Hospital, Regional Referral- with surgery unit				
Design Criteria	**Abbreviations and Dimensions**	**DWD Design Manual (2013)**	**Zirobwe Water Supply Project (2012)**	**Adopted Design Criteria**
In patients	l/bed/d	400	100	150
Out patients	l/c/d	NA	5	10
Non-Resident staff	l/c/d	NA	10	10
Resident staff	l/c/d	NA	-	100
Administrative Offices				
With pit latrine	l/worker/d	-	NA	5

With water closet	l/worker/d	70	NA	40
Mosque	l/c/d	NA	20	20
Church	l/c/d	NA	5	5
Prisons	l/inmate/d	NA	20	50
Commercial / Industrial Consumption				
Hotels / Lodges	l/bed/d	600	100	600
High class				
Medium class	l/bed/d	300	100	300
Low class	l/bed/d	50	40	50
Bars / Restaurants				
High class	l/bar/d	1000	60	1000
Low class	l/bar/d	700	60	700
Shops				
Small	l/shop/d	150	20	50
Town				
Fuel Station/Washing Bays				
Small Town	Station/d	5000	2000	5000
Markets	l/ha/d	20000	2000	2000 l/market/day
Public Sanitation				
Small Town	l/person/d	50	NA	20
Food Industry				
Dairy	Milk received (m^3)	2 - 5	200 l/d	200 l/d
Abattoir	Animals slaughtered (ton)	5 -10	90 l/animal/d	200 l/abattoir/day
Butchery	l/d	NA	50	50
Grain millers (Dry processing mills)	Grain received (ton)	2 - 5	30 l/d	30 l/d
Other Industries				

Tannery	Raw skins (ton)	50 - 150	NA	50
Cotton mill	Cotton thread (tufi)	50 - 150	NA	50
Medium Scale (water intensive)	m^3/ha/d	40	NA	40
Medium Scale (medium water intensive)	m^3/ha/d	15	NA	15
Small Scale (dry)	m^3/ha/d	5	NA	5

3. DETAILED DESIGN- WATER SUPPLY

3.1 Water Supply Option

In the design, the system for the town was sized on the basis of the maximum day water demand of 55m^3/day.

3.1.1 Introduction

The main source of ground water in the town and surrounding areas are Boreholes. This scenario evaluates whether boreholes can be used as the source of water.

For the demand of 55 m^3/d, (3.45m^3/hr.) the production boreholes, operating on a 16-hour operation period, need to have the following minimum yields.

- Using 1No. production borehole, 3.5m^3/hr.;
- Using 2No. production boreholes, 1.7m^3/hr each,

3.1.2 Ground Water Supply Assessment

As previously mentioned, a total combined yield of 3.45m^3/hr is required from production wells in order to meet the ultimate year demand.

The Constant Discharge Yield of the drilled production well after test pumping results is 20m^3/hr. This is sufficient to meet the ultimate year 2041 demand for the waters supply system.3.1.3 Beneficiary Project Areas The Population Clusters are the Uderu and Ejembwe Villages in Unna Parish, Pachara Sub county.

3.1.4 Beneficiary Population in the Cluster Areas

The basic data for the domestic population are the provisional UBOS Population and Housing Census 2014 figures. The number of households in the year 2014 have been projected to give the 2040 population. The historical growth rate of 3% p.a. for the period 2002 to 2014 has been adopted from the UBOS Population and Housing Census 2014 for Adjumani District, as opposed to the historic growth rate of the district from the period 1991 to 2002 of 6.37%. The adopted growth rate has been maintained as the future growth rate up to the year 2041. It is expected that the institutional, Industrial and commercial activity will grow at the same rate as the domestic population. Not all the population in the project area will be served by the piped water supply. The project mainly targets the core area population in the population clusters along the pipeline route / highway. The summary of the total and served domestic population projections are contained in **Annex 6.1** and summarized at Parish level in **Table 3.1** and **Table 3.2** below.

Table 3.1 Summary of Total Population Projections- Clusters

Water System	S/County	Parish	Village	Total Population					
				2017	2022	2027	2032	2037	2041
Uderu Water System	**Pachara**	Unna	Uderu	1,243 828	1,317 878	1,396 931	1,480 987	1,569	1,644
			Ejembwe					1,046	1,096
			Parish Total	**2,071**	**2,195**	**2,327**	**2,467**	**2,615**	**2,740**

Table 3.2 Summary of Served Population Projections- Clusters

Water System	S/County	Parish	Village	%	Served Population					
				Population Served	2017	2022	2027	2032	2037	2041
Uderu Water System	**Pachara**	Unna	Uderu	50%	622	659	698	740	785	822
			Ejembwe	50%	414	439	466	494	523	548
			Parish Total	**50%**	**1,036**	**1,09 8**	**1,16 4**	**1,23 4**	**1,30 8**	**1,37 0**

3.1.5 Water Demand

The per capita Domestic and Non Domestic consumption rates used in the determination of the water demand are detailed under **Section 2.2.11 "Specific Water Demand"** and summarized in **Table 2.5**.

The levels of service have been assessed at the same tariffs as given. Based on this, the levels of service, based on ability to pay at various tariffs for the water, have been computed. The levels of service at selected tariffs will thus be as in **Table 3.3** below**.**

Table 3.3 Levels of Service- Affordability (5% Income)

Tariff	HC	YT	SP	NS
36/20Litres	0%	16%	33%	51%
30/20Litres	0%	25%	33%	42%
41/20Litres	0%	10%	33%	57%
92/20Litres	0%	0%	33%	63%

The water demand computation has been made on the basis of the ability to pay (5% of Income); with the demand based on the unit consumption rates, the levels of service and the served population figures. The summaries of the demand for the town is given in **Table 3.4** below

Table 3.4 Summary of Water Demands

Served	2017	2022	2027	2032	2037	2041
Population.	1,036	1,098	1,164	1,234	1,308	1,370
Domestic	*18*	*19*	*20*	*22*	*24*	*25*
Govt/Institution	*3*	*3*	*3*	*4*	*4*	*4*
Industrial/Commercial	*6*	*6*	*6*	*7*	*7*	*7*
UFW	*7*	*7*	*8*	*8*	*9*	*9*
ADD	*33*	*35*	*38*	*40*	*43*	*46*
MDD	***39***	***42***	***45***	***49***	***52***	***55***

3.2 Detailed Design of Common Water Supply Interventions

3.2.1 Introduction

Detailed designs have been carried out for the ground water supply scenario. The system components include Storage Reservoir, Distribution Network, Service Connections, Production Borehole(s), and Raw Water Transmission Main.

