Omo Valley Farm Co-operation P.L.C

Addis Ababa

Feasibility Study and Detail Design of Omo Valley Farm Irrigation Project

Section-I: Design Reports

Volume-III: Operation and Maintenance Manual for the Irrigation and Drainage System

May, 2015

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Operation and Maintenance Manual for the Irrigation and Drainage System

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Issue and Revision Record

Issue	Date	Originator	Checker	Approver	Description
A	May 2015	Various	Seid Shimels	Dr. Tilahun D.	Final

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1. Introduction

1.1 General Background

Management of an Irrigation System comprises of the Administration, Operation and Maintenance of the Irrigation Outlet, Canal and Drainage System and related structures. It also concerns both the water supply to the users and drainage of the excess water.
To ensure an optimum use of the irrigation facilities, an adequate management structure has to be provided once the construction of the complete system is over. This manual describes the activities of the Project Management Unit (PMU); The PMU will be in charge of the operation of the outlet structure and Head Regulator, complete irrigation and Drainage System etc. This PMU will be responsible for the maintenance of the complete project.

1.2 Objective and Scope of the Manual

This manual provides the most important information on the principles of the operation and maintenance of Omo valley Irrigation and Drainage system. It is however, recommended that the user of this manual refers, for more detailed information on the Omo valley Irrigation Project documents.

The report structure has been summarized to have brief introduction in the first chapter. While the Irrigation and drainage system is described in chapter 2 of the report. The Operation of the Main irrigation System is given in chapter 3. The general inspection and maintenance activities are described in chapters 4, 5, 6, and 7.

Manpower requirement for management of the operation and maintenance are indicated in chapter 8. This section also gives the job description of the key personnel involved in the Operation and Maintenance.

2. Description of the Irrigation and Drainage System

2.1 The Location and Accessibility

The Omo valley farm irrigation project is located in South Omo Zone of Southern Nations, Nationalities and Peoples Regional State (SNNPRS), in Hamer Woreda, Karo Kebele of South Omo zone. The Project area is located in the plain areas of Lower Omo-Gibe River Basin and falls in Hamer Woreda, Karo Kebele of South Omo zone.

The project area is part of Omo-Gibe River Basin and all of the proposed 5,600ha gross irrigable command area lies on the left side of the Omo River. Geographically, the entire project area is located 05^{O} 10'N to 05^{O} 16'N latitude and 36^{O} 12'E to 36^{O} 17'E Longitude i.e., between UTM189561m – 198452m N and 572087m – 575368m E.

The project site can be reached by the 750 km road from Addis Ababa, which is only asphalt road up to Keye Afer Village and the rest 130km is a paved dry-weather road and the site is about 60km from Turmi village.

2.2 Topography and Climate

The topography at the command area of omo valley farm irrigation project is considered as plain with an average altitude of about 420m a.s.l. The elevation ranges from 490m a.s.l. at the head of branch main canal (MC01) supplied by the booster pump to 490m a.s.l. at tail end of the irrigation command area. The slope of command area is considered as flat with a slope of less than 3 per cent in most places.

The climate of Omo valley farm site is of tropical type of climate. It is hot during the dry season and humid during the rainy season. The mean annual temperature is 17.4 to 35.4^{o}C and the mean annual rainfall is 511.4 mm

2.3 Purpose and Objective of the Project

The main purpose of the project is to produce cotton in the lower Omo plain through the development of irrigated agriculture on a 5,600 ha Gross Command Area.

The objective of the irrigation and drainage study are to design an efficient and suitable irrigation system which ensures reliable delivery of irrigation water at the right time and to the

required amount as well as to design an efficient drainage system that ensures removal of excess moisture on and within the surface of the field.

2.4 System Operation

The gross command area is about 5,600ha. The water is supplied through a system of Main Canal, Secondary Canals and Tertiary Canals along with the quaternary Canals. The main Canal off takes from pumping station to irrigate command area on the left bank of Omo river, It was aligned as a contour canal running at a considerably gentle slope of ranging from 1/5000 to 1/4500 and structure losses are provided at cross regulators and gully/river crossings.

The branching Main Canal (MC-01) would be supplied by the booster pumping station to irrigate the command area between 420 and 490m.a.s.l it was also aligned as a contour canal running at a considerably gentle slope of ranging from 1/5000 to 1/4500 and structure losses are provided at cross regulators and gully/river crossings.
Drainage requirements for the project, where most of the command area is considered as flat or almost-flat, it is apparent that the system is expected to comprise surface drains with free outfalls. A surface drainage system is comprises a network of drainage canals (secondary, and tertiary and field drains) of different sizes and capacities to collect and remove excess irrigation water and surface runoff.

The detail list of all canals, drains and their structures, showing designation, length, bed width, side slopes, full supply depth, free board, bank width, bed slope, discharge etc. are given in a separately compiled appendices document, which submitted to the client with this main document.

3. Main Irrigation System Operation Plan

3.1 Introduction

The objective of the operation of the main irrigation works is the timely delivery of the required irrigation water to the farms. This objective is achieved by the following activities.

- Preparation of an irrigation plan
- Operation of the water distribution according to the irrigation plan
- Monitoring of the water distribution and

- Adjustment of the plan, if required

In this section the planning of the operation or the preparation of an irrigation plan has been discussed briefly only. A detailed irrigation plan should be prepared once at least 50 to 60 % command area is under irrigation. The major emphasis of this section will be on the actual operation of the scheme and especially the operation of the main canal system and its structures.

The Project management Unit will be responsible for the Operation and Maintenance of the overall irrigation system e.g. main canal, secondary canals, and tertiary canals, quaternary canals with related controlling structures and cross drainage works. Operation of system downstream of quaternary canals will be the responsibility of the irrigators.

