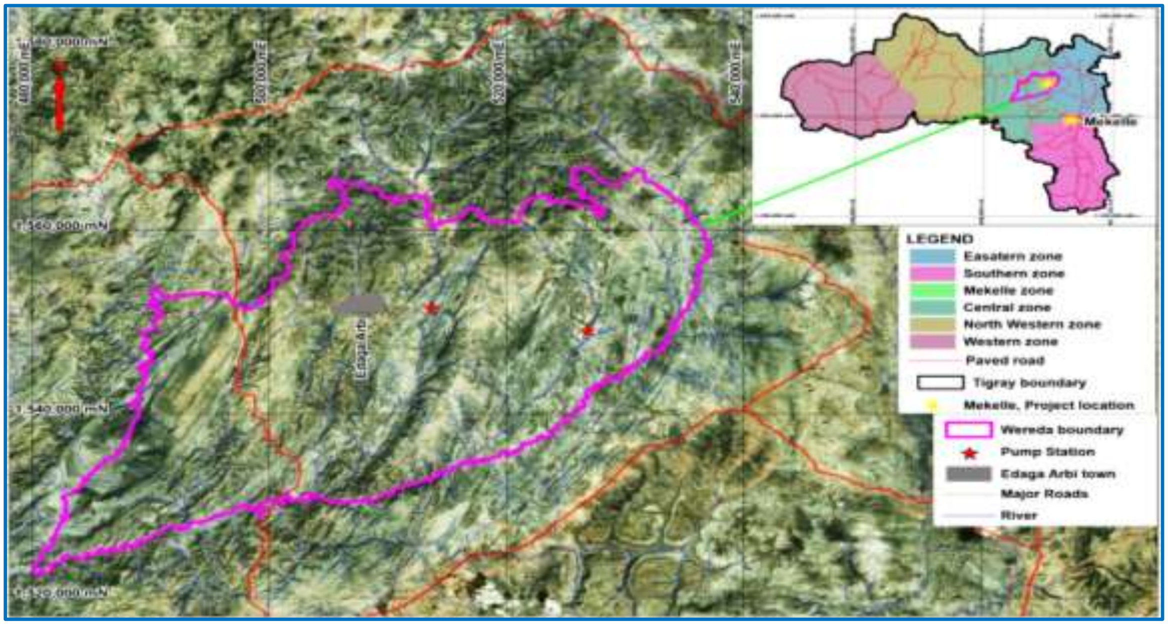
The Federal Democratic Republic of Ethiopia Regional State of Tigray Bureau of Water Resources



Ruba-Chemiet Pump Irrigation Project

Detail Design Final Report of Headwork and infrastructure

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April, 2018

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Acronyms

Amsl. Above Main Sea Level

DEM Digital Elevation Model

UTM	Universal Transverses Marcater
Km	Kilometer
m	Meter
min	Minutes
lit/s	litter persecond
mm/hr	milimeter per hour
m/s	Meter per second
M^3/s	Meter cubic per second
mm	Milimeter
ha	hectar
Q	Discharge in (m^3/s)
TWWSDSE	Tigray Water Works Study Design and Supervision Enterprise.
TWRB	Tigray Water Resource Bureau

Salient Features

Name of the project: Ruba-Chemiet Pump Irrigation Project

a. Location

Region: Tigray

Zone: Central Zone

Woreda: Werie Leke

Tabiya: Adi Hedem

b. Accessibility: Total distance from the Woreda capital (Werie leke) :33*Km*

c. Geographic location:

Pump Station

Easting = 526737 m

Northing = 1548921m

Elevation = 1717.5m m.a.s.l

d. Headwork structure: - Pump irrigation type

Type of pump: Surface pump (Centrifugal)

Pump Power: 187.00KW

e. Command Area:

Dry time command area: 97 ha

f. Design discharge

Discharge of two pump-152.07 lit/s

1. INTRODUCTION

1.1. General

It has been studied that irrigation projects have impacts on the cultural, social, and economic development and transformation of people. The impact can also particularly include significant improvements to economic development, in household income levels and security of livelihoods. Understanding the potential breadth of the impact that irrigation projects can have on poor people lives achieved a sustainable economic level. In order to ensure sustainable economic level of people, it becomes essential to plan and build sustainable and suitable irrigation projects, which will provide water to the irrigation area accordance with their water requirement.

This study is taken place in lot-5 of Ruba-Chemiet project and it is a pump irrigation system project. It contains the project back ground, objectives, the approach and methodologies to conduct the study, project area identification, provisional routes for pipes, conditional sites or locations for major irrigation components and the detailed work plan.

1.2. Background of the study

The project site area is predominantly traditional agriculture area. The rain fall is variable, erratic, seasonal and short duration, which is insufficient for proper growth and maturity of crops. So far very little irrigation has been developed in the area and most of the area is dependent on rains resulting in mono cropping. Hence to reduce the food deficient the regional government of Tigray has given prime importance to the improvement of water resource and improved agricultural technologies.

Therefore, the Tigray water resource bureau in collaboration with non-governmental organizations like, IFAD (International Fund for Agricultural Development) assists the development goal of the region. This context IFAD give due attention for the upgrading and sustaining traditional irrigation schemes to ensure the food security of the farming system.

To introduce the irrigation system, it has been decided to undertake an intensive study. As a result, Tigray Water Works Study, Design and Supervision Enterprise, the consultant, has been given by the client of BoWR (Bureau of water resource) to undertake full scale study, to identify and undertake the feasibility of the Ruba-Chemiet as a potential water source to irrigate the project area.

The study has been started by deploying a team composing of a multidisciplinary higher level professional who have vast experience in studying, planning and designing irrigation projects to identify the feasibility of the Ruba-Chemiet project as a source of water for pump irrigation system project due considerations to its technical and economic viability, environmental soundness and operational suitability.

As a result, the study and design team has identified possible scenarios and alternatives and conducted all necessary evaluations to come up with the suitable and viable irrigation system components as part of the prefeasibility study. From the finding that the team has revealed, based on the terms of reference prepared by the IFAD (International Fund for Agricultural Development) as guideline.

1.3. Objective of the study

- To introduce a farmer to modern Irrigation and drainage techniques for upgrading the local agricultural productivity based on our local resources development.
- Insuring the farmer in sustainable food sufficiency and family income Generating.
- Upgrade the Skill of local farmer’s capacity for proper use of existed water resources and land managements.

- Motor Pump system design on the Ruba-Chemiet river as a source of water for pump irrigation.
- Survey and Prepare topo maps for Head and command area.
- Detail Survey for pipe line route.
- Locate proper place for detention ponds.
- Survey and Location the pound detentions for the project.

1.4. Methodology

The methodology comprises to design surface pump irrigation system from river Ruba-Chemiet to detention pond. Based on the reconnaissance investigation, field assessment has carried out to check the topographical future of the project area. Satellite image, spot image and DEM of the project area have been used. Detail surveying has carried out. Command areas have been identified and delineated. Alternative pipe route has been assessed out of which the best route is selected.

1.5. Project area description

Geographical location of an Adindan reading Ruba-Chemiet site on the on the pump station is 526737 E 1548921 N UTM and elevation of 1717.5m m.a.s.l.The site is located at central zone of Tigray regional state wereda werie leke tabiya Adi Hedem kushet Hedem.The commands area of Ruba-chemiet irrigation schemes is found at a 33km along the main road running from Edag arbi to nebelet. Ruba chemiet to the right side of River Chemiet.

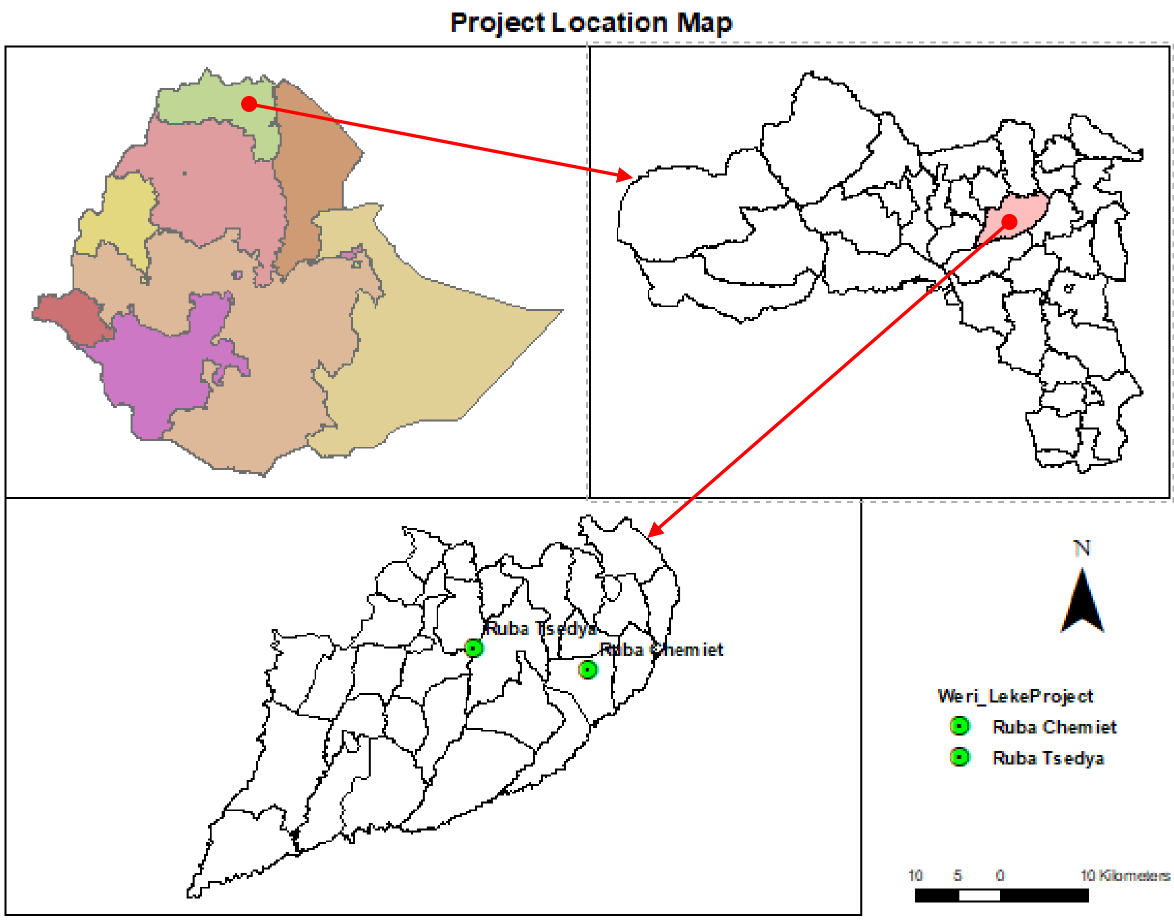


Figure 1:Location of project area Ruba-Chemiet

Table 1:Bench Mark location

X	Y	Z	Remark
526435.0550	1548933.3840	1748.722	GPS_1
526696.158	1548975.233	1732.0411	GPS_1A
525802.022	1549749.695	1761.554	GPS_2
525845.110	1549773.470	1761.4320	GPS_2A