3.2.2 Storage Reservoir Site / Location

One site was considered for the reservoir location. A location with Co-ordinates 370928.1 E, 379000 N and Altitude = 769.856 mASL) was considered.

It will therefore be upon the Sub County and Adjumani district to acquire the land.

3.2.3 Storage Reservoir Capacity

The required storage capacity has been computed as 100% of the maximum day demand. The required storage capacity is therefore 55 m^3. A 60m^3 main reservoir has been adopted.

It is recommended to erect a pressed steel tank with square 1.22m panels measuring 6.0m long, 4.1 m wide, and 2.44 m high. Due to the topography of the village and the low pressures experienced in the distribution network around the tank and in the far reaches of the network, it is recommended to erect the reservoir tank on a 12 m high steel tower.

3.2.4 Distribution Network

The preliminary distribution network has been analyzed and sized using **EPANET 2.0.** This Water Distribution Modeling Software has been used due to its interoperability with AutoCAD. The model was constructed in AutoCAD, using GPS Waypoints, and topographic surveys from Field studies. It was then exported to **EPANET 2.0** for completion and analysis.

The model was analyzed by performing an Extended-Period Simulation (EPS) over a 72-hour period. A flow pattern using Diurnal Demand was adopted with consideration of the selected peak hour factor and in reference to the MWE Manual 2013. Diurnal Demand is the variation in water demand over a 24-hour period. Simulations were done for Night flows (Night flow factor= 0.5), Normal Flows (Normal Flow Factor= 1.0 - 1.5) and Peaked Flows (Peak Flow Factor= 2.0).

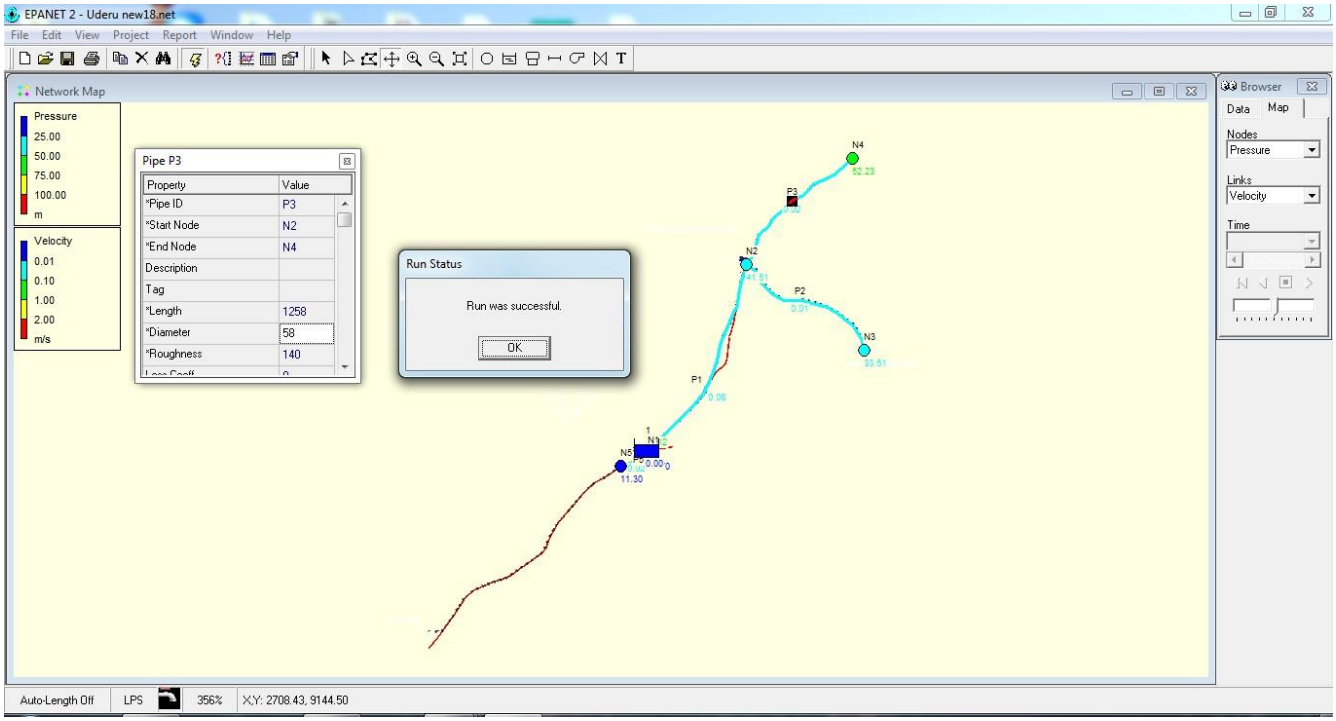
The network was designed for those areas with defined access roads but the possibility of extending it was catered for since the village is expected to expand from the core into the fringe areas. Consequently, the smallest size of pipe recommended is OD 63 HDPE. Pipes

smaller than this will be laid as Network Intensification lines. Details of the model are attached in **Annex 6.3**. **Table 3.5** below shows the estimated sizes and length of the distribution pipes while **Figure 3.1** shows a map of the model.

Table 3.5 Distribution Mains

Pipe Details (OD)(mm)	**Length** (m)
OD 90 HDPE PN 6	1,264
OD 63 HDPE PN 6	3,315
Total	**4,579**
Source: Project estimates	

Figure 3.1: Water Distribution Network Model (in EPANET 2.0)



3.2.5 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.

The population served by the system is given in **further** above. The criteria used to determine the number of service connections for each served population category is as follows.

Table 3.6 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

There are currently No Service Connections and public stand posts in the area. It is therefore proposed to make 10 public stand posts connections. 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.

3.2.6 Production Boreholes

Designs of the production boreholes include:

a) Drilling 1No. High Yield Borehole (recommended No.) due to the possible cost saving from developing several boreholes.

b) Construction of borehole pump house and installation of respective pumps and pipework.

c) Pumping main from the boreholes to the storage reservoir.

d) Mechanical and Electrical works associated as per Bill of Quantities

e) Associated Borehole Pump House site works.

The calculation for the design of the borehole and the transmission main is given in **Table 3.7** below.