3.2 Basic Concepts of Irrigation Planning

Irrigation plans are prepared well in advance of the irrigation season. The plan will be based on the expected available flow in the river and the water required by the farms for the crops proposed to be sown. This will mean carrying out of the following activities:

- Estimating the future supply
- Estimating the water demand of the envisaged cropping pattern
- Matching supply and demand.

The expected water demand shall be estimated from the planned cropping pattern, irrigation requirements, irrigation efficiencies and the estimated effective rainfall. The information on the cropping pattern, including date of sowing and areas sown, has to be collected from field. Climatological information has also to be collected and utilized for water requirement computation. Once the supply and demand is estimated, irrigation plan can be prepared.

3.3 Description of Distribution (Conveyance) Systems

The water is supplied through a system of Main Canal, Secondary Canals and Tertiary Canals along with the quaternary Canals. The main Canal off-takes off from the pumping station on the left bank of Omo River and the details of Canal System are given in the actual layout of the system.

As it is described, the present developed area consists of Main canal (MC) and branch Main canal (MC-01). Each of these canals contains 5 and 3 secondary canals as well as 32 and 15 tertiary canals respectively. Under these tertiary canals there are 72 and 53 quaternary canals,

which directly feed furrows.

The maximum number of quaternary canals under tertiary canals in MC is 5 and minimum is 1. Most of tertiary canals contain 2 and 3 field canals under them. The maximum number of field canals under tertiary canals in MC-01 is 9 and minimum is 1. Most of tertiary canals contain 4 and 5 field canals under them. Each quaternary canal of Omo valley project irrigates approximately 60 ha.

The exact number of irrigators to be assigned in each quaternary canal depends on the actual area of each quaternary canal. Based on 400 meter furrow length as well as the crop selected being cotton plant (as in the case of present Omo valley irrigation project), an irrigator can cover up to 13 hectares in each interval. Therefore, based on the area under each tertiary as well as an approximate area that can be irrigated by each irrigator, the number of irrigators that can be assigned for each tertiary can be determined.
Based on the above analysis, main, secondary and tertiary canals supply water continuously, while rotation is within quaternary canals.

3.4 Efficient Working

Normally no silt deposition should be permitted to take place in a canal network. Sometimes the canal may have to be run at less than the designed full supply discharge on account of fluctuating water demands, over the base periods of the crops to be irrigated. Also even for a single crop discharge requirements vary from month to month. Such low discharge conditions include deposition of silt over the canal bed owing to low velocities of flow. Consequently, the discharge carrying capacity of the canal is adversely affected. Silt deposition in canals can be minimized by judicious operation of gates of cross regulators, silt ejectors/de-silting basins, wherever provided the maintenance.

3.5 Plantation

Acquired land width of canal should be demarcated by planting suitable species of trees at suitable intervals. Sowing seed or plantation should commence in June and be finished by the middle of the month; so as to get the full benefit of the rains. In low ground liable to flooding, seeds reclining sideways. Where necessary, a prop should be sown on ridges. The roots of seedlings should not be cut nor broken when transplanting. They should be dug out with a good ball of earth adhering and so carried to the new site. If grown in pots like eucalyptus, the roots

are sure to be pot-bound. In such cases the pot should be carried to the new site and the seedling roots bare of earth and straightened down into the holes dug for them. This greatly facilitates their subsequent growth. If the tree is completely covered by the parasite, it is recommended to cut it down and burn the parasitic plant at once. All large roots found in the plantations should be taken out during the rains and burnt into charcoal when dry. All newly planted trees and also those which are less than 2 m in height should be properly protected by suitable tree guards. The old tree guards should be repaired properly where necessary and all grass should be weeded out. Newly planted trees should be watered regularly but not in excess and the top soil loosened soon after watering. Established plants which have only been less than two years on the shade line require to be given similar treatment though not so often.

3.6 Operation of Gates

All lift gates should be operated at suitable intervals to free the mechanism and wash out of extraneous material. In low supplies when openings are not desirable, rising of gates by 150 mm for a few minutes should suffice. If the gates have not been moved for a sufficiently long time, they should not be forcibly raised all at once but should be lifted by about 30 mm or so and left at that position for about 10 to 15 minutes till the silt deposited against the gates gets softened and water begins to ooze out. This is essential to avoid heavy strain on the machinery. The speed of operation of the gates should be limited to the maximum speed indicated by the manufacturer. The operation shall be so done that the safety of the structure is not jeopardized at any time is not exceeded beyond the safe limit, which shall be clearly specified.

3.7 Lighting

All flood lighting and intake illumination should be checked daily during flood season and once in a week during slack season.

3.8 Painting

The painting of super structures should be done once in two / three years.

3.9 Hoisting

IS 10096, 1986 may also be referred for inspection/maintenance of hoists considering the type of hoist provided on the intakes before the onset of rainy season and after passing the floods.

4. Inspection of Works

The following is given a description of inspection of related matters.

4.1 Inspections of Canals

Whenever canal is closed for periodical inspection and repairs, the lining, its-auxiliaries and special design features should be carefully inspected. The following points should be noted while carrying out the inspection:

a) Whether any cavities or pockets have been formed behind the canal embankment and lining; At places where considered necessary these may be checked by sounding the lining tiles inspection of wet patches on outside slopes on regular basis should be done.
b) Development of any cracks or displacement or damage to canal embankment and lining;
c) Silt deposits and weed growth; and
d) Bench marks, Boundary pillars, full supply water levels gauge at suitable intervals be Pointed or fixed to know about the hydraulic efficiency of the canal.