1.6. Data Requirements

a. Agronomical data

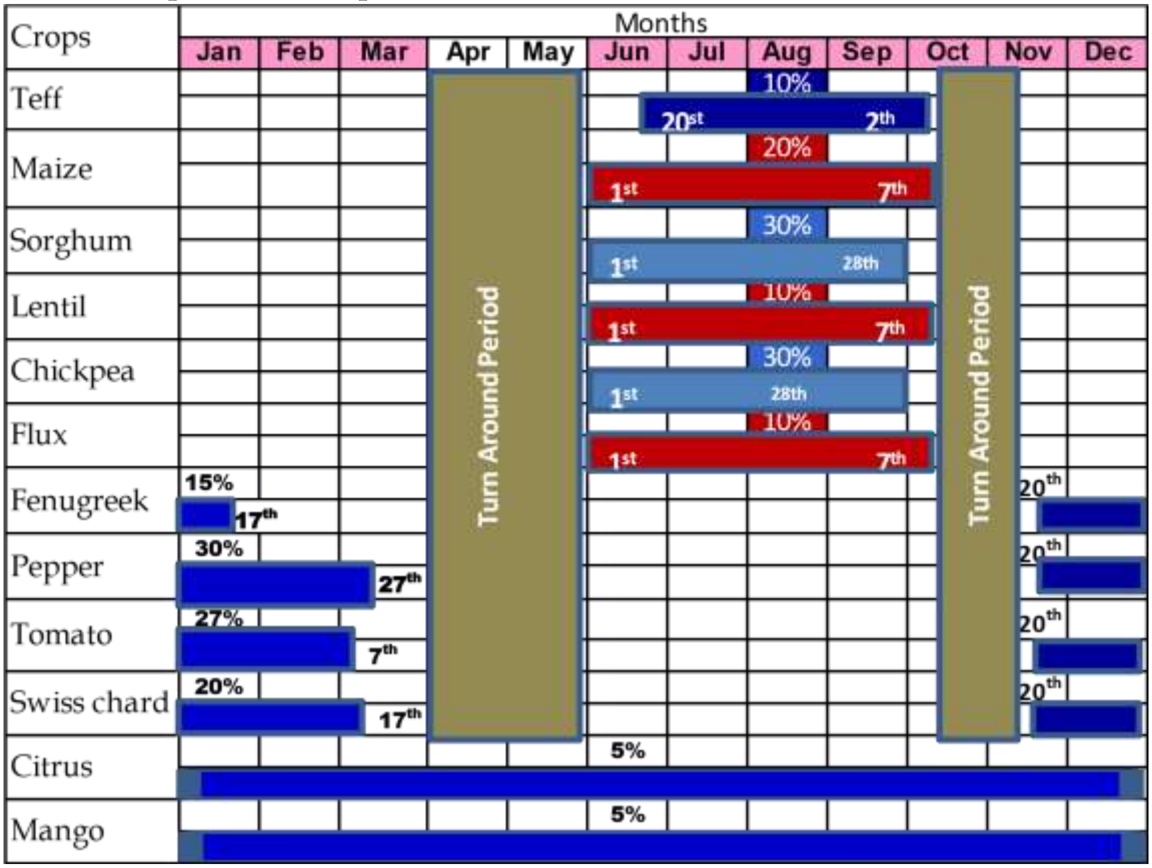
For Ruba-chemiet the agronomy of the area most practiced is studied suited for the growth of several field crops, vegetables and fruit trees. The following crops are selected and proposed to be grown under the envisaged irrigation scheme. These crops are selected after thorough evaluation of:

- Agro climate and soil of the area; experience and preference of farmers; Economic consideration (marketability of the crop) and improved seed availability; and response of the crop toward irrigation (yield potential).

Table 2:Proposed cropping pattern

Crops	Area (%)	Planting date	Harvesting date	Growing season
Linseed	10	June 1	Oct 07	Rainy season
Chickpea	10	June 1	Aug 28	
Lentil	10	June 1	Oct 07	
Maize	20	June 1	Oct 07	
Sorghum	30	June 1	Sep 28	
Teff	10	June 20	Oct 09	
Pepper	30	Nov 20	Mar 27	Dry season
Tomato	25	Nov 20	Mar 07	
Swiss chard	20	Nov 20	Mar 17	
Fenugreek	15	Nov 20	Jan 17	
Mango	5	Nov 20		Perennial crops
papaya	5	Nov 20		

Actually, the farmers are not limited to grow only these crops. They can shift to other more profitable crops when conditions are convenient.



The net irrigation need of the scheme during both dry and wet seasons 134.3 mm/month on Feb and per hectare irrigation water budget of the scheme is about 8470.59 m3/ha. Additionally, considering 57 % over-all project efficiency and 14 scheme operation is 1.57 l/s/h.

b. Soil characteristic of the project area

The command area of Ruba-Chemiet irrigation project is situated to the right side of Ruba-Chemiet River. According to survey of soil expert the dominant soil types of Ruba-Chemiet irrigation scheme is Leptosol, cambisol and regosol. For detail, refer to soil study report of the scheme.

Agricultural soils are best classified based on texture. Texture affects practically all of the factors governing plant growth; in other words, texture influences the movement and availability of soil moisture, aeration, nutrient availability, and the resistance of the soil to root penetration. Soil texture also influences how best the soils are managed.

Accordingly, the soils of Ruba-Chemiet irrigation project are dominated with loam textured soils. For detail we can see in the soil report.

c. Socio economic

The construction of the Ruba-Chemiet pump irrigation scheme will provide a regulated water supply for irrigation. Both agricultural and non-agricultural benefits are identified as arising from new opportunities created by the changed crop varieties and the increased productivity throughout the year. With the project completed, the full-season irrigable area is expected to be 102 hectares.

According to the Tabia administrations the total population of the study area is 62,150 (in 2006 E.C.) 33,554 (54%are male and 28,596 (46%) are female. Moreover, there are 12,347 households of whom 3,158 female headed households and 9,189 male headed households. The population data shows the average family size 4.1 in the project area. The project can irrigate 102 hectares of land under dry season irrigation and expect to benefit for 222 farm households, 23% are female headed households and 77% are male headed household, assuming that each farm household can have 0.25 hectare of land under the proposed irrigation project. For detail we can see in the socio economy report.

d. Environmental impact assessment

The proposed Ruba-Chemiet pump irrigation project has been assessed in accordance with possible Ethiopia (National) & Regional Environmental Impact Assessment guidelines. The project site is selected by investigating different locations along Ruba-Chemiet river course based on its geological stability, capacity to irrigate 102ha area, low adverse environmental impacts and low construction cost. The project has both positive and negative environmental and socioeconomic impacts, but the positive impacts more crucial than the negative once making the proposed project acceptable. For detail we can see in the EIA report.

e. Geological formation of the project area

The investigation process has been involved sound geological knowledge for visual inspection to define the surface geologic and engineering properties of the supporting ground. Test pitting and sample collection have been conducted for sub-surface investigation. Six (6) test pits varying in depth from 2 to 4 meters' dip have been opened on pump, pond and canal foundations. Longitudinal and transverse geologic and engineering geologic profile mapping along the chosen canal routes have been prepared and depths of cut and heights of embankments were determined. Soil samples have been taken for laboratory test to determine necessitated design parameters. For detail we can see in the engineering geology report.

2. General Approach

2.1 Material used

The following materials were used during the study:

- *14.1pix*Digital camera
- GPS (Datum: ADINDAN)
- Tape meter (5m and 50m);
- Digital Elevation Model (30 m resolution);
- Mosaic Land sat Image northern Ethiopia;
- Different software's like GIS (Arc GIS), Global Map per, Google earth and AutoCAD.

2.2 Methods Used

The methodologies used during the study were:

- Meetings with each profession they have work and compile it the to make to one solid feasibility study
- Conducting intensive office work
- And field detail investigations works

i. Office Work

In the office work activities that are carried out:

- Review of previous studies conducted around the project area.
- Review of available topographic feature and DEM data which enabled to select possible structures site location and pipe routes.
- Interpretation of topographic variables (30 m resolution DEM) in order to understand the overall terrain conditions.

ii. Field Work

The following activities were carried out in the field

- Identified the possible intake location for Ruba-Chemiet from the morphological, hydrological, engineering, and geological point of view:
- Pipe line and canal detail route survey from the raw water intake up to command peak places of the irrigable area.

- Topo survey of command areas for the Ruba-Chemiet pump irrigation system project that could be benefited or included in the project.

2.3 Results of office and field work

Based on the clients (BOWR) demand detailed feasibility is made on the development of pump irrigation system in the Ruba-Chemiet pump irrigation system project. In this section the results and the feasibility outcomes will be presented and discussed in detail. In addition, the possibilities of developing pump irrigation system and continue for the detailed design of the project will be evaluated.

After performing intensive office and field work, outputs and result of the different aspects of pump irrigation system: location and detail survey of pumping station site, reservoir pound, main pipe line routes, surface canals (main and branch) route, project area draft design feasibility designs are done and presented below.

2.3.1 Topographical Survey of the Project area

Topographic survey (command survey) has been conducted during the pre-feasible study to know the size of the available command and to understand the topographic features on which the pipe lines and canals route is going to be aligned as per the TOR given by the client (BoWR). Such as Topographic survey of pump stations and irrigable areas surveyed and a general topo-map shows all engineering features of the project such as command area, access road and so on with appropriate scale should be produced. The survey used as a base data for the subsequent activities and includes:

- The location of the existing structures, roads, buildings etc.
- All bench marks, stations and natural features.
- The maximum command area by.

3. Head Work

The irrigation is to be undertaken by pumping water from the Ruba-chemiet River channel. To make the irrigation system as efficient as possible, proper planning and design of the pumping station is vital. To this effect field visit was undertaken to get data and information mainly on the following areas:

- Appropriate pumping site identification and selection
- Topographic map preparation for the irrigation system design of head work structures and the irrigation system layout
- Geological and geotechnical investigations for foundation stability, river bank conditions, construction materials etc.
- Hydrological assessments, mainly interview of the local elder people as regard to flooding conditions during the rainy season and during of river flows in the year.

3.1. Pump

3.1.1. General

Pump is generally a device which drives irrigation water to the command area by pressure. The small scale pumping irrigation is one of the modern irrigation developments techniques which considered practical to take as a main strategy for Improving, Expanding and introducing the Modern Irrigation substituting the traditional ways of irrigating and to make sustainable development the agro-Irrigation sector and try to upgrade the productivity Incrementing the farmers Income Upgrading these natural Indigenous Knowledge maximizing the use of possible Arable lands. The possible existing water resources, for irrigating can be practically exercised to develop in purposes to insure, the food security across the Region and Nation.

3.1.2. Small Scale Pumping Irrigation

The present family based pumping irrigation facility is one of the most efficient and simple to operate and manage Irrigation techniques for small farmers plot development to make sustainable and profitable sector with clear vision of the strategies. The pumping proposal strategies for small farming; now a day is one of the most considered development Ideas for community based Irrigation Which Targeted to make productive and Sustainable Irrigation sectors at medium farming level. Therefore, the main considered area to cover with present filed based application related to pump are on that community based farming sectors which traditionally classified as an area that difficulties to cover in irrigation and drainage techniques a cause of the topographical and water resources location to deliver; but the locality is considered which are potential in natural subsurface, surface water recourse and farm lands. In addition to this, it's very Important for farmers to Introduced such kinds of technologies of facility with helpful trainings and discussion focusing on awareness creation to make capable and interested to transfer the mentioned farming systems is considered non sustainable at all level and it is difficult to overcome the food shortages and drought prone- problems in general.

According to the above indicated main core summery this report presents the design of community based pumping irrigation in the area of Werie Leke with specific site name Ruba chemhit.