Table 3.7: Boreholes Pump and Mains Design

Number of Boreholes	**Uderu BH**
Borehole Yield (m^3/hr)	**25**
Hours of Pumping (hr)	8
Efficiency Pump (%)	70.0%
Efficiency Motor (%)	80.0%
Total Daily Delivery (m^3/day)	55.22095934
Pumping Main Section No. 01 (From Pump Installation Point to Ground Level at Borehole)	
Ground Level at Borehole (m AMSL)	771.830
Pump Installation Depth in Borehole (m BGL)	85.000
Static Lift (m)	85.000
Cwh	120
Pipe Details	**DN 40 Stainless Steel Pipe PN10**
Pipe Diameter ND (mm)	40.00
Pipe Diameter ND (m)	0.040
Flow in Pipe (m^3/hr)	3.451
Flow in Pipe (m^3/s)	0.001
Velocity (m/s)	0.76
Length of Pipe Section No. 01 (m)	**85.00**
Friction Loss (m)	2.12
Fittings losses - 10% (m)	0.21
Total Head in Section 01 (m)	**87**
Pumping Main Section No. 02 (From Ground Level at Borehole to Reservoir)	
Reservoir inlet level (m AMSL)	807.000
Ground Level at Borehole (m AMSL)	771.830
Static Lift (m)	35.170
Cwh	140
Pipe Details	**OD 50 HDPE PN16**
Pipe Diameter ND (mm)	40.80
Number of Boreholes	**Uderu BH**
Pipe Diameter ND (m)	0.041
Flow through pipe section 02 (m^3/day)	3.451

Flow through pipe section 02 (m^3/s)	0.001
Velocity (m/s)	0.73
Chainage at Borehole	0+000
Chainage at Reservoir	2+367
Length of Pipe Section No. 02 (m)	**2,367.00**
Friction Loss (m)	40.31
Fittings losses - 10% (m)	4.03
Total Head in Section 02 (m)	**80**
Total Head from Borehole to Reservoir (m)	**167**
Summary of the Design	
Total Length of Transmission	
DN 40 Steel PN10 (m)	85
OD 50 HDPE PN16	2367
Capacity of pump in borehole	
Head (m)	167
Flow (m^3/hr)	18
Power (KVA)	**18**
Source: Project estimates.	

The borehole will have pumps and transmission mains with the following characteristics:

1) Flow of 18 m^3/hr at 167 m head; borehole riser pipe of Stainless Steel Pipe DN 40 PN 10, 85 m long; and transmission main of OD 50 HDPE PN 16, 2,367 Km long.

The borehole pump house will be the standard 3.5m X 3.0m floor area pump houses and will house the associated pipework, fittings and electrical switch gear.

3.2.7 Power Supply Options

Three power supply options for the operation of the submersible borehole pump were considered as follows:

1. Power from a solar system installed at the borehole pump house. The systems will consist of multi crystalline PV solar panel rated at 280pW 24 Volts DC, 72 cells, with a control unit, support structure, and electrical accessories and cabling.

The power requirement of the pumps has been calculated using the formula Box 3.1 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 and associated investment and O&M costs is summarized in **Table 3.8** below.

Table 3.8: Borehole Pumps Power Requirements

Location	Head (m)	Flow (m^3/h)	Required Motor Size KW	Available Motor (kW)	Total power (KVA)	Amperage (A)	Starting KVA	Grundfos Pump Type
Uderu	177.00	3.06	3.4	3.5	4.38	6.09	10.94	SP 3A-39

Source: Project Estimates

The below should be noted;

- Although Installation of solar power requires a high capital investment cost, it has low operation and maintenance costs. However, installation of the panels requires land and secure areas and the panels will be susceptible to theft. Additionally, these investment costs have to be reinvested after the 15 years' life cycle of the Electrical & Mechanical items.

3.3 Summary of the Water Supply Components

The components of the different water supply scenarios are summarized in **Table 3.9**below

Table 3.9: Water Supply Components

Description	**Unit**	**Ground Water Supply**
		Quantity
Distribution Network		
OD 90 HDPE PN 6	m	3,315
OD 63 HDPE PN 6	m	1,264
Service Connections		
OD 32 Public Stand Posts	No.	12
Storage Reservoir		
60m^3 Pressed Steel Reservoir	No.	1
10 m High Steel Tower	No.	1
Production Borehole		
Uderu: yield 3.6m3/hr (Drilled & Test Pumped)	No.	1
New Risers/Pumping Mains No.1		
DN 40 steel pipe PN 16	m	85
OD 50 HDPE PN 16	m	2,367
Mechanical and Electrical Items		
Multi crystalline PV Solar panels rated at 280pW 24 Volts DC, 72 Cells.	No.	20

PV Solar Panels Control Unit including high/low pressure and dry run protection.	No.	1
M&E Items for Borehole House	No.	1
Mechanical Tools and Equipment	No.	1

4 PROJECT COST ESTIMATION

4.1 Capital Investment Cost Estimates

The capital investment costs for the works have been estimated and presented in **Table 4.1** below.

Table 4.1 Capital Investment Cost Estimates

Item	Description	Cost (USh)
		Ground Water Supply
1	Preliminary and General Items	80,582,400
2	Distribution Network and Service Connections	135,736,470
3	Storage Reservoir	85,838,500
4	Production Borehole Pumping station	39,663,659
5	Mechanical and Electrical Items	150,746,900
6	Transmission Main System	64,757,155
7	Public Stand Posts	15,498,000
	Sub-Total	**572,823,084**
	Add 10% Contingencies	57,282,308
	Grand Total	**630,105,392**
Source: Project Estimates		

The following observations should be made concerning the investment capital costs:

- In terms of investment costs, the water supply system will cost a total of USh 630,105,392.
- The investment costs have 18% VAT equivalent to USh 113,418,971.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Water Supply Improvement

The various advantages and disadvantages of the water supply scenario are given below.

5.1.1 Service Areas and Beneficiary Population

Ground water supply has the potential of supplying all the villages in the village. The boundaries of the village are the extents of the beneficiary population.

5.1.2 Financial Investment Costs

The water supply system will cost a total of USh 630,105,392 and an 18% VAT equivalent to USh 113,418,971.

5.1.3 Adequacy / Sustainability of the Sources

Ground water supply has the disadvantage of being dependent on poor and reducing yields from Production Boreholes and is dependent on the siting, drilling and abstraction of 18 m^3/day of the maximum day demand from ground water. The adequacy of this source cannot be guaranteed.