4.2 Performance of Canals

An accurate and systematic record of the performance of a canal should be maintained by Periodic observations of Manning's roughness coefficient, evaporation and seepage losses, life and behavior of the lining adopted, surge wave heights, and performance of any special design features like pressure release system, provision of humps or regulators, etc.

4.3 Canal Head Regulator

The work shall be carefully examined every year in the cold weather by probing in case of upstream floor and examination under dry condition of downstream floor during closure or isolating the area where closure may not be possible. Visual inspection of upstream floor should also be carried out once in three to five years by isolating the area. All necessary repairs shall be carried out in time.

4.4 Performance of Structure

The performance shall be evaluated as below.

Suspended sediment:

During the rainy season, water sample should be taken in accordance with IS 4890: 1968 simultaneously upstream and downstream of the under sluices and in the canal below the head regulator to assess the suspended sediment there in such observations should be taken at least

once a week (closer intervals in case of high sediment side. Similarly, the survey on downstream side concentration) to judge the efficiency of sediment should extend to a length up to which river bed exclusion and to decide if any change in the mode changes occur. Sufficient number of permanent gauges or other reference marks should be established on both banks to facilitate superimposition of old and new survey. The changes in the river course shall be examined and remedial measures should be taken.

Aggradations upstream

The river bed upstream of the dam is likely to aggraded resulting in increased afflux and reduction in freeboard provided in design. To determine the increase in the afflux, if any, gauges should be established on the upstream, one immediately upstream of the work and one each at 500m and 1000 m upstream of the first, and observed regularly. The necessity of raising/constructing any afflux banks may have to be considered to restore the designed freeboard.

Discharge distribution and cross-flow

For head and cross regulators, observations should be taken to find the discharge distribution through different bays of the intake. If there is significant cross-flow and/or difference in discharge intensities through different bays, remedial measures should be taken to check this tendency for which improved regulation may be a great help.

4.5 Operation and Regulation

Adequate regulation staff should be provided and their duties should be clearly specified. Adequate stocks of stores, tools and plants required to meet emergencies should be maintained on all intakes. These should be listed in detail in the regulation orders and their availability checked periodically by the engineer-in-charge.

In general, operation of the main gates should ensure the following features:

- The required full supply Level is maintained both during the peak and low seasons.
- To evolve the operation of gates to exclude maximum silt/debris deposits on the upstream side and also to minimize the entry of same in canals/channels.
- A relatively high intensity of flow is avoided in the deep scour zones, if formed.
- If a shoal has formed on either upstream or downstream or both of the intakes, it is washed out and kept away from the intake, as far as practicable.
- The canal gate operation schedule should also consider constraints regarding rates of

lowering / raising of water levels in the canal. It should also consider the safe rate of filling of the canals.

And during The operation should consider the following points

- The discharge tables shall be occasionally checked for accuracy by actual measurements in the canal.
- It is important to keep a constant watch over the sediment entering the head, the portion there of ejected by the escapes if any, there fore Sediment charge observations (both suspended sediment and bed load) shall be made at least once a week/ fortnightly/ month (as per necessity) in low flows immediately below the head regulator, below the silt ejector, if any, and at any other sensitive point lower down the canal. The frequency of observations may be decreased in medium and high flows.
- Cross section of the canal shall be taken occasionally at a few sensitive points to watch the extent of sediment deposition of the canal,
- Water surface slopes in the sensitive head reach of the canal shall be kept under observation daily with the help of gauges;

4.6 Discharge Measurements

4.6.1 General

Discharge observations on main canal and branches shall be carried out at least once a month during non-rainy seasons. During rainy seasons discharges should be observed more frequently for diversion canals. Percentage to normal discharge should be revised from time to time for purposes of regulation and distribution of water. In case of high seepage losses in the main canal, discharge observations should be high and suitable remedial measures should be taken to reduce it. Current meters should be used for observation of discharges. Where such facility is not available or where depth of water in the channel is insufficient, floats may be used.

Discharge sites should be fixed at suitable points and may preferably be in the form of flumes, falls or straight runs of lined section. All discharge observations should conform to relevant Standards.

Gauges at the head and tail of all the channels and at important points in between on long channels should be observed and recorded daily.

4.6.2 Evaluation

To evaluate the possibility of establishing level recorder staffs within the system, their modular property under design and operation flow conditions in the parent and off-taking canals should be known. These properties could be studied from detail design documents. After studying their modular property flow can be measured by fixing level recorder staff. In-addition, to fix the level meters and to develop reasonable Stage-Discharge rating curve, Field work should be arranged to carry out the following works:

- The best representative structure to measure the intended flow will be selected.
- The actual level and dimensions pertinent to discharge calculation will be measured.
- Calibration will be conducted by taking records of actual heads and discharges.

4.6.3 Flow Measurement in Off Takes (OT) of Secondary Canals

The flow measuring devices of the Off Take (OT) structures from secondary canals (SC) are types of measuring structure that measure head. The flow in Off Takes (OT) is based upon Orifice relationship. For a circular shaped orifice the continuity equation for discharge Q becomes:-

$$Q=C_D B w\sqrt{2gy_1}$$

Where Q is the discharge in m^3/s, y_1 is the entrance water depth above the sill or floor in m, B is the width of the gate in m, w is the opening of the vertical gate in m, C_D is the discharge coefficient.

C_D is the discharge coefficient C_D should be calibrated according to site condition

4.6.4 Flow Measurement in Cross Regulators (CR) of Main and Secondary canals

The flow measuring devices of the Cross Regulator (CR) structures of main and secondary canals are types of measuring structure that measure head. The flow in Cross Regulators (CR) is based upon Orifice relationship. For a rectangular shaped orifice the continuity equation for discharge Q becomes:-

$$Q=C_D B w\sqrt{2gy_1}$$

Where Q is the discharge in m^3/s, y_1 is the entrance water depth above the sill or floor in m, B is the width of the gate in m, w is the opening of the vertical gate in m, C_D is the discharge coefficient.