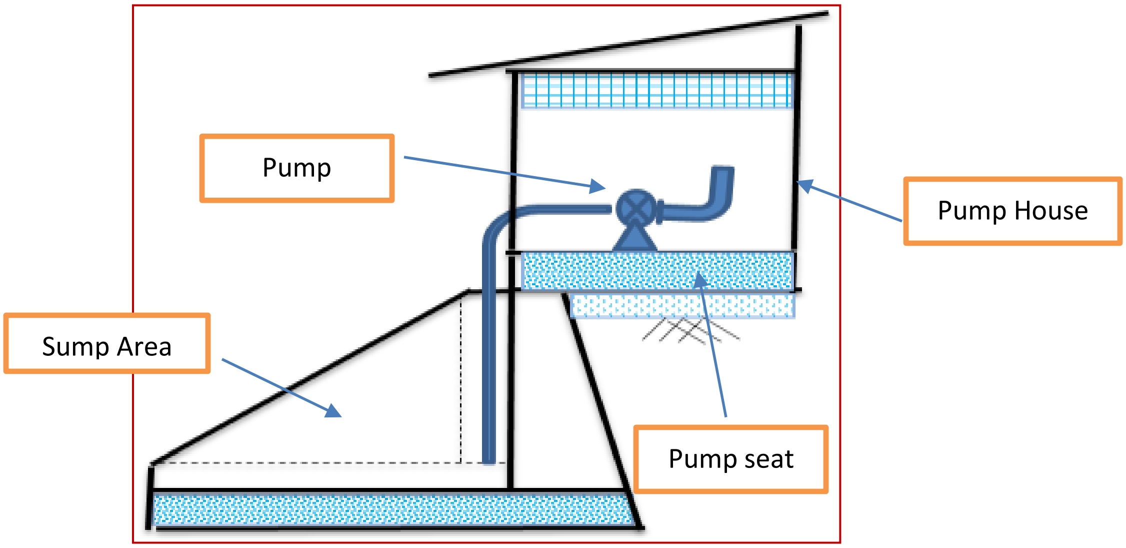


Figure 2:Arrangements of Sump and Pump Seat

3.1.3. Raising Main line and gravity main line

I. Route selection

The first step in designing a raising main is to select the route and prepare a contour map that shows elevation, surface configurations and distance from the source. The routes for the raising mains have been selected by considering the shortest possible distance with minimal obstacle and less social and environmental disturbance. Fortunately, the areas between the source and the delivery point along the selected route have no residence and it will not make any social and environmental complexity. The total length of the conveyance from the pump house up to the pond station structure is around 1332m.

II. Material Selection

In selecting the type of material and pipe size to be used one should consider carrying capacity, durability, maintenance cost, first cost, availability of the pipe material, ease of construction and repair. The character of the water and its potential effect upon pipe of different materials is an important consideration as well. Buried piping for water transmission must resist internal pressure, external loads, differential settlements and corrosive action of both soils and potentially the water it carries. The pipe materials most often used for water conveyance include plastic, galvanized iron pipe, cast iron and asbestos cement. Among these pipes cast iron is used in most large transmission lines because of its size availability. However, due to the presence of the material and easy in construction, for this project HDP pipe is selected. Therefore, HDP pipe is selected.

III. Size of Discharge Line

The rising mains and gravity main is aligned across the contour from lower elevation to higher one. The rising and gravity line designed to be effective pipe having a capacity to discharge 152.07 lit/sec. Therefore, from economic considerations the flow velocities through raising mains are normally kept 2.5m/s to 2.0m/s. Hence taking a flow velocity of 2m/s the

$$D = 1.128 * \sqrt{\frac{Q}{V}}$$

Where, D=Diameter of pipe

Q= discharge flow of the pipe line (1.57 lit/sec/ha *97 ha=152.07 lit/sec=0.15207 m^3/sec)

V= recommended flow velocity (2 m/sec)

$$D = 1.128 * \sqrt{\frac{0.15207}{2}} = 0.311m$$

Then diameter of the pipe will be 315mm for the rising main and for the gravity outlet form pond to the canal and gravity pipe line, whereas for the gravity pipe line having a discharge of 0.021 m3/sec the pipe is:

$$D = 1.128 * \sqrt{\frac{0.021}{2}} = 0.115m = 125mm$$

IV. Trench, Supporting pillars and anchorages

The trench width must be greater enough to provide room to join the pipe sections and install required fittings. Clearance of 150mm on either side is normally adequate. This requires a trench width of about 650mm for 315mm pipe ϕ. The trench width must be increased at joints and fittings. An extra width of 250mm on either side should be provided.

Covers (backfill) provide protection against traffic loads and other environmental factor and it varies depending on the local condition. Here the raising main is laid on communal grazing areas and hence, a minimum cover of 20cm should be provided. An extra depth of 150mm should be provided at joints and fittings. In rock formation the trench should be cut to a level at least 150mm below the final grade of the pipe and a cushion of sand or clean bedding material should be placed between the rock and the pipe. Back material should be free of cinders, refuse, and large stones. Careful backfilling decreases the load on the pipe and will decrease the probability of failure. Fortunately, the selected pipe route has no significant up and downs that demand the provision of supporting pillars and anchorages.

3.1.4. Pump Selection and its hydraulic design

3.1.4.1. Selection of pump

The key requirement in pump selection and design of pump systems for typical irrigation installation is that there is a correspondence between the requirements of the irrigation system and the maximum operating efficiency of the pump. The requirements of the irrigation system are the flow rates and pressure output. The maximum operating efficiency of the pump can be obtained from the performance characteristics curve of the pump. But before matching the system requirement and the performance characteristics curve of the pump selection has to be done on the type of pump. Because pumps used in irrigation system are available in a wide variety of pressure and discharge configurations and with different operating principles and requirements.

The total operating head includes the static head, the suction head and the head losses. The static and suction head can be obtaining from the pipe profile. Whereas the head losses that include the frictional head loss and minor losses may be estimated by using appropriate models. To estimate the frictional head loss, the Hazen-William's equation is used, because of:

- For smooth pipes like HDPE, PVC to calculate the frictional loss Hazen-William's equation is good and,

The equation has the form:

$J = 1.31x10\text{^}11 \times (Q/C)^{1.852} \times D^{-4.87}$

$J = (H_d/L) \times 100$

Where:

J - head loss in meters per 100-meter length of pipe, or in percent of the pipe length

Q – the discharge [m3/hr]

C – Coefficient of friction loss in the pipe. Practically it varies in the range of 130-160 depending on the smoothness of the pipe inner wall. (take 150)

D – the inner pipe diameter [mm]

L – length of pipe [m]

H_f – head loss [m]

The pump house floor level for pump station is at: 526737 m E, 1548921 m N and at 1716.00 m m.a.s. l and the end of the rising main is at: 525599.82mE, 1549420.99 m N and 1773m m.a.s.l. Hence, the static head between the pumping station and the stabilizing pond is = 1773.00-1717.5= 55.5m.

In order to estimate the frictional head loss through the raising (supply) main based on the above equations, parameters like the pipe roughness coefficient C, the inner diameter of the pipe D, the flow discharge Q, and the length of the supply main are required. For the selected pipe the roughness coefficient C is 150.

Using the capacity of the supply main and size of HDPE pipe outer diameter 315mm determined above and the inner pipe diameter is 277.94mm at 17 SDR and also from the topographic survey, the lengths of the supply mains is 1332m.

Hence, $J = 1.31x10^{11} \times (Q/C)^{1.852} \times D^{-4.87}$

Substituting all the known values:

J=1.31*10^11*(547.45/150) ^1.852*277.94^-4.87

J=1.81%

But, $J = (H_{fd} / L) * 100$:

hence: $H_{fd} = (J*L)/100 = (1.81*(1338))/100 = 24.218m$

In designing the size of the suction pipe the hydraulic gradient should be maintained to generate velocities which are neither so small as to require large size diameter pipe, nor so large as to cause excessive loss of pressure head. The velocity should be non-silting and non-scouring.

Lifting capacity of the suction pipe is determined as shown below:

$$Q = \pi \frac{{D_s}^2 V_s}{4} \rightarrow D_S = \left(\frac{4 * Q}{\pi * V_S}\right)^{0.5}$$

Where Ds = Suction pipe diameter (m)

Vs = Velocity in the suction pipe (m/s). (USBR recommends to keep the velocity in the suction pipe to be 0.9m/s or less. Hence take Vs= 0.9m/s).

Q = Discharge, 0.076m3/s.

Hence, substituting all the known values,

$Q = \pi \frac{D_S{}^2 V_S}{4} \rightarrow D_S = \left(\frac{4*0.076}{\pi*0.9}\right)^{0.5} = 327.89mm$= we will take 355mm

The suction pipe diameters will be 355mm HDPE pipe having a length of 6m.

The common values for impeller speed of pumps are 1800 and 3500rpm. Considering critical time water levels at the intake and topographic conditions (Suction water level at the river bed for both conditions), a static head of 57.00m is available for this case. The total operating head of the pump including the friction losses at the delivery and suction pipes, minor losses and velocity head calculated as:

For pump station: Ht = Hs + Hd + Hf +Hm

Where, H_t-total head at the pump (m)

H_s-suction head

H_d-static head (m)

H_f-energy lost to pipe friction loss between pump station to reservoir pond (m)

H_m-minor losses (energy lost in fitting and valves), (m)

Then: H_t = Hs + Hd + Hf +Hm

H_t =4+55.5+24.218+3 = 86.718m

3.1.4.2. Power required

Finally, the power of the pump can be estimated using the following equation:

Water horse power(HP)=(Q*H)/270* η

Where P = power HP

Q = capacity (flow rate or discharge) m3/hr

H = Total dynamic head (m)

η = Pump & Motor efficiency

P= (547.45*86.718)/ (270*0.7)

P=251.18HP

Pump power in Kw=0.743*HP

=0.743*251.518HP

=187.00Kwatt

However, for getting performance curves of different pumps an efficiency of 70% is assumed (Pump efficiency usually range from 60 to 85% (H.S.Peavy, 1985)) and the power of the pump has been calculated. Substituting all the values, the required power will be 190.00KW for pump station. Since for single pump the discharge is high, there will be two pump operate parallel having a discharge capacity of 273.73 M^3/hr and 86.718m delivery head and the power capacity 93.5Kwatt.

Taking an impeller speed of 1800rpm and using the discharge and total operating heads leads to the calculation of the specific speed. The specific speed is

$$N_s = 0.2108 * N \frac{Q^{0.5}}{H^{0.75}}$$

When N is the rotation of the impeller in rev/min,

Q is the flow rate in l/min

H is the pump head (total operating head) in m

- 1.57 lit/sec/ha duty per 14-hour per day
- 97ha net irrigable area

River flow can be pump 152.07 lit/sec (0.152.07 m^3/sec or 9124.2 lit/min by the two pumps.

Ns= (0.2108*1800*(4562.105^0.5))/ (86.718^0.75)

Ns=901.86 = take 902.00

The required water by pump station is 9124.21 lit/min (1.57 lit/sec/ha*97ha*60min). From proper operation and management of maintenance considerations two pumps at the station is provided with the indicated discharge capacity. The pumps operate parallel. Thus, a pump works for 14 hours where, the actual velocity of flow through the rising mains is 2 m/s for the station.

These specific speed values indicate that a centrifugal pump is found to be the appropriate type of pump for the system. Indeed, centrifugal pumps are used in applications requiring high heads but limited discharge. The discharge limitation can be easily managed by providing pumps working in parallel.