6. ANNEXES

Annex 6.1: Demography

Annex 6.2: Water Demand Calculations

Annex 6.3: Water Supply Pre-Design Calculations

Annex 6.4: Pre-Design Drawings

Annex 6.5: Borehole Completion Report

Annex6.1

Demography

Table 6.1 Total and Served Population Projection by Enumeration Area

Water System	S/County	Parish	Village	Base Population	Total Population						Served Population					
				2014	2017	2022	2027	2032	2037	2041	2017	2022	2027	2032	2037	2041
Uderu Water System	**Uderu**	Unna	Uderu	1,200	1,243 828	1,317 878	1,396 931	1,480 987	1,569 1,046	1,644 1,096	622 414	659 439	698 466	740 494	785 523	822 548
			Egebwe	800												
			Parish Total	**2,000**	**2,071**	**2,195**	**2,327**	**2,467**	**2,615**	**2,740**	**1,036**	**1,098**	**1,164**	**1,234**	**1,308**	**1,370**

Table 6.2 Levels of Service and Population Categories (2022 & 2032)

Water System	S/County	Parish	Level of Service 2022				Population Categories 2022				Level of Service 2032				Population Categories 2032			
			House Conn	Yard Tap	Stand Pipe	No Supply	House Conn	Yard Tap	Stand Pipe	No Supply	House Conn	Yard Tap	Stand Pipe	No Supply	House Conn	Yard Tap	Stand Pipe	No Supply
Uderu Water System	**Uderu**	Unna	1%	15%	40%	44%	7	101	262	289	1%	16%	42%	41%	8	119	309	304
			1%	15%	40%	44%	4	67	175	193	1%	16%	42%	41%	5	79	206	202
			1%	**15%**	**40%**	**44%**	**11**	**168**	**437**	**482**	**1%**	**16%**	**42%**	**41%**	**13**	**198**	**516**	**506**

Table 6.3 Levels of Service and Population Categories (2037 & 2041)

Water System	S/County	Parish	Level of Service 2037				Population Categories 2037				Level of Service 2041				Population Categories 2041			
			House Conn	Yard Tap	Stand Pipe	No Supply	House Conn	Yard Tap	Stand Pipe	No Supply	House Conn	Yard Tap	Stand Pipe	No Supply	House Conn	Yard Tap	Stand Pipe	No Supply
Uderu Water System	Uderu	Unna	1%	16%	43%	40%	9	129	336	310	1%	17%	44%	38%	9	139	361	312
			1%	16%	43%	40%	6	86	224	207	1%	17%	44%	38%	6	93	241	208
			1%	**16%**	**43%**	**40%**	**14**	**216**	**561**	**517**	**1%**	**17%**	**44%**	**38%**	**15**	**232**	**602**	**521**

Table 6.4 Health Institutional Population (2017)

Health Institutions										
Sub County	**Parish**	**Health Institution**	**In patients (Beds)**	**Out Patients (No.)**	**Non Resident Staff (No.)**	**Resident staff (No.)**	**2017 Demand** (m^3/d)	**2041 Demand** (m^3/d)	**Institution Type**	**Ownership**
	Unna	Uderu HC II	0	80	7	0	0.9	1.2	HC II	Government
		Totals	**0**	**80**	**7**	**0**	**0.9**	**1.2**		

Table 6.5 Educational Institutional Population (2017)

Parish	**School Name**	**No. of Students**		**Staff**	**Total**	**2017 Demand** (m^3/d)				**2041 Demand** (m^3/d)				**School Type**	**Ownership**
		Day	**Boarding**			**Day**	**Boarding**	**Staff**	**Total**	**Day**	**Boarding**	**Staff**	**Total**		
Unna	Ibibiaworo primary school	400		18	418	2.0		0.2	2.2	2.6		0.2	2.8	Primary	Private
	Totals	**400**		**18**	**418**	**2**		**0**	**2**	**3**		**0**	**3**		

Table 6.6 Cluster Populations by Enumeration Area

Water System	Village	Total Population						Served Population						Population Categories 2017				Population Categories 2041			
		2017	2022	2027	2032	2037	2041	2017	2022	2027	2032	2037	2041	House Conn	Yard Tap	Stand Pipe	No Supply	House Conn	Yard Tap	Stand Pipe	No Supply
Uderu Water System	Uderu	1,243	1,317	1,396	1,480	1,569	1,644	622	659	698	740	785	822	6	93	242	280	9	139	361	312
	Egembwe	828	878	931	987	1,046	1,096	414	439	466	494	523	548	4	62	161	186	6	93	241	208
	Parish Total	**2,071**	**2,195**	**2,327**	**2,467**	**2,615**	**2,740**	**1,036**	**1,098**	**1,164**	**1,234**	**1,308**	**1,370**	**10**	**155**	**404**	**466**	**15**	**232**	**602**	**521**

Annex 6.2

Water demand calculations

Table 6.7 Demand by Enumeration Area (2022)

Water System	S/County	Parish	Village	Population Categories 2022				Demand Year 2022 (m^3/d)					
				House Conn	Yard Tap	Stand Pipe	No Supply	Domestic	Institutions	Industrial / Commercial	UFW	Total Demand	Max Day Demand
Uderu Water System	Uderu	Unna	Uderu	7	101	262	289	11.4	1.6	2.9	4.0	19.9	23.9
			Egembwe	4	67	175	193	7.6	1.6	2.9	3.0	15.2	18.2
			Parish Total	**11**	**168**	**437**	**482**	**19**	**3**	**6**	**7**	**35**	**42**

Table 6.8 Demand by Enumeration Area (2032)

Water System	S/County	Parish	Village	Population Categories 2032				Demand Year 2032 (m^3/d)					
				House Conn	Yard Tap	Stand Pipe	No Supply	Domestic	Institutions	Industrial / Commercial	UFW	Total Demand	Max Day Demand
Uderu Water System	Uderu	Unna	Uderu	8	119	309	304	13.3	1.8	3.3	4.6	23.0	27.6
			Egembwe	5	79	206	202	8.8	1.8	3.3	3.5	17.4	20.9
			Parish Total	**13**	**198**	**516**	**506**	**22**	**4**	**7**	**8**	**40**	**49**

Table 6.9 Demand by Enumeration Area (2037)

Water System	S/County	Parish	Village	Population Categories 2037				Demand Year 2037 (m^3/d)					
				House Conn	Yard Tap	Stand Pipe	No Supply	Domestic	Institutions	Industrial / Commercial	UFW	Total Demand	Max Day Demand
Uderu Water System	Uderu	Unna	Uderu	9	129	336	310	14.3	1.9	3.5	4.9	24.7	29.6
			Egebwe	6	86	224	207	9.5	1.9	3.5	3.7	18.7	22.4
		Parish Total		**14**	**216**	**561**	**517**	**24**	**4**	**7**	**9**	**43**	**52**

Table 6.10 Demand by Enumeration Area (2041)

Water System	S/County	Parish	Village	Population Categories 2041				Demand Year 2041 (m^3/d)					
				House Conn	Yard Tap	Stand Pipe	No Supply	Domestic	Institutions	Industrial / Commercial	UFW	Total Demand	Max Day Demand
	Uderu	Unna	Uderu	9	139	361	312	15.3	2.0	3.7	5.2	26.2	31.4
			Egembwe	6	93	241	208	10.2	2.0	3.7	4.0	19.8	23.8