C_D is the discharge coefficient C_D should be calibrated according to site condition

4.6.5 Use of Siphon

Omo valley farm field irrigation is designed to supply water from the quaternary canal into the field by using siphon. In fact the most common method of releasing water from a canal in the area is by embankment breaching. Thus this method damage canals. In addition it is difficult to control the discharge. Based on these facts for Omo valley farm irrigation project, it is proposed to keep water level at the head of siphons.

In order the siphons to work properly; there are two conditions, when the outlet from the siphon is just above the water level in the field which is known as free discharge condition. And when the water level in the farm canal is lower, then the outlet is below the field water level. This is known as drowned discharge. The first type of mode of operation is intended in Omo valley field irrigation. The equation used to determine discharge through siphons is:-

$$Q = CA\sqrt{2gh}$$

Where C is constant, A is flow area and h is the head difference between the water level in the field canal and the field.

4.6.6 Rating curve

Based on the evaluation method explained in the above section rating curves, a stage-discharge relationship used for the measurement of discharge, of Cross Regulators (CR) and Off Takes (OT) of the main and secondary canals are developed. For the detail of each rating curve refer ANNEX-I.

5. Maintenance of Irrigation and Drainage System

5.1 General

Cause of damage to the irrigation and drainage system obviously is due to the human and

animal interference in the natural environment, which could be indirectly by destroying the natural environment or directly by destructing the irrigation infrastructure. This causes excess flood laden with silt, which cause destruction of protection embankments, breaching of canals, growth of weeds and other unwanted plants in the canals, cracking in the canal structures, etc. These all reduce the discharge capacity of canal, which intern affects the irrigation management.

5.2 Types of Maintenances

There are three main types of maintenance namely:

a) Special maintenance

b) Deferred maintenance

c) Routine or normal maintenance

5.2.1 Special maintenance

Special maintenance includes work that is done to repair the irrigation system in response to unforeseen damages, such as those caused by floods or earthquakes. In this case no specific preventative measures would have been taken to circumvent the damage.

5.2.2 Deferred maintenance

Deferred maintenance or rehabilitation includes any work that is done on the irrigation infrastructure in order to restore the capacity of the system. In this case, the system is allowed to deteriorate to a certain level, beyond which it would not operate well, before it is restored to its design operational level. Sometimes, deferred maintenance and rehabilitation are differentiated on the basis of the source of funds. The funds for deferred maintenance come from the operation and maintenance budget, while that of rehabilitation comes as an investment funded by loans or national development budgets.

5.2.3 Routine maintenance

This includes all the work that is done in order to keep the irrigation system operating satisfactorily. It is normally done annually. Clear that the long-term operation of the irrigation installation depends upon the quality of simple maintenances carried periodically.

5.3 Maintenance Activities

The chief requirements of uniform canal are as follows:

a) A clean regular bed,

b) Straight clean slopes,

c) Uniform berm widths, and

d) Uniform regular top width and outer and inner faces of both banks.

Closure on main canal and branches shall be notified sufficiently in advance. Whenever a canal is closed it should be inspected as soon as possible. All pipes and openings in the crest of falls shall be opened so as to drain off the water upstream of the fall. The canal shall be cleaned before it is run again. All masonry work shall be periodically cleared of rubbish, stones, brickbats, etc, as the opportunity offers, especially the siphons and the stilling basins.

5.3.1 Bed and Berm

Bed and berm shall be scraped, where necessary and especially in tail reaches. Berm and bed lines shall be correctly aligned before scraping. Berm shall not be scraped if it has not silted properly. Before starting work on either the bed or berms, they shall be aligned by flags and string. The former are necessary for the alignment in general and the latter to correct small irregularities in that. Every opportunity shall be taken to straighten the canal and to get rid of kinks and irregularities in the alignment and also to ease of all curves where scouring or silting takes place. Clearing operation shall be started from downstream to upstream starting either from the tail or a fall

All grass shall be scraped and weeds removed from the silted bed wherever they are found to exist since their presence induces silt deposit.

All local accumulations or continuous deposits or mounds of silt shall be removed to correct bed level. Beds shall be leveled and their gradients regularized by the removal of silt mounds and all mounds higher than correct bed level. Bed levels shall be fixed correctly at close intervals by means of sounding rods. In case of main canals, \ branches, and distributaries, silt at the junction of bed and slopes should not be removed if the section of waterway: is not unduly affected. Small minors and all rail reaches shall, however, be cleared to the correct trapezoidal section. The practice of cutting the silt deposited at the junction of side slope and bed and throwing it on the bed to level it shall not be permitted.

Note-It will be desirable to prepare a longitudinal section of main canal canals during closure

once a year. Cross-sections should be taken in reaches where the section is over-wide or too much scoured. The behavior of canal should be studied and longitudinal section readjusted, if required. Closure register should be maintained in which brief inspection report for each work along with details of repairs if any carried out shall be entered by the Engineer In charge.

Berm cutting shall not be started until sample profiles have been cut and the lines carefully laid. Where earth is required for repair of banks, berm pockets may be made.

Irregular protruding and overhanging berms shall be cut back to proper alignment and slope. If this is neglected berms fall in or protrude abnormally and the canal tends to adopt an irregular section or winding course. Wherever berms have grown excessively thereby tightening the waterway they shall be cut to proper section.

Berms shall be kept straight by trimming projections after aligning them correctly. Heavy berm cutting may be avoided by regular trimming and scraping as the situation calls for every year.