3.1.4.3. Net Positive Suction Head

Every pump has its own minimum net positive suction head requirement (NPSHr). This requirement is described by the pump manufacturer in the characteristics curve of the pump. In the absence of such characteristic curve the suction lift is determined based on the general considerations. Net positive suction head available (NPSHA) is the head available above vapor pressure head to move a liquid into the impeller unit of the pump. The value is specific to each pump inlet design. It is independent of the suction piping system. It is necessary to ensure that the NPSHA exceeds the NPSHR to prevent cavitation. The following equation is used to compute NPHSA:

NPSH available = available suction head - atmospheric pressure head– vapor pressure head – suction head losses = all are determined by local condition

$$NPSHa = Ha - Hs - Hvp - Hf$$

Where:

- Ha = the atmospheric pressure head on the surface of the liquid or in the sump (m) = 8.276 for the elevation around 1717.5m m.a.s.l using a standard table. Where-Ha=10.337-(Elevation*0.36/300)

- Hs = static suction head of liquid. This is height of the surface of the liquid above the centerline of the pump impeller (m) =4m
- Hf = total friction losses in the suction line (m) = 0.045m. (The value is determined by taking 4m length of suction pipe).
  - Hvp = the vapor pressure head of the liquid at the operating temperature (m) = 0.22 m for 18.87^{o}C average temperature on the area from standard table.

    The vapor pressure of a liquid is the absolute pressure at which the liquid vaporizes or converts into a gas at a specific temperature. The vapor pressure of a liquid increases with its temperature. For this reason, the temperature should be specified for a declared vapor pressure.

Substituting all the values as below, the NPSHa will be:

NPSHa for station-1 =8.276-4-0.22-0.108 =3.948m

Hence, the actual pump should have less value of suction head to prevent cavitation phenomenon.

3.1.4.4. Flood Height and Elevation of Pump Centre Line

Surveying work was done for the command area and the pumping station. Considering the flood level and the suction head requirement, the following is proposed:

Pumping Station Ruba-Chemiet:

- ✓ Pump floor elevation = 1717.5m m.a.s.l.
- ✓ Pump center line elevation = 1718.00m m.a.s.l, (which is 0.5m above the house floor elevation).
- ✓ Minimum water level at the sump = 1713.5m
- ✓ The maximum flood height is estimated to be 1715.35masl.
- ✓ Need of flood protection structure = No need for the pump house.
- ✓ Total suction head = 4m (for detail see pump station drawing)

Table 3:Summary of pumping system for Ruba-Chemiet

Parameter	Ruba-Chemiet pump Station
Altitude (masl)	1717.5
Mean Temperature (0c)	18.87
Atmospheric pressure (m)	8.276
Vapor Pressure (m)	0.22
Total Discharge (l/s)	152.07
Diameter of supply line(mm)	315
Flow Velocity (m/s)	2
Length of supply line(m)	1332
Head loss including suction (m)	24.218
Suction Head (m)	4
Static Head (m)	55.5
Hm-minor losses (energy lost in fitting and valves	2
Total Dynamic head (m)	86.718
Number of pumps provided	2
Discharge of one unit (l/s)	76.00
Pump impeller speed (rpm)	1800
Specific speed	902.00
Recommended type of pump	Centrifugal
NPSHr(m)	3.948
Power (KW) (for two pump)	187.00

3.1.4.5. Design of Pumping Station

Pumping station here is used to mean the total pumping and water handling facility including the building for pumping equipment, inflow facilities, discharge facilities, flow conduits, retaining walls, and other appurtenant structures and facilities. This section deals with the planning and design of the pumping station for the project. Consists of a pumping station 15m apart from the main river. The following are the main components of the pumping station.

- The sump well
- Suction pipes and accessories
- Pump house and equipment in the house
- Delivery pipe and accessories
- Retaining walls
- Earth works and accessibility works to the pump house

i. Suction Pipe and Controls

For the sump well, two suction pipes suck the water to the pumps. The suction pipe has a length of around 6m and the suction lift height (maximum) is fixed to be 4m. Please refer to the drawing for the general arrangement of the pipes. The material of the suction pipe is selected to be HDPE.

ii. Water Intake from the Sump Well

A sump wells and sedimentation tanks with trash rack fitted at the entrance to the sump well to prevent entry of large debris into the suction pipe and not interfere during pumping has been provided. The minimum water surface elevation in the river is kept at the river bed for the pumping station. Minimum horizontal pounding area will be provided to permit adequate spacing of pumps and intake systems and to provide adequate space for installation of discharge and suction lines and associated equipment and flows to the pump.

For the detail of elevation regarding for the pump house setting and other accessories, please refer section 3.4.1.4 of this report.

iii. Provision of trash rack

The water entering to the pump should be screened before reaching the pumps. Conventional bar screens (trash racks) are the preferred method of screening. Trash racks should be located to allow incoming flows to pass through the rack before reaching the pump intake.

For this particular intake, a bar screen consisting steel strips (bars) spaced at 100mm shall be used. Therefore, trash racks of 100mm by 100mm opening are provided to the river face the pump. (See the drawing for details).

iv. Design of Settling Basins

The settling basin placed right side of the bank of the intake canal for removal of sediments. It consists of an enlarged section of the channel where the flow velocity is sufficiently low so that the sediment settles on the bed. The settled sediment may be removed by flushing or by manual desilting. In this case, manual desilting of the basin is recommended because of topographic limitations. The design of the basin is expected to remove as much silt load and consequently as low fraction of sediment load as is economically and hydraulically possible. An approximate design of the settling basin is carried out considering the fall velocities of sediment particles are the same at any point in the basin. In both cases, let the settling basin will be used to settle a sediment particle having a mean diameter greater than or equal to 0.1mm. The corresponding fall velocity (w) to this sediment particle will be 6cm/s (0.06m/s) (from standard curves). The design discharge is 152.07 lit/sec (547.45 m^3/sec).

The fall velocity may then be obtained as: $t = L / V = H / w_o$, $V = Q / H * B$ and $L * B = Q / w_o$

Where: t=fall time, V=mean flow velocity, L= Effective length of the settling basin, H=depth of the settling basin, Q=Design discharge, B=width of the settling basin and w=fall velocity of a particle

These relationships will provide the main dimensions of the basin where all particles with fall velocity equal or larger than “w” will settle may be derived. Based on the previous assumptions the following will hold true:

V= 0.14m/s (permissible velocity in the chamber)

Let H, B and L be the dimensions of settling basin

For this case, permissible velocity in the basin is fixed according to Camp, T.R. using the following relation: $V = a\sqrt{d}$

Where V = flow velocity in m/s

d = diameter of particle up to which sediment load is desired to be removed (mm)

a = constant which is

0.36 for, d > 1mm, 0.44 for 1mm > d > 0.1mm and 0.51 for 0.1mm > d

The discharge coming from the intake is 0.15207m^3/s. The objective of the settling basin is to accumulate a sediment particle having a diameter greater than or equal to a mean diameter of 0.10mm. The corresponding fall velocity w will be 6cm/s (0.06m/s).

$$V_{cr} = a\sqrt{d_e} = 0.44\sqrt{0.5} = 0.311m/s$$

If the depth of the basin is fixed 1m, then the length of the Basin will be:

$$L = \frac{h*V}{\omega} = \frac{1*31.1}{6} = 5.2m \cong 5m$$

The width of the basin will be: $b = \frac{Q}{h*V} = \frac{0.15207}{1*0.311} = 0.488m \cong 0.5m$ and we will take 1m

Conclusion: provide 5m basin length, 1m depth and 1m basin width for settling basin.

v. Design of the Sump wells

The size of the sump may affect the selection of size and number of pumps with regard to the minimum desirable operating cycle.

For pumping station from ponding areas, the maximum water surface elevation of the sump will be fixed by the maximum permissible ponding elevation. The minimum water surface elevation in the sump is determined by the hydraulic and protection requirements of the protected area and economic considerations.

Minimum horizontal sump area will be that required to permit adequate spacing of pumps and intake systems to provide adequate space for installation of discharge and suction lines and associated equipment and flows to the pump. If it is found important to provide more area for storage, it is possible to increase the horizontal area. In this case, the dimensions of the well are purely decided based on engineering judgment. A well with depth 2m (from minimum river bed level), width 5.0m and length 3.0m is provided for both cases. For detail of the sedimentation tanks and sump wells, please refer the working drawings. The usable sump volume in cubic meters should equal or exceed twice the volume pumped in one minute. This ensures adequate size to dissipate inflow turbulence.

vi. Submergence Depth and other sump well parameters

The minimum height of water above the pump intake bowl or volute, S, should be the higher of that required by the manufacturer for net positive suction head and the height determined using the following Equation, which is based on USBR Hydraulic Institute standards.

$$S = D + \frac{C_u Q_p}{D^{1.5}}$$

Where:

S = height from lowest pumping level to pump bell/volute, m

D = outside diameter of pump bell, 0.355m

Cu = unit conversion coefficient = 0.935

Qp = individual pump capacity, 0.076m3/s

Substituting all the known values, S=0.69m, say 0.70m

Table 4:Design criteria for the sump wells and other parameters

Parameter	Description	Recommended Value	Ruba-Chemiet	
			Calculated Value	Adopted Value
A	Distance from centerline of pump inlet bell to sump entrance	5D	1.775	1.8
a	Length of constricted bay section at pump	2.5D	0.8875	1
B	Clearance from back wall to centerline of pump inlet bell/volute	0.75D	0.26625	0.3
C	Clearance between pump inlet bell and sump floor	0.3D - 0.5D	0.142	0.15
D	Outside diameter of pump inlet bell/volte	Ds= ((4*Q/π*Vs) ^0.5	0.355	0.35
S	Submergence Depth	S=D+[(Cu*Qp)/D^1.5]	0.69	0.7
H_{min}	Minimum water depth in sump	S + C	0.83	1

4. Reservoir pond

1) Pond Types

Depending on the source of water and their location with respect to the land surface, in our case pond type is dug out (excavated) ponds:

- Dug out (excavated) ponds are excavated at the site and the soil obtained by excavation is used to construct embankment around the pond.
- The pond could be fed by pumping through rising main line from river.
- Excavated ponds is the simplest to build.

2) Site selection

Site selection and placement of the pond are critical to the success of the pond. Selection of the location for a pond has a major importance in reducing time, labors and expense involved in construction and maintenance. The primary use of the pond is important factor to consider in pond location. Irrigation ponds should be located near to the command irrigable area. The site for the pond is to be selected keeping in view of the following considerations.

- The site should be such that largest storage volume is available with the least amount of excavation.
- Large areas of shallow water should be avoided as these will cause excessive evaporation losses and also cause waterweeds to grow.
- The site should not cause excessive seepage losses.
- The pond should be located as near as possible to the area where the water will be used.

3) Topography

- Excavated ponds are satisfactory and most commonly used in areas of comparatively flat but well drained terrain.
- A site with largest storage volume with least amount of excavation is preferred.
- The slope of the site is preferred to be less than 3%.

- The topography of the site should be suitable for construction of spill way (if there is a need) and is should be suitable to use the stored water easily.

4) Foundation of ponds

The dominant formation orientation in the project area is vertical and near vertical, but in the test pit that opened near the pond is near horizontal bedding. During the logging of the pit, there were vertical intercalation contacts with calcareous (carbonated) silt. The foundation will not have a problem for supporting the load. The problem with the rock is will have an affinity for water loss, because of the discontinuities in the rock. The excavation workability for the pond 1 and near the pond has described as medium excavation.

