

**BUSITEMA
UNIVERSITY**
Pursuing excellence

**FACULTY OF ENGINEERING
DEPARTMENT OF WATER RESOURCES ENGINEERING
FINAL YEAR PROJECT**

DESIGN AND INSTALLATION OF A HYBRID WATER TRANSMISSION SYSTEM.

CASE STUDY: BUSITEMA UNIVERSITY, BH1

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Final year project report submitted to the department of water resources engineering in partial fulfillment for the award of bachelors of science in water resources engineering.

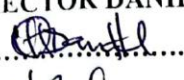
DECLARATION

I **AHEBWA CLINGTON, ANEBO ESTHER, AKELLO NERIE PEACE, KAMUHANDA BENON** hereby declare that this final year project proposal report is our own work and has not been previously submitted to any institution of higher learning for achievement of any kind of award.

APPROVAL

This is to satisfy that this work was carried out under strict supervision and has been approved for submission to the department of water resources engineering at Busitema University.

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DEDICATION

We dedicate this report to our parents, our lecturers, fellow students and friends for their support.

ACKNOWLEDGEMENT

We are overwhelmingly thankful to the Almighty God for his abundant provision and love throughout the years of our lives. Special appreciation to our supervisors Eng. Badaaza Mohammed and Mr. Ologe Hector Daniel for the guidance, assistance and advice you gave us towards completion of this work. Sincere thanks to our fellow students, lecturers and other support staff for their continuous provision of knowledge and guidance.

May God reward you abundantly!

Table of Contents

DECLARATION.....	iv
APPROVAL.....	v
DEDICATION	vi
ACKNOWLEDGEMENT	vii
LIST OF TABLES	x
LIST OF FIGURES	xi
ACRONYMS.....	xii
1 CHAPTER ONE: INTRODUCTION	1
1.1 Background of the study	1
1.2 Problem statement.....	4
1.3 Objectives of the study.....	5
1.3.1 Main objective.	5
1.3.2 Specific objectives:.....	5
1.4 Justification of the study	5
1.5 Scope of the study	6
1.5.1 Conceptual scope	6
1.5.2 Time scope	6
1.5.3 Geographical scope.....	6
2 CHAPTER TWO: LITERATURE REVIEW	7
2.1 Introduction	7
2.2 Borehole water availability and accessibility:.....	8
2.3 Water pumping	8
2.4 Solar radiation:	9
2.5 Solar irradiance	9
2.6 Water Transmission Main.....	10
2.7 Water demand.....	11
3 CHAPTER THREE: METHODOLOGY	12
3.1 SPECIFIC OBJECTIVE ONE: TO CONDUCT WATER RESOURCES ASSESSMENT.....	12
3.1.1 DETERMINATION OF CURRENT INSTITUTIONAL WATER DEMAND .	12
3.1.1.1 POPULATION PROJECTION	12
3.1.1.2 PEAK DEMAND.....	14
3.1.2 HYDRAULIC ANALYSIS OF THE EXISTING WATER DISTRIBUTION SYSTEM	14

3.1.3	TEST PUMPING	16
3.1.3.1	Step tests.....	16
3.1.4	WATER QUALITY ANALYSIS	19
3.1.4.1	TURBIDITY	19
3.1.4.2	PH AND ELECTRICAL CONDUCTIVITY.	19
3.1.4.3	TEMPERATURE	20
	PROCEDURE.....	20
3.1.4.4	TOTAL HARDNESS (Calcium, Magnesium)	20
3.1.4.5	TESTING DISSOLVED OXYGEN (DO):	21
3.1.4.6	TOTAL DISSOLVED SOLIDS (GRAVIMETRIC)	21
3.1.4.7	TESTING FOR IRON USING THE FERROZINE METHOD.....	21
3.1.4.8	TESTING FOR ESCHERICHIA COLI AND FECAL COLIFORMS	22
3.2	SPECIFIC OBJECTIVE TWO: TO DESIGN THE SYSTEM COMPONENTS.....	24
3.2.1	Sizing of the water transmission mains.	24
	Pipe Friction losses	24
	HYDRAULIC CALCULATIONS:.....	24
3.2.1.1	Measurement of distance between water source and reservoir	24
3.2.1.2	Calculation of the head loss in the pipe:	24
3.2.1.3	Determining the total head	26
	Static head.....	26
	Dynamic head	26
3.2.1.4	Determining the total hydraulic energy required per day:	27
	Power requirements	27
3.2.1.5	PIPE AND PUMP SELECTION.....	28
A.	Pipe selection:	28
3.2.2	Designing of solar photovoltaic system.....	29
3.2.2.1	Panel Sizing.....	29
3.2.2.1	Tilt angle.....	30
3.3	SPECIFIC OBJECTIVE THREE: TO CONSTRUCT THE WATER TRANSMISSION SYSTEM.	31
3.3.1	Trenching for the water pipes:	31
3.3.2	Solar Installation	32
	Tools and equipment to use;	32
3.3.3	Pump and Motor Installation Requirements	35
3.3.4	Advise on how control should be done	36

