FIRI KEBSO SMAL SCALE IRRIGATION

AND

DRAINAGE PROJECT

FEASIBILITY STUDY AND DETAIL DESIGN

ENGINEERING FEASIBLITY DRAFT REPORT

Consultant:

Oromia Water Works Design & Supervision Enterprise

P.O.Box 870/1250
Finfinne,

Email:owwdse@ethionet.et

Client:

Oromia Irrigation Development Authority

Tel-+251 111-2622-63
Email:- oidaatmjoprgmail.com

P.O.Box 3306

March 2019
OWWDSE

Table of Contents

LIST OF FIGURE iv

LIST OF TABLE iv

LIST OF ABBREVIATION v

EXCUTIVE SUMMARY vi

1. INTRODUCTION 1

1.1. Location and Topography 1

1.2. General Description 1

1.3. Soil of study area 3

1.4. Land use/ cover 4

1.5. Objective of study 4

1.5.1. Major Objective 4

1.5.2. Specific Objective 5

1.6. Scope of the study 5

2. MATERIAL AND METHODOLOGY 6

3. DESIGN OF THE IRRIGATION AND DRAINAGE SYSTEM 7

3.1. Hydrology 7

3.2. Geology 8

3.3. Headwork Site 10

3.4. Irrigation System Layout 11

3.4.1. Topography 11

3.4.2. Project Layout 11

3.4.3. System Nomenclature 12

3.4.4. System Description 14

3.4.5. Road/Access Sub-System 15

4. DESIGN OF ONFARM STRUCTERE 16

4.1. Irrigation Design Duties 16

4.2. Analysis of Demand of Spring Water 16

4.3. Irrigation System Design 19
4.3.1. General 19
4.3.2. Canal Geometry Design 19
4.3.3. Manning's Roughness Coefficient 20
4.3.4. Canal geometric design and Flow Profile Computation for Irrigation Canals 21
5. IRRIGATION INFRASTRUCTURES 24
5.1. General 24
5.2. Types of Irrigation Infrastructures 24
5.2.1. Off take Structures 25
5.2.2. Drop Structures 26
5.2.1. Road Crossing Pipe culvert 26
5.3. Night Storage (pond) Irrigation System & Operation of the Project 28
5.3.1. Design of night storage 28
5.3.2. Inlet structure of pond 34
5.3.3. Coordinate and Dimension of storage pond. 34
5.4. Spill way 36
6. PROJECT COST 37
6.1. BOQ for Camp construction 38
6.2. On farm and infrastructure BOQ 39
6.3. Drainage BOQ 42
7. REFERENCES 44

LIST OF FIGURE

Figure 1 Location map of the study area 1

Figure 2 Soil map of the study area 3

Figure 3 land use and land cover of study area 4

Figure 4. Topographical condition of the spring area 9

Figure 5.plan and section of Division Structure 11

Figure 6. General System layout of Firi kebso Small scale Irrigation project 12

Figure 7. Night storage pond inlet and spillway Design sample 32

LIST OF TABLE

Table 1 Mean Monthly firi kebso Spring Flow Time Series 8

.Table 2: Proposed lining structures along the main canal routes 9

Table 3. Hydraulic Design of Division structure 11

Table 4. Irrigation Duties Calculations 16

Table 5. Demand analysis and Storage Requirements 18

Table 6. Recommended value of roughness coefficient for Lined & unlined canals. 20

Table 7. flow Capacity and geometry parameter for main canal 21

Table 8. flow capacity and Geometric Parameter for Secondary canal 22

Table 9. flow Capacity and Geometric parameter of Tertiary canal 23

Table 10. Summary of available Canal Structures 24

Table 11 . Canal Offtake Hydraulic Design 25

Table 12. Canal Drops Hydraulic Design and Table of Dimension 26

Table 13 . Hydraulic Design, Transition and table of dimension of Box Culvert 27

Table 14. Stability analysis of night storage. 32

Table 15 inlet structure of pond 34

Table 16.Night storage pond excle calculation part 35

Table 17 .Dimension and Quantity of side spillway on Canal and NSP 36

Table 18. Summary of Bill of quantity. 37

LIST OF ABBREVIATION

Eth Birr	Ethiopia Birr (currently approx.
DEM	Digital Elevation Model
DB	Division box
ETo	Reference Evapotranspiration
FK	Firi Kebso
GIS	Geographic Information system
ha	hectare
km	Kilometers
km2	Kilometers square
m	meter
m.a.s.l.	Meters above sea level
m3	meter cube
m3/s	meter cube per second
MC	Main Canal
NSP	Night Storege Pond
OIDA	Oromia irrigation Development Authority
OWWDSE	Water Works Design and Supervision Enterprise
UTM	Universal Transverses Marcater
SSP	Small Scale Irrigation Project
SC	Secondary Canal
TC	Tertiary Canal

EXCUTIVE SUMMARY

Firi Kebso spring located nearest (Under) the mountains; often have sufficient slope to deliver water (base flow of 0.030m^3/s & maximum 0.057m^3/s during July respectively) by gravity to the location where it is used. This configuration can result in significant savings, as there are no additional energy requirements like electricity or pump costs. This spring is able to meet farmers' demand (including domestic & other) and is accessible for irrigating the proposed command area (net 30.43ha). To meet this Demand two Night storage with their spillway on each Main canal proposed. At source the division structure to supply for main canal, cattle trough and masonry fence are designed.

There are two Lined Main Canal 952.88km &969.45km long and will irrigate 15.15 ha &15.28 ha respectively. Also there are one(1) secondary canals serve 3.63 ha , 2 tertiary Canals off taking from the secondary canal and 18 field canals .Out of this 14 field canal is directly off taking from Main Canal while the remaining 4 are from tertiary canal. On that supply canal except field canal there are 14 drops, 8 culvert, 20 off take, 1 D.box and two night storage pond are cross structure proposed for this project.

There are also Two Collector and tertiary drainage canal, which has total length of 349.95 and 418.3m and Compromise to collect 11.49 and 7.40 ha respectively. This collector drain structure has 5 vertical outfall and 11 vertical drops. But for collector drainage drop, proposing vegetation cover are the best alternative rather than vertical drop based on condition of canal alignment of site.

1. INTRODUCTION

1.1. Location and Topography

Firi Kebso small-scale irrigation project area is situated at UTM of 751974E & 993543N with altitude of 1619.176m.a.s.l. in Oromia National Regional State, East Hararge Zone, Melka Belo Woreda and Firi Kebso Kebele. It is found at a distance of about 520km from Addis Ababa to the east direction and accessed 60 km weathered road from Deder twon to the spring head work site .The main source for irrigation project is Firi Kebso Spring. The catchment area is covered with wood & cultivated land. The upper reaches of the catchment area is forest land with rugged mountain terrain slope, while the lower part of the drainage area is flat and the spring is located in Wabe shebele River basin.

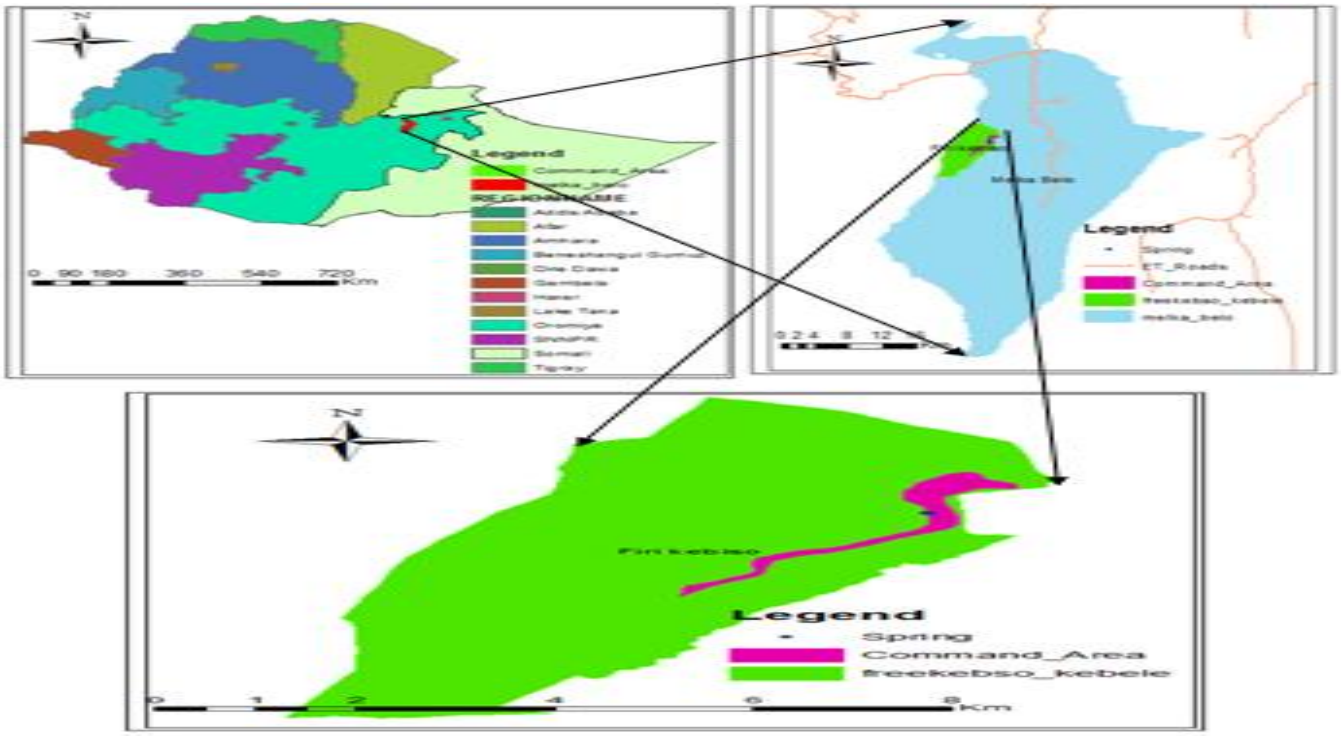


Figure 1 Location map of the study area

1.2. General Description

Spring water is a natural flow of water from the ground at a single point and/or several points within a restricted area, usually along hillsides, at the base of slopes, or in low areas/valley bottoms, etc. Thus, they may emerge at different points on dry land or in the beds of streams, ponds, or lakes. Spring water

can also be defined as a groundwater emerging naturally through a weak surface of the earth's outcrops of groundwater that often appear as small water holes or wet-spots at the foot of hills or along river banks.

The water that flows from springs is usually safe from contaminants, due to the fact that groundwater is naturally filtered as it flows through the earth. Therefore, once the spring is developed it can be used for irrigation and domestic consumption, requiring little to no treatment. This makes springs relatively inexpensive yet safe as water sources and used for multipurpose.

This spring should be able to meet farmers' demand and is accessible for irrigating the proposed command area. Therefore, Firi Kebso is the only alternative and one of spring used for irrigation, domestic livestock & others, but this study is more considered on irrigation purpose.

Based on topography and soils suitability, a total gross of 130 ha land has been surveyed and is found suitable for the gravity irrigation. Out of this gross surveye-area about 30.43ha, net irrigable area is identified. For the design of irrigation system layout, surveying of all existing physical features has been carried out. The basic system layout design was conducted on topographic map of the area.

This layout or on farm structure are Secondary and Tertiary canals off Taking from the main canal to convey water to subsequent field canals.

Within the system, there are two Lined Main Canal (right and left) and one secondary canal ,two tertiary Canals off taking from the secondary canal, and 18 field canals ,out of this 14 field canal is directly off taking from Main Canal while the remaining 4 is from tertiary canal.

Further, each secondary canal feeds the tertiary canals. Each tertiary canal feeds the field canals Based on social aspects, topography, and occurrence of natural drains and size of irrigable area. The entire irrigable area is intended for smallholder family farming

1.3. Soil of study area

Soil classification of the study area is based on soil characteristics, which can be observed and measured or inferred from these observations. Field morphologic properties are sometimes inadequate for accurate definition of classes. In such cases additional chemical and physical properties, determined in the laboratory can be used to define the class.

Soil map of the study area was obtained from Ministry of Agriculture in a soft copy; subsequently modified using observed and collected sample data during fieldwork. According to the FAO soil classification, the soil-mapping units have been identified in the study area at a scale of 1:250,000. From these soil classifications map units, broad divisions of soil types in to different families were grouped as clay and clay loam. The whole study area is covered by two types of major soils those are Eutric Cambisols and Rendzinas. In this project the soil type of the proposed project site is Rendzinas which is clay with hydrologic soil group D having high runoff potential due to slow infiltration rate.

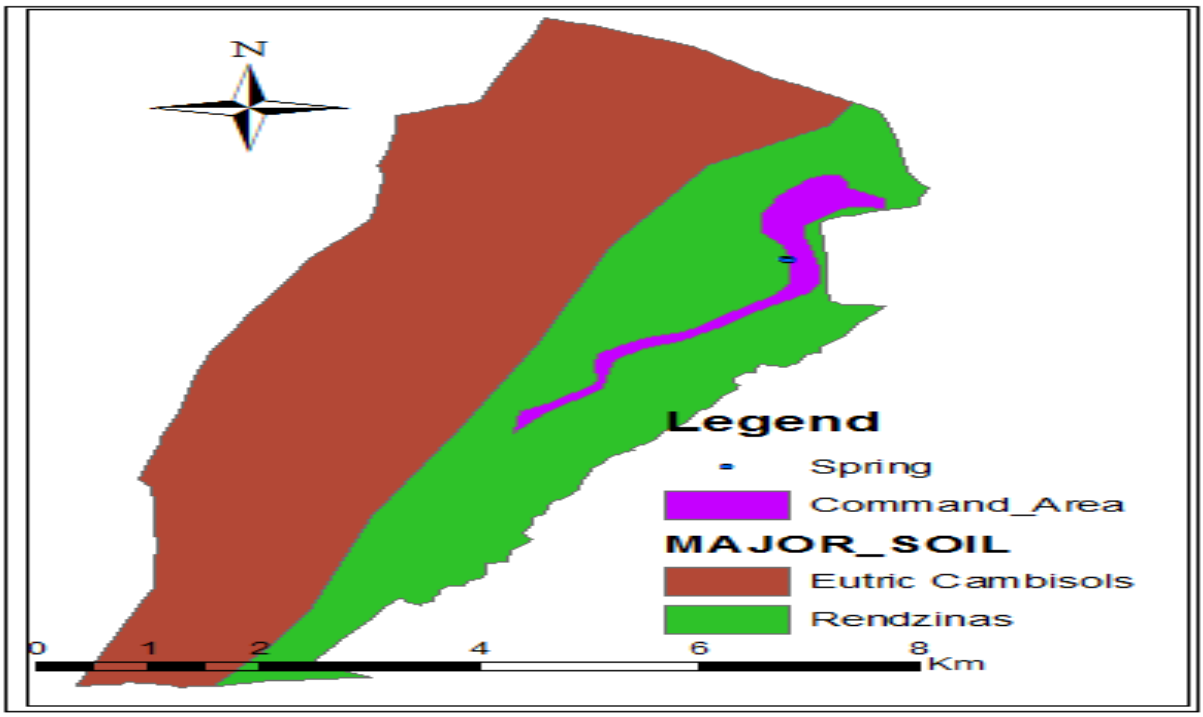


Figure 2 Soil map of the study area

1.4. Land use/ cover

Land use map of the study area was obtained from Ministry of Agriculture in a soft copy; subsequently modified using observed and collected sample data during fieldwork.