5) Pond Capacity and design

The design procedure of the pond is based on the minimum time that the pond to reserve after the power off during operation. The calculation of the pond is based on inverted frustum of trapezoidal shape. All the steps & design outputs are tabulated in table 6.

Design data for the reservoir pond:

Since the aim of the reservoir pond is to reserve for a few of time in case of pump maintenance and take reserving time is for 30 minute (0.5hour)

Time for water flow (T) = 30min =1800 sec

Water flow in to the pond (Q) = 0.15207 m^3/sec

V= TxQ

V=1800sec*0.152.07m^3/sec

V=274 m^3

Dead storage 20% V

D_D-sto=V*0.2

D_D-sto =274*0.2

D_D-sto =55

V_{Total}=329 m^3

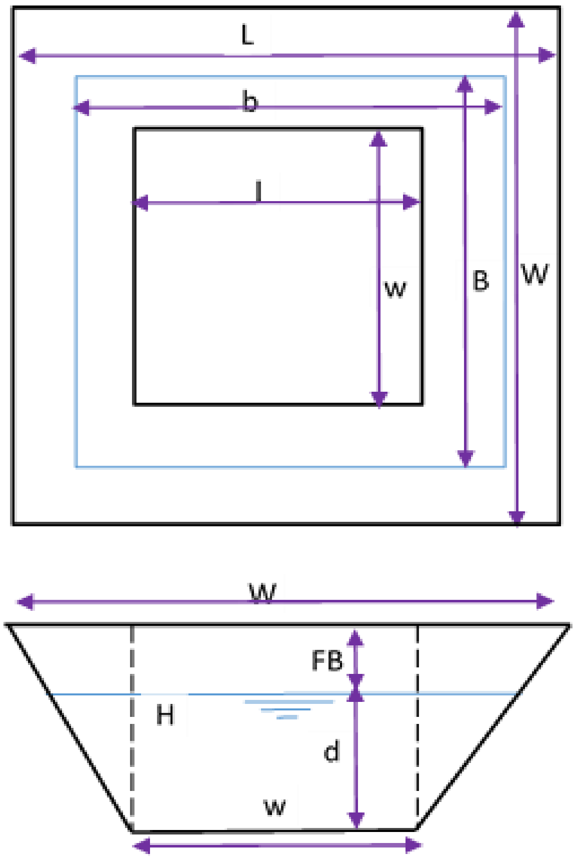


Figure 3:Reservoir detention pond

Table 5:the reservoir pond dimension and its capacity

Description	Value	Remark
Peak live storage Capacity, V_{live} (m^3) = Q*t	274 m3	
Minimum storage capacity including 20% for dead storage, V_{req} (m^3) =	329 m3	
Allowed dead storage, V_d=V_{req} - V_{live}	55 m3	
Depth of water to be stored for irrigation/live storage, d-d'	2	
Depth of dead storage, d'	0.2	
Freeboard, FB	0.3	
Therefore, total height of storage structure, H	2.5	
Assume a square inverted frustum shape		
Internal side slope of Storage, m (H: V)	2.0	

External side slope of Storage, m (H: V)	3.0	
Proposed length and width of Storage		
Bottom width of Storage, w	8.0	Taken
Bottom length of Storage, l	9.5	Taken
Storage width to Top of pond level, W=w+2mH i.e. Crest width	18.0	
Storage length to Top of pond level, L=l+2mH i.e. Crest length	19.5	
Storage width to Top of stored water surface level, B	17	
Storage length to Top of stored water surface level, b	18	
Designed capacity of the storage		
Pond size is computed from, $V_{cal}=H/3*(A_t+A_b+SQRT(A_t+A_b))$		
Where, V=Volume of the pond,m^3		
At= Pond top Area = LxW,m^2	351	
Ab=Pond bottom area = lxw, m^2	76	
$V_{cal}= H/3 * (A_t+A_b+SQRT(A_t+A_b))$	373	
Check that $V_{cal} > V_{req}$	OK	This needs to be "Ok"
Thus, provide a pond with 8x9.5m bottom and corresponding crest size of 18x19.5m for storing 0.5 hour		
Top width of Water surface, B=w+2md	16.8	
Top length of Water surface, b=l+2md	18.3	
Water surface Area, $A_w=b*B$	307	
Volume of stored water, $V_w=d/3 * (A_w+A_b+SQRT(A_w+A_b))$	296	Including dead storage
Top width of dead storage, B'=w+2md'	8.8	
Top length of dead storage, b'=l+2md'	10.3	
Water surface Area, $A_d=b'*B'$	91	
Volume of dead storage, $V_d=d'/3 * (A_d+A_b+SQRT(A_d+A_b))$	12	
Thus, computed volume of live storage $V_{cs}=V_w - V_d$	284	
Check that V_{cs} ³ V_{live}	OK	This needs to be "Ok"

5. Canal Design

5.1. Irrigation net work

5.1.1. Introduction

Canal network is designed to convey irrigation water from gravity main line to fields and to deliver it as equitably as possible, matching the supply closely to the water requirements of crops in the command, during all stages of crop growth. A network of surface drains is designed to drain out excess water (due to rainfall or irrigation) from fields and to covey it safely to natural drains, by integrating it in the conveyance network. Surface /subsurface drains are to be provided in the command area where deep black soils (Vertisol) having non drainable substrata is met with. A network of roads along canals & subsidiary canals is established to ensure satisfactory operation and maintenance of the irrigation & drainage network and to facilitate transport of required inputs for irrigated agriculture (seeds, fertilizers, insecticides, farm equipment etc.) and to transport agricultural produce to the markets.

Objective of the design of the irrigation water conveyance facility to have performs at an optimum operational efficiency so that it is;

- Functionally capable to deliver irrigation water to crops & drain out surplus water within overall technical feasibility of the entire system.
- Economically viable by keeping overall cost of the system within the financial norms/yardsticks.
- Amenable for easy operation and maintenance at present, as well as in future.
- Socially acceptable to the mindset of the cultivator, who is going to utilize the irrigation water (as a primary input) to achieve higher productivity through irrigated agriculture.

5.1.2. Canal System

A canal can be defined as an open channel excavated to the required cross section in natural earth or formed by compacted fill; with or without special treatment (lining) to the wetted surface. The canal system is made of the following components:

- Primary canal or the Secondary (in our case) off-taking from the reservoir and the gravity main line.
- Secondary Canal (also called the Branch/Distributaries) off-taking from the primary canal. It generally runs along sub ridges.
- Tertiary Canal (also called the Minor) off-taking from the secondary canal.
- Quaternary Canal or the watercourse off-taking from an irrigation outlet, generally catering to a block of 10 to 20ha.
- Field Channel

The entire planning process for the layout of the canal system is divided into two parts -

- ➢ Macro planning for primary, secondary and tertiary canals
- ➢ Micro planning for tertiary, quaternary and field channels.

Tertiary canals lie at the interface of macro and micro planning and are thus common to both.

The planning for the canal layout will require the preparation of the complete layout for macro irrigation system from primary to tertiary canals for the entire command area on large scale topographic maps. The planning for micro irrigation system inside the command of tertiary canal for quaternary canals and field channels is done on topographic map of scale, 1:1000 with contour interval of 0.50 m.

5.1.3. Command Area

Area commanded by canal is classified as

- **GCA (Gross Command Area)** – Total geographical area over which the canal water can flow by gravity is 222.60ha.
- **CCA (Cultivated Command Area)-** It covers all area within the command on which cultivation is possible i.e. including fallow land & pastures but excluding area under villages, ponds, forest, stream courses, rocky outcrops, marshy land etc. is 102.00ha
- **Net Irrigable Area (NIA)/Net CCA/Service Area** – It is CCA minus the area under subsidiary canals, water courses, field channels, surface drains, infrastructure roads etc.is 96.86ha.

5.1.4. Fixing Canal Capacities

The furrow surface irrigations adopt total project efficiency of 50% for design of canals considering not efficient of conveyance efficiency. However, this irrigation efficiency is expected to increase with time as they get well acquainted with the irrigation operation because of the partial of the conveyance is pressurized (surface pump irrigation system).

Water application efficiency adopted = 80%

Conveyance efficiency = 90%

Storage efficiency in root zone = 80%

Total = 0.80 * 0.90 * 0.80 = 57%

As the agronomical study report, the crop water requirement (duty) calculated is 1.57 liters per second per hectare. Canal capacity is fixed based on the command area that is delivered by the canal.

Canal discharge = duty* irrigated area.

Q=1.57*Irrigation interval day*A

5.1.5. Design of Open Canals (Canal Cross-Sections)

The design of open canals is concerned with the determination of the cross sectional dimensions of the canal to convey the required amount of discharge intended to meet the peak requirement of crops grown in the entire command area during the supplementary case and dry season cases.

The dimension of the channel can be calculated using the general formula of Manning's, which is given by:

$$Q = \frac{1}{n} * AR^{2/3}S^{1/2}$$

Where, Q = discharge of the channel

R = Hydraulic radius = A/p

A = Wetted cross-sectional area

m = side slope

p = wetted perimeter

s = bed slope

n = Manning's roughness coefficient

Normally the solution for B and d are obtained by trial and error. Also various monographs, tables and computer program are available to find the area.

According to the recommended value of the open channel design, canals that have a discharge value less than 200lit/sec, the bed width to depth of flow ratio shall be in the range 1 to 1.5 for clay and up to 1.6-2.0 for masonry. Therefore, taking b/d ratio, which will lead as to attain the permissible non-scouring and non-silting velocity, the bed width and depth of canals have been computed by using the computer program tray and error and it is adopted b/d ration is 2.

As the geological formation along the canal routes is pervious, a rectangular masonry section is provided for the secondary canals as well as chute sections of the tertiary ones (it is to construct sustainable structure) which does not involve any formwork and the beneficiaries can easily maintain it.

The thickness of the masonry lining depends on the height of the wall to retain the saturated earth pressure and available size of boulders. For the Secondary canal the thickness of wall is 30cm in a mortar mix of 1:3

1. **Design of the Secondary Canal**

The Secondary canal is a section which is masonry work water transport from pipe line lines having of division box to tertiary canal. The design of the secondary canal capacity is based on the coverage of command area to be irrigated measured on the season to fulfill the need of water require of the command area.

Design of Masonry Lined Canal Section

Design Parameters: Example of Secondary canal

coverage of area to be irrigate by one section of secondary canal, A =23 ha

duty = 1.57 lit/sec/ha

Design discharge, Q = Duty*area

= 23 ha*1.57 lit/sec/ha

= 36.11 lit/sec ≈ 36 lit/sec

Canal side slope, m = Vertical (rectangular canal),0

Canal bed slope, So = 1/500

Free board, Fb = 0.2m

Manning's Roughness, n = 0.017(for mortar plastered canal)

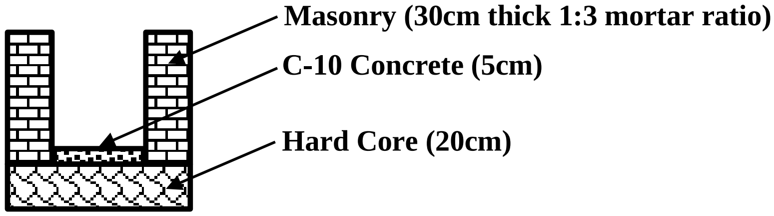


Figure 4:Cross -section of Masonry Lined Canal

Let B/d = 2

$A = B*d = 2d^2$

$P = B+2d = 4d$

$R = A/P = 2d^2/4d = 0.5*d$

Using Manning's equation

$$Q = \frac{A}{n} * R^{2/3} * S^{1/2}$$

$0.036 = (2*d^2)/0.018*(0.5d)^{2/3}*(1/500)^{1/2}$

From which: d = 0.1937 ≅ 0.19m

B =2*0.19 = 0.38 m

D = d+Fb = 0.39m

2. Design of the Tertiary Canal

The tertiary canal is a section which is rectangular lined masonry water transport from secondary canal to field canals. The design of the tertiary canal capacity is based on the maximum command area to be irrigated.

