DESIGN REPORT FOR WATER SUPPLY EXTENSION SYSTEM IN ODWEYNE

ARP PROJECT

ODWEYNE

Dec, 2024

Introduction

The project site is in Odweyne town, Odweyne District. This water supply project aims to improve access to water for the people in Odweyne. The project will include extending the water system from the Odweyne Haffir Dam to an elevated storage tank, using solar power, and adding pipelines to connect to the existing water system. Once completed, the project is expected to benefit about 12,000 people by providing clean and reliable water.

Scope of the Report

This report focuses on designing a water supply system and creating a Bill of Quantities (BOQ) to guide the project. The goal is to help the community get clean water for daily use and drinking.

The report covers the following:

* Designing the water supply system.
* Detailed plans for:
o Installing a pump and solar panels.
o Extending a transmission pipeline from the Haffir Dam to the elevated tank.
o Extending the pipeline to connect to the existing water system.

Components of the Water Project

The project is designed to:

* Help the community deal with constant water shortages.
* Provide water for different uses, including livestock and small-scale farming.

Water Consumption Rates

The quantities of water needed for domestic use is context based, and may vary according to the climate, the sanitation facilities available, people's habits, their religious and cultural practices, the food they cook, the clothes they wear, and so on. Water consumption generally increases the nearer the water source is to the dwelling. Where possible, 15 litres per person per day (l/p/d) can be exceeded to conform to local standards where that standard is higher. Below table details the standard of water need as per sphere standards:

Basic survival water needs (SPHERE STANDATDS)

Survival needs: water intake (drinking and food)	2.5–3 litres per day
Basic hygiene practices	2–6 litres per day
Basic cooking needs	3–6 litres per day

Total basic water needs	**7.5–15 litres per day**

Existing Infrastructure

1. **Water Supply**:
    - Currently reliant on water trucking services.
    - Haffir dam, the nearest water source, is 2225 meters from the town and managed by the Odweyne ministry of water coordinator and collect through a water trucking.
2. Elevated water tank was located center of the town which constructed by UNICEF and connected part of town distribution pipeline. They connected to the elevated tank to the shallow well which was located a distance of 4km far from elevated tank and become functional due to ground water potential for the shallow well.
3. Distribution mains: Even though, 246m of part of the distribution system was damaged due to the construction of local government.

Proposed Infrastructure

1. **Water Supply**:
    - **Pipeline Extension**:
        - Length: 2,471 meters including 2225 of transmission mains and 246 of distribution mains.
        - Diameter and material: Based on hydraulic design using EPANET.
        - Transmission mains connected to haffir dam and distribution connected to the elevated tank to the existing water pipeline.
        - Haffir dam dimension is 120mx140m x 4m
        - The volume of reservoir is 67200m3
    - **Elevated tank fence rehabilitation**:
        - With 25m length and 2m height
    - **Solar system**
        - 10 solar panels are existing with each 300 w
        - Surface pump with a 9m head that pump a water into elevated tank located near the dam.

DESIGN OF WATER DISTRIBUTION PIPELINES

WATER DEMAND CALCULATION

Water demand can be defined as the **total water usage of an area per unit of time**. Typically, we express it in terms of daily usage or average usage per second.
To find it, we can multiply the average daily water demand per person by the population size living in the area or city. We write more about it in the following sections.

Water demand formula

The water demand calculated is based on the following average daily water demand formula:

$ADD=LPCD\times P+10\%\times P$
where:

- ADD — Average daily water demand;
- LPCD — Liter per capita per day; and
- P — Size of the population.