3.4	SPECIFIC OBJECTIVE FOUR; TO TEST THE EFFECTIVENESS OF THE SOLAR POWERED WATER TRANSMISSION SYSTEM.....	37
3.4.1	Flow Rate Test	37
3.4.2	Pressure Test	38
3.4.3	Solar Panel Output Test.....	38
3.4.4	System Efficiency Test.....	39
3.4.5	Inspection Of System Components.....	40
4	CHAPTER FOUR: RESULTS AND DISCUSSION	42
4.1	Results for specific objective one.....	42
4.2	Results for specific objective two	48
4.2.1	Panel Sizing	48
4.2.2	FINANCIAL ANALYSIS	50
4.2.3	Energy consumption economic analysis	51
4.2.4	Maintenance cost	52
4.3	Results for specific objective three	57
4.4	Results for specific objective four.....	58
5	RECOMMENDATIONS AND CONCLUSION.....	60
6	References	61

LIST OF TABLES

Table 3-1:	Peak Hour Factors for rural areas.....	14
Table 4-1:	Current university population and water demand	42
Table 4-2;	Summary of water demand.....	42
Table 4-3;	Population projection	43
Table 4-4;	Water demand projections taking an average of 50liters per person per day.(18m ³ /person per year)	43
Table 4-5:	Previous Water supply to the university by the different water sources	44
Table 4-6;	Yield of all water sources, pumping hours and total water delivered to the piped system currently	45
Table 4-7;	Test pumping results	45
Table 4-8;	Recovery test of the borehole	46
Table 4-9;	Water quality parameters results	47
Table 4-10;	Results for specific objective two	48
Table 4-11;	Cost of the materials	50
Table 4-12;	Cost of labour	50
Table 4-13;	Expenditure on solar power.....	51
Table 4-14;	Cash flow, depreciation, net value	52
Table 4-15;	maintenance costs.....	53

Table 4-16; Material selection criteria and materials selected for the system	57
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LIST OF FIGURES

Figure 1-1: Evolution of global water withdrawals, 1900-2018 (km ² /year).....	2
Figure 1-2: details of existing boreholes. (Source: Busitema University main campus master plan, water supply, sanitation and irrigation report)	3
Figure 1-3; The system design layout	5
Figure 1-4: Aerial view of the proposed transmission line.....	6
Figure 2-1: Solar irradiance and peak sun hours (Source: “Renewable Energy Primer-Solar.”)	9
Figure 3-1; The controller	35
Figure 3-2; Pump connection.....	35
Figure 4-1: A line graph of the students/staff numbers against the population projection.....	44
Figure 4-2: Hydraulic analysis of the existing water transmission and distribution system ...	53
Figure 4-3: Pump pressures of the existing system.	54
Figure 4-4: Pressure distribution plot along the network.....	55
Figure 4-5: Pipe network layout with pressure and velocity values at various nodes and junctions.....	55
Figure 4-6: table of Epanet results generated after running the system successfully	56
Figure 4-7: Elevation, demand, head and pressure at different points of the system.	56
Figure 4-8: 1. Pressure and flow rate at different points in the system.....	58
Figure 4-9: Simulation of the water transmission system.....	59

ACRONYMS

FAO - Food and Agriculture Organization

SDGs - Sustainable Development Goals

WASH - Water, Sanitation and Hygiene

Org. - Organization

BH. – Borehole

Hr- Hour

uPVC.- Unplasticized Polyvinyl chloride

GIS - Geographic Information System

DO - Dissolved Solids

HDPE- High Density Polyethylene

PVC- Polyvinyl Chloride

1 CHAPTER ONE: INTRODUCTION

1.1 Background of the study

There is nothing more essential to life on earth than water yet there is a global water crisis. Water scarcity is one of the most pressing development challenges of our time.(Lifeng Li, 2023) Today, 2.4 billion people live in water stressed countries. Many are small holder farmers who already struggle to meet their daily needs for drinking water, nutritious food and basic services such as hygiene and sanitation. Competition for this precious resource is on the rise, as water scarcity increasingly becomes a cause of conflict. Fresh water resources per person have dropped by 20% over the past two decades, while water availability and quality are deteriorating quickly due to decades of misuse, lack of coordinated management, over abstraction of ground water, pollution and climate change. (Lifeng Li, 2023)

Water has been a major issue on the international agenda for several decades as the most essential resource for life (Mancosu, Noemi, 2015).