The area extent of land use and land cover mapping units in the catchment areas is highly dependent on the climatic, topography and edaphic factors. Population, remoteness and traditional factors attribute to the type of use and the natural vegetation as they are presently expressed in the catchment area. The reclassified land use/cover map is used for the computation of peak flood. The overall study area is covered by three major land use land cover type such as intensively cultivated, moderately cultivated and open shrub land. The entire selected project site is covered by moderately cultivated land

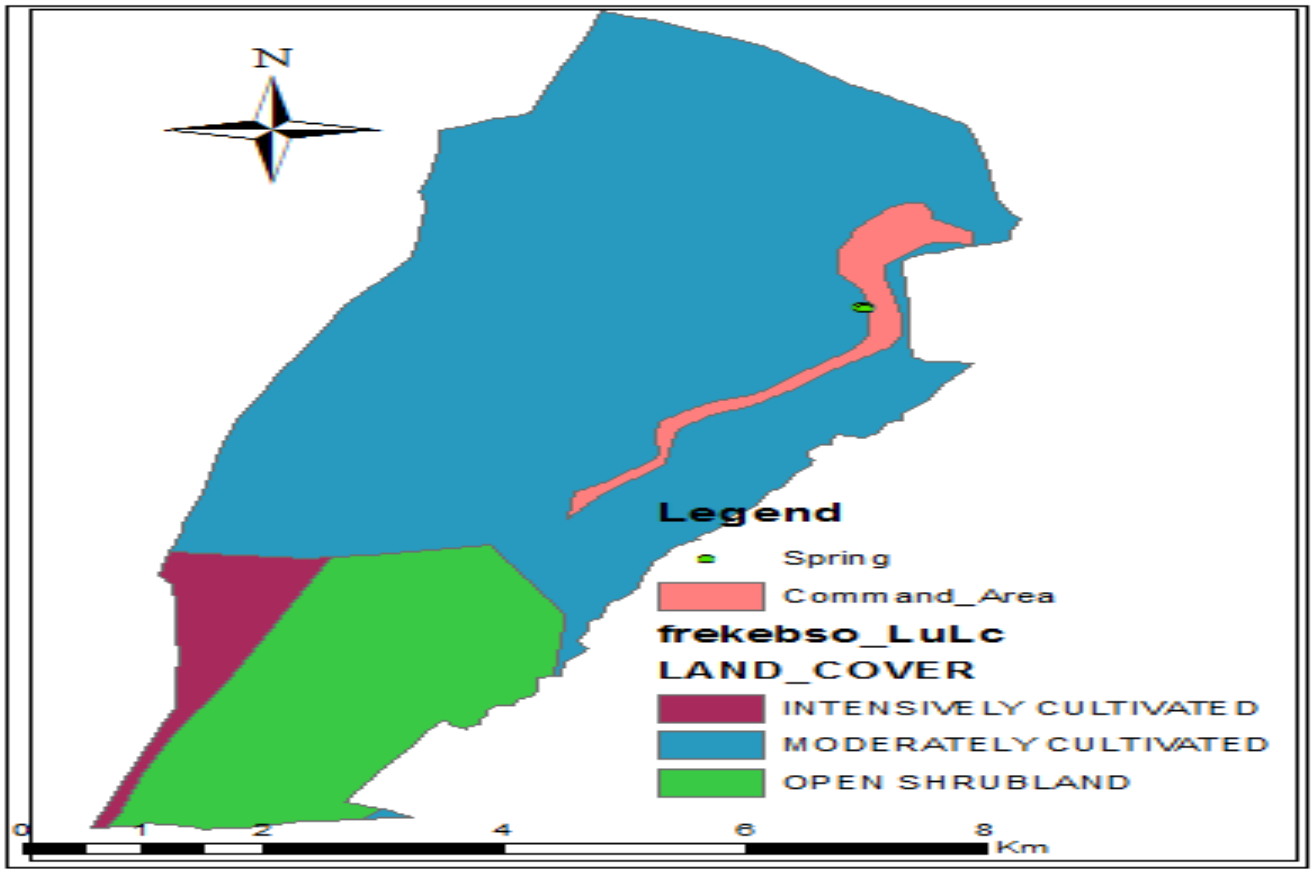


Figure 3 land use and land cover of study area

1.5. Objective of study

1.5.1. Major Objective

Maximize the use of the spring water and potential land resources of the project area by design structure, which is suits to this particular site.

1.5.2. Specific Objective

Specific Objective of this study was increasing productivity of Farmer by design of division structure at spring head work with its pertinent components and all canal system and farm structures that:

- Is feasible both technically and economically (Drawing type and cost)
- Enables to efficiently utilize the flow of spring for irrigation both in dry and rainy seasons to make extra production for net area of 30.43 ha through irrigation.
- Allows safe, easy and low-maintenance operation in the service life of the project.

1.6. Scope of the study

The irrigation design shall ensure reliability, equity and flexibility of water delivery to farmers. It will aim at reducing conflicts among water users and will lead to operation and maintenance costs.

- Design proper irrigation system compatible with local conditions and management capabilities,
- Establish flood protection measures for the command area and canal structures and design the respective drainage system accordingly,
- Check and test hydraulic and structural designs of main canal considering total demand and the required capacity and the base flow of spring availability.

2. MATERIAL AND METHODOLOGY

In the study and design procedure, the following material and methodology are used

Specific Site identification:

- Review of the reconnaissance survey conducted by the Client
- 50,000 scale top map and GIS information
- Local farmers interview and discussion
- Woreda and Zone Agriculture section expertise
- Previous studies
- On foot travel along the farm areas and spring source.

Topographic survey:

- Surveying the headwork site (spring) and the Command area with sufficient radius, using Total station

Flow estimation

- Data organizing, pre-processing, producing relevant maps (i.e. DEM, drainage system, sub-catchments area delineation from DEM data using Global Mapper 15, Arc GIS 10.2 with extension Arc SWAT.
- Physical observation on local information about high flood and critical base flow condition of the Spring.
- Estimate the monthly water availability of the catchment's based on the available daily hydro meteorological data and assess the magnitude of surface water of the catchment

Irrigable area identification and Design:

- Collecting the Completed survey data from survey experts.
- Digitize all input raw data by using global Mapper, Google Earth, GIS Arch Veiw, Auto cad Eagle point and other software.
- Launched Topo data taken from surveyor (by "DWG". forms) by an Eagle point; understanding feature x_cs and decided the surface model of the command area
- Design of Irrigation and Drainage system based on ,topographical configuration, hydrological data, and geology of the area(spatially for canal alignments).
- Prepare BOQ and Z profile.

This (3^{rd}) procedure is the area of this Document is Concerned

For instance, the following are major areas of concern in Documents.

- ✓ Study and design of the irrigation method to be adopted
- ✓ Design of the irrigation system layout and associated structures
- ✓ Design of the different irrigation and drainage structures
- ✓ Preparation of the longitudinal profiles of the different irrigation and drainage canals
- ✓ Making drawing for each structure, prepare Zprofile and BOQ preparation.

3. DESIGN OF THE IRRIGATION AND DRAINAGE SYSTEM

The proposed Firi Kebso small scale Irrigation Project is based on the Diversion division structure which will be proposed on upstream (54.37m away)of the eye of springs to keep the canal full supply level and elevation of spring eyes(i.e may be clogged, if water is back). The available base water flowed from this source is not sufficient for irrigating an area of 30.43 hectares based on the hydrology study mentioned bellow.

3.1. Hydrology

The main source of irrigation water for Firi Kebso small scale irrigation project is from Firi Kebso spring, which originates from the Mountainous area. It is also used for the livestock consumption and for peoples drink. There is no river gauge that describes about Firi Kebso spring flow characteristics. There is relatively good vegetation cover in the catchment area, at upstream of Firi Kebso spring. There is a widely traditional irrigation used at the downstream that means below proposed site for the head work.

Base flow determination has been done one time in the middle of January 2011E.C. where discharge is measured during in the driest season. Based on this and other climate data the water balance analysis is going on.

In the middle of January the discharge is found to be about 30 liter per second. At downstream, there is no another spring was observed. Therefore, the downstream and upstream users can use this stream together; especially water user association should be established and strengthen at this area. Concerning the domestic water consumption at the project area, there is no spring or borehole is observed. Both Community and livestock use for water consumption only this spring. Therefore, to solve this problem water budgeting system was done by population forecasting and analysis the demand as seen on section 4.2 table 5 .As you see from table total demand for downstream and near area was 2 l/s and only the remaining was used for irrigation.

The sample for irrigation water quality test is also taken and submitted to the Laboratory. For designing sustainable and economical structures the peak flow analysis will be carried out with in assigned frequency using different alternative methods of flow analysis for un-gauged rivers.

Firi Kebso spring base flow was measured by using float method in January month 2011 E.C. The flow was estimated at about 0.03m3/sec.

Table 1 Mean Monthly firi kebso Spring Flow Time Series

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Corrected discharge m3/s	0.034	0.033	0.051	0.057	0.048	0.045	0.057	0.065	0.048	0.047	0.030	0.032

3.2. Geology

Detail engineering geological and geotechnical site investigation works has been conducted using appropriate surface mapping tools. An assessment of Sub-surface materials has been conducted upon excavation of geological test pits (exploration holes) to depth in the order of 2.5mts.

The geological engineering issues related to this small scale irrigation project included: technical and economic feasibility of project site, the geomorphologic setting, stability, workability, and water tightness of the diversion headwork site, main canal route, crossing-drainage structure sites and the storage pond site. Topographically Firi Kebso spring catchment is characterized by chain of hills and undulating ragged topography. The geology of the catchment is characterized by sedimentary rock successions with hundreds of meters thick Adigrat sandstone overlain by the Hamanlei limestone formations. These rock types in the escarpment are cliff forming sand stone and the limestone made the catchment good recharging zone. The topography of the area is mainly controlled by effects of the sedimentary rock strata formed by the marine transgression and regression as well as the result of late-Cenozoic volcanic episodes associated geomorphologies. Consequently, streams and many eyed springs emanate from these uplands and flow in favorable direction to lower altitudes. The pattern and stream course is further affected by lithology and geologic structures.

Topography and Drainage Condition at the Head Work Site: The elevation around the headwork site is about 1619.2m.a.s.l and it is generally low-lying area (Figure 1). Firi Kebso catchment drainage is based on spring emanates from the fractures at the contact of overlaying limestone and theunderlying sandstone formations and the diversion (spring developing structure) site is pointed on the spring eye. The relative position of headwork site is at straight and direct reach of the stream of the spring. Topography of the proposed Head work axis is relatively gentle, narrower and at streambed with stable stream banks slope.

Figure 4. Topographical condition of the spring area

Topography and Drainage Condition at the Canal Rout: The proposed canal routes stretch NW and NE ways along the right and left sides of the stream/spring following surface topography. These canal routes go elongated under the chain of hilly and ragged limestone mountain ridges that surrounding the command area.

In the following Table part shows necessary lining along these main canal routes due to the loose sandy characteristics of the earth to pass the canal safely on its intended way have been indicated.

.Table 2: Proposed lining structures along the main canal routes

SN	Description	Chainage	From (starting)			To (ending)			Engineering treatment required
			X	Y	Z	X	Y	Z	
1	The whole main canal route along the proposed left and right main canal routes need masonry and(or) lining in order to eliminate the high infiltration capacity of the low water tightness behaviour of the sandy soil covers and the underlying sandstone formation	0 to end of the canal routes							Lining

Fence for spring developing; - To protect the spring safely from animal and other contaminating materials masonry wall having 1.5m,10m &10m height ,width & length respectively are proposed based on site condition and drainage ditch are designed for protecting the spring eye from silt and other eroded materials . The detail drawing and bill of quantity are shown on excel.

3.3. Headwork Site

Slope Stability Conditions;-The proposed Division structure location has stable bank on both of the right and left side along the proposed weir axis (spring developing structures). The stream bank slopes (right and left banks) are made up of sandstone rock with thin soil covers. The slopes of both the left and right banks have relatively gently sloped to the riverbed stream. Both abutment slopes are stable. At both the right and left bank the sandstone bedrock out cropped so that there could be no stability issues at any condition. Therefore, both banks of the stream have no slope instability issues.

Hydraulic Design;- The two main canal is off-taking directly from the spring (division structure proposed) and aligned at both side and has capacity to irrigate 30.43 net hectares by off taking from the spring canal minimum flow of 0.030m^3/s (January) and maximum 0.057m^3/s (august) for 24 hour continuous flow *(from hydrology data*) . But from this minimum flow the demand of population livestock, puplic institution& other was 0.002m^3/s and should have to be released correctly (see section4.2 table 5).

Based on minimum flow (0.03m3/s) and duty (0.92l/s/ha for 24hr see section 4.2 table 4) only 15.21 ha are fully irrigated during 12 hr. and to increase and store the next 24 hr flow, two night storage was proposed on each main canal at left and right of spring. To keeping the elevation of spring eyes and canal full supply off take the division structure are proposed 54.37m away toward the south. This 54.37m is simple lined canal directly off taking water from spring (i.e w/t out disturbing the spring) and conveyor outfall water to this Division structure. Both main canals off take have a controlled gate and Cattle trough has two valves to operate and manage. See Drawing and excel sheet for detail.

The following table and figure are the hydraulic design, table of Dimension & plan and section of Division structure for Main canal and Cattle trough.