3. Longitudinal Section of Canals

The longitudinal section along the canals is prepared with levels at intervals based on the natural topographic changes indicating the following details:

- Chainage
- Existing ground level (OGL)
- Canal bed level (CBL)
- Full supply level (FSL)
- Canal Top Bank level (CTBL)
- Bed slope, Bed width (S, B)
- Discharge, velocity (Q, V)
- Location of turnouts and drops

The longitudinal profile of the secondary and tertiary canals is shown in the drawings with canal section details.

Figure 5:Hydraulic Characteristic of secondary canal and tertiary Canal

	Hydraulic Characteristics of the Canal													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Duty(l/s/ha)	Command Arae(ha)	Flow Discharge	Side Slope	b/d Ratio	Area	Wetted Perimetre	Hydraulic Radius	Water Depth	Free board	Bed Width	Canal Depth(D=d+Fb)	thickness of lin econcrete	thickness of Masonary
Name of Canal	Du(l/s/ha)	A(ha)	Q(m3/sec)	s(m/m)	b/d	A(m2)	P(m)	R(m)	d(m)	Fb(m)	b(m)	D=d+Fb(m)	t(m)	T(m)
Sc_1	1.57	83.70	0.13	0.002	2.00	0.18	1.20	0.15	0.30	0.20	0.60	0.50	0.05	0.30
Sc_2	1.57	67.28	0.11	0.002	2.00	0.18	1.20	0.15	0.30	0.20	0.60	0.50	0.05	0.30
Sc_3	1.57	62.06	0.10	0.002	2.00	0.18	1.20	0.15	0.30	0.20	0.60	0.50	0.05	0.30
Sc_4	1.57	37.59	0.06	0.002	2.00	0.08	0.80	0.10	0.20	0.20	0.40	0.40	0.05	0.30
TC_1	1.57	16.42	0.03	0.002	2.00	0.04	0.56	0.07	0.14	0.20	0.28	0.34	0.05	0.30
TC_2	1.57	5.22	0.01	0.002	2.00	0.02	0.40	0.05	0.10	0.20	0.20	0.30	0.05	0.30
TC_3	1.57	24.47	0.04	0.002	2.00	0.05	0.64	0.08	0.16	0.20	0.32	0.36	0.05	0.30
TC_4	1.57	13.26	0.02	0.002	2.00	0.03	0.52	0.07	0.13	0.20	0.26	0.33	0.05	0.30
TC_5	1.57	24.33	0.04	0.002	2.00	0.06	0.68	0.09	0.17	0.20	0.34	0.37	0.05	0.30
TC_6	1.57	13.16	0.02	0.002	2.00	0.03	0.52	0.07	0.13	0.20	0.26	0.33	0.05	0.30

6. Conclusions and recommendations

During field study, the team has observed that the farmers have some years of experience for irrigation by constructing traditional canal. Therefore, the team recommends the launching of integrated water use system for the river and hence, the designing of modern pump irrigation scheme is vital for scarce water management.

1. The pump house is located at relatively free from flood plains. However, regular monitoring is vital for the sustainability of the project
2. Pump characteristics curve match will be selected from manufacturer as per the design of pump head and discharge with the recommended efficiency pumps.
3. Part of the stilling basin is inside to the river bank by approach channel. Hence, regular removal of sediment deposition is necessary.
4. In this project, the operation period of one pump at the time is 14 hours per day. If there is a need to pump water for more additional time, the pump should be rested for some period in order to control the overheating of the pump.
5. During project construction, it should be based on the design document, if not possible to follow the design, it should be consulted the consultant to minimize the risk of failure.

7. Bill of quantity and Cost Estimation

Most of the quantity is incorporated in table below on the consultant's experience in the field work of draft design report of the feasibility study and the unit price taken from previous work take form bruh tesfa PLC for the pipeline and pump and also for canal from construction, Road and Transport Bureau.

	Ruba Chemit Pump Irrigation System Total BOQ				
1	General and Preparatory Cost for Ruba-Chemiet Pump irrigation system				
S/N	Item description	Unit	Qty	Unit price	Total Price
1.01	Moblization & demoblization of machinery and equipments	LS	1.00	80,000.00	80,000.00
1.02	Construction of contractor's camp or temporary residence from G-32 CIS and that has to be handed over to the IWUA at the end of the construction. The rooms are well ventilated equipping with windows and doors of the same material as per given drawings. The camp should be constructed at the appropriate place for camping and IWUA purpose.	LS	1.00	165,000.00	165,000.00
1.03	Supply and install 2*1m rectangular metal sign board with 60*60*3mm RHS frame, 1.5mm thick metal sheet at both sides and 2Ø4inch GS pipe post for the purpose of scheme information as specified by the Engineer. Price includes all necessary cutting, welding, painting, writing works on both sides & C-10 concrete for foundation fill.	LS	1.00	10,000.00	10,000.00
	Sub Total				**255,000.00**
2	Pump and Pipe Line				
S/N	Item description	Unit	Qty	Unit price	Total Price
2.01	Pump with Full Accessories Centrifugal Pump Type 273.73 m^3/hr and 86.718m Head having pump and motor efficiency 70%	pcs	2	1408845.04	2817690.07
2.02	HDPE pipe 315mm/10 bar	m	1425	1423.00	2027775.00
2.03	HDPE pipe 125mm/10 bar	M	970	242.00	234740.00
2.04	HDPE Butt Weld Reducer 315mmX125mm	pcs	1	17224.81	17224.81

2.05	HDPE Butt Weld Tee 315mmX315mmX315mm	pcs	1	18062.20	18062.20
2.06	HDPE Butt Weld Tee 125mmX125mmX125mm	pcs	1	584.90	584.90
2.07	Butt Weld Elbow 90^0 315mm /10bar	pcs	4	16569.30	66277.20
2.08	Butt Weld Elbow 90^0 125mm /10bar	pcs	2	775.12	1550.24
2.09	Stub Flange with Backing Ring 355mm	pcs	1	37470.24	37470.24
2.10	Butter Fly Valve 315mm/10bar	pcs	2	17611.01	35222.03
2.11	Stub Flange with Backing Ring 125mm	pcs	1	8841.13	8841.13
2.12	Flanged Get Valve 125mm/10bar	pcs	1	16048.00	16048.00
2.13	Welding points for connection with 315mm pipe	pcs	246	400.00	98466.67
2.14	Welding points for connection with 125mm pipe	pcs	108	125.00	13472.22
2.15	Excavation at all formation	m^3	1761	121.52	213972.42
2.16	Back fill with selected material	m^3	1191	60.76	72345.41
	Sub Total				**5679742.54**
3	**Pump Station Civil Work**				
3.01	Clearing the site to remove top soil at an average of 20cm for pump station	m^3	11.2	12.15	136.08
3.02	Excavation of side river bank for construction of pump station	m^3	560	121.52	68051.20
3.03	Excavate for foundation trench for settling basin	m^3	13.75	121.52	1670.90
3.04	Back fill with selected material and Compacting	m^3	112.5	60.76	6835.50
3.05	Basaltic stone or equivalent hardcore inside the wall compacted and blinded with crushed stone to a finished depth of equal to 30 cm height	m^3	20	100.30	2006.00
3.06	5cm thick C-15 cement screed	m^2	1.25	76.48	95.60
3.07	15 cm thick RC - concrete in class C-25 for base top slab as indicated on the drawing	m^3	7.5	2931.41	21985.58
3.8	15 cm thick RC - concrete in class C-25 for the retaining face of the River from the settling	m^3	4.8	2931.41	14070.77

	basin				
3.9	Re-inforcement bar Ø 12	KG	164.61	41.43	6819.627574
3.10	Re-inforcement bar Ø 10	KG	367.81	44.43	16341.65
3.11	Re-inforcement bar Ø 6	KG	111.81	55.82	6241.05
	Sub Total				**164238.55**
4	**BOQ and Quntity Pond Civil StructureWork**				
S/N	**Item description**	**Unit**	**Qty**	**Unit price**	**Total Price**
	Earth Work & Concrete Work				
4.01	Clearing the site to remove top soil at an average of 20cm for pump station	m^3	84.46	12.15	1026.14
4.02	Normal Material excavation at Detention Pond up to the design grade and desired dimentions at all formation.	m3	296.70	121.52	36054.98
4.03	Disposal of Surplus Excavated material as directed by the engineer	m3	381.16	144.47	55065.61
4.04	Provide, fill and compact selected granular material at a minimum of 95% Procter density in layers of not greater than 300mm thick for fill around the detention pond	m3	105.30	60.76	6398.03
4.05	Provide and place 50mm thickness Class C-10 Concrete bedding below foundations.	m2	6.17	1731.90	10681.37
4.06	Provide and Place 15cm thick Class C-25 Concrete for the Detention pond bed slab.	m3	19.65	2931.41	57602.21
4.07	Re-inforcement bar Ø 10	kg	1006.84	44.43	44733.71
4.08	Re-inforcement bar Ø 6	kg	191.05	55.82	10664.60
	Sub Total				**222226.65**
5	**BOQ and Quntity of Canal Work for Ruba- Chemiet project**				
S/N	**Item description**	**Unit**	**Qty**	**Unit price**	**Total Price**
1	**Secondary Canal**				
5.01	Total Masonry Work	m3	637.4256515	999.23	636934.8337
5.02	Plastering Work	m2	1709.549129	106.72	182443.083
5.03	Excavation Work	m3	898.9364786	121.52	109238.7609

5.04	Back Fill	m3	84.192	60.76	5115.50592
	Sub Total				**933732.1835**
2	**Tertiary Canal**				
5.05	Total Masonry Work	m3	1496.46246	999.23	1495310.184
5.06	Plastering Work	m3	4436.211787	106.72	473432.5219
5.07	Excavation Work	m3	1960.139669	121.52	238196.1725
5.08	Back Fill	m3	3.727745618	60.76	226.4978238
	Sub Total				**2207165.377**
3	**Division Work (From PDB to Division Box of SC or TC)**				
5.09	Excavation Work	m3	19.13715574	121.52	2325.547165
5.10	Total Masonry Work	m3	12.21692116	999.23	12207.51413
5.11	Stone Pitching	m3	15.29425896	100.30	1534.014173
5.12	Plastering Work	m2	14.67276528	106.72	1565.87751
5.13	Back Fill	m3	0.280890037	60.76	17.06687865
	Sub Total				**17650.01986**
4.1	**Drop Structure (Secondary Canal)**				
5.14	Total Masonry Work	m3	162.7638807	999.23	162638.5525
5.15	Plastering Work	m2	34.93408358	106.72	3728.165399
5.16	Excavation Work	m3	49.48300828	121.52	6013.175166
5.17	Back Fill	m3	75.17609332	60.76	4567.69943
	Sub Total				**176947.5925**
4.2	**Drop Structure (Tertiary Canal)**				
5.18	Total Masonry Work	m3	117.7294356	999.23	117638.7839
5.19	Plastering Work	m2	9.641513445	106.72	1028.942315
5.2	Excavation Work	m3	10.78585916	121.52	1310.697606
5.21	Back Fill	m3	3.225524805	60.76	195.9828871