Uderu Water System		**Parish Total**	**15**	**232**	**602**	**521**	**25**	**4**	**7**	**9**	**46**	**55**

Table 6.11 Cluster Service Levels and Demand Categories (2022 & 2041)

Water System	S/County	Parish	Village	Level of Service 2022				Demand Categories 2022 (m^3/d)				Level of Service 2041				Demand Categories 2041 (m^3/d)			
				House Conn	Yard Tap	Stand Pipe	No Supply	House Conn	Yard Tap	Stand Pipe	No Supply	House Conn	Yard Tap	Stand Pipe	No Supply	House Conn	Yard Tap	Stand Pipe	No Supply
Uderu Water System	**Uderu**	Unna	Uderu	1%	15%	40%	44%	0.7	4.0	5.2	1.4	1%	17%	44%	38%	0.9	5.6	7.2	1.6
			Egembwe	1%	15%	40%	44%	0.4	2.7	3.5	1.0	1%	17%	44%	38%	0.6	3.7	4.8	1.0
		Parish Total		**1%**	**15%**	**40%**	**44%**	**1**	**7**	**9**	**2**	**1%**	**17%**	**44%**	**38%**	**2**	**9**	**12**	**3**

Table 6.12 Maximum Day Demands (2022 & 2041)

Water System	S/County	Parish	Village	Demand Year 2022 (m^3/d)						Demand Year 2041 (m^3/d)				
				Domestic	**Institutions**	**Industrial / Commercial**	**UFW**	**Total Demand**	**Max Day Demand**	**Domestic**	**Institutions**	**Industrial / Commercial**	**UFW**	**Total Deman**
Uderu Water System	**Uderu**	Unna	Uderu	11.4	1.6	2.9	4.0	19.9	23.9	15.3	2.0	3.7	5.2	26.2
			Egembwe	7.6	1.6	2.9	3.0	15.2	18.2	10.2	2.0	3.7	4.0	19.8
			Parish Total	**19**	**3**	**6**	**7**	**35**	**42**	**25**	**4**	**7**	**9**	**46**

Annex 6.3

Water Supply Pre-Design Calculations

Table 6.13 Design of Distribution Network

Link ID	Nodes	Length	Proposed Design Details		
			Pipe Details	Internal Diameter (mm)	Roughness
Pipe P1	N to N2	1760	HDPE OD 63 PN6	58	140
Pipe P2	N2 to N3	1264	HDPE OD 90 PN6	83	140
Pipe P3	N2 to N4	1258	HDPE OD 63 PN6	58	140
Pipe P4	N1 to N5	247.14	HDPE OD 63 PN6	58	140
Pipe P5	N1 to Reservoir(R)	50	HDPE OD 63 PN6	58	140
Source: Project Estimates - EPANET 2.0					

Table 6.14 Design of Distribution Network (Node Demand)

Node ID	Elevation (m.a.s.l)	Base Demand (lps)	Off Peak Flows (Peak factor = 0.5)			Normal Flows (Peak factor =1)			Peak Flows (Peak factor =2)		
			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)
N1	795.28	0.02075	0.01	807	11.72	0.02	806.99	11.71	0.04	806.98	11.7
N2	765.11	0.05575	0.03	806.97	41.86	0.06	806.89	41.78	0.11	806.62	41.51
N3	773	0.035	0.02	806.97	33.97	0.04	806.89	33.89	0.07	806.61	33.61
N4	754.38	0.02075	0.01	806.97	52.59	0.02	806.89	52.51	0.04	806.61	52.23
N5	795.68	0.02075	0.01	807	11.32	0.02	806.99	11.31	0.04	806.98	11.3
Resvr R1	807	-0.15	-0.08	807	0	-0.15	807	0	-0.31	807	0

Table 6.15 Transmission Main Design

Number of Boreholes	**Uderu BH**
Borehole Yield (m^3/hr)	**3.5**
Hours of Pumping (hr)	16
Efficiency Pump (%)	70.0%
Efficiency Motor (%)	80.0%
Total Daily Delivery (m^3/day)	55.22095934
Pumping Main Section No. 01 (From Pump Installation Point to Ground Level at Borehole)	
Ground Level at Borehole (m AMSL)	771.830
Pump Installation Depth in Borehole (m BGL)	85.000
Static Lift (m)	85.000
Cwh	120
Pipe Details	**DN 40 Stainless Steel Pipe PN10**
Pipe Diameter ND (mm)	40.00
Pipe Diameter ND (m)	0.040
Flow in Pipe (m^3/hr)	3.451
Flow in Pipe (m^3/s)	0.001
Velocity (m/s)	0.76
Length of Pipe Section No. 01 (m)	**85.00**

Friction Loss (m)	2.12
Fittings losses - 10% (m)	0.21
Total Head in Section 01 (m)	**87**
Pumping Main Section No. 02 (From Ground Level at Borehole to Reservoir)	
Reservoir inlet level (m AMSL)	807.000
Ground Level at Borehole (m AMSL)	771.830
Static Lift (m)	35.170
Cwh	140
Pipe Details	**OD 50 HDPE PN16**
Pipe Diameter ND (mm)	40.80

Number of Boreholes	**Uderu BH**
Pipe Diameter ND (m)	0.041
Flow through pipe section 02 (m^3/day)	3.451
Flow through pipe section 02 (m^3/s)	0.001
Velocity (m/s)	0.73
Chainage at Borehole	0+000
Chainage at Reservoir	2+367
Length of Pipe Section No. 02 (m)	**2,367.00**
Friction Loss (m)	40.31
Fittings losses - 10% (m)	4.03

Total Head in Section 02 (m)	**80**
Total Head from Borehole to Reservoir (m)	**167**
Summary of the Design	
Total Length of Transmission	
DN 40 Steel PN10 (m)	85
OD 50 HDPE PN16	2367
Capacity of pump in borehole	
Head (m)	167
Flow (m^3/hr)	18
Power (KVA)	**18**
Source: Project estimates.	

Annex 6.4

Pre-Design Drawings

Figure 6.5 Proposed Distribution Network – Epanet Model

Annex 6.5

Borehole Completion Report

CHAPTER THREE: ENVIRONMENT IMPACT ASSESMENT

3.1 Introduction

The *Third Schedule of* Uganda's National Environmental Act (Cap 153) directs that all projects should be subjected to Environmental scrutiny before they are implemented and Water works are among those for which this requirement applies. Additionally, World Bank (WB) requires environmental assessment (EA) of projects to ensure that they are environmentally sound and sustainable.