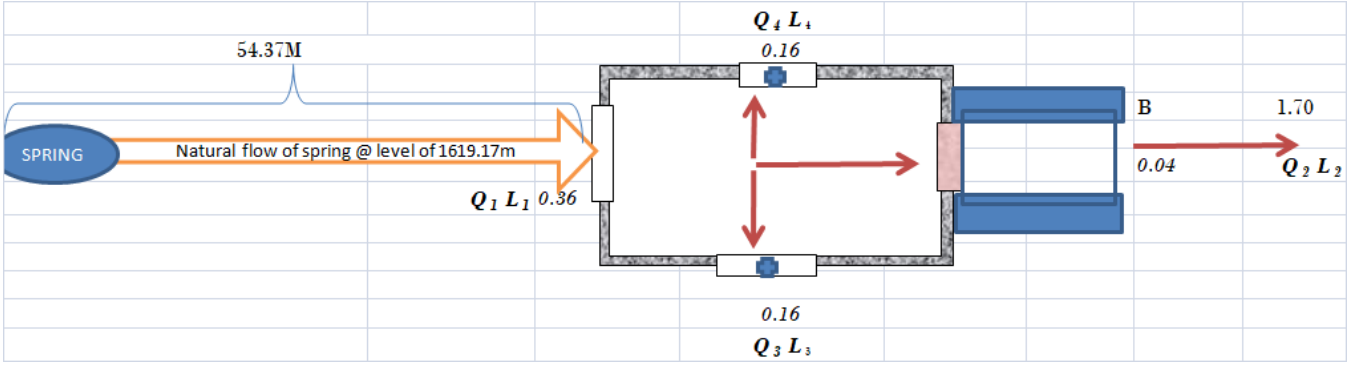


Table 3. Hydraulic Design of Division structure

DB	Canal	Chainage(m	$Q_1(m^3/s)$	$Q_2(m^3/s)$	$Q_3(m^3/s)$	$Q_4(m^3/s)$	h(m)	$h^{3/2}$	$L_1(m)$	$L_2(m)$	$L_3(m)$	$L_4(m)$	d(m)	fb(m)	D(m)	b(m)	B(m)
FIRI KEBSO	FROM SPRING	54.0	0.08	0.010	0.0445	0.0445	0.300	0.164	0.29	0.04	0.16	0.16	0.30	0.30	0.60	0.60	1.80

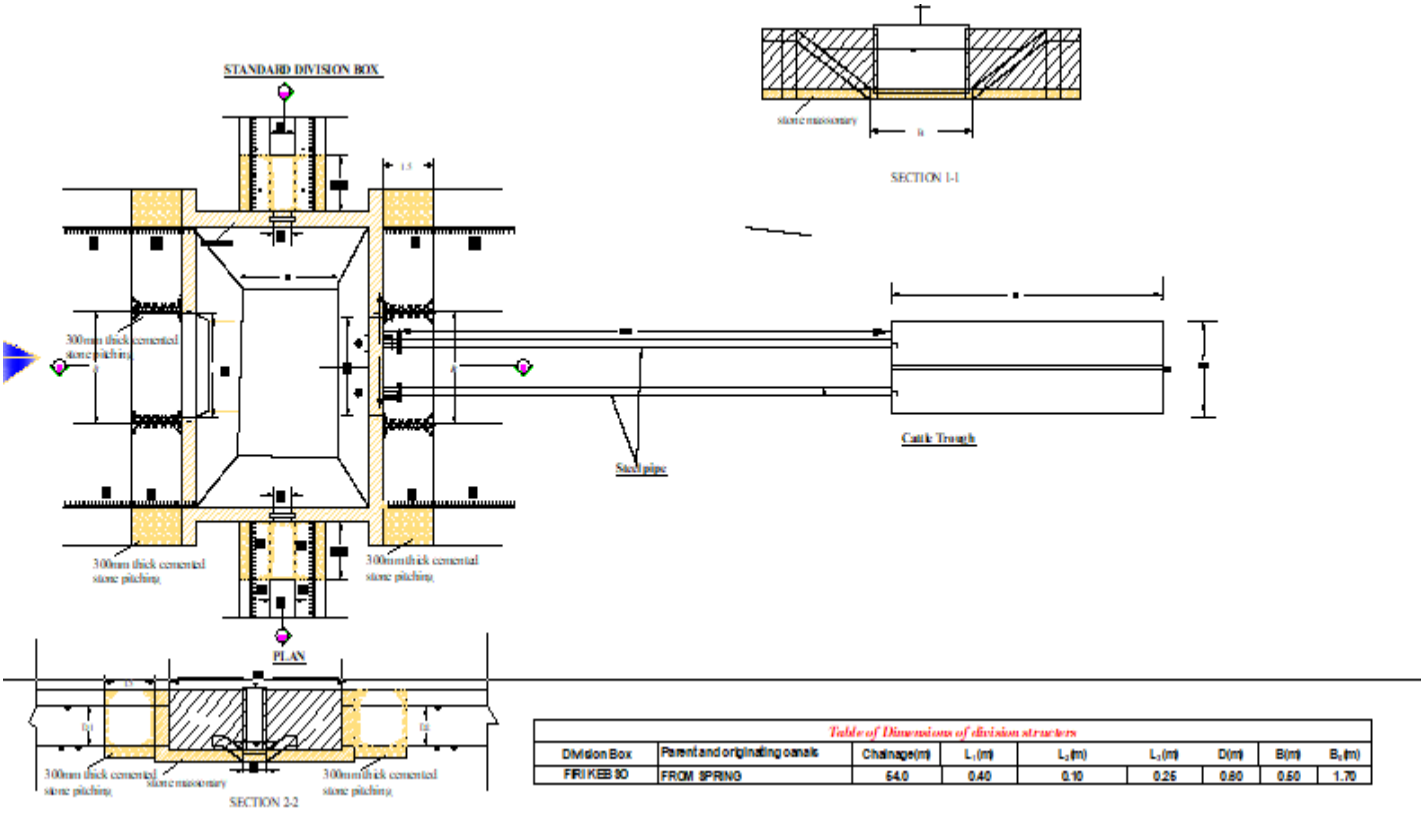


Table of Dimensions of division structures

Division Box	Parent and originating canals	Chainage(m)	L_1(m)	L_2(m)	L_3(m)	D(m)	B(m)	B_1(m)
FIRI KEBSO	FROM SPRING	54.0	0.40	0.10	0.25	0.60	0.50	1.70

Figure 5.plan and section of Division Structure

3.4. Irrigation System Layout

3.4.1. Topography

In order to prepare a realistic system layout it would be inevitable to scrutinize the local topographic condition of the area. For this purpose and as part of the present feasibility study, detailed topographic survey was done .topographic data was used to extract the topography of the irrigable area. This was augmented by field level surveys alone.

3.4.2. Project Layout

The irrigation system layout for the project was made based on the 1:10,000 scale topographic maps (with 1m contour interval) of the area prepared by the assigned crew team for this project.

The layout of irrigation canals, furrows are made to run more or less parallel to contours and field canals are aligned perpendicular to contour lines, subsequent higher level canals were made to run perpendicular and/or near perpendicular to lower level canals that they discharge into.

The alignment procedure used for drainage canals is such that the positioning of higher-level drainage channels would more or less be along depressions. Accordingly, field ditches are placed at the foot of furrows and are aligned down the contour lines. Similarly, tertiary and secondary drains are made to run perpendicular to field ditches and to each other.

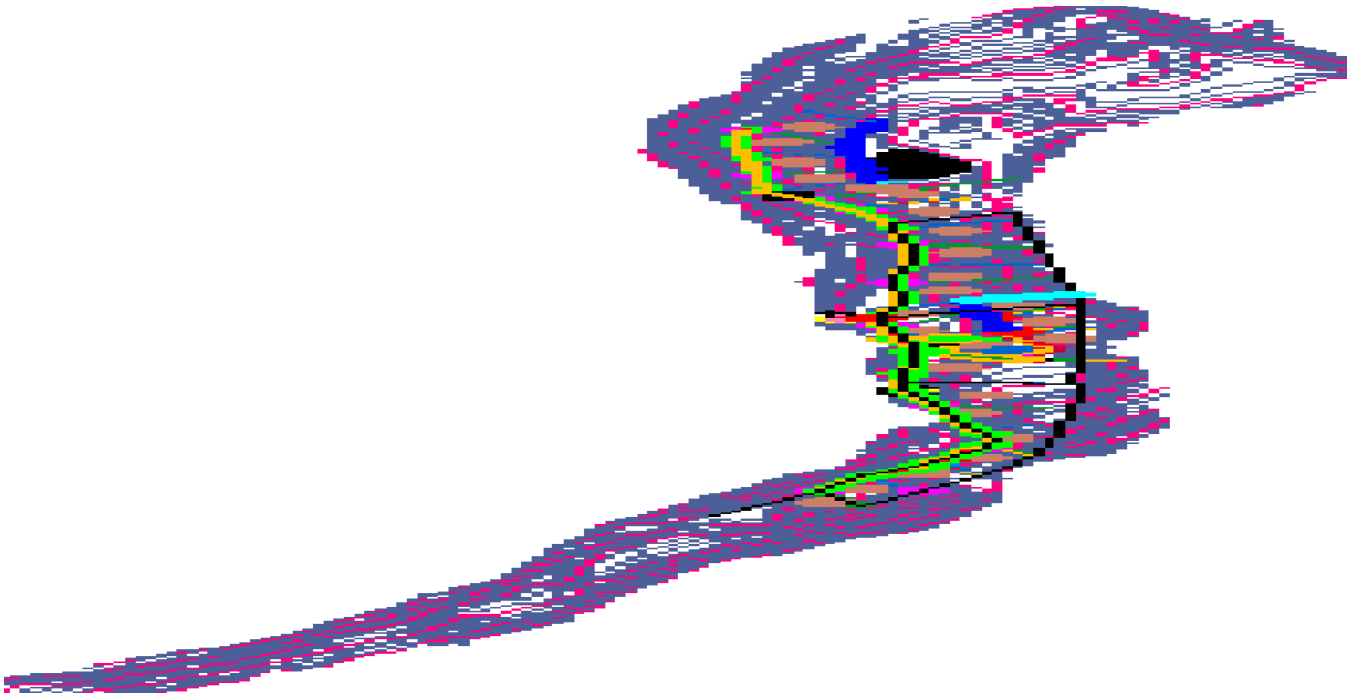


Figure 6. General System layout of Firi kebso Small scale Irrigation project

3.4.3. System Nomenclature

General

The multitude irrigation and drainage canals including their hydraulic structures in the present irrigation system will call for proper designation and naming of each canal and drain their accompanying structures in a systematic way. Ultimately every drawing will be prepared in relation to the designation and naming of each canal and drain their accompanying structures. For this purpose it will be inevitable

to designate and name every canal and drain in the irrigation system in a systematic and standard manner.

Irrigation Canals

Main Canal: The main canal is given the name of the scheme called as Firi Kebso and abbreviated as "FK" in association with the letter "MC" which is the index of the main canal. Thus the main canal is designated as*" FKMC"*.

Secondary Canals: Secondary canals are given the name of the area the canal conveys water to suffixed by the main canal number it takes off from hyphenated by sequential numbers designating the number of the secondary canal. Thus the first secondary canal in the system taking off from the main canal is designated as *"FCSC-1-1***".**

Tertiary Canals: Tertiary canals are given the name of the area the canal conveys water to prefixed by "G" and suffixed by the main canal and secondary canal number it takes off from hyphenated by sequential numbers indicating the secondary canal it takes-off from hyphenated by sequential numbers to indicate the number of the tertiary canal. Thus the first tertiary canal taking off from the first secondary canal that takes off from the main canal is designated as *FKTC-1-1-1*.

Filed Canals: Field :-canals are named by an abbreviated field canal name "FC" prefixed by "G" and suffixed by a sequence number which indicates the main canal unit they are in followed by the secondary and tertiary canal number that it takes off and the farm plot number. Thus the first filed canal supplying water to the first farm plot in the first tertiary, secondary and main canal is designated as FKFC-1-1-1-1.

Drainage Canals

Collector Drain: The *collector* drain is given the name of the area in to which all drains evacuate to prefixed by the letter "G" to indicate that it is a drain followed by the letters "CD" to indicated the irrigation area Firi Kebso and that it is a *collector* drain. Thus **FKCD** indicates the *collector* drain in the project area.

Tertiary Drain: Tertiary drains are given the name of the secondary drain they dewaters in to from followed by sequence number to indicate the number of the tertiary Thus , FKTD-1-1-1 indicates the first tertiary drain that dewaters in to the first *collector* drain that again outfalls in to the first natural drain in Firi Kebso area.

Field Drains: Field drains are named by an abbreviated field name which is "FD" preffixed byletter "FK "and the farm number from which they dewater. Thus FKFD-1-1-1 designates the field drain which drains the first farm field that drains in to tertiary drain number one in the first secondary unit.

3.4.4. System Description

General

Based on the geographic setting of the irrigable area with respect to the Firi Kebso Spring, the command area for this Project is divided into in to two main canal, one secondary canal and two tertiary canals. The first Main canals comprises a total of 15.15 ha land while the second Main Canals comprises a total of 15.28 ha.

Irrigation Sub-System.

Secondary Command Units:-The entire command area at Firi Kebso Irrigation Projects supplied with irrigation water by a main conveyor canal designated as FKMC and starts at the Intake of Springs. The main canal is designed for **24 hrs** contentious supply.

Based on the geographic setting of the command area, is divided into one secondary command units and field command units. Each of the secondary canals and field canals will take off from the main canal to convey water to subsequent tertiary canals and command area.

Tertiary Command Units;-To facilitate a systematic classification for design and management purposes each secondary command unit is sub divided into tertiary command units. Each tertiary command unit will be a self-contained irrigation sub-system within the secondary command unit it is found in. Based on social aspects, topography, occurrence of natural drains and size of irrigable area one secondary command units and field command units are defined.

Unless situation dictates, each of the secondary command units will be supplied with irrigation water via one secondary canal, which takes off from main canal. As a result the designation of the secondary command units will be similar to the secondary canal they are supplied from.

Further, each secondary system is sub-divided into tertiary units as the case may be. Based on the above approach within the one secondary units, there are 2 tertiary command units are defied.

Drainage Sub-System

Drainage System;-Drainage system protects the Irrigation system such as secondary, tertiary, field canals, and irrigation land from damage, which would result from uncontrolled excess flow of irrigation water and surface runoff caused due to rainfall. Rainwater and excess irrigation water must be controlled to prevent erosion and damage of the irrigation system and the land. Rainwater and excess irrigation water should be removed safely from the irrigation land by different drainage systems. Lastly, the collected drainage water should enter the natural drainage system

To evacuate excess irrigation water and rainfall runoff a network of drainage channels are provided. At field and tertiary level, the designation, arrangement and layout of the present drainage system more or less follows the designation, arrangement and layout of the irrigation system. As each secondary command unit is a self-contained system, the higher level drainage canal that exists in the system in this project is collector drain. In addition, the system comprises tertiary drain and field drains. Based on the above argument the drainage system is divided in to two(2) collector drain units, two (2) tertiary drainage units and five (5) field drainage units.

3.4.5. Road/Access Sub-System

Road System

The present irrigation area is provided with a network of road systems. While the main road which runs parallel to the main canal and serves as a major artery to connect the project area with the nearest Road. In this study the various types of roads within the project areas is dealt with.