5.3.2 Escapes

Escapes shall be kept clear of silt and vegetation growth. These shall be run occasionally to test their discharging capacity and to maintain right of escaping excess water into natural drains in which such escapes join and to avoid tendency of cultivators to sow in low lying lands in the bed and along the sides of such natural drains.

5.3.3 Silt Clearance

If a canal is in regime and taking its full supply, it is not necessary to clear silt to the theoretical cross-section. If the canal is not functioning properly, it may be sufficient merely to clear a portion of silt to get it into efficient working order or it may be necessary to clear to full theoretical cross-section on runoff the river canals and specially those which are also run for paddy irrigation silt is likely to deposit in distributaries and minors which may get picked up when clear water runs in the channel after rainy season. Longitudinal sections of silted bed of such channels should be taken during closure

Immediately after rainy seasons and the gradient at which silt should not be cleared below falls but if outlets in such places are overdrawing water due to rise in water surface, they should be raised. Boning rods should be used to see whether the silt has been properly cleared.

As soon as a canal is closed for a fairly long period the bed bars shall be uncovered and the depth of silt over them recorded.

5.4 Maintenance of Embankments

Proper maintenance of embankments is extremely important as breaches in them can be disastrous and may cause even greater damage than the inundation by floods where no Embankments are provided. The maintenance work may be divided in two parts

a) Pre rainy season maintenance

b) Rainy season maintenance.

5.4.1 Pre-rainy season maintenance

Existing embankments have to be repaired or reconditioned to the original design section in advance for their efficient performance during the ensuing rainy season. The free board may be checked up for any rise in bed level of the river or other constrictions which may result in higher design flood and provided/ maintained accordingly.

All hollows and depressions in the embankment's section, wherever existing, should be made up with rammed earth after clearing the site of loose earth and vegetal materials. Where the top material is sandy or silty, it is desirable to provide a cover of soil containing 10 or 15 percent of clay well rammed or rolled.

A register of leaks should be maintained indicating the location and action taken during the rainy period. The leaks, which could not be fully treated during the rainy season, should be attended to immediately afterwards. Such leakage sites should be opened in full width of the embankment taking care to trace to its upstream ends, and then be refilled, watered and rammed, the old earth being stepped or benched back at sides and new earthwork properly bonded and interlocked into the old.

Rodents and other animals make holes, cavities and tunnels through and under embankments. These are source of danger causing leakage and excessive seepages which may give rise to serious breaches during flood period. Such holes should be carefully located, examined, provided with an inverted filter, filled with earth and rammed. Alternatively such holes should be filled with well rammed stiff clay.

All the masonry works should be carefully inspected to detect if there is any danger of seepage of water along the planes of contact between the earth and masonry. The earth adjacent to the masonry work should be laid in 15 cm layers, watered and compacted, brought to the design section.

For embankments which were severely threatened by erosion during the previous rainy season,

revetment/riprap or other river training works should be separately examined. In case of wave action, pitching may have to be provided 30 cm above the water level in flood.

Approach roads and also top of embankments, wherever they are designed to carry vehicular traffic, as well as ramps provided for inspection so far they serve the purpose of transport of materials and inspections both during the pre-rainy season and rainy season periods.

- No habitation should be permitted on the embankments.
- All departmental vehicles should be kept operational.
- All pumping equipment should be repaired and kept in readiness before onset of rainy season.
- All sluice gates, valves are kept greased, oiled and treated, if provided.
- All tools and equipment including torch lights, lamps, spades etc. and flood lighting articles as well as materials for erecting temporary sheds at the work sites for workers should be arranged and stored at suitable places.
- Proper communication system should be installed before onset of the rainy season.

5.4.2 Maintenance during the Rainy Season

During the rainy season, prompt maintenance of the embankment is required as the flood water of river threatens the safety of the embankment mostly during this period. This is all the more important in case of new embankments and also in case of those reaches of old embankments where breaches occurred in the past. The establishment required to be engaged for proper maintenance of an embankment will necessarily depend on the importance of the embankment and behavior of the river. As the river touches the embankment and river shows rising trend, round the clock patrolling should start by staff engaged for this purpose and continue till water finally recedes. During this period, inspection of senior officers should be carried out systematically and all the concerned staff and officers should remain alert to meet any emergent situation. Special vigilance is necessary in the countryside of the embankment to detect any boil formation due to seepage. This should be immediately attended to by providing loading berm to counterbalance exit gradient. A suitable filter material may be placed around the boil below the loading berm to arrest fines in seepage water. To prevent the water from overtopping and washing out a portion of the dyke, a dowel of half sand-filled bags at the riverside at the top of the embankment may be provided. Repair of rain suits in the embankments, stacking of material and machinery required for repairing, putting the top embankment in order, etc., should also be

made. Scouring and eroding behavior of the river should be carefully watched for taking necessary precautionary measures. In this way, by proper vigilance and timely action for repair works, flood disaster can be reduced to a great extent. All information connected with rising flood water level and flood situation should be passed on to the concerned higher authorities to enable them to take safety measures in time.

5.4.3 Banks

Banks shall be brought up and maintained to full section. The minimum width and free board of the bank shall be in accordance with the relevant Standard.

Before continuous bank repairs are started, profiles shall be made at about 100m apart. These shall be at the correct height and width of the bank repaired and shall be checked before work is started.

All holes and rain cuts shall be fully opened up to the bottom by digging steps not more than 0.5m deep in the sides and removing all the fallen or loose lumps of earth, bushes, grass roots, etc. Filling and repairing shall be done by placing level layers of earth (not more than 15cm deep). The earth in each layer should be free from clods, roots, grass, brickbats and other debris and it shall be compacted at adequate moisture content.