	Sub Total				**120174.4068**
6	**Bill of Quantity for Supply and Installation of Electrical Materials (Ruba_Chemiet Pump Irrigation System Project)**				
S/N	**Item description**	**Unit**	**Qty**	**Unit price**	**Total Price**
	Electrical manhole:				
6.01	Supply and install Electric Manhole in bricks and with concrete base internally of 600x600x700mm including concrete cover with lifting hole.	No	2	2,000	4000
	Low Voltage System Earth:				
6.02	Earthing materials, including all inpection chamber, roads, tape bonding straps, bare copper wire, etc as necessary for the earthing requirements within and around pumping station	LS	1	20,000	20000
	Distribution Board,MCC & MSG				
6.03	Supply and install Surface Mounted Sub Distribution Board **SDB-GHP**, LPP-CL,in steel enclosure with lockable door, bus bars+Neutral+Earth Terminals, all necessary fixing and connecting accessories, complete and consisting:- 1pc, 40A, MCB/1ph: 1pc, 10A, MCB, 1phase; 5pc, 16A,MCB, 1Phase;1pc, 25A, MCB, 1phase; and with ample reserve space.	set	1	10,000	10000
6.04	supply and install Flush Mounted Sub Distribution Board **SDB-GP**, LPP-CL, in steel enclosure with lockable door, bus bars +Neutral+Earth Terminals, all necessary fixing and connecting accessories, complete and consisting:- 1pc, 40A, MCB,1Phas 4pc, 10A, MCB,1Phase;1pc, 10A, MCB,1Phase; 2pc,25A,Main MCB,1Phase; and with ample reserve space.	set	1	12,000	12000
	supply and install Flush Mounted Sub Distribution Board **SDB-GP**, LPP-CL, in steel enclosure with lockable door, bus bars +Neutral+Earth Terminals, all necessary fixing and connecting accessories, complete and consisting:- 2pc, 16A, MCB,1Phase;3pc, 10A, MCB,1Phase; 1pc,32A,Main MCB,1Phase; and with ample reserve space.	set	1	15,000	15000

6.05	supply and install Flush Mounted Sub Distribution Board **SDB-PH**, LPP-CL, in steel enclosure with lockable door, bus bars +Neutral+Earth Terminals, all necessary fixing and connecting accessories, complete and consisting:- 1pc, 63A, MCB,1Phase;3pc, 10A, MCB,1Phase; 5pc,25A,Main MCB,1Phase; and with ample reserve space.	set	1	650000	650000
6.06	Supply and install Floor Standing Motor Control Center Panel Board **MCC-RCH**, LPP-CL,in steel enclosure with lockable door, bus bars+Neutral+Earth Terminals, control cables, indicators, phase sequence relays, overload relays, Star Delta Motor Starters with isolated Cubicles for each Pump, Power Factor Correctors, Lighting arrestor, Earth leakage relays, Proper Cable size from MSG-RCH, all necessary fixing and connecting accessories, complete and consisting:- 1PC,560A/3ph, MCB; 2pc, 250A/3ph , MCB ; and with ample reserve space.	set	1	550000	550000
	Feeder Cable:				
6.07	Supply and install Copper power cable of 3x6sq.mm from MSG-RCH to SDB-GHP through PVC conduit & minimum diameter of 25mm.	m	60	180	10800
6.08	Supply and install Copper power cable of 3x6sq.mm from MSG-RCH to SDB-GP through PVC conduit & minimum diameter of 25mm.	m	50	180	9000
6.09	Supply and install Copper power cable of 3x10sq.mm from MSG-RCH to SDB-PH through PVC conduit & minimum diameter of 50mm.	m	25	250	6250
6.1	Supply and install Copper power cable of 3x70/35sq.mm from MSG-RCH to MCC-RCH through PVC conduit & minimum diameter of 50mm.	m	40	380	15200
6.11	Supply and install Copper power cable of 3x35/25sq.mm from MCC-RCH to each pump through PVC conduit & minimum diameter of 50mm.	m	60	280	16800
6.12	Supply and install Copper power cable of 3x95/50sq.mm from EEPCo to MSG-RCH through PVC conduit & minimum diameter of 50mm.	m	80	380	30400
	Light Points:				

6.13	supply & install Flush mounted light points fed through PVC insulated conductors of 2x2.5mm2 inside PVC conduits of 16mm diameter, the cable length as indicated on the drawing ,including its switch, with all accessories as indicated on the drawing and junction boxes with covers and insulating screw cap connectors, complete	No	28	1200	33600
	Flush mounted switches:				
6.14	Supply and install Flush mounted single switch type ABB,legrand, Suno or equivalent	No	1	150	150
6.15	Supply and install Flush mounted double switch type ABB, legrand, Suno or equivalent	No	7	150	1050
6.16	Supply and install Flush mounted two way switch type ABB, legrand, Suno or equivalent	No	2	150	300
	Light Fittings and Lamps				
6.17	Philips TMS 012/236I + 2xTLD 36w Fluorescent lamp	No	22	400	8800
6.18	Philips TMS 012/236I + 1xTLD 18w Fluorescent lamp	No	4	250	1000
6.19	RZB 301/58139.004/671521.002	No	2	120	240
	Socket Outlet Points:				
6.20	supply & install 16A/1P socket outlet points (water proof) fed through PVC insulated stranded copper conductors of 3x2.5mm2 inside PVC conduit of 16mm diameter, the cable length as indicated on the drawing , including junction boxes with covers and insulating screw cap connectors	No	5	1400	7000
6.21	supply & install 25A/1P socket outlet points (water proof) fed through PVC insulated stranded copper conductors of 3x4mm2 inside PVC conduit of 16mm diameter, the cable length as indicated on the drawing , including junction boxes with covers and insulating screw cap connectors	No	4	1600	6400
	Flush mounted Socket Outlets:				
6.22	Supply and install 16A/1ph,220v Normal socket outlet with eart contact , ABB,legrand, suno or equivalent.	No	5	200	1000
6.23	Supply and install 25A/1ph,220v Normal socket outlet with eart contact , ABB,legrand, suno or equivalent.	No	4	250	1000
	Fire detecting System:				

6.24	Flush mounted Fire detectors with flush mounted fire alarm sounder fed through PVC insulated conductors of 2x2.5mm2 inside PVC conduits of 16mm diameter, with complete accessories, as indicated on the drawing and junction boxes with covers and insulating screw cap connectors.	No	1	10000	10000
	Fan Points and fittings:				
6.25	supply & install flush mounted fan points fed through insulated conductors of 3x4mm2 inside PVC conduits of 16mm diameter , including junction boxes with covers and insulating screw cap connectors, complete	No	6	2000	12000
6.26	Supply and install wall mounted axial fan with, outer casing mode from shock resistant UV stablized ABS, internal components from shock resistant PS and with its complete accessories.	No	6	5000	30000
	Telephone Outlet:				
6.27	Supply wireless public telephone for operator at guard house	No	1	1000	1000
	Compound light:				
6.28	supply & install compound light points through PVC insulated copper cable of 3x4mm2 inside PVC conduits of 21mm diameter, with the cable length as indicated on the drawing, steel pole including its switch, with all accessories as indicated on the drawing and junction boxes with covers and insulating screw cap connectors, complete	No	20	5000	100000
	Standby Generator:				
6.29	Supply and install Standby Generator of **330KVA** (diesel driven), automatically operated, with complete generator set including all accessories, with proper cable size, control panel of parallel operation, circiut breaker for each generator, one set of standard mechanical and one set of standard electrical tools included and Gensets abiding all technical criterias according to the specification document.	No	2	1300000	2600000
	Fire Protection and Safety				
6.30	Supply Fire extinguisher, international ISO standard	No	2	5000	10000
6.31	Supply First Aid Facility in the Pump House of pump station	set	1	5000	5000

	Transformer & KWH-meter:				
6.32	Supply and install LV outdoor, oil immersed Distribution Transforemer 315 KVA 15 kV/380V,220V , Dyn11 configuration,four wire system muonted on wooden pole, with 10meter height impregnated wooden pole , Lightning Arrester (15kV), grounding system,HRC fuse in fuse box, and all fixing and mounting accessories as per EEPCos' requirment.	NO	1	730000	730000
6.33	Supply and Installation of three-phase energy measuring instruments (Active and reactive meter) including power factor correction installations and earthing protection by EEPCo (Ethiopian Electric Power Corporation).	NO	1	20000	20000
	Sub Total				**4927990**
7	**Power house, Generator house and Gard houseof the pump and control panel and gard house**				
S.N	**DESCRIPTION**	**UNIT**	**QTY**	**UNIT PRICE**	**TOTAL PRICE**
7.01	Clearance of trees &rough leveling	ls	3	2000	6000
7.02	Excavation to remove top soil to a depth of 20cm.	M^3	11.616	121.52	1411.57632
7.03	Excavate for foundation trench to a depth of 50cm	M^3	29.04	121.52	3528.9408
7.04	Basaltic stone or equivalent hardcore under floor slab well compacted and blinded with crushed stone to a finished thickness of 25 cm.	M^3	14.52	100.30	1456.356
7.05	Back fill with selected material and Compacting 25 cm	M^3	14.52	60.76	882.2352
7.06	40cm thick Trachytic or equivalent semi-dressed stone masonry wall cement sand mortar (1:3) ratio	M^3	9.6	999.23	9592.608
7.07	10 cm thick mass concrete in class C-10 base slab	M^3	5.808	1731.9	10058.8752
7.08	2cm cement screed for the floor	M^2	1.1616	76.48	88.839168
7.09	Wall Masonry work with 1:3 mortar ratio	M^3	13.44	999.23	13429.6512
7.1	2cm cement screed for the inside wall	M^3	1.92	76.48	146.8416
7.11	Concrete for beam C-15	M^3	9.6	2931.41	28141.536
7.12	Concrete for Column C-15	M^3	11.52	2931.41	33769.8432

7.13	Re-inforcement bar Ø 10	kg	325.776	44.43	14474.22768
7.14	Re-inforcement bar Ø *6*	kg	140.08368	55.82	7819.471018
7.16	Eucalyptus for side wall and roofing 12	Pcs	225	46.49	10460.25
7.18	GI -32 galvanized corrugated iron sheet for Roofing	Pcs	189	264.82	50050.98
7.19	Nail 8 ncm	Kg	9	54.05	486.45
7.2	Nail 10 cm	Kg	24	54.05	1297.2
7.21	Nail 12 cm	Kg	10.5	54.05	567.525
7.22	Nail for roofing	Kg	24	63.25	1518
7.23	Hing H	Pcs	24	13.8	331.2
7.24	Hing T	Pcs	24	23	552
7.25	Locker 12	Pcs	12	150	1800
	Sub total				**197864.6064**
	Total				**14902731.93**
	Vat 15%				**2235409.789**
	Grand Total				**17138141.72**

I. ANNEXES

1) Design of a typical drop structure (1m height), (USBR Type)

In order to reduce the number of drops, the secondary and tertiary canals have variable slope. There are some drops along the secondary and tertiary canals. Typical drop design for 1m and 0.5m height is presented below:

Design data for drop structure for the secondary canal.