The following types of roads are defined for the present system:

Secondary Roads: Secondary roads will run parallel to secondary irrigation canals and will connect tertiary Roads with the main road. Connecting roads will have 4m(2m c/c) width and 0.4m tickness.

Main Road: Main roads run alongside the main canal and are meant to link the connecting roads with the nearest national highway around 8m width. While their entire width is formed from compacted earth fill sub-base, 4m of their width will be surfaced with road base material (gravel).

4. DESIGN OF ONFARM STRUCTERE

4.1. Irrigation Design Duties

The duties for design canals are based on peak crop water demand, cropping pattern, crop intensities and canal efficiencies. The design duty for 24hrs from agronomy report **0.92**/s/ha. The design duties of all canals are calculated in the table below for 12 and 24 hour period.

Table 4. Irrigation Duties Calculations

Dry-season Duty

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. Tomato	125.5	90.7	0	0	0	0	0	0	0	49.5	86	121.8
2. Onion	23.4	0	0	0	0	0	0	0	0	60.8	105	113.7
3. Pepper	112.8	38.4	0	0	0	0	0	0	0	44.4	78.9	110.6
4. Sweet Potato	128	92.7	14.1	0	0	0	0	0	0	24.9	95.9	130.9
Net scheme irr.req.												
in mm/day	3.1	2	0.1	0	0	0	0	0	0	1.5	3	3.8
in mm/month	97.3	55.4	2.8	0	0	0	0	0	0	46.1	91	118.8
in l/s/ha	0.36	0.23	0.01	0	0	0	0	0	0	0.17	0.35	0.44
Irrigated area (% of total area)	100	75	20	0	0	0	0	0	0	100	100	100
Irr.req. for actual area (l/s/ha)	0.36	0.31	0.05	0	0	0	0	0	0	0.17	0.35	0.44
Project Efficiency	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Project Duty (l/s/ha)	0.75	0.65	0.10	-	-	-	-	-	-	0.35	0.73	**0.92**
Application Time = 24hrs												

The derivation of canal and off take duties below is based on the assumption that within small holding sectors that the crop rotations are distributed equally within a sector, and equally within an irrigation block. This assumption forms the basis for determination of the cumulative peak irrigation demand and therefore peak duties for canal design.

4.2. Analysis of Demand of Spring Water

Demand of spring water in general need to determine the amount of water required for irrigation, drinking water, livestock and domestics and losses. Based on the monthly potential evapotranspiration determined in Hydrology and estimated monthly crop water requirement in Agronomy part we need to compute monthly water balance in consideration of the above consumption rates.

Domestic and livestock water requirements can be estimated using the expression:

V_d=N*q*t ……...…… (1)

Where, V_d = Volume of water required for domestic purposes (liters or m^3)

N= Number of people and livestock (Number)

q = Daily water consumption (lpcd)

t = Number of days for water consumption (days)

Usually, twenty percent of the above estimated water demand is considered as various losses, consequently,

Total water demand = Total Irrigation req't + Total domestic water req't + 20% for loss ….. (2)

To estimate projected population after base year, P_o:

$$P_n = P_0\left(1+\frac{r}{100}\right)^n \quad \text{…….. (3)}$$

Where, P_0 = Initial or base year population (Nr)

P_n= Projected population after n decades (Nr)

r = Growth rate (%)

n=Number of years

Table 5. Demand analysis and Storage Requirements

Population Forecast and Demand Analysis

SN	Description	Unit	2012	2017	2022	2027	2032
1	Population to be served						
1.1	Rural Population(let)	Nr	2,000	2,000	2,000	2,000	2,000
1.2	Livestock Population(LET)	Nr	1,500	1,500	1,500	1,500	1,500
	Sub Total		3,500	3,500	3,500	3,500	3,500
2	Demand						
2.1	Rural Domestic demand	m^3/d	40	40	46	46	50
2.2	Institutional water demand	m^3/d	6	6	7	7	8
2.3	Public Demand	m^3/d	1	1	1	1	2
2.4	Livestock Demand	m^3/d	18	18	18	18	18
	Sub Total of daily demand	m^3/d	65	65	72	72	77
2.5	Unexpected d/s release	m^3/d	7	7	7	7	8
	Total average daily demand	m^3/d	72	72	80	80	85
		l/s	*0.8*	*0.8*	*0.9*	*0.9*	*1*
2.7	Average per capita demand	l/c/d	20	20	23	23	24
2.8	Maximum daily factor		1.25	1.25	1.2	1.2	1.2
2.9	Maximum daily demand	m^3/d	90	90	95	95	102
2.1	*Maximum daily flow*	*l/s*	*1*	*1*	*1.1*	*1.1*	*1.2*
2.11	Peak hour factor		1.9	1.9	1.7	1.7	1.7
2.12	*Overall Peak hour Demand*	*l/s*	*2*	*2*	*1.9*	*1.9*	*2*

Storage Requriments(m3)

	Table: Demand and Water Balance Analysis (Mm^3/Month)														
SN	Demand & Supply	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg	Annual
1	Nr. of Days in a Month	31	28	31	30	31	30	31	31	30	31	30	31		
2	Domestic														
2.1	Institutional														
2.2	Public														
2.3	Livestock														
2.4	D/s release														
Sub total of Peak demand other than irr. (Mm3)		0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.06
3	Spring supply (base flow, Mm3)	0.080	0.073	0.080	0.078	0.080	0.078	0.080	0.080	0.078	0.080	0.078	0.080	0.079	0.95
4	Water available for irr. (Mm3)	0.075	0.068	0.075	0.073	0.075	0.073	0.075	0.075	0.073	0.075	0.073	0.075	0.074	0.88
5	∴ Taking 75% for irrigation	0.056	0.051	0.056	0.054	0.056	0.054	0.056	0.056	0.054	0.056	0.054	0.056	0.055	0.66
6	or in (l/s)	21.0	19.0	21.0	20.3	21.0	20.3	21.0	21.0	20.3	21.0	20.3	21.0	20.6	0.021
7	Duty (l/s/ha for 24hr)	0.75	0.65	0.10	-	-	-	-	-	-	0.35	0.73	0.92		
8	%Area to be irrigated	100	75	20	0	0	0	0	0	0	100	100	100		
9	Actual Area, (ha)	82	62	16	0	0	0	0	0	0	82	82	82		
10	Irr. Demand, Q (m3/s)	0.06	0.04	0.00	-	-	-	-	-	-	0.03	0.06	0.08		
11	Total Demand (Mm3)	0.17	0.101	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08	0.16	0.21		0.77
12	Water Budget (Mm3)	-0.114	-0.050	0.046	0.049	0.051	0.049	0.051	0.051	0.049	-0.027	-0.106	-0.151		-0.103

4.3. Irrigation System Design

4.3.1. General

The design of irrigation canals is mainly concerned with the adoption of proper canal geometry to accommodate the design discharge within the specified limits and at the same time to allow gravitational flow of irrigation water to farm fields. This situation will call the close scrutiny of the farm fields which are to be irrigated as the level of the farm field is the major parameter that would influence the relative vertical positioning of irrigation canals in the system.

Prior to the design of the longitudinal profile of irrigation canals it would be necessary to define the design flow in each irrigation canal and to proportion the geometric parameters of the canal in such a way that it is capable to carry the design flow within acceptable tolerances.

In design of irrigation canals, Plan and Profile Sheets for Excel Calculation is provides the drawing sheet of strip topo map along with respective profile, for instance

- Discharge design of command area
- Hydraulic design >>>>>>.
- D e s i g n of profile.
- Structural design for: •culvert , Drops, Division box, Off take & Outfall for drainage

4.3.2. Canal Geometry Design

To proportion the geometric dimensions of all irrigation canals Manning method is employed. To solve the resulting equation in terms of the canal bed width and depth of flow a bed width depth of flow ratio (b:d) of 1:0 to 1:5 is used.

$Q = 1/n [R^{2/3} S^{1/2}]*A$

Where; Q= discharge (m3/s)

n= Manning's Roughness coefficient

R= Hydraulic radius

S= Bed slope

A= Area (m2)

4.3.3. Manning's Roughness Coefficient

The roughness coefficient recommended by USBR design standard No. 3 is used to derive the roughness coefficients to be used in the present project. USBR recommends a value of n of 0.025 for earthen canals.

Table 6. Recommended value of roughness coefficient for Lined & unlined canals.

Canal	**Lining**	**Standard "n"**
Main	lined	0.014
Secondary	Unlined	0.025
Tertiary	Unlined	0.025

Permissible Velocity

The limiting velocity (non erodible velocity)in canals is recommended and are shown in **Error! Reference source not found.**

Recommended value of permissible velocity

Discharge	**Velocity**
0-0.15	**0.25-0.30**
0.15-0.3	0.30-0.35
0.4-0.50	0.40-0.45

Note: For heavy clay earth canals, the velocity may be increased up to a maximum of 200%

- *Firi qebso required discharge(0.03m^3/s) is fall b/n0-0.15m^3/s*

4.3.4. Canal geometric design and Flow Profile Computation for Irrigation Canals

2.3.4.1 Main Canal

The main canal is off-taking directly from the spring (division box prepared) and aligned at both side of the spring and irrigating 30.43 net hectares by in taking from the spring 0.028m^3/s for 24 hour continuous flow. According to geological report, the main canal is lined with masonry at the side and concrete at the base, starting from Intake up to end. The total length of the both main canal is about 1.92km. They are crossed natural drainage at different places and have 15 off taking canals at different location including secondary and field canal. The canal geometric design results for irrigation canals including related hydraulic particulars such as design discharge, flow depth, velocity etc. are given in the standard longitudinal profile drawings of canal. Table below gives flow capacities and canal geometric parameters.

Table 7. flow Capacity and geometry parameter for main canal

Feeder canal	**W.D**	**C.B.W**	**Top width**	**Wetted X^n, A**	**Wetted Perimtr, P**	**Hydr Rad, R**	**n**	**S**	**Velocity**	**FB**	**Q_{cal}**	**Q_{act}**
	m	**m**	**m**	**m2**	**m**	**m**		**m/m**	**m**	**m/s**	**m3/s**	**m3/s**
FK_MC-1	**0.16**	**0.320**	**0.32**	**0.0512**	**0.64**	**0.08**	**0.03**	**0.0050**	**0.53**	0.25	**0.027**	**0.023**
Reach-2	0.16	0.32	0.32	0.05	0.64	0.08	0.0140	0.0015	0.51	0.25	0.03	0.02
Reach-3	0.16	0.32	0.32	0.05	0.64	0.08	0.0140	0.0015	0.51	0.25	0.03	0.01
Reach-4	0.16	0.32	0.32	0.05	0.64	0.08	0.0140	0.0015	0.51	0.25	0.026	0.00
Reach-5	0.16	0.32	0.32	0.05	0.64	0.08	0.0140	0.0015	0.51	0.25	0.026	0.01
Reach-6	0.15	0.30	0.30	0.05	0.60	0.08	0.014	0.0020	0.57	0.25	0.026	0.006
Reach-7	0.15	0.30	0.30	0.05	0.60	0.08	0.014	0.0020	0.57	0.25	0.026	0.002
Reach-8	0.15	0.30	0.30	0.05	0.60	0.08	0.014	0.0020	0.57	0.25	0.026	0.001
Reach-9	0.15	0.30	0.30	0.05	0.60	0.08	0.014	0.0020	0.57	0.25	0.026	0.002
Reach-10	0.15	0.30	0.30	0.05	0.60	0.08	0.014	0.0020	0.57	0.25	0.026	0.003
FK_MC_2	**0.16**	**0.32**	**0.32**	**0.0768**	**0.64**	**0.12**	**0.014**	**0.0010**	**0.55**	0.25	**0.042**	**0.024**
Reach-2	0.16	0.32	0.32	0.08	0.64	0.12	0.0140	0.0010	0.55	0.25	0.04	0.018
Reach-3	0.16	0.32	0.32	0.08	0.64	0.12	0.0140	0.0010	0.55	0.25	0.04	0.016
Reach-4	0.16	0.32	0.32	0.08	0.64	0.12	0.0140	0.0010	0.55	0.25	0.04	0.013
Reach-5	0.16	0.32	0.32	0.08	0.64	0.12	0.0140	0.0010	0.55	0.25	0.04	0.009
Reach-6	0.16	0.32	0.32	0.08	0.64	0.12	0.0140	0.0010	0.55	0.25	0.04	0.004
Reach-7	0.16	0.32	0.32	0.08	0.64	0.12	0.0140	0.0010	0.55	0.25	0.04	0.004
Reach-6	0.15	0.30	0.30	0.07	0.60	0.11	0.014	0.0010	0.53	0.25	0.036	0.004
Reach-7	0.15	0.30	0.30	0.07	0.60	0.11	0.014	0.0010	0.53	0.25	0.036	0.005

Secondary Canals

Generally, secondary canals will flow for 24hr/day and flow will be distributed down each tertiary canal in proportion to the area they irrigate. Secondary canals run down the natural slope. There are three secondary canals are designed for Firi Kebso small scale irrigation project. All secondary canals are earthen canals aligned across the contours. The canal geometric design results for irrigation canals including related hydraulic particulars such as design discharge, flow depth, velocity etc. are given in the standard longitudinal profile drawings of each irrigation canal. Table below gives flow capacities and canal geometric parameters for sample secondary canals.

Table 8. flow capacity and Geometric Parameter for Secondary canal

Feeder canal	**W.D**	**C.B.W**	**Top width**	**Wetted X^n, A**	**Wetted Perimtr, P**	**Hydr Rad, R**	**n**	**S**	**Velocity**	**FB**	**Q_{cal}**	**Q_{act}**
	m	**m**	**m**	**m2**	**m**	**m**		**m/m**	**m**	**m/s**	**m3/s**	**m3/s**
FK_SC-1-1	**0.15**	**0.30**	**0.60**	**0.0675**	**0.72**	**0.09**	**0.025**	**0.0015**	**0.32**	0.20	**0.021**	**0.007**
Reach-1	0.15	0.30	0.60	0.07	0.72	0.09	0.0300	0.0015	0.27	0.20	0.02	0.002
Reach-2	0.15	0.30	0.60	0.07	0.72	0.09	0.0300	0.0015	0.27	0.20	0.02	0.005

Flow Regime

Secondary canals comparatively run down steep slopes or along the ridge and in most cases the flow regime in secondary canals is supercritical. To avoid the prevalence of super-critical flow in secondary canals it was inevitable to provide drop structures where conditions permit.