Leaks should be stopped from the upstream side by cutting off the penetrating water. If practicable cracks should have good earth worked into them by chisel pointed poles, but if the presence of water against the bank prevents this, the leakage should be stopped by a cover of good earth thrown over it. Subsequently, in dry season the defective part should be opened up and properly remade. Top of bank shall be smooth and free from clods and silt mounds. They shall be given a slight outward cross slope of about 1 in 80 in order to take the rain water away from the canal. Both edges of banks especially the inner ones shall be neatly aligned parallel to the canal. They shall be absolutely straight in straight reaches and regular on curves.

Both inner and outer slopes and toes of banks shall be free from irregularities. Only projections shall be cut down and earth thus obtained should be utilized in filling hollows.

Loose earth shall not be left lying on top of a bank. Wherever filling is necessary, it shall be well compacted. Grass or turfing shall not be scraped. It should only be cut as far as necessary to show the surface of the bank and to avoid the holes being hidden under long grass. Scraping the top edges of banks for appearance shall not be permitted. Earth from any surface for bank repairs shall be placed where required and in such quantities only as needed, otherwise banks

will become irregular by developing unwanted bulges and hollows

The top of both banks shall always be kept smooth and free from holes. One bank, at least, should be maintained as an inspection bank.

Banks that are too low should be raised to the proper design levels as early as possible.

In previous reaches where seepage is excessive puddle clay core, in place of sand core, may be provided where water logging is observed seepage drains shall be provided on either bank.

5.4.4 Sources of Earth for Repair

Suitable earth for repairs may be obtained from the following sources:

- Material obtained from internal clearances shall be utilized
- By Removal of Irregularities - High banks can be lowered and bumps or projections on top or sides cut down to fill in the hollows.
- From Spoil Banks
- From Prominent Mounds in the fields Near the Site
- From Beds of Drains Near the site

The following precautions shall be observed in taking earth from out-side borrow pits:

- No borrow pits shall be dug within 6m from the toe of banks or driving road or ramps of bridges.
- Earth shall not be taken from the toe of banks, as the natural rounding of the corner should not be disturbed.

5.5 Maintenance of Hydro-Mechanical Installations

5.5.1 General

All machinery at the works should be kept clean, tidy and in proper working order and care should be taken to ensure that it is properly handled in conformity with the manufactures' instructions. The main mechanical items are generally the gates and the winches.

5.5.2 Maintenance of Gates

All cavities and angles in the gates/shutters should be kept clear of debris, driftwood, moss and silt accumulations. All drainage holes in the webs of horizontal structural members should be kept open and no water allowed remaining entrapped. Green stains should not be allowed to form on the steel members at the back of the gates/shutters. The gates and counter balanced boxes should hang perfectly level and in plumb. This should be checked occasionally and

adjustment made as needed. In case of shutters, the chains/anchors holding them should be kept free from rust.

No painting is required for machined surfaces and surfaces of stainless steel, brass or bronze. These surfaces shall be protected by a coating of gasoline soluble rust preventive non-corrosive compound.

The upstream face of the skin plate which comes in contact with water should preferably be painted with a suitable primer and subsequently with high quality long life in water for a long life. The other parts of the gates/shutters which do not come in contact with water should be painted with paint conforming to IS 158:1981 or chlorinated rubber based paint or epoxy coal tar paint (cold application). The upstream face may also be painted with any of these paints. These paints may be substituted with decorative paint (synthetic enamel) (see IS 2932:1974) for better appearance.

The application procedure for sanded aluminum paint on new work shall be as detailed below:

a) Cleaning

- Weld spatter or other surface irregularity shall be removed by any suitable means.
- Oil, grease or dirt, if any, shall be removed from the surface by the use of solvents, that is, clean mineral spirits, naptha or white gasoline;
- SI No. (1) And (2) above shall be followed by sand blasting for removal of rust or mill scale, to present a uniform bright base metal. Any dust or grit remaining from this cleaning operation should be completely removed from the surface by brushing or with dry air, and
- Painting shall be immediately commenced after cleaning in accordance with SI No.(3) above.

b) First Primer Coat

The first primer coat should be prepared by mixing 1 kg of aluminum past (see IS 289: 1963), 4.5 liters of zinc chromate mixing paint and thinning it suitably with oil of turpentine (see IS 6646: 1972). This shall be applied by brushing at a coverage rate of 10 to 12.5 m2. Drying time shall be at least 18 h unless otherwise specified by the paint manufacturer.

C) Second Primer Coat

The paint shall be prepared in a similar manner as in (b) except that no thinner shall be added. The paint shall be applied by brushing at a rate of approximately 7.25 m2/l. Immediately after the application of the second coat, clean and dry sand with rounded grains of 30-50 mesh size

shall be sprayed with low air pressure of 35,000 to 70,000 Pa (0.35 to 0.7 kg/cm2) so that the sand grains get embedded in the wet second priming coat and do not puncture the first coat. Drying time shall be at least 24 hours. Sand spraying is omitted in the case of surface on the downstream side not coming in contact with water.

d) Finish Coat

This is prepared by mixing 1 kg of aluminum pigment paste with 4.5 liters of phenolic resin maxing varnish. The first coat shall be applied by spraying at a coverage rate of approximately 5.7 m^2/l. The second finish coat shall be applied not earlier than 24 h after the completion of the first finishing coat at coverage of approximately7.25 m^2/l. This may be substituted by coal tar paint or decorative paint in case of downstream side. The equipment shall be kept idle for 5 days after this treatment before it is put into service.

The application procedure for bituminous black paint shall be as detailed below:

- The surface cleaning should be done as for sanded aluminum paint' detailed.
- The paint is then applied cold with brushes in 4.3 or 5 coats to obtain a desirable thickness of 0.45 mm.
- Each coat should be allowed to dry thoroughly before applying the succeeding coat.
- The minimum drying time is 24 hrs even under favorable conditions.