As part of improving rural infrastructure in providing safe and clean water within Uganda as part of stimulating National Development, MoWE commissioned an Environmental Monitoring and Management Plan for the proposed upgrading of select/prioritized rural water schemes. The upgrading of the selected water schemes is therefore significant to the efforts to improvement of livelihoods of the people in the given the Districts and Surrounding environs.

3.2 Study Objectives

The objectives of the Environmental Impact Assessment (EIA) Study are to investigate the possible environmental impacts resulting from the provision of water and sanitation facilities for the project and to propose solutions for mitigating the negative impacts.

3.3 Environmental Policy and Institutional Framework

As part of the EMMP a review of the policy, legal and administrative framework was conducted to determine the framework for environmental management of the proposed water works

The National Environmental Management Policy advocated the promotion of long-term sustainable socio-economic development through sound environmental and nature management policies. The National Environmental Management Authority (NEMA) is the principal agency responsible for the management of the environment and was created as a result of the National Environmental Action Plan (NEAP) of 1994.

One of the important functions of NEMA, under the National Environment Act (NEA), Cap 153 is to establish, in consultation with various lead agencies and National Environmental Standards. Construction of water systems is among the projects listed in schedule 3 of the National Environmental, Act of 1995. The following list of environmental legislation; policies, regulations and guidelines have applicability to the construction of the water works.

3.4 Structure of the Environmental Report and Amending the Plan

The environmental management and monitoring plan (EMMP) is comprised of a series of management plans. Each management plan contains specific environmental protection measures. Included in each management plan is the responsibility and reporting structure.

This environmental management and monitoring plan has been specifically developed with the project knowledge and information available to-date. As project staging and scheduling plans are developed and changed, and construction techniques determined, components of the environmental management and monitoring plan might require amending.

3.5 Biophysical Environment

The team assessed the Biological and Physical Environment of the project area from the existing Literature and worked out the state of the environment within the project area. The dominant species (without carrying out a comprehensive inventory) were noted.

3.6 Assessment and Analysis of Impacts

Identified Potential impacts include but not limited to: -

- ♦ Soil erosion during ground clearance
- ♦ Dust pollution during drilling and trench excavation
- ♦ Accumulation of unwanted soil
- ♦ Creation of soak pits
- ♦ Accidents

Mitigation measure

Some of the mitigation measures proposed was the following: -

- ✓ Construction of drainage channels
- ✓ Grass planting to control erosion
- ✓ Land scarping
- ✓ Planting grass and trees on the borehole
- ✓ Proper disposal of unwanted soil
- ✓ Restoration of sites
- ✓ Proper waste management

3.7 Reporting

Construction activities will be carefully planned and scheduled in a manner that ensures the avoidance or absolute minimization of environmental impacts. The Supervisor's Representative will be familiar with and be able to identify those areas and times that present environmental issues and will prepare schedules and the work methods accordingly. Schedules will be forwarded to the Environmental Officer/Monitor at least one week in advance of commencement of each operation.

3.8 NEMA Approvals

Darvis and Shirtliff submitted request for re-scoping report for an Environment audit for the use of the restoration of the drilling site located at Unna Villages Pachara Sub County, Adjumani West County, in Adjumani District to NEMA for the use of the drilling site which they had early received NEMA approval. This Re-scoping was approved for use on the Uderu water Project.

CHAPTER FOUR: EXECUTION OF WORKS

4.1 Introduction

This chapter gives a detailed account of the various project activities that took place on the project construction of Uderu motorized piped water project.

4.2 Contract Details

The UNICEF infrastructure projects were grouped in District Council Clusters where Adjumani, Obongi and Arua were clustered together as cluster-1. The procurement for the works and consultancy services was done at once for all the towns in the cluster.

The works contract was awarded to M/S Darvis and Shirtliff and the supervision consultancy services awarded to M/S Geobot water Engineering Ltd. See attached the Contracts here with attached in Appendix 1.

Table 1: General Contract Data

PROJECT PARTICULARS AND IMPORTANT DATES	
General Contract Data	
Project Name	Construction of Uderu Motorized piped water system in Adjumani District.
Project Reference Number	Adjumani-Obongi-Arua/Works/UNICEF/17-18/00004
Executing Agency	UNICEF GULU ZONAL OFFICE
Project Manager	Adjumani District Local Government
Project Manager's Representative	Geobot Water Engineering Ltd
Contractor	Darvis and Shirtliff
Project Implementation Progress	
Date of Submission of Tender	January 5th 2019
Date of Contract signing	14th March, 2019
Commencement Date	31st March, 2019
Original Project Duration	Twelve (12) Months

Original Expected Completion Date	31st March, 2020
Defects Liability Period	Twelve (12) Months
Payment in Local Currency	Local component, Uganda shillings: UGX 100%
Financial Status and Bonds	
Original Contract Amount	UGX 923,404,114
Revised contract sum	UGX 1,339,457,521
Amount of Advance Payment	UGX 184,680,822/= i.e. 20% of Original Contract Price payable in the stated currency proportions
Amount of Retention Money	10% of value of works
Amount of Liquidated Damages	0.05% of the Final Contract Price per day
Limit of Liquidated Damages	5% of the Final Contract Price
Performance Guarantee	Guarantee Ref. No. 160202PS1239UG from Stanbic Bank, Valid till April, 1st, 2019.
Advance Guarantee	Guarantee No. no 160405AP0800UG from Stanbic Bank; Valid Till February, 1st, 2020

Work Progress

The contractor performed and completed works within the initial intended completion time and per the contract provisions. After substantial completion, a snag list was developed as per the appendix 8. The Project Manager on 28th March 2018 accordance issued the substantial completion certificate to the contact as per the attached appendix 7.

4.3 Commencement

A start up meeting was held with the contractor at the Project Managers office in Adjumani,

The key issues discussed were:

- Submission of updated work program See attached in Appendix 4
- The formats for communication

- All workers must ensure proper use of PPE
- All insurances submitted
- Environment and health issues to be adhered to
- working drawings like Shop drawings, steel bending schedules, stress sheets, fabrication and erection drawings, false work drawings, and any other supplementary drawings or data which the Contractor is required to submit to the Engineer for approval before such Works commence.

4.4 Mobilisation

(a) Site camp

The contractor established main site camp at Unna, Pachara along Uderu Road. This site houses the offices, clinic, parking yard for some of the equipment not in use, laboratory and stock pile for material.