Tertiary Canals

Tertiary canals will also flow for 12hr/day and flow will be distributed down each off-taking field canals in proportion to the area they irrigate. The command area of each tertiary canal is in the order of blocked hectares, on average and discharging capacity is also depending on the area of the block. The canals are earthen open channels, which are generally laid along the contours. The canal geometric design results for irrigation canals including related hydraulic particulars such as design discharge, flow depth, velocity etc. are given in the standard longitudinal profile drawings of each irrigation canal. Table below gives flow capacities and canal geometric parameters for representative canals.

Table 9. flow Capacity and Geometric parameter of Tertiary canal

Feeder canal	W.D	C.B.W	Top width	Wetted X^n, A	Wetted Perimtr, P	Hydr Rad, R	n	S	Velocity	FB	Q_{cal}	Q_{act}
	m	m	m	m2	m	m		m/m	m	m/s	m3/s	m3/s
FK_TC-1-1-1	**0.15**	**0.30**	**0.60**	**0.0675**	**0.72**	**0.09**	**0.025**	**0.0012**	**0.28**	0.20	**0.019**	**0.002**
Reach-1	0.15	0.30	0.60	0.07	0.72	0.09	0.0250	0.0012	0.28	0.20	0.02	0.002
FK_TC-1-1-2	**0.15**	**0.30**	**0.60**	**0.0675**	**0.72**	**0.09**	**0.025**	**0.0012**	**0.28**	0.20	**0.019**	**0.005**
Reach-1	0.15	0.30	0.60	0.07	0.72	0.09	0.0250	0.0012	0.28	0.20	0.02	0.002
Reach-2	0.15	0.30	0.60	0.07	0.72	0.09	0.0250	0.0012	0.28	0.20	0.02	0.002
Reach-3	0.15	0.30	0.60	0.07	0.72	0.09	0.0250	0.0012	0.28	0.20	0.02	0.001

Flow Regimes

As tertiary canals are aligned nearly along contours in most cases the flow regime in tertiary canals will be sub-critical and therefore the number of drops are decreased.

1.7.2.4 Field Canals

The command area of tertiary canal will be divided in to sub blocks/fields depend on the topography. The maximum length of field canals are 200 m and the maximum furrow length is about 100m.The field channels which are earthen open channels will takeoff water from tertiary canal(incase main canal). The alignment of the field canals are across the contour on the ridge so that it can supply furrows on both sides.

5. IRRIGATION INFRASTRUCTURES

5.1. General

The selection and design of irrigation infrastructures is primarily dictated by various factors among which are economy, safety and ease of operation and maintenance. By and large the following factors were considered to select the required structure in the present system:

- Operation and maintenance of the structures should be simple
- Experience obtained from on-going similar construction work in the area was considered
- The structures were evaluated from safety perspectives, such that the system be safe from unforeseen damages
- Availability of construction material in the vicinity of the project site was considered

5.2. Types of Irrigation Infrastructures

The type and nature of irrigation infrastructures that are adopted in the present system are varied. In general the irrigation infrastructures that are found in the present system are off takes, Division Box, Drops, culverts, flume and CD structure

Summary of infrastructure Structures.

Table 10. Summary of available Canal Structures

S.NO	Canal Name	DROP	CULVERT	OFFTAKE	D.box	NSP
1	FK MC-1-	6	3	8	---	1
2	FK_MC_2	---------	2	7	----	1
3	FK_SC-1-1	8	1	2	---	---
5	FK_TC-1-1-1	---	---	1	---	---
6	FK_TC-1-1-2	---	2	3	---	---
MC TOTAL		**6**	**11**	**15**	---	**2**
SC TOTAL		**8**	**1**	**2**	**1**	---
TC TOTAL		**---**	**2**	**4**	**0**	**0**

5.2.1. Off take Structures

The offtake structures are made simple pipe off takes with a suppressed rectangular inlet part followed by a rectangular bay at the pipe inlet and a masonry guide walls at the pipe outlet. All pipes are circular reinforced concrete pipes with standard dimensions. At the upstream end gates are provide to control the flow. All the dimensions are shown on typical drawing and Table below shows the hydraulic design. See detail table of dimension and quantity on excels sheet.

Table 11 . Canal Offtake Hydraulic Design

FK_TERTIARY CANAL OFFTAKE													
No	Supply canal	Offtaking Canal	Chainage (m)	Parent canal FSL	Parent canal depth	Offtake CBL	Offtake FSL	Offtake canal depth	Qd (m^3/s)	Coeff. Q Cd	Headloss (m)	Pipe intake Diameter.(D)	Selected Pipe Diameter
1	FK MC_1	Branch(FC-1-1)	40.44	1618.50	0.20	1618.31	1618.35	0.15	0.0407	0.6	0.15	0.25	0.3
2	FK MC_1	Branch(SC-1-1)	161.73	1618.30	0.18	1617.49	1617.65	0.16	0.0310	0.6	0.65	0.15	0.3
3	FK MC_1	Branch(FC-1-2)	170.08	1618.29	0.18	1617.99	1618.14	0.15	0.0294	0.6	0.15	0.20	0.3
4	FK MC_1	FK_FC-1-3	430.27	1610.66	0.17	1610.36	1610.51	0.15	0.0238	0.6	0.15	0.20	0.3
5	FK MC_1	FK_FC-1-4	635.76	1604.24	0.16	1603.94	1604.09	0.15	0.0221	0.6	0.15	0.20	0.3
6	FK MC_1	FK_FC-1-5	642.52	1604.23	0.16	1603.93	1604.08	0.15	0.0206	0.6	0.15	0.20	0.3
7	FK MC_1	FK_FC-1-6	728.03	1604.06	0.16	1603.76	1603.91	0.15	0.0190	0.6	0.15	0.20	0.3
8	FK MC_1	FK_FC-1-7	952.88	1603.61	0.16	1603.31	1603.46	0.15	0.0174	0.6	0.15	0.15	0.3
9	FK MC_1	FK_SC-1-2	961.19	1603.58	0.15	1603.13	1603.28	0.15	0.0108	0.6	0.30	0.10	0.3
10	FK_MC_2	Branch(FC-2-1)	168.95	1618.63	0.16	1618.13	1618.28	0.15	0.0386	0.6	0.35	0.20	0.3
11	FK_MC_2	Branch(FC-2-2)	339.57	1618.46	0.16	1617.96	1618.11	0.15	0.0363	0.6	0.35	0.20	0.3
12	FK_MC_2	Branch(FC-2-3)	348.13	1618.44	0.15	1617.94	1618.09	0.15	0.0332	0.6	0.35	0.20	0.3
13	FK_MC_2	Branch(FC-2-4)	519.33	1618.27	0.15	1617.32	1617.47	0.15	0.0295	0.6	0.80	0.15	0.3
14	FK_MC_2	Branch(FC-2-5)	601.10	1618.19	0.15	1617.04	1617.19	0.15	0.0248	0.6	1.00	0.15	0.3
15	FK_MC_2	FK_FC-2-6	754.19	1616.06	0.15	1615.81	1615.96	0.15	0.0210	0.6	0.10	0.20	0.3
16	FK_MC_2	FK_FC-2-7	969.45	1615.84	0.15	1615.54	1615.69	0.15	0.0166	0.6	0.15	0.15	0.3
17	FK_SC-1-1	Branch(TC-1-1-1)	3.17	1617.49	0.16	1617.18	1617.33	0.15	0.0143	0.6	0.16	0.15	0.3
18	FK_SC-1-1	FK_TC-1-1-2	148.88	1603.09	0.16	1602.78	1602.93	0.15	0.0098	0.6	0.17	0.15	0.3

5.2.2. Drop Structures

The economical drop size is designed on Firi Kebso small scale irrigation project. Since secondary canals are aligned across the contour, the numbers of drops are increased. Typical drawing is prepared with table of dimensions. Table below shows the hydraulic design of all drops

Table 12. Canal Drops Hydraulic Design and Table of Dimension

FIRI KEBSO MC & SC Drop structure

Canal	**Chanage**	h (Drop)	Q	$Q^{1/2}$	V	V^2	b (canal)	d (flow)	$d^{3/2}$	He	$(h*He)^{1/2}$	L (Stilling basin)	B (Stilling Basin)	x (Cistern height)
FK MC-1	80	1.50	0.026	0.162	0.51	0.264	0.32	0.16	0.064	0.173	0.490	2.45	0.32	0.10
FK MC-1	380	1.75	0.026	0.160	0.57	0.323	0.30	0.15	0.058	0.166	0.512	2.56	0.30	0.20
FK MC-1	400	2.00	0.026	0.160	0.57	0.323	0.30	0.15	0.058	0.166	0.548	2.74	0.30	0.20
FK MC-1	440	2.00	0.026	0.160	0.57	0.323	0.30	0.15	0.058	0.166	0.548	2.74	0.30	0.20
FK MC-1	460	1.75	0.026	0.160	0.57	0.323	0.30	0.15	0.058	0.166	0.512	2.56	0.30	0.20
FK MC-1	480	1.50	0.026	0.160	0.57	0.323	0.30	0.15	0.058	0.166	0.474	2.37	0.30	0.10
FKSC_1_1	10	1.75	0.018	0.136	0.27	0.074	0.30	0.15	0.058	0.154	0.512	2.56	0.30	0.20
FKSC_1_1	50	1.50	0.018	0.136	0.27	0.074	0.30	0.15	0.058	0.154	0.474	2.37	0.30	0.10
FKSC_1_1	60	2.00	0.018	0.136	0.27	0.074	0.30	0.15	0.058	0.154	0.548	2.74	0.30	0.20
FKSC_1_1	70	2.00	0.018	0.136	0.27	0.074	0.30	0.15	0.058	0.154	0.548	2.74	0.30	0.20
FKSC_1_1	89	2.00	0.018	0.136	0.27	0.074	0.30	0.15	0.058	0.154	0.548	2.74	0.30	0.20
FKSC_1_1	100	2.00	0.018	0.136	0.27	0.074	0.30	0.15	0.058	0.154	0.548	2.74	0.30	0.20
FKSC_1_1	110	1.75	0.018	0.136	0.27	0.074	0.30	0.15	0.058	0.154	0.512	2.56	0.30	0.20
FKSC_1_1	120	1.50	0.018	0.136	0.27	0.074	0.30	0.15	0.058	0.154	0.474	2.37	0.30	0.10

5.2.1. Road Crossing Pipe culvert

Pipe culvert is used where canals crosses the road. Typical drawing is also prepared with table of dimensions. Table below shows the hydraulic design of all pipe culvert.

Table 13 . Hydraulic Design, Transition and table of dimension of Box Culvert

Hydraulic design of the box par															
Canal	**Chainage (m)**	**L (m)**	**n**	**v_2** (m/sec)	**d (m)**	B (m)	**A (m^2)**	**P (m)**	**R (m)**	**b/d**	**Fr**	**cond.**	**hf (m)**	**I (%)**	**D (m)**
FK MC-1	**166.04**	6	0.014	0.69	0.32	0.16	0.05	0.8	0.06	0.50	0.55	ok!	0.0218	0.363	0.570
FK MC-1	**639.15**	6	0.014	1.33	0.30	0.15	0.05	0.8	0.06	0.50	1.09	ok!	0.0881	1.468	0.550
FK MC-1	**724.21**	6	0.014	1.33	0.30	0.15	0.05	0.8	0.06	0.50	1.09	ok!	0.0881	1.468	0.550
FK MC-2	**343.63**	6	0.014	0.42	0.32	0.16	0.05	0.8	0.06	0.50	0.33	ok!	0.0081	0.135	0.570
FK MC-2	**523.64**	6	0.014	0.35	0.32	0.16	0.05	0.8	0.06	0.50	0.28	ok!	0.0057	0.095	0.450
FKSC-1-1	**144.77**	6	0.014	0.74	0.30	0.15	0.05	0.8	0.06	0.50	0.61	ok!	0.0271	0.451	0.400
FKTC-1-1-2	**165.28**	6	0.014	0.36	0.30	0.15	0.05	0.8	0.06	0.50	0.29	ok!	0.0063	0.106	0.400
FKTC-1-1-2	**239.16**	6	0.014	0.36	0.30	0.15	0.05	0.8	0.06	0.50	0.29	ok!	0.0063	0.106	0.000

FK-TABEL OF DIMENSION FOR BOX CULVERT

No	**Canal**	**Chainage (m)**	**U/S CBL**	**D/S CBL**	**Q (m^3/sec)**	**v (m/s)**	**b (m)**	**d (m)**	**fb (m)**	**D (m)**	**L (m)**
1	FK MC-1	166.04	1618.11	1618.10	0.035	0.55	0.16	0.32	0.25	0.57	6
2	FK MC-1	639.15	1604.07	1603.96	0.060	0.57	0.15	0.30	0.25	0.55	6
3	FK MC-1	724.21	1603.90	1603.79	0.060	0.54	0.15	0.30	0.25	0.55	6
8	FK MC-2	343.63	1618.30	1618.30	0.021	0.42	0.16	0.32	0.25	0.57	6
9	FK MC-2	523.64	1618.12	1618.12	0.018	0.40	0.16	0.32	0.25	0.57	6
12	FKSC-1-1	144.77	1603.10	1603.06	0.033	0.32	0.15	0.30	0.25	0.55	6
16	FKTC-1-1-2	165.28	1602.58	1602.57	0.016	0.24	0.15	0.30	0.25	0.55	6
17	FKTC-1-1-2	239.16	1602.49	1602.48	0.016	0.24	0.15	0.30	0.25	0.55	6

In let open transition					Outlet open transition				
Canal	**Chainage (m)**	**Invert Elevation Cut Of Transition**	**Water Surface Elevation Cut of transition**	**Invert Elevation Flume In let**	**Invert Elevation Flume Out let**	**Invert Elevation Cut Of Transition**	THL(m)	HT(m)	Condition
FK MC-1	***166.04***	1618.11	1618.43	1618.10	1618.08	1618.08	0.03	0.03	ok!
FK MC-1	***639.15***	1604.07	1604.37	1603.96	1603.88	1603.90	0.18	0.18	ok!
FK MC-1	***724.21***	1603.90	1604.20	1603.79	1603.70	1603.73	0.18	0.18	ok!
FK MC-2	***343.63***	1618.30	1618.62	1618.30	1618.29	1618.29	0.01	0.01	ok!
FK MC-2	***523.64***	1618.12	1618.44	1618.12	1618.12	1618.11	0.00	0.00	ok!
FKSC-1-1	***144.77***	1603.10	1603.40	1603.06	1603.04	1603.04	0.05	0.05	ok!
FKTC-1-1-2	***165.28***	1602.58	1602.88	1602.57	1602.56	1602.57	0.01	0.01	ok!
FKTC-1-1-2	***239.16***	1602.49	1602.79	1602.48	1602.48	1602.48	0.01	0.01	ok!