Maximum daily water demand — the largest volume of water that may need to be delivered in a day:

- $MDD=1.4\times ADDMDD=1.4\times ADD$

Population size is: 12,000

Per capita per day: 15 L/P/d

ADD= 12,000x15 + 0.1x180,000 = 198,000 l/d

Maximum water demand: 1.4x198,000 = 277,200 l/d

Daily water consumption: 11.55 m3/h

Haffir dam Data

Haffir dam Total Depth	= 4m
Pumping Water Level	= 4m
Required Yield	= 11.55m^3/hr
Elevation at outlet haffir dam	= 1034m
Elevation of existing elevated tank	= 1033m
Distance of transmission main	= 2225m

Calculation of Total Head

Supply Design Criteria

Static head

Elevation difference = (1034 – 1033) = 1m

Height of tank inlet = 9m

Pumping water level = 4m

Total Static Head = (1+9+4) m = 14m

Dynamic head

Using Q=VA, Where Q=Safe discharge, V=Velocity and A=Cross sectional area of pipe,

Assume V =0.8m/s

Q = 11.55m^3/hr = 11.55/3600 = 0.003208333m^3/s

Area (A) =Q/V=π *D^2/4

Pipeline diameter (D)= $(4Q/\pi*V)^{1/2}$

= $(4 \times 0.003208333/\pi*0.8)^{1/2}$

= 71.4mm Pipeline of Length 2225m

Therefore, adopt a 75mm ND pipeline

Dynamic head =

Pipe size = 75mm

Pipeline Length = 2225m

Pipe Material = HDPE PIPE

Total Frictional Losses = **15.677**

https://www.omnicalculator.com/physics/friction-loss

Total Head

= dynamic Head + Static Head

=15.677 + 14

= 29.677m say 30m

= **30m**

due to high cost of 75mm pipe, let's try a lower diameter pipe of 63mm

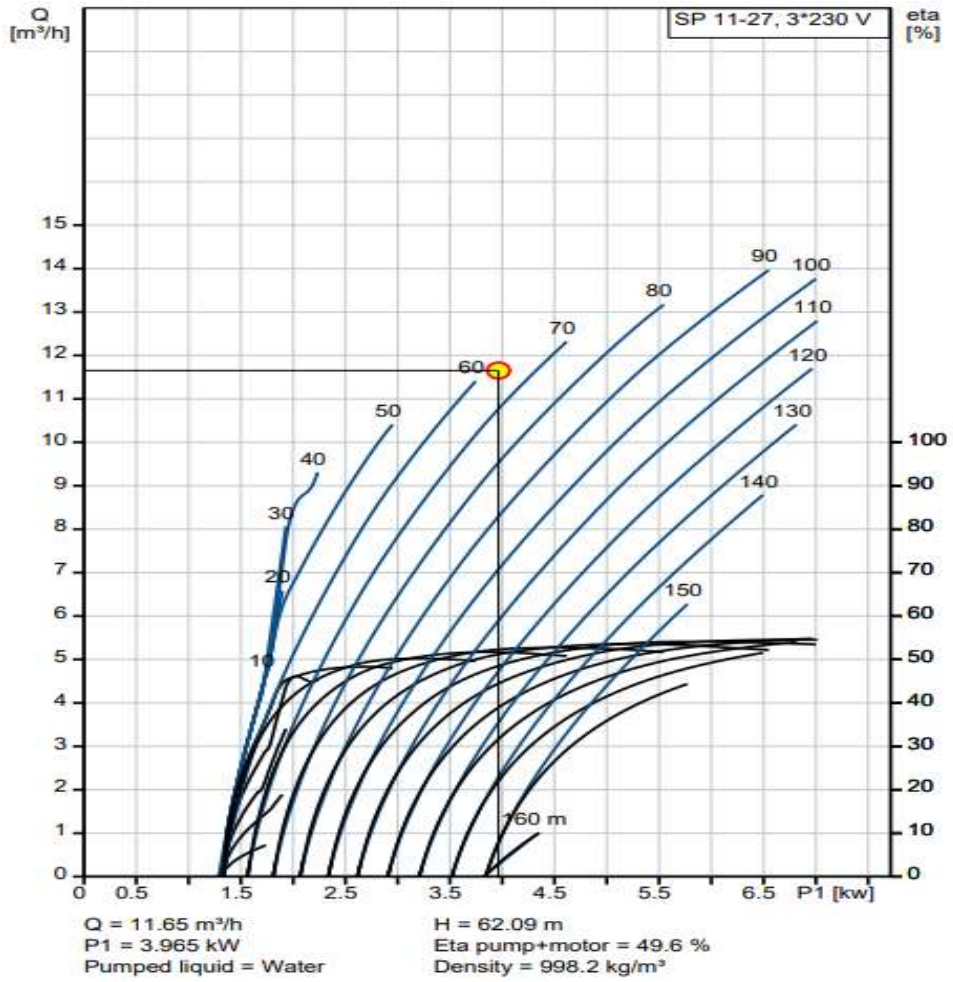
Q= 0.003208333, D= 0.063m

v= Q/A = 0.003208333*4 / (3.142*0.063*0.063) = 1.029 m/s. This is still within the velocity range and more economical

frictional loss from this diameter using the online calculator is **42.972m**

The New TOTAL HEAD = 42.972m +14m = 56.972m

Pump Selection



The SP 11-27 Grundfos Pump rated 5.5kw is selected, that is therefore used for the design of the solar power system

Design of Solar Pumping Components.

Losses due to	**Acceptable ranges**	**Adopted**
Wire resistance	1-2%	2%
Inverters efficiency	1-4%	4%
Manufacturers deficiency	1-3%	2%