Gate Grooves

Grooves and particularly their machined faces should be kept clean and lubricated well and all sticky deposits should be scraped off before application of lubricant.

Seals

Efficiency of rubber seals should be tested initially after construction and at time of closures or isolation of different portions for repairs. The horizontal and verticality of the seal set and wall plates shall be checked with spirit level and seal faces of the rubber seal should be tested to press uniformly both by light test and by use of paper strip inserts. Seals of the gate should be checked for wear and tear and deterioration. These should be checked for wear and tear and deterioration. These should be adjusted/rep laced as necessary. Few sets of spare seals should be tested to press uniformly both by light test and by use of paper strip inserts. Seals of the gate should be checked for wear and tear and deterioration. These should be adjusted/ replaced as necessary. Few sets of spare seals should be kept in stock and stored for emergency in such a way that these seals do not get damaged/ withered with the passage of time while in stores.

Staunching Pipes

Staunching pipes, where provided, should be checked for their sealing efficiency and necessary repairs/replacements carried out.

Steel Wire Ropes

All steel wire ropes must be cleaned to remove all dust accumulation and lubricated with suitable greases at least once a year. The portion of steel wire rope which is submerged in water should be lubricated frequently, preferably thrice a year. The clamps shall also be inspected.

Roller Trains and Fixed Rollers

The roller trains should be examined at least once a year. Partially jammed rollers should be cleaned, freed and greased but totally jammed rollers should be replaced. The bolts of roller guard should be checked and tightened. The sliding/fixed rollers should be extracted at the time of closure (unless necessitated otherwise due to some defects which may need immediate repairs), and cleaned and greased properly. Worn out pins should be replaced and suitably held against rotation by filling the empty space between the pin and the side plates through welding or by other approved means. Spare rollers should be kept in stores for ready replacement.

Winches/Hoist

All winches and lifting drums should be examined at least once a year to see if all the gears and axles are clean and properly lubricated. All grease-fed bearings should be cleaned, old grease removed with kerosene oil and fresh grease applied. The alignment of shafts should be checked and coupling bolts tightened.

All grease cups must be kept full of lubricants and covers tightened periodically to ensure lubricant moving and causing an effective seal against dust getting into the bearings. For winches with ratios of 60:1 to 100:1, four men should be able to operate the hoist easily. If the working of any winch becomes hard and it requires more men to operate it, it should be examined and the defect removed before it is used. Winch ear covers should have felt or rubber washers to check the entry of dust. The winches should be operated in correct direction and to ensure this, direction or operation should be correctly marked and the limits of operation indicated.

Issue of Certificate

The engineer-in-charge should test all lift gated, and chain and clips of falling shutters and submit a certificate to the competent authority (as laid down in regulation orders) before the advent of the rainy season that all gates/falling shutters are in good operation condition.

5.6 Roads and Ramps

Roads and ramps shall be kept smooth and shall have a regular longitudinal grade. Ramps and approaches to bridges should be maintained smooth and to the designed gradient. Where there are spoil banks on the side of the roadway and higher than it, there shall always be a continuous drain along the outer edge of the road as well as cross drains through the spoil banks, the latter being at right angles to the former and leading with a gentle slope to the boundary ditch. Cross drains shall not be allowed to get higher than side drains. Where there are no spoil banks outside the roadway no drain is required. Where the service road has a longitudinal gradient such as near bridges, side drain along dowel (earth in parapet) should be provided.

The roadway shall be never allowed to remain blocked by fallen trees or in a dangerous condition by holes and hollows. Kilometer stones shall be adjusted to the correct position, white washed and lettering re-colored, when necessary. Guard stones and bumping stones should be adjusted and white-washed. While undertaking any repair work on service road suitable diversion shall be provided to allow uninterrupted traffic during repairs.

Ordinary repairs to canal roadway should be taken in hand after first heavy rain falls and should never be postponed till the end of the rainy season.

The canal roadway should be inspected after heavy rain and holes where seen shall be filled in accordance with 3.3. Silt from canal berm may be used for closing these holes where there are no spoil banks. Holes generally result from defective drainage which should be looked into and remedied otherwise the holes will quickly re-open.

5.7 Vegetation growth

All vegetative growth on canals, distributaries and minors should be cleared from toe to toe of the outer slopes of the banks. Shrubs, large grass, small trees, etc should be dug out by roots. Stumps of trees that have been standing should be cut down to at least below the ground. Ant hills shall be dug out and leveled off. All vegetative growth on escapes and drains should be cleared from the outer edge of the inspection bank to the inner edge of the opposite bank.

The surroundings of chainage stones should be kept clear of jungle, grass or any other rubbish to enable them to be seen from a distance.

To save maintenance money and enhance income, grass can be auctioned after 10 days of the first rains of the rainy season and many cut may be permitted. Labor only with photo identity

cards should be permitted within the premises.

All vegetative growth on escapes and drains should be cleared from the outer edge of the inspection bank to the inner edge of the opposite bank.

The surroundings of chainage stones should be kept clear of jungle, grass or any other rubbish to enable them to be seen from a distance.

More details of all the drains discharge and dimensions, etc are given in appendices in order to maintain the design parameter. All the drains are below ground level for easy flow of drainage water.

The inspection bank should be maintained in good condition. Silt cleared from the bed of a drain should be used to fill up holes and ruts on the inspection path / raise the canal banks/ service roads. This silt should not be thrown up in drains.