5.3. Night Storage (pond) Irrigation System & Operation of the Project

Night storage was constructed when drawing water directly from the source is failed to satisfy the consumer demand during extremely low flow. This problem is face Firi Kebso small scale project and irrigation will take place during 12 hours of the day light but the Main canal station will operate at constant flow, appropriate to the irrigation demand for the whole 24 hours period. During the night the night storage reservoir will be emptied and full again for 12hr.For the farm distribution the method adopted for the project is gravity type. This reservoir should have to be operated and regulated efficiently by experts. See the following design sample procedure figure and table of pond.

5.3.1. Design of night storage

Night storage ponds designed on ***main canals*** for storing minimum discharge from source and due to deficiency of water supply (fluctuation of demand and supply). During at night time spring supplies consistently 30 l/s (in January) for reservoir and irrigation water requirements of project for 12 hr is1.84 l/s/ha ,based on this value the volume water stored was determined to serve another command of area 16.2 ha. This storage pond designed at elevated location on both MC.

Carrying capacity of the Night storage, With the given irrigation duty of 1.84 l/s/ha for 12-hours, the volume of water required to be stored in the storage to irrigation the entire area (16.2ha) will be as follows.

Total volume required V=1.84 l/s/ha*16.2ha 12hr* 3600*s/hr=**1287.706 m^3**

Dimension of night storage:-To determine dimension of night storage, the following simple formula has been used.

Design procedure:- sample design for Night storage one(on MC_1 , see detail on excel)

Let B=13m Add free board of F_b = 0.50m and Dead storage = 0.2m

Gross Volume= (h/3) $[B^2+ (T^2) + (B*B2)^{0.5}]$ where

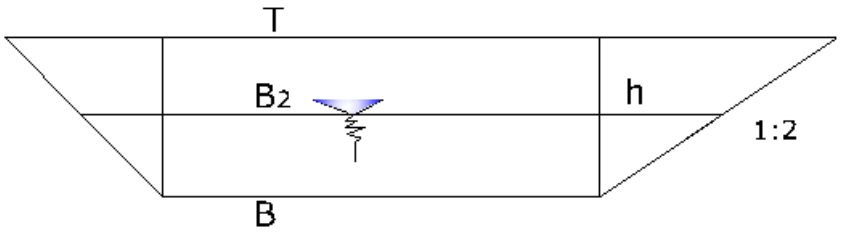
T = Top width= B+2*(2*(free board +useful storage + dead storage))

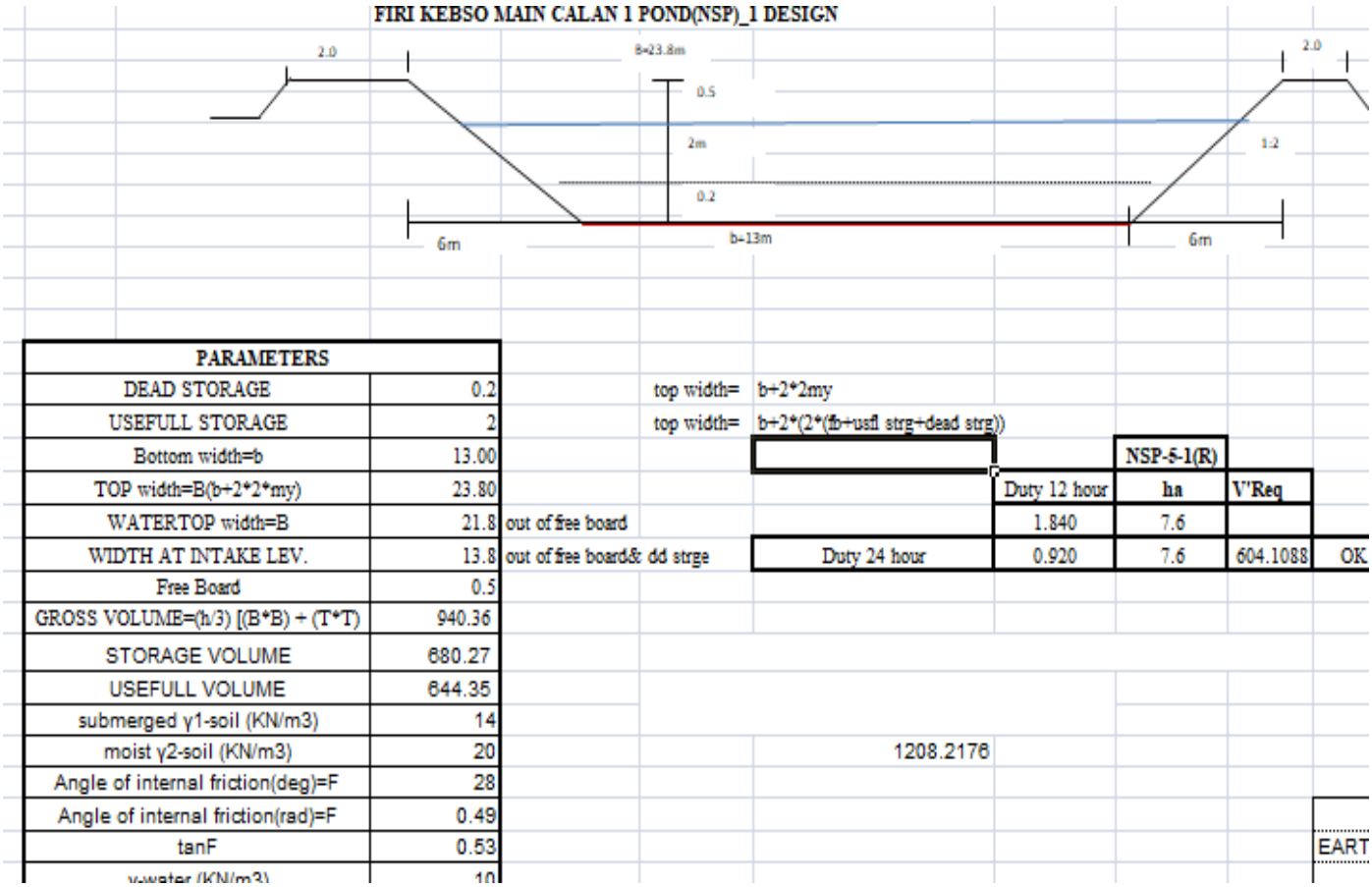
T=13+2*2(0.5+2+0.2) =23.8m and

B2 = B+2*(2*(useful storage + dead storage))= 13+2*2(0.5+2+0.2)=21.8

Therefore the value of h calculated from 680.27 m3=h/3$(13^2+23.8^2)+(13^2+21.8^2)\wedge^{0.5}$
By trial and error h≈ 2m

Useful Volume= (h/3) $[B^2+ (B_2^2) + (B*B2)^{0.5}]$
=2/3*$[13^2+21.8^2+(13^2+21.8^2)\wedge^{0.5}]$
=644.35m^3



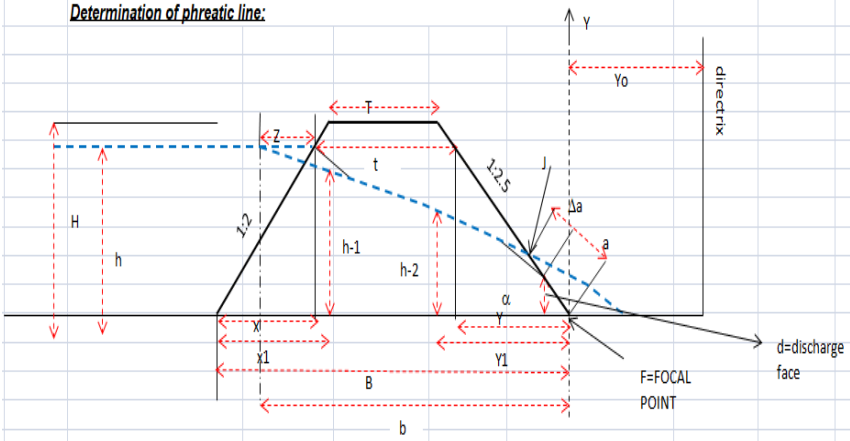


PARAMETERS								
DEAD STORAGE	0.2		top width=	b+2*2my				
USEFULL STORAGE	2		top width=	b+2*(2*(fb+usfl strg+dead strg))				
Bottom width=b	13.00					NSP-5-1(R)		
TOP width=B(b+2*2*my)	23.80				Duty 12 hour	ha	V'Req	
WATERTOP width=B	21.8	out of free board			1.840	7.6		
WIDTH AT INTAKE LEV.	13.8	out of free board& dd strge		Duty 24 hour	0.920	7.6	604.1088	OK
Free Board	0.5							
GROSS VOLUME=(h/3) [(B*B) + (T*T)	940.36							
STORAGE VOLUME	680.27							
USEFULL VOLUME	644.35							
submerged γ1-soil (KN/m3)	14							
moist γ2-soil (KN/m3)	20			1208.2176				
Angle of internal friction(deg)=F	28							
Angle of internal friction(rad)=F	0.49							
tanF	0.53							EART
γ-water (KN/m3)	10							

Figure 6. Pond dimension drawing

Geometry of the pond	
The total water depth in the pond is taken to be	2.2
Spill way height	0.5
Total pond depth	2.7
The bottom is 50m by50m and the top is 62m by 62m	
pond center design bed elevation	1615.68
Pond inlet design bed elevation	1617.88

Determination of phreatic line:



PARAMETERS	
H	2.7
h	2.2
X1	5.4
Y1	6.8
X	4.4
Y	5.5
T	3.0
B	15.2
t	5.3
Z	1.6
b=Z+t+y	12.4
tana=h/y	0.4
cosa	0.8
sina	0.6
a	33.7
yo = (h^2+b^2)^0.5- b	0.2
Area=(B+T)/2*H	24.5
For a=33.67,Da/(Da+a)=C	0.4
D a+a = yo/1-cos a	1.2
Da=C*(a+Da)	0.4
a	0.7
d=sina*a	0.4

OVER ALL STABLITY	
Equation Of phreatic line,$Y=(2xyo+yo^2)^{0.5}$	
$\rightarrow Y=(0.48X+yo^2)^{0.5}$	
At Y=h-2,x=	6.8
At Y=h-1,x=	9.8
$h\text{-}2=(0.48X+yo^2)^{0.5}$	1.6
$h\text{-}1=(0.48X+yo^2)^{0.8}$	2.0
weighted unit wt of soil is given by: ys = (y1h1+ y2(H-h1))/H	15.7
Resisting Force=ys*Area*tana, a is angle of int. friciction(KN/m)	203.8
Water pressure = $\gamma_w h^2/2$ (KN/m)	24.2
Available factor of safety =Resisting/water pressure	8.4
OK	

	Hgl	**1615.61**			
	Hbl	**1615.68**			
	Htl	**1618.38**			
		Hc(m)	Hf(m)	La(m)	V(m³)
EARTH V	CUT V	0.00		13.0	0
	FILL V		2.77	56	9585
		Ls(m)	La(m)		W(m²)
GEOMEM	area	5.59	20.4		1264.55
OUTLET	D(m)	B1(m)	L1(m)	b1(m)	
	0.4	2.4	6.0	1.0	
INLET	h(m)		Vb(m³)	Vw(m³)	V(m³)
-MASONI	0.35		3.15	2.20	5.35
-STONE PITCHING					1.00
OUTLET			Vb(m³)	Vw(m³)	V(m³)
-MASONRY			11.86	14.33	26.20
-STONE PITCHING					0.93
					V(m³)
MASONRY SUM					31.55
STONE PITCHING SUM					1.93
LEAN CONCRETE					0.51
CONCRETE(C-15)					0.50

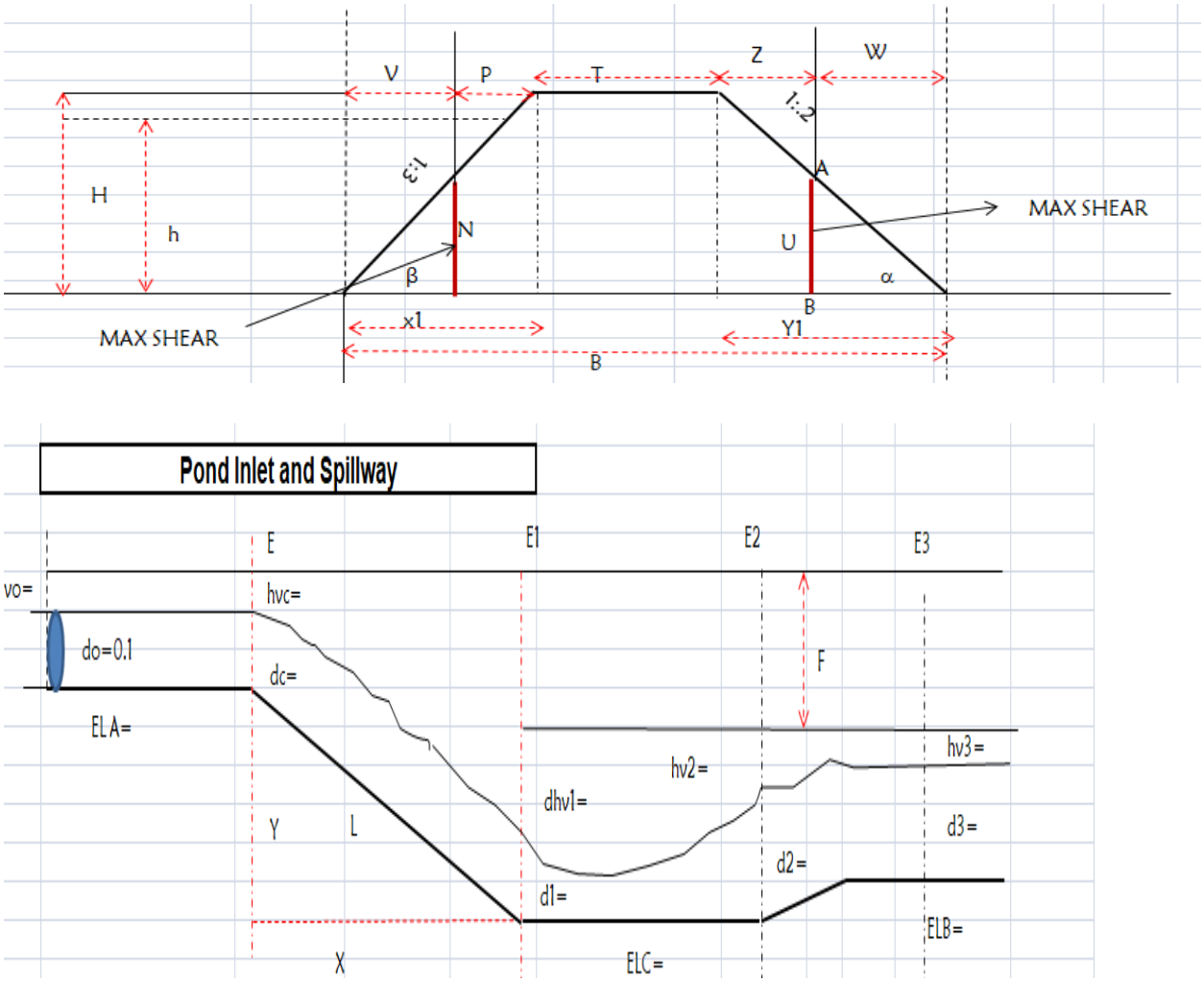


Figure 7. Night storage pond inlet and spillway Design sample

Table 14. Stability analysis of night storage.