(b) Equipment Mobilisation

At the start of works the contractor mobilised the following equipment's on site. The equipment was inspected and approved by the supervisor to ascertain their suitability for the works

Table 4-2; Equipment mobilized by the contractor

Equipment	Description	Quantity	Condition	Comments
Tipper Truck	ACTROSS SX3234BM324,26t	01	Good	Approved
Water Tanker	MASTUBISHU SX1254BM434, 8000L and 20000L	02	Good	Approved
Wheel loader	CLG 856, 162KW	01	Good	Approved
Grader	KOMATSU, G930 with 150KW HP	01	Good	Approved
Vibrating Roller	DYNAPC, XS183J115KW	01	Good	Approved
Excavator	Volvo, EC240BLC 138KW	01	Good	Approved

Bull Dozer	MATSHUBISHI, SD32257KW	01	Good	Approved
Low Bed truck	MATSHUBISHI SX 1254UM504 25000kg	01	Good	Approved

(c) Personnel Mobilisation

The contractor mobilised both local, international personnel for the project comprising of both female and male.

(d) Material Mobilisation

The contractor identified manufactured water works and materials sampled the material for testing to be used for the project before procuring them in bulk.

The contractor had earlier mobilised crushed rock to be used as CRR, DR, CRS and aggregate for the foundation works and slab of pump house and generator house project from an existing machine crushed aggregates quarry.

Other materials like cement were delivered on demand.

4.5 Occupation Health and Safety

The main objective of this OHSE plan is to promote Health, Safety & Environment of person working with CR18G and prescribe certain rules, procedures and safe practices in order to create a working environment free of condition and factors that might contribute to an accident or injury /Illness.

(a) Policies

It is a government policy to carry out all its work in a way that provides healthy and safe working practices and avoids risks of injury to anyone as a result of the activity for which the company is responsible

(b) Specific Objectives of the Company OHSE Policy

- Prompt accident notification, investigation and reporting.
- The establishment and maintaining of Healthy, Safe and Productive Working Environment.

- Protection of property equipment and material from all down grading incidents.
- Protection of Environment by removing all hazardous wastes and by proper housekeeping

(c) Zero Accident Tolerance Policy

All endeavors to adopt a zero accident tolerance attitude to any occurrence threatening the Health, Safety & Environment of our work force and the general public.

(d) Specific Objectives of the Company OHSE Policy

- Prompt accident notification, investigation and reporting.
- The establishment and maintaining of Healthy, Safe and Productive Working Environment
- Protection of property equipment and material from all down grading incidents.
- Protection of Environment by removing all hazardous wastes and by proper storage.
- The integral part of effective management in the Construction industry is awareness that high standards of Health, Safety &Environment is required.

4.6 Quality Control and Assurance

The contractor was utilising a fully-fledged laboratory at Arua along Arua-Koboko Road 30km from Arua town. It's from this laboratory that soil/Aggregates, concrete tests were performed. The laboratory is adequately equipped to do relevant concrete, steel and aggregate testing equipment, Water quality analysis laboratory for NWSC for the project.

At every stage of the works, samples were drawn and taken to the central government laboratory for testing for quality control. In-situ strength tests were also variously done to ascertain concrete strength with respect to specified standards. See attached test results in Appendix 6

4.7 Setting Out

The contractor set out the trench for pipe works using the control points and the setting out data provided by the design consultant. These were then verified and approved to start earthworks.

Tools and Equipment's used for setting out

- Pegs
- Hoes Sledge hammer

- Total Station and accessories
- Dumpy level and accessories
- Assorted Nails

Using the control points a temporary benchmark using concrete was established on the site to guide construction of the trench on three locations.

4.8 Location of Services

The contractor identified any utility with the position of all existing services, such as electricity lines, poles, water mains, fittings, etc. before any excavation or other work likely to affect the existing services is commenced. These were reported to the consultant and advised on how to handle them.

The utility services issued quotations for the relocation of these utilities to the contactor for approval by the consultant. These relocation works were subcontracted to the utility services for purposes of quality assurance

4.9 Earth Works

(a) Bush clearance

The whole site was cleared of shrubs; trees fell using a chain saw and held with ropes. Pulling down the roots was done by a bull dozer. Areas below the prospective trenches where the holes were left after pulling out the stumps was backfilled and well compacted. The removed stumps of trees and roots were disposed in an approved location.

(b) Excavation of the pipe trench

The depth of excavation of the trench was 1000mm deep, the excavated material was shipped to a site adjacent to the trench. This was cleared by the District environment officer. This was kept near the site in order to be placed back after excavations and filling works are done. The surplus material was disposed near the site for restoring the pits. The area that had weak soils at ch 0+200 to Ch 0+300 were excavated deeper and refilled using DR.

CHAPTER FIVE: PROJECT MANAGEMENT

5.1 Over view

Balancing the elements of a complex project - time, cost, quality, with scope and people - is one of the jobs of a project manager (Villanova University, 2016). Project management involves coordinating various aspects of a project so as to bring forth a positive result. This role includes elements such as personnel, materials, procedures and facilities. Over the past five to ten years, there have been increasing challenges faced by project managers (Doucet, 2007).

After the project has been defined and the project team has been appointed, you are ready to enter the second phase in the project management life cycle: the detailed project planning phase

5.2 Project Initiation

During the first of these phases, the initiation phase, the project objective or need is identified; this can be a business problem or opportunity. An appropriate response to the need is documented in a business case with recommended solution options. A feasibility study is conducted to investigate whether each option addresses the project objective and a final recommended solution is determined. Issues of feasibility ("can we do the project?") and justification ("should we do the project?") are addressed.

Once the recommended solution is approved, a project is initiated to deliver the approved solution and a project manager is appointed. The major deliverables and the participating work groups are identified, and the project team begins to take shape. Approval is then sought by the project manager to move onto the detailed planning phase

5.3 Project Planning

Project planning is at the heart of the project life cycle, and tells everyone involved where you're going and how you're going to get there. The planning phase is when the project plans are documented, the project deliverables and requirements are defined, and the project schedule is created. It involves creating a set of plans to help guide your team through the implementation and closure phases of the project. The plans created during this phase will help you manage time, cost, quality, changes, risk, and related issues. They will also help you control staff and external suppliers to ensure that you deliver the project on time, within budget, and within schedule.

The project planning phase is often the most challenging phase for a project manager, as you need to make an educated guess about the staff, resources, and equipment needed to complete your project. You may also need to plan your communications and procurement activities, as well as contract any third-party suppliers.