The world is rapidly urbanizing. From 1950 to 2020, the global population living in cities increased from 0.8 billion (29.6%) to 4.4 billion (56.2%) and is projected to reach 6.7 billion (68.4%) by 2050. Water scarcity, where demand exceeds availability, is a key determinant of water security and directly affects the health and wellbeing of urban residents, urban environmental quality, and socioeconomic development (He Chuyang, 2021)

Globally, water use has been increasing by roughly 1% per year over the last 40 years (AQUASTAT, n.d.). The bulk of this increase is concentrated in middle- and lower-income countries, particularly in emerging economies (Ritchie and Roser, 2017). This trend has been driven by a combination of population growth, socio-economic development and changing consumption patterns. Regions with the largest water withdrawals per capita have been Northern America and Central Asia (FAO, 2022). Between 2010 and 2018, municipal withdrawals increased by 3%, whereas agricultural withdrawals increased by 5%, and now represent 72% of total withdrawals.

6 References

- Feron, S. (2016). Sustainability of off-grid photovoltaic systems for rural electrification in developing countries: A review. *Sustainability (Switzerland)*, 8(12). <https://doi.org/10.3390/su8121326>
- Frateur, I., Deslouis, C., Kiene, L., Levi, Y., & Tribollet, B. (1999). Free chlorine consumption induced by cast iron corrosion in drinking water distribution systems. *Water Research*, 33(8), 1781–1790. [https://doi.org/https://doi.org/10.1016/S0043-1354\(98\)00369-8](https://doi.org/https://doi.org/10.1016/S0043-1354(98)00369-8)
- Futurepump. (2019). *Productive use of off-grid solar: appliances and solar water pumps as drivers of growth*. 2018, 8.
- Hobbs, I., Anda, M., & Bahri, P. A. (2019). Estimating peak water demand: Literature review of current standing and research challenges. *Results in Engineering*, 4, 100055. <https://doi.org/10.1016/J.RINENG.2019.100055>
- Jara-Arriagada, C., & Stoianov, I. (2024). Pressure-induced fatigue failures in cast iron water supply pipes. *Engineering Failure Analysis*, 155, 107731. <https://doi.org/https://doi.org/10.1016/j.engfailanal.2023.107731>
- Kahn, C., Damiani, A., & Ge, S. (2020). Validation of water main failure predictions: A 2-year case study. *AWWA Water Science*, 2(3), 1–14. <https://doi.org/10.1002/aws2.1179>
- Kurian, M., & McCarney, P. (2010). Peri-urban water and sanitation services: Policy, planning and method. In *Peri-urban Water and Sanitation Services: Policy, Planning and Method* (pp. 1–300). <https://doi.org/10.1007/978-90-481-9425-4>
- Lifeng Li. (2023). Water Scarcity, the Climate Crisis and Global Food Security: A Call for Collaborative Action. *UN Chronicle*. <https://www.un.org/en/un-chronicle/water-scarcity-climate-crisis-and-global-food-security-call-collaborative-action>
- Makris, K., Langeveld, J., & Clemens, F. (2019). A review on the durability of PVC sewer pipes: research vs. practice. *Structure and Infrastructure Engineering*. <https://doi.org/10.1080/15732479.2019.1673442>
- Mesalie, R. A., Aklog, D., & Kifelew, M. S. (2021). Failure assessment for drinking water distribution system in the case of Bahir Dar institute of technology, Ethiopia. *Applied Water Science*, 11(8), 1–24. <https://doi.org/10.1007/s13201-021-01465-7>

- Tak, S., & Vellanki, B. P. (2018). Natural organic matter as precursor to disinfection byproducts and its removal using conventional and advanced processes: State of the art review. *Journal of Water and Health*, 16(5), 681–703. <https://doi.org/10.2166/wh.2018.032>
- Tchórzewska-Cieślak, B., Pietrucha-Urbanik, K., & Piegdoń, I. (2023). The Failure Risk Analysis of the Water Supply Network. *Water (Switzerland)*, 15(21). <https://doi.org/10.3390/w15213815>
- U.N Habitat. (1993). *The Maintenance of Infrastructure and Its Financing and Cost Recovery*. 72.
- Waqas, U., Farhan, A., Haider, A., Kumar, U., & Raza, A. (2023). Advancements in biofilm formation and control in potable water distribution systems: A comprehensive review and analysis of chloramine decay in water systems. *Journal of Environmental Chemical Engineering*, 11(6), 111377. <https://doi.org/https://doi.org/10.1016/j.jece.2023.111377>
- Zhang, C., Campana, P. E., Yang, J., Yu, C., & Yan, J. (2018). Economic assessment of photovoltaic water pumping integration with dairy milk production. *Energy Conversion and Management*, 177, 750–764. <https://doi.org/10.1016/j.enconman.2018.09.060>