STABLITY OF D/S SLOPE	
y1	6.75
Max.shear occurs at 0.4 *Y-1=Z	2.70
W=Y1-Z	4.05
45-F(in degrees)	31.00
45-F(in radians)	0.54
tan (45-F)	0.60
Total horizontal force= Hd = $(\gamma s H^2 \tan^2(45\text{-}F)/2)\text{-}\gamma w h1^2/2$	39.69
Resisting force due to internal friction and cohesion=Rd = Wd tan f + CY1	413.31
C = for clay fill material(KN/m2)	50.00

Wd=0.5*H*Y1*γs		142.66
Available factor of saftey=Rd/Hd>2	ok	10.41
According to the theory of elasticity maximum shear (tmax) is twice the average shear (tav).		
tmax = 2 tav = 2 (Hd/Y1) ----------KN		11.76
Shear strength by Mohr - Coulomb shear equation at shear plane AB=S=(gsU) tanf+C		63.48
U=W*tana		1.62
Factor of safety at point of maximum shear, F's=S/tmax>1.5	ok	5.40

STABLITY OF U/S SLOPE		
X1		5.40
Max.shear occurs at 0.4 *x-1=P		1.16
V=X1-P		4.24
45-F(in degrees)		45.00
45-F(in radians)		0.79
tan (45-F)		1.00
Total horizontal force= Hu = $(\gamma 1h^2 \tan^2(45\text{-}F)/2)\text{-}\gamma wh2^2/2$		47.12
Resisting force due to internal friction and cohesion=Ru= Wutan f + Cx1		324.23
C = for clay fill material(KN/m2)		50.00
Wu=0.5*H*x1*γ1		102.06
Available factor of safety=Ru/Hu>2	ok	6.88
According to the theory of elasticity maximum shear (tmax) is twice the average shear (tav).		
tmax = 2 tav = 2 (Hd/Y1) ----------KN		17.45
Shear strength by Mohr - Coulomb shear equation at shear plane AB=S=(g1U) tanf+C		65.77
tan β		0.50
N=V*tanβ		2.12
Factor of safety at point of maximum shear, F's=S/tmax>1.5	ok	3.77

Q(M3/s)	0.02630
Y	2.20
X	4.40
L	4.92
do	0.1
Vo	1
hVo	0.051
Width of notch=bc=0.734Q/$do^{2/3}$	0.090
use practical width of notvh=bc=	0.3
Unit discharge=q=Q/bc	0.08

Critical depth =dc=$(q^2/g)^{1/3}$	0.088
Critical velocity, vc=q/dc	0.931
Critical velocity head=hvc=vc2/2g	0.044
Water area at critical flow=Ac=bcxdc	0.028
Wetted perimeter=Pc=bc+2dc	0.497
Hydraulic radius=Rc	0.057
Water surface slope at critical flow =Ic=$((nVc)/(Rc^{2/3}))^2$	0.011
Roughness coefficient=n	0.017
Elevation of A=	1617.88
Elevation of B=	1,615.68
F=	2.20
Energy at Section-C=Ec=dc+hvc+F	2.33

5.3.2. Inlet structure of pond

Drawing of inlet Dimension and position is shown detailing on Tendering Drawing Documents, the value of excel part is shown bellow.

Table 15 inlet structure of pond

No	Canal	Chanage	h (Drop)	Q	$Q^{1/2}$	V (canal)	V^2	b (canal)	d (flow)	$d^{3/2}$	He	$(h*He)^{1/2}$	L (Stilling basin)	B (Stilling Basin)	a (Cistern height)	Bt	u/s FSL	u/s CBL	d/s CBL	cistern level
1	FK_MC-1	337.74	3.50	0.03	0.162	0.56	0.309	0.36	0.18	0.076	0.196	0.794	3.969	0.360	0.200	0.20	1618.03	1617.85	1614.35	1614.15
2	FK_MC_2	622.29	2.00	0.04	0.188	0.53	0.277	0.30	0.15	0.058	0.164	0.548	2.739	0.300	0.200	0.36	1618.17	1618.02	1616.02	1615.82

5.3.3. Coordinate and Dimension of storage pond.

Drawing of those Dimension and position is shown detailing on Tendering Drawing Documents, the value of excel part is shown bellow.

Table 16.Night storage pond excle calculation part

FK-DIMENTION OF POND INLET STRUCTURES

Iterms	Description	Flow	b	Y	L	L_{Sb}	B_{Sb}	a	E1	E2	E3	E4
		m^3/s	m	m	m	m	m	m	m	m	m	m
1	FK_MC_1 POND(NS)-1	0.03	0.32	2.21	4.92	0.60	0.30	0.01	1617.88	1615.38	1617.88	1615.67
2	FK_MC-2POND(NS)-1	0.04	0.32	2.30	4.92	1.00	0.40	0.10	1618.02	1615.52	1618.02	1615.72

DIMENTION OF POND OUTLET STRUCTURES

Iterms	Description	Flow	D	B1	L1	h1	b1	E5	E6	E7	E8	E9
		m^3/s	m	m	m	m	m	m	m	m	m	m
1	FK_MC_1 POND(NS)-1	0.04	0.18	0.78	1.17	0.17	0.34	1614.88	1614.13	1613.83	1614.51	1614.34
2	FK_MC-2POND(NS)-1	0.04	0.15	0.75	1.13	0.15	0.30	1615.02	1615.80	1615.50	1616.15	1616.00

COORDINATE OF NIGHT STORAGE PONDS FOR FIRI KEBSO

Iterms	Description	Point		A	B	C	D	E	F	G	H	I
1	_MC_1 POND(NS	X	m	752073.13	752053.13	752053.13	752073.13	752063.13	752050.94	752055.41	752064.087	752064.267
		Y	m	993246.10	993246.10	993226.10	993226.10	993236.10	993257.61	993246.10	993226.097	993220.922
2	_MC-2POND(NS	X	m	751915.68	751915.68	751897.68	751897.684	751906.68	751925.39	751915.69	751905.00	751890.44
		Y	m	994100.15	994118.15	994118.15	994100.147	994109.15	994100.49	994107.22	994110.09	994118.17

FK-1 DIMENTION OF NIGHT STORAGE PONDS

Area	Iterm	Description	Bottom	Bottom	Top	Top	Pond	Free Board	Max. Water	Dead	Live	Dead
			m	m	m	m	m	m	m	m	m^3	m^3
7.60	1	_MC_1 POND(N	20.00	20.00	32.00	32.00	3.00	0.50	2.50	0.50	680	36
7.60	2	_MC-2POND(NS	18.00	18.00	24.00	24.00	1.50	0.50	1.00	0.50	680	36

Command	Q_{act}	d	A	h_{min}	Q_{cal}	remark	H	B	L
ha	m3/s	m	m2	m	m3/s		m	m	m
7.6	0.03	0.18	0.03	1	0.07	Ok!	0.40	0.78	1.17
7.6	0.02	0.15	0.02	1	0.05	Ok!	0.35	0.75	1.13

5.4. Spill way

For this document Side Spillway is constructed on each Reservoir and at the end of both Main canal and Secondary canal, for effectively flashing of flood or surplus flow from upstream through the canal.

Table 17 .Dimension and Quantity of side spillway on Canal and NSP

DIMENSION AND LEVELS OF SIDE SPILLWAY STRUCTURE FOR FIRI KEBSO

№	CANAL NAME	STRUCTURE NAME	CH	LEVEL				S no.	FK_QUANTITY				
				(1)DB	(2)	(3)	(4)		Excavation	Back Fill	Masonry	Cement(C20)	Cemented Stone
			m	m	m	m	m		m3	m3	m3	m3	m3
1	FKMC-1	SIDE SPILLWAY - 1	952.88	1603.89	1604.14	1604.44	1603.49	1	0.00	1.12	3.42	1.02	4.98
2	FKMC-2	SIDE SPILLWAY - 2	969.45	1616.35	1616.60	1616.90	1615.95	2	0.00	1.12	3.42	1.02	4.98
3	FK SC-1-1	SIDE SPILLWAY - 3	148.88	1602.99	1603.24	1603.54	1602.59	3	0.00	0.78	3.42	1.02	4.98
								TOTAL	***0.00***	***3.02***	***10.26***	***3.06***	***14.95***

DIMENSION AND LEVELS OF EMERGENCY SPILLWAY STRUCTURE FOR FIRI QABSO SMALL IRRIGATION

№	NIGHT STORAGE POND NAME	STRUCTURE NAME	LEVEL				S no.	*FK -SIDE SPILLWAY QUANTITY*				
			(1)	(2)	(3)	(4)		Excavation	Back Fill	Masonry	Cement(C20)	Cemented Stone Pitching
			m	m	m	m		m3	m3	m3	m3	m3
1	MC_1 POND	*EMERGENCY SPILLWAY - 1*	1617.00	1619.50	1620.00	1616.50	1	0.00	88.00	20.16	4.14	5.58
2	MC_2 POND	*EMERGENCY SPILLWAY - 2*	1618.82	1621.32	1621.82	1618.32	2	0.00	88.00	20.16	4.14	5.58
						MC	TOTAL	**0.00**	**176.00**	**40.31**	**8.28**	**11.17**

6. PROJECT COST

The cost calculation of the project is based on the unit rate calculated for the area. The unit rate is adopted from other similar projects but may be its not the exact market value (i.e may cheap or expensive).

Table 18.Summary of Bill of quantity.

	Summary of Project Cost	
S.No.	**Description**	**Total Cost**
1	CAMP CONISTRUCTION	710,098.36
2	Main canal cost with all infrastructure	7,780,654.28
3	Secondary canal cost with all infrastructure	336,885.76
4	Tertiary canal cost with all infrastructure	99,657.66
5	Collector Drain cost with all infrastructure	593,087.26
6	Tertiary Drain cost with all infrastructure	340,917.41
7	Cattle Trough cost	21,640.67
	Total Engineering Cost Estimate of the project	**9,882,941.40**
	15% VAT	**1,482,441.21**
	Total Cost	**11,365,382.61**

6.1. BOQ for Camp construction

	BOQ FOR CAMP CONISTRUCTION				
Item No.	**Description of works**	**Unit**	**Quantity**	**Unit cost**	**Total cost**
1.80	Camping (3m x 13.85m office & bed room, 4m x 6m kitchen & Cafeteria, 5m x 5m store, 4mx2m Toilet & Shower, 2m x 2m guard house				
1.8.1	Site clearing	m^2	175	9.25	1,618.75
1.8.2	Excavation	m^3	63.336	53.52	3,389.74
1.8.3	Cart away all excess excavated material for safe place with a radius of more than 500m	m^3	88.52	55	4,868.60
1.8.4	25cm thick hard core	m^3	89.7	260	23,322.00
1.8.5	Masonry work with 1:3 mortar mix	m^3	38.404	2115	81,224.46
1.8.6	5cm thick mass concrete (1:2:4 mix ratio)	m^3	12.71	3195.5	40,614.81
1.8.7	2cm cement screed	m^2	91	1150	104,650.00
1.8.8	CIS walling G-32	m^2	337	360	121,320.00
1.8.9	CIS roofing G-32	m^2	194.5	370	71,965.00
1.8.10	Chip wood wall ceiling	m^2	256	185	47,360.00
1.8.11	Supply, assemble and fix in position eucalyptus wall post of length 3 m with span length of 1.2m	No	161	200	32,200.00
1.8.12	Supply and fix purlin in Eucalyptus wood size 50 x 70 mm nailed into eucalyptus truss	m	586	100	58,600.00
1.8.13	Supply, assemble and fix in position eucalyptus roof truss	No	36	95	3,420.00
1.8.14	Supply and fix purlin in zigba wood size 50 x 70 mm nailed into eucalyptus truss including three coats of anti - termite external treatment	m	190	145	27,550.00
1.8.15	Supply and fix CIS doors size 1.0x2.10m	No	14	2100	29,400.00
1.8.16	Supply and fix CIS windows size 1x1.2m	No	9	955	8,595.00
1.8.17	Fence 2.0m height & 15cm φ eucalyptus poles placed every 2m with barbed wire at 20cm vertical interval & erected in 0.6m depth embedded with concrete	LS	1	50000	50,000.00
					710,098.36