Heating effect	5-10%	9%

Soiling	0-5%	5%
Time/Aging factor	1% per annum Max 20 years (take 20 years)	20%
Shadows/shading	1-5%	4%
Orientation towards true north	0-5%	4%
Total		**50%**

Pump power = 7.5 KW

Electrical data:

- Motor type: MS4000
- Power input - P1: 5.5 kW
- Rated power - P2: 5.5 kW
- Rated voltage: 3 x 380-400-415 V
- Rated current: 13-13-13.4 A

Electrical data of the Inverter:

The SP 11-27 pump operates with both AC (220 V) and DC (400V) inputs, which means it can be powered directly by DC solar panels without the need for an inverter

Step 1: Calculate the Total Power Requirement from the solar

Pump requires 5.5kW (8400 W) of power

Solar panel power requirement = 5.5 *1.5 = 8.25 KW

Minimum number of panels required =8250/350 = 23. 57, say 24 panels

Each solar panel has a maximum power (Pmax) of 350W.

Number of panels required = 8400 W/350W = 24 panels

The existing solar is 10 panels

So, we require 14 solar panels

Summary of solar system components

A. Equipment

i. Pump –submersible pump SP 11-27 Grundfos Pump rated 5.5Kw

ii. Solar panel: Provide JA solar panels capable of delivering amount of power required by the pump and compatible with the controller.

iii. Accessories – Provide Underground cables and the submersible cables.

Scope of Work

1. Supply and installation of Solar pump and panels
2. Construction of 25m perimeter fence for existing elevated tank
3. Extension of water supply pipeline for both distribution and transmission mains

SUMMARY

Item	Specifications
Solar pump	SP 11-27 Grundfos Pump rated (7.5 KW)
Rising Main	Laying of 2225m of DN50 PN16 inch (63mm OD) HDPE pipe pipeline to transmit water to elevated Concrete tank

1. DESIGN OF WATER DISTRIBUTION PIPELINES

1. Water Tank to existing water pipeline

Design Criteria

Ministry of Water - 2015 Design Manual (Kenya), Velocity of a gravity system to be taken from the range 0.3m/s – 1.2 m/s

Assumptions

V = 0.8m/s

Q =12000*15L =180,000L assuming the kiosk will run for 10hr discharge will be $18m^3$/hr, 18/3600= 0.005m3/s