Data: Q=0.152 m3/s

U/s flow depth = d1 =0.25 m

Height of drop = h =1m

1. Critical flow hydraulics

a. Design discharge, Q= 0.0946 m3/s

b. Height of drop h=1 m

c. Width of drop, $b_c = \frac{0.734Q}{d_1^{3/2}} = \frac{0.734(0.0946)}{(0.42)^{3/2}} = 0.26m$

But, canal bed width, B=0.6m; hence provide bc=0.6m.

d. Unit discharge, $q = \frac{Q}{b_c} = \frac{(0.0946)}{(0.6)} = 0.16m^3/\sec/m$

e. Critical depth, $d_c = \left(\frac{q^2}{g}\right)^{1/3} = \left[\frac{(0.16)^2}{9.81}\right]^{1/3} = 0.14m$

2. Stilling basin

i. Lip height, $a = \frac{d_c}{2} = \frac{(0.14)}{2} = 0.07m \rightarrow use\,0.10m.$

ii. Length

$$Length,\ L = \left[2.5 + 1.1\frac{d_c}{H} + 0.7\left(\frac{d_c}{H}\right)^3\right]\sqrt{H * d_c}$$

$$= \left[2.5 + 1.1\frac{(0.0946)}{(1.0)} + 0.7 * \left\{\frac{0.0946}{(1.0)}\right\}^3\right]\sqrt{1.0 * 0.14}$$

$$= 0.98m \rightarrow use\,1.00m$$

iii. Width. $B = \frac{18.46\sqrt{Q}}{Q + 9.91} = \frac{18.46\sqrt{(0.0946)}}{(0.0946) + 9.91} = 0.57 \rightarrow use\,0.6m.$

Accordingly, the hydraulic parameters for all drop height for the main canal is calculated and tabulated as below:

Table 6:Hydraulic parameters of drops on main canal

	Drop Dimension Ruba- Chemiet													
Dimension	**SC_1 of 1**	**SC_1 of 2**	**SC_1 of 3**	**SC_2**		**SC_1 of TC_1**		**SC_1 of 1_TC_2**		**SC_1 of 2_TC_3**		**SC_1 of 3_TC_4**	**SC_1 of 3_TC_5**	**SC_2 of TC_1**
	1m	**1m**	**1m**	**0.5m**	**1m**	**0.5m**	**1m**	**0.5m**	**1m**	**0.5m**	**1m**	**0.5m**	**0.5m**	**1m**
Tw	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
dc	0.50	0.48	0.40	0.33	0.33	0.34	0.34	0.31	0.31	0.36	0.36	0.33	0.37	0.33
m	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00
BW1	0.82	0.82	0.80	0.45	0.78	0.45	0.79	0.45	0.78	0.46	0.79	0.45	0.46	0.78
BW2	0.57	0.56	0.50	0.37	0.45	0.37	0.46	0.35	0.43	0.39	0.47	0.37	0.40	0.45
X	1.14	1.13	1.01	0.73	0.90	0.75	0.91	0.70	0.86	0.78	0.95	0.74	0.79	0.90
Y	1.20	1.19	1.07	0.73	0.96	0.74	0.97	0.70	0.92	0.77	1.01	0.73	0.78	0.95
Z	1.65	1.64	1.61	0.90	1.57	0.91	1.57	0.89	1.55	0.91	1.59	0.90	0.92	1.57
W	0.31	0.29	0.21	0.08	0.08	0.10	0.10	0.05	0.05	0.13	0.13	0.09	0.15	0.08
F	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
D	0.30	0.28	0.20	0.13	0.13	0.14	0.14	0.11	0.11	0.16	0.16	0.13	0.17	0.13
T1	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
B	0.59	0.57	0.40	0.26	0.26	0.28	0.28	0.22	0.22	0.33	0.33	0.27	0.35	0.26
Lb	1.20	1.19	1.07	0.73	0.96	0.74	0.97	0.70	0.92	0.77	1.01	0.73	0.78	0.95

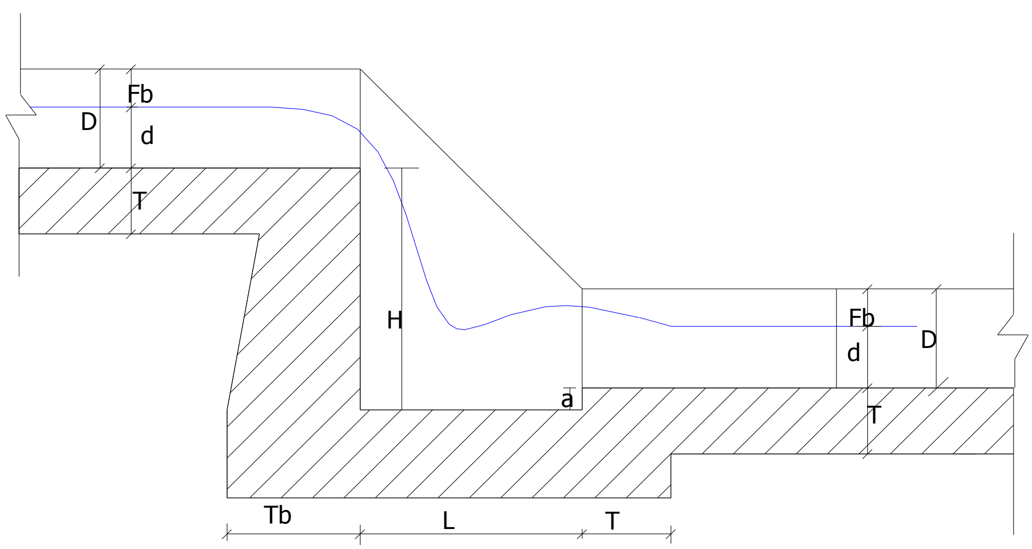


Figure 6:Typical Drop Structure

2) Design of Typical division box and turn outs

To ensure proper distribution of water for the command area, 6division boxes/turnouts are provided on the main canal to divert the water direct to Field canals. Stop loges are also provided to control the water on the canals.

The design of the division box is achieved according to the broad crested weir formula.

Q = $C_d BH_d^{2/3}$

Where: Q = design discharge from canal design m3/sec

C_d = discharge coefficient = 1.77

B = crest width (m)

H_d = Head of water above crest.

Assume the following to calculate the water to the tertiary canal

1. Q1, B1 are the design discharge & opening width from parent canal.
2. Q2 & B2 are the design discharge & opening width of the receiver canal one (may be the main canal).
3. Q3 & B3 are the design discharge & opening width of the receiver canal two (may be tertiary canal).

For $H_{d1} = H_{d2}$ $\frac{Q1}{Q2} = \frac{B1}{B2} \Rightarrow B2 = B1\left(\frac{Q2}{Q1}\right)$, and Q_o =Q1 + Q2

Note: Q1 and Q2 are already determined from the command area and duty of the crop hence, Q1 & Q2 are known. Their values are calculated & tabulated as below:

Table 7:Hydraulic parameters of division boxes and turnouts Ruba-Chemiet.

S. N	Division Box	Parent and originating canals	Chainage(m)	L1(m)	L2(m)	L3(m)	D(m)	B(m)	B0(m)
1	ML_1_DB_1	ML_1 to SC_1	0+70	0.56	0.48	0.08	0.52	0.64	1.70
2	ML_1_DB_2	ML_1 to SC_2	0+120	0.25	0.25	0.00	1.33	0.26	3.00
3	SC1 _DB_3	SC_1 to SC1 of 1& TC1	0+42	1.64	1.34	0.30	0.34	0.28	1.00
4	SC1 of 1_DB_4	SC_1 of 1 to SC1 of 2 & TC2	0+111	2.01	1.79	0.22	0.31	0.22	0.90
5	SC1 of 2_DB_5	SC_1 of 2 to SC1 of 3 & TC3	0+359	0.96	0.62	0.35	0.36	0.33	1.10
6	SC1 of 3_DB_6	SC_1 of 3 to TC4 & TC5	0+157	0.57	0.19	0.38	0.37	0.35	1.10
7	SC_2_DB_7	SC_2 to TC1	0+939	0.27	0.28	-0.01	1.33	0.26	3.00

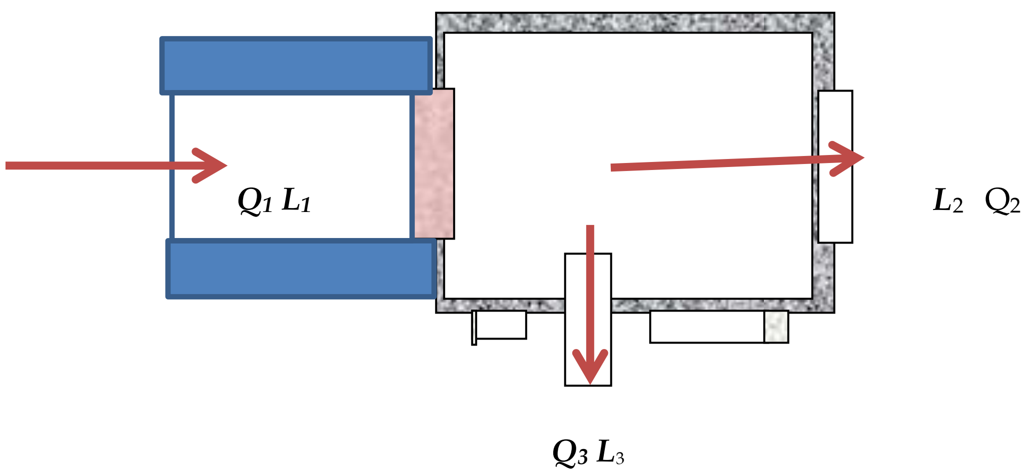


Figure 7:Typical two-way turnouts

3) Hydraulic Analysis from pump station to pond station Ruba- Chemiet

Figure 8: Hydraulic Analysis from Pump Station - Pond – Reservoir

CALCULATION OF HEAD LOSSES			
Calculation of head loss along the critical path			
Factors	1,131,000,000.00	1.852	4.87
C	150		

The calculation is based on the required discharge

Hydraulic Analysis from Pump Station Pond Reservoir												
From-To	Q(m^3/hr)	OD(mm)	WT(mm)	ID(mm)	L(m)	J(%)	DH(m)	Zend(m)	Zin(m)	DZ(m)	Pend(m)	Pin(m)
Pound-Point-1	547.452	315	18.53	277.94	397.82	1.56	6.20	1773.00	1756.20	16.80	9.00	32.00
Point-1 to Point-2	547.452	315	18.53	277.94	554.80	1.56	8.65	1756.20	1737.00	19.20	32.00	59.85
Point- 2 to Point-3	547.452	315	18.53	277.94	136.66	1.56	2.13	1737.00	1735.20	1.80	59.85	63.78
Point-3 to Point-4	547.452	315	18.53	277.94	139.44	1.56	2.17	1735.20	1728.20	7.00	63.78	72.95
Point-4 to Pump	547.452	315	18.53	277.94	109.28	1.56	1.70	1728.20	1717.500	12.20	72.95	83.218
Losses at the system				3.00								
Total operating head (H)				**86.718**	**Q=**	**547.45**						
Pump Power Determination												
Water Horse Power=(QXH)/270*Eff.												
Where Q=Total Flow(m^3/hr)												
H=Total Operating Head (m)												
Eff.=Pump & Motor Efficiency												
Therefore,Water Horse Power=(Q*H)/(270*0.7)=				HP	251.18							
Pump Power in KW=0.743*HP=				KW	187.00							