6.2. On farm and infrastructure BOQ

FIRI KEBSO SMALL SCALE IRRIGATION PROJECT					
S/No	DESCRIPTION	UNIT	QNTY	UNIT	TOTAL PRICE (Br)
1	**Main Canals including supply canal from spring**				
1.1	Site clearing				
1.1.1	Clearing and grubing bushes trees and shrubs on the alignment of mian canal to the width of canal and embankment and debth of 0.2m.	m2	7024.43	8.52	59,848.13
1.2	Earth Work				
1.1.1	Channel Excavation	m3	773.71	53.52	41,409.08
1.1.2	Canal Embankment fill and compaction Spread & comp	m3	4741.86	171.00	810,857.68
1.3	**main Canal Structures**				
1.3.1	**Offtake**				
1.3.1.1	Excavation for foundation in all sorts of soil including dep	m3	5.70	132.44	754.32
1.3.1.2	RCC Concrete CC20	m3	30.20	1878.23	56,720.64
1.3.1.3	Lean concrete CC10(t=75mm)	m2	51.77	1850.30	95,784.48
1.3.1.4	Cemented Stone pitching	m2	17.60	400.00	7,040.00
1.3.1.5	selected material Backfill with selected material for struc	m3	5.70	171.00	973.95
1.3.1.6	Renforecement Bar				
1.3.1.7	Bar ø-8	kg	1057.54	49.32	52,157.84
1.3.1.8	Dia 300mm	m	16.22	450.00	7,300.78
1.3.2	**Drop**				
1.3.2.1	Excavation for foundation in all sorts of soil including dep	m3	201.60	132.44	26,699.78
1.3.2.2	selected material Backfill with selected material for struc	m3	133.38	171.00	22,808.80
1.3.2.3	Cemented Stone Pitching	m3	3.89	444.39	1,726.53
1.3.2.4	Masonry work with Cement Mortar (1:4) ratio	m3	46.84	1577.99	73,909.28
1.3.2.5	Plastering with Cement Mortar (1:4) mix thick complete	m2	49.15	277.82	13,654.34
1.3.3.	**Road crossing Culvert**				
1.3.3.1	Excavation for foundation in all sorts of soil including dep	m3	0.69	132.44	91.72
1.3.3.2	selected material Backfill with selected material for struc	m3	26.01	171.00	4,447.32
1.3.3.3	Masonry work with Cement Mortar (1:4) ratio	m3	48.23	1577.99	76,099.91
1.3.3.4	Plastering with Cement Mortar (1:4) mix thick complete	m2	26.96	277.82	7,491.13
1.3.3.5	Renforecement Bar Dia 12mm	kg	65.14	49.32	3,212.56
1.3.4	***Division box at the beginning***				0.00
1.3.4.1	Excavation for foundation in all sorts of soil including dep	m3	3.24	132.44	429.10
1.3.4.2	selected material Backfill with selected material for struc	m3	1.14	171.00	194.94
1.3.4.3	Cemented Stone Pitching	m3	7.56	926.08	7,001.15
1.3.4.4	Masonry work with Cement Mortar (1:4) ratio	m3	3.10	1577.99	4,885.44
1.3.4.5	Plastering with Cement Mortar (1:4) mix thick complete	m2	7.56	277.00	2,094.12
1.3.5	**SPILLWAY**				
1.3.5.1	Excavation	m3	0.00	20.00	0.00
1.3.5.2	Back Fill	m3	2.24	170.00	380.80
1.3.5.3	Masonry	m3	6.84	1577.00	10,788.57
1.3.5.4	Cement(C20)	m3	2.04	200.00	408.00
1.3.5.5	Cemented Stone Pitching	m3	9.96	400.00	3,985.94
1.3.6	**Night Storage**				0.00
1.3.6.1	Excavation for foundation in all sorts of soil including dep	m3	584.99	132.44	77,476.14
1.3.6.2	selected material Backfill with selected material for struc	m3	10549.35	171.00	1,803,938.23
1.3.6.3	Masonry work with Cement Mortar (1:4) ratio	m3	2528.88	1577.99	3,990,532.93
1.3.6.4	Concrete				
1.3.6.5	C-15	m3	1.00	2314.88	2,304.10
1.3.6.6	C-10	m3	1.02	1878.23	1,921.43
1.3.6.7	Cemented Stone Pitching	m3	3.86	926.08	3,576.67
1.3.6.8	Geomemberane (t=2mm)	m3	2528.88	150.00	379,331.82
1.3.7	Gate				0.00
1.3.7.1	Single Spindle Flat Gate dia 300mm	No	16.00	1800.00	28,800.00
1.3.8	**Night storage spillway**				
1.3.8.1	Excavation	m3	0.00	20.00	0.00
1.3.8.2	Back Fill	m3	176.00	170.00	29,920.00
1.3.8.3	Masonry	m3	40.31	1577.00	63,573.67
1.3.8.4	Cement(C20)	m3	8.28	200.00	1,656.00
1.3.8.5	Cemented Stone Pitching	m3	11.17	400.00	4,466.98
	Total for main Canal				**7,780,654.28**

FIRI KEBSO SMALL SCALE IRRIGATION PROJECT					
S/No	DESCRIPTION	UNIT	QNTY	UNIT PRICE	TOTAL PRICE (Br)
2	**Secondaryary Canals**				
2.1	Site clearing				
2.1.1	Clearing and grubing bushes trees and shrubs on the alignment of mian canal to the width of canal and embankment and debth of 0.2m.	m^2	9970.60	8.54	85,148.92
2.2	Earth Work				0.00
2.2.1	Channel Excavation	m^3	82.24	53.52	4,401.39
2.2.2	Canal Embankment fill and compaction Spread & compact 20 cm thick	m^3	307.36	171.00	52,557.80
2.3	**Secondary Canal Structures**				
2.3.1	**Offtake**				
2.3.1.1	Excavation for foundation in all sorts of soil including depositing the excavated material as directed.	m^3	4.16	132.44	551.51
2.3.1.2	RCC Concrete CC20	m^3	3.77	1878.23	7,082.63
2.3.1.3	Lean concrete CC10 (t=75mm)	m^2	6.47	1850.30	11,964.04
2.3.1.4	Cemented Stone pitching	m^2	2.20	400.00	880.00
2.3.1.5	selected material Backfill with selected material for structure suport	m^3	0.46	171.00	79.11
	Renforecement Bar				
2.3.1.6	Bar ø-8	kg	132.16	49.32	6,517.91
	Gate				
2.3.1.7	Single Spindle Flat Gate dia 300mm	No.	2.00	1800.00	3,600.00
2.3.2	**Drop**				
2.3.2.1	Excavation for foundation in all sorts of soil including	m^3	201.60	132.44	26,699.78
2.3.2.2	selected material Backfill with selected material for	m^3	133.38	171.00	22,808.80
2.3.2.3	Cemented Stone Pitching	m^3	3.89	444.39	1,726.53
2.3.2.4	Masonry work with Cement Mortar (1:4) ratio	m^3	46.84	1577.99	73,909.28
2.3.2.5	Plastering with Cement Mortar (1:4) mix thick complete for water exposed faces of masonry walls	m^2	49.15	277.82	13,654.34
2.3.3	**Road crossing Culvert**				
2.3.3.1	Excavation for foundation in all sorts of soil including depositing the excavated material as directed.	m^3	0.81	132.44	107.68
2.3.3.2	selected material Backfill with selected material for structure suport	m^3	1.68	171.00	286.56
2.3.3.3	Concrete C-20				
2.3.3.4	Masonry work with Cement Mortar (1:4) ratio	m^3	9.56	1577.99	15,085.54
2.3.3.5	Plastering with Cement Mortar (1:4) mix thick complete for water exposed faces of masonry walls	m^2	5.27	277.82	1,463.27
2.3.3.6	Renforecement Bar Dia 12mm	kg	12.91	49.32	636.83
2.3.4	**SC SPILLWAY**				
2.3.4.1	Excavation	m3	0.00	20.00	0.00
2.3.4.2	Back Fill	m3	0.78	170.00	132.60
2.3.4.3	Masonry	m3	3.42	1577.00	5,394.29
2.3.4.4	Cement(C20)	m3	1.02	200.00	204.00
2.3.4.4	Cemented Stone Pitching	m3	4.98	400.00	1,992.97
	Total for Secondary Canal				**336,885.76**

3	**Tertiary Canal**				
3.1	Site clearing				
3.1.1	Clearing and grubing bushes trees and shrubs on the alignment of mian canal to the width of canal and embankment and debth of 0.2m.	m^2	834.96	8.54	7,130.57
3.2	**Eart Work**				
3.2.1	Channel Excavation	m^3	122.00	53.52	6,529.55
3.2.2	Canal Embankment fill and compaction Spread & compact 20 cm thick	m^3	1.37	171.00	233.73
3.3	**Tertriary Canal Structures**				
3.3.1	**Offtake**				
3.3.1.1	Excavation for foundation in all sorts of soil including depositing the excavated material as directed.	m^3	48.38	132.44	6,406.72
3.3.1.2	RCC Concrete CC20	m^3	6.26	1878.23	11,750.22
3.3.1.3	Lean concrete CC10(t=75mm)	m^2	9.68	1850.30	17,910.90
3.3.1.4	selected material Backfill with selected material for structure suport	m^3	0.42	171.00	71.20
3.3.1.5	Cemented Stone Pitching		4.40	444.39	1,955.30
3.3.1.6	Renforecement Bar dia 8mm	kg	194.51	49.32	9,593.23
	1m PVC pipe for off-take				0.00
3.3.1.7	Dia 100 mm	m	2.90	150.00	435.00
3.3.2	**Road crossing Culvert**				
3.3.2.1	Excavation for foundation in all sorts of soil including depositing the excavated material as directed.	m^3	5.97	132.44	790.71
3.3.2.2	selected material Backfill with selected material for structure suport	m^3	0.00	171.00	0.00
3.3.2.3	Concrete C-20	m^3	1.32	1878.23	2,479.27
3.3.2.4	Masonry work with Cement Mortar (1:4) ratio	m^3	19.12	1577.99	30,171.07
3.3.2.5	Plastering with Cement Mortar (1:4) mix thick complete for water exposed faces of masonry walls	m^2	10.53	277.82	2,926.54
3.3.2.6	Renforecement Bar Dia 12mm	kg	25.82	49.32	1,273.66
	Total forTC				**99,657.66**

6.3. Drainage BOQ

4	**Collector Drains**				
4.1	Site clearing				
4.1.1	Clearing and grubing bushes trees and shrubs on the alignment of mian canal to the width of canal and embankment and debth of 0.2m.	m^2	1475.04	8.54	12,596.86
4.2	**Eart Work**				
4.2.1	Channel Excavation	m^3	140.74	53.52	7,532.38
4.2.2	Canal Embankment fill and compaction Spread & compact 20 cm thick	m^3	1683.18	171.00	287,824.26
4.3.1	**Drop**				0.00
4.3.1.1	Excavation for foundation in all sorts of soil including depositing the excavated material as directed.	m^3	513.83	132.44	68,051.06
4.3.1.2	selected material Backfill with selected material for structure suport	m^3	304.59	171.00	52,084.89
4.3.1.3	Cemented Stone Pitching	m^3	25.81	926.08	23,898.36
4.3.1.4	Masonry work with Cement Mortar (1:4) ratio	m^3	69.26	1577.99	109,295.35
4.3.1.5	Plastering with Cement Mortar (1:4) mix thick complete for water exposed faces of masonry walls	m^2	77.49	277.82	21,529.62
4.3.3	**Outfalls**				
4.2.3.1	Excavation for foundation in all sorts of soil including depositing the excavated material as directed.	m^3	8.60	132.44	1,412.46
4.2.3.2	Concrete C-10	m^3	1.46	1878.23	2,737.08
4.2.3.3	Masonry work with Cement Mortar (1:4) ratio	m^3	0.65	1577.99	1,028.59
4.2.3.4	wet rip rap (1:4)	m^3	5.50	926.08	5,096.34
	Total for collectoer drains				**593,087.26**
5	**Tertiary Drains**				
5.1	Site clearing				
5.1.1	Clearing and grubing bushes trees and shrubs on the alignment of mian canal to the width of canal and embankment and debth of 0.2m.	m^2	1,301.11	8.54	11,111.51
5.2	**Eart Work**				
5.2.1	Channel Excavation	m^3	140.74	53.52	7,532.38
5.2.2	Canal Embankment fill and compaction Spread & compact 20 cm thick layer by layer	m^3	1683.18	171.00	287,824.26
5.3	**Culvert**				
5.3.1	Excavation for foundation in all sorts of soil including depositing the excavated material as directed.	m^3	11.88	132.44	1,573.37
5.3.2	selected material Backfill with selected material for structure suport	m^3	7.39	171.00	1,264.03
5.3.3	Concrete C-20	m^3	0.66	2314.88	1,527.82
5.3.4	Masonry work with Cement Mortar (1:4) ratio	m^3	4.88	1577.99	7,706.88
5.3.5	Cemented Stone Pitching	m^2			0.00
5.3.6	Plastering with Cement Mortar (1:4) mix thick complete for water exposed faces of masonry walls	m2	14.52	277.82	4,033.99
5.3.7	Renforecement Bar Dia 12mm	kg	163.60	49.32	8,068.69
5.4	**Outfalls**				0.00
5.4.1	Excavation for foundation in all sorts of soil including depositing the excavated material as directed.	m^3	10.67	132.44	1,412.46
5.4.2	plain Concrete C-10	m^3	1.46	1878.23	2,737.08
5.4.3	Masonry work with Cement Mortar (1:4) ratio	m^3	0.65	1577.99	1,028.59
5.4.4	Wet Rip Rap (1:4)	m^3	5.50	926.08	5,096.34
	Sub Total of TD drain				**340,917.41**

6	**CATTLE TROUGH**				
6.1	Site clearing	m^2	20.00	8.54	170.80
6.1.1	Excavation	m^3	12.00	53.52	642.24
6.1.2	compacted sellected materials	m^3	4.00	171.00	684.00
6.1.3	hard core	m^3	6.00	55.00	330.00
6.1.4	Concrete (C20)	m^3	8.19	2419.25	19,813.63
	Cattle trough sub Total				**21640.67**
6	**Fence for spring Developments**				
6.1	Site clearing	m^2	10.00	8.54	85.40
6.1.1	Excavation	m^3	7.50	53.52	401.40
6.1.2	compacted sellected materials	m^3	3.00	171.00	513.00
6.1.3	hard core	m^3	4.50	55.00	247.50
6.1.4	Masonry work with Cement Mortar (1:4) ratio	m^3	13.80	2419.25	33,385.60
	Fence sub Total				**34632.90**
	SUM				**9,207,475.94**

7. REFERENCES

(OWWDSE), O. W. (Jan2014). *Enviromental assessments and anlysis.* finfinne/Addis ababa: OROMIA WATER WORKS DESIGN & SUPERVISION ENTERPRISE In Association with Intercontinental.

Awlachew, M. e. ((2007),et al. (2009).

BEKELE, A. S. (JULY,2010). *IRRIGATION POTENTIAL IN ETHIOPIA ,CONISTRAINT & OPORTINITY FOR ENHANCING THE SYSTEM.* INTERNATIONAL WATER INISTITUTE,.

Eyasu Yazew (PhD), A. M. (2015). *Multi Reservoir Operation and Challenges of the Omo River Basin.* MEKELE ETHIOPIA: IGAD INLAND WATER RESOURSE MANEGEMENT PROGRAM.

Garg, S. K. (1976). *irrigation engineering & Hydroulics structere.* Nai Sarak,Dhalhi: Sh,Romesh Chander Khana.

Gebremadhin, D. B. Integrated water and land management research and capacity building priorities for Ethiopia.

JARSO, S. (2002). *WATER SECTOR DEVELOPEMENTAL PROGRAM.* Addis abab: ministry of water resourse,.

Moeti, L. D. *DETERMINATION OF THE POTENTIAL FOR IRRIGATION IN THE SENQU VALLEY: A GIS MODELLING EXERCISE WITHIN IWRM CONTEXT.* LESOTHO: Department of Geography and Environmental Studies.

OWWDSE. (April,2014).

Seleshi Bekele, a. d. (2007). *Water irrigation development in Ethiopia.* International Water Management Institute,With Arba Minch & Haremaya university.

VEN TE CHOW, P. *OPEN-CHANNEL HYDRAULICS.* Tokyo: McGRAW·HILL BOOK COMPANY; .

FAO 56,(2006).*Water Resourse and management development service***.** Roma Italy