$Q=(3.14*D^2) * V$

Pipeline diameter (D)= $(4Q/\pi*V)^{1/2}$

$= (4 \times 0.005/\pi*0.8)^{1/2}$

= 89.23mm Pipeline

Hence the existing water distribution pipeline is 75mm let we consider as same diameter which gives us a less frictional loss of 3.96m

v = Q/A = 0.005/ (3.142*0.075*0.075/4) = 1.132m/s. This is within the recommended design manual range of 0.3m/s – 1.5m/s hence adopt a pipeline diameter of 75mm ND

https://www.omnicalculator.com/physics/friction-loss

Total Head Difference

Height of Tank outlet = 6m

Ground elevation of Steel Tank= 1033m

Elevation of Water existing pipeline = 1034m

Therefore, Total head difference

= Height of ST outlet + Elevation difference

= 6 +(1033-1034)

= 5m

There is a head difference of 5m against frictional head loss of 3.96m hence water should flow by gravity to fill the water kiosks using a 3inch HDPE pipeline with a residual head of (5-3.96) m = 1.04m

Summary of Pipelines

S/No	Description	Length (m)	Pipeline
1	Transmission pipeline	2225	2.5inch HDPE PN16
2.	Water distribution pipeline	246	3inch HDPE PN10
Total Pipeline length		**2,471**	

To design the water distribution pipeline network and calculate hydraulic parameters, EPANET software is used. This software computes key parameters such as velocity, pressure, head loss, and discharge. Detailed information and analysis are available in the EPANET report.

Key report informations

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**************************************************************************
*                    E P A N E T                     *
*              Hydraulic and Water Quality             *
*              Analysis for Pipe Networks              *
*                   Version 2.2                        *
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Input File: Odweyne water extension.net

Odweyne Water connection Water from existing haffir and it distributed directly to the distribution tank located to the center of the town

Link - Node Table:

Link ID	Start Node	End Node	Length m	Diameter mm
1	2	3	75	75
2	3	4	850	75
3	4	5	400	75
4	5	6	900	75
5	6	7	71	75
6	7	8	105	75
7	8	9	70	75

8	1	2		#N/A	#N/A Pump

Energy Usage:

Pump	Usage Factor	Avg. Effic.	Kw-hr /m3	Avg. Kw	Peak Kw	Cost /day
8	100.00	75.00	3.75	151.72	151.72	0.00

Demand Charge: 0.00
Total Cost: 0.00

Node Results:

Node ID	Demand LPS	Head m	Pressure m	Quality	
2	2.00	1182.27	130.27	0.00	
3	1.50	1174.12	122.12	0.00	
4	1.50	1107.51	58.51	0.00	
5	1.50	1086.47	38.47	0.00	
7	1.00	1057.31	3.31	0.00	
8	0.75	1056.92	3.92	0.00	
9	0.75	1056.85	2.85	0.00	
1	-11.25	150.00	0.00	0.00	Reservoir
6	2.25	1058.00	4.00	0.00	Tank

Link Results:

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status	
1	9.25	2.09	108.77	Open	
2	7.75	1.75	78.37	Open	
3	6.25	1.41	52.60	Open	
4	4.75	1.07	31.63	Open	
5	2.50	0.57	9.65	Open	
6	1.50	0.34	3.75	Open	
7	0.75	0.17	1.04	Open	
8	11.25	0.00	-1032.27	Open	Pump

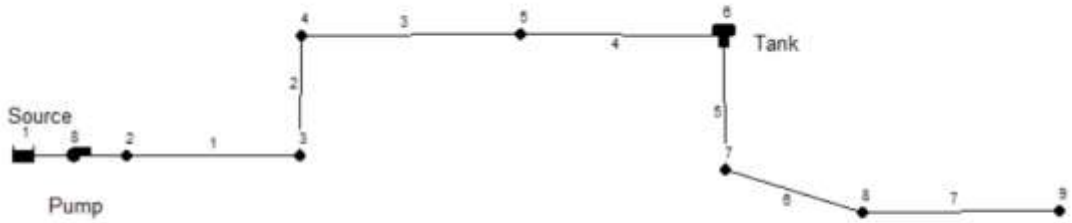

Figure 1 Water distribution layout

Figure 2 Topographic layout of water supply system