Trees should not be allowed to grow on the inner slopes of drains. The dead branches and rubbish that may have accumulated in the drains should be cleared before the rainy season breaks. Bunds should not be permitted in drains and should be removed if found existing before rainy season breaks. Discharge of drains should be observed each year at suitable points and recorded in a register.

5.8 Maintenance of Lined portions of Canals

In case of omo valley farm project, masonry lining will be provided in small reaches only, if required from the considerations of the seepage in weathered rock area. A lined canal should be maintained so that it continues to function efficiently and serves the purpose, for which it has been constructed, throughout its effective span of life. In addition to maintaining its imperviousness, the lining should be maintained so that it also continues to have the same discharge capacity for which it has been designed and which it had when it started operating soon after the construction was over. The reduction in discharge may generally be due to accumulation of silt; cracking \ of lining; failure of the drainage; growth of weeds, algae and moss; seepage and evaporation etc.

There can be distress to the lining ranging from small settlement cracks to excessive heaving displacement and sinking of the lining in the following situations.

a) Cuts in soft fine grained soils, especially when the lining was laid directly on the soil without any special preparation of the sub grade;

b) Freshly laid embankments, especially if composed of clayey soils;

c) High continuous spoil banks, left too near the canal excavation without sufficiently wide berms and adequate arrangements for draining the rain water away from the canal;

d) Cavities behind lining caused due to sucking out action on sub grade material by oscillating waves or fluctuating supplies of water of the canal through cracks, open joints and holes in lining, such action as may be necessary to avoid recurrence of any failure in the lining should be taken by investigating the causes of the failure and remedying them. The defects or damaged parts of the lining, joint I filler, etc, should be immediately attended to and repaired so as to ensure a sound, stable and watertight lining.

Any activities or pockets detected behind the lining should be carefully packed with sand or other suitable material. Care should be taken to ensure that the lining does not get damaged or displaced during the operation.

Damaged or displaced portions of lining should be removed and replaced by fresh lining of quality comparable to the original lining. The sub-grade should be thoroughly compacted .and prepared in accordance with IS 3873: 1992 before laying the fresh lining. The cracks (other than hair cracks) should be filled with bitumen or other suitable filler so as to ensure water-tightness of the lining. A more effective sealing of cracks may be obtained by cutting a V-groove along the face of the cracks before filling with sealing compound. Minor cracks on the lining may be sealed by dumping powdered clay upstream of the cracks

The lining should be protected from the ingress of rain water behind the lining. The free edge should be well tucked into the canal bank. Turfing of the slope above the lining level would greatly help in preventing scours and gully formation.

Suitable measure should be taken to bring the canal to carry its authorized discharge when it is noticed that the discharging capacity is reduced. It should be done by maintaining the lined surface of the canal to its original shape and slopes.

6. Maintenance of Canal and Drainage Structures

6.1 General

To the register, the drawings of all the masonry structures are maintained and kept in site office and re-modeling or repairs, etc, carried out from time to time, are marked in different colors and note to this effect is given on drawing, so that the relevant case and document could be linked.

All masonry structures should be maintained through proper repairs in a sound condition. Any damage noticed in these works should be speedily rectified. Care should be taken to ensure proper curing of repair work.

No grass should be allowed to grow near the parapets or wings of canal structure which should be kept scrupulously neat and tidy.

Metalling over bridges and earthwork in both minor and major ramps should be complete and well consolidated everywhere.

Ramps for bridges over canal should be maintained in proper condition so as to ensure the canal bank is not encroached upon.

All drainage crossings, downstream of canal structure where significant canal erosion persists due to turbulence of the wave action, dumped riprap consisting of gravel/small boulders should be provided. Protection by launching apron should be provided only in a length so as-to cover maximum scour in a slope of 2:1. Dumping of boulders should not be above bed level. Embankments should be protecting by pitching on the side slope with stones. Stones left out protruding in a staggered fashion will be, helpful in dissipation of energy. However, if this provision does not improve the situation, the cause should be investigated and suitable energy dissipating device provided downstream of the canal structures. Scour charts showing the depth and extent of scour should be maintained for all major canal structures where this tendency persists. The charts should be re-plotted and revised at least once a year after the annual closure.

6.2 Outlets

All outlets should be regularly checked and set right, if found defective, in accordance with the detailed instructions issued by the department. Outlet pipes should not be left lying about the canal. They should be carried to the nearest inspection house as soon as change in outlet has taken place and pipes are found surplus. They should be stacked neatly.

Water courses should have culverts/siphons wherever needed and should be properly maintained to avoid wastage of water. Register should be maintained and head of water (H) of each outlet i.e. the difference between the water level in the canal and the center line of the outlet at its exit end, when the canal is running at full supply level should be measured every month. It will be of great help for ensuring that the outlets draw their authorized share of canal water. The outlets should be so fixed that these draw their proportionate discharge/silt when compared to the supply in the parent channel. The working of the outlets can be evaluated from the register and these can be adjusted suitably during the month of April and October.

6.3 Over Growth of Grass and Bushes

Grass and bushes should not be allowed to grow on the structures; it should be dug out by roots. Slime and Moss which often coat masonry structures should be carefully scraped off, care being taken not to injure the mortar or plaster in doing so.

6.4 Regulation

No leakage should be permitted through the heads of canals that have been closed, as a little water dribbling down a canal promotes the growth of grass and weeds in the bed. When a canal is first opened after clearances a low supply should be run, for a few hours and the gauge then gradually raised according to the requirements.

The gates at the cross regulators should be lowered only after the parent channel has been run for some time. The lowering of gates should be to the extent necessary to create the designed reservoir level. The downstream of the parent channel should not be kept dry with full reservoir level upstream of the regulator unless conditions require the same and the structure is designed for it.

For regulating supplies into the distributaries the discharge