5.4 The purpose of the project planning phase

- Establish project requirements
- Establish cost, schedule, list of deliverables, and delivery dates
- Establish resources plans
- Obtain management approval and proceed to the next phase

5.5 The basic processes of project planning are:

- Scope planning – specifying the in-scope requirements for the project to facilitate creating the work breakdown structure
- Preparation of the work breakdown structure – spelling out the breakdown of the project into tasks and sub-tasks
- Project schedule development – listing the entire schedule of the activities and detailing their sequence of implementation
- Resource planning – indicating who will do what work, at which time, and if any special skills are needed to accomplish the project tasks
- Budget planning – specifying the budgeted cost to be incurred at the completion of the project
- Procurement planning – focusing on vendors outside your company and subcontracting
- Risk management – planning for possible risks and considering optional contingency plans and mitigation strategies
- Quality planning – assessing quality criteria to be used for the project
- Communication planning – designing the communication strategy with all project stakeholders

The planning phase refines the project's objectives, which were gathered during the initiation phase. It includes planning the steps necessary to meet those objectives by further identifying the specific activities and resources required to complete the project. Now that these objectives have been recognized, they must be clearly articulated, detailing an in-depth scrutiny of each recognized objective. With such scrutiny, our understanding of the objective may change. Often the very act of trying to describe something precisely gives us a better understanding of what we are looking at.

5.6 Project Execution

The Project Execution Phase is the third phase in the *project life cycle*. In this phase, you will build the physical project deliverables and present them to your customer for signoff. The *Project Execution Phase* is usually the longest phase in the project life cycle and it typically consumes the most energy and the most resources.

To enable you to monitor and control the project during this phase, you will need to implement a range of management processes. These processes help you to manage time, cost, quality, change, risks and issues. They also help you to manage procurement, Client acceptance and communications

5.7 Problems experienced and how they were handled

5.7.1 Identification

The following were the some of the major challenges faced during execution of the problem.

- Wrong alignment of trench for pipe laying
- Wrong property valuation including allocation of Government investments such as trees and roadside structures to adjacent private developers.
- Costly relocation of utilities such as existing water pipes and telephone lines at Unna central village.
- Wrong design and incomplete designs (shop drawings), leading to repeat of activities or drawings.
- Fluctuating weather conditions.
- Delay in approvals by the client

5.7.2 Mitigation measures

Some mitigation measures put in place by the project manager included the following.

- Identification of available spaces in public markets to accommodate roadside sellers.
- Review of the valuation process. (Eventually only one hundred thousand Uganda shilling was paid as compensation for one tree since most of the wrong valuations were rectified after realignment of the road).
- Thorough review of all the designs so as to avert construction errors.
- Approval of method statements for all stages of work before commencement.
- Fast tracking work certification while engaging the client to stream line the payment system - in order to remain within the specified payment clearance period.

5.7.3 Effects on the project

The following were some of the effects of the constraints aforementioned.

- Contract revision (variation)
- High risk of claims due to delayed payment to the contractor.
- Time overrun
- Increase in final cost of project.

CHAPTER SIX: DISCUSIONS, CONCLUSION AND RECOMENDATIONS

6.1 Discussion

The author was able to have first-hand experience on a large scale Mini Water project, with a high precision a long transmission and distribution main. Introduction of new groundwater abstraction method using a submersible pump technology also provided new practical exposure.

Any significant construction project will involve various stakeholders who arrive on the project at different stages as parties to the construction process. It's therefore very important to involve the different stakeholders from the initial stages of the project with a collective aim of delivering the project to meet the client's requirement of delivery on time, to the required quality and at a defined budget.

All parties to the project must always understand their roles and responsibilities and limits in a project. Otherwise any crisscrossing and poor communication can affect the project negatively thus causing cost overruns and delays in project implementation

Innovations in Construction material and Technology

Installation of elbow taps or spring loaded taps for their operation was the greatest innovation that excited the public in Uderu Village Pachara Subcounty. This has greatly improved waste of water during supply.

The construction industry is hugely innovative, despite popular conceptions. As new technologies develop to make things faster and easier, construction is quick to adopt those advances to reduce costs, increase safety, and improve the way the industry operates.

The use of CAD (Computer Aided Design) CAM (Computer Aided Manufacture) allows products to be designed and manufactured more quickly and accurately. Examples of CAD software's used during design include among others AUTOCAD 10, TOPO Surv, EPANET and WATER CAD

6.2 Conclusion

The major challenges faced on this project included- lack of adequate construction space, High costs of relocation of utilities, delayed payment, delayed in specialized equipment mobilization, inclement weather conditions, theft and vandalism.

Despite the many challenges enumerated, the project management team was able to review the designs to fit the planned sections on the site layout plan; delays were moderated by fast tracking other activities such as construction of the pump house and construction of the generator thus paving way for the other activities. Considering the magnitude of the project and internal technical

failures of the client's payment system, this time loss was quite reasonable. Overall, the project was completed within the prescribed cost range and time.

The author learnt that project control was very essential in mitigating many of the management challenges that could arise during execution process.

6.3 Recommendations

The author recommends that students be guided thoroughly on what is required of them to come up with a compressive project report during the course.

A comprehensive and integrated planning of projects within the District in the bid to minimize damages and re-works

Project managers engage all relevant project stakeholders such as utility companies early enough.

Design reviews should be thoroughly done at project commencement so as to properly define the scope and hence guide the contractor on smooth progress accordingly.

REFERENCES

KK Chitkara, 2014, Construction Project Management, McGraw Hill Education (India) Private Limited,P-24 Green Park Extension, New Delhi.

Ahuja H.N., 1984, Project Management: Techniques in planning and controlling projects, John Willey & Sons, New york.

Muir, B. (2005). Challenges Facing Today's Construction Manager. University of Delaware.

Kohli, Uddesh and Chiktara, K.K., 1998, Project Management Handbook: for engineer, Construction professionals and business managers, Tata McGraw-Hill Publishing Company Limited, New Delhi.
General Specification of water works,2013, Ministry of Water and Environment, Uganda

Geobot Water Engineers ltd, 2016/2016, Project reports, Kampala

Internet:

https://project-management.com/project-management-challenges-in-the-construction-industry/: By Steve Wright, April 2016: Access: October 29, 2018

https://www.google.com/maps/place/Arua+Market, +Arua/: Access: October 29, 2018

Joadah Consults, 2017, Final Needs Assessment, Joadah Consults Printery

https://esub.com/7-most-common-challenges-in-construction-project-management/ By May 31, 2018 by Rachel Novotny: Access: October 29, 2018

APPENDIX 1: Drawings

APPENDIX 2: Bills of Quantities

APPENDIX 3: Work Program

APPENDIX 4: Completion Certificates

APPENDIX 5: Contract Communications

APPENDIX 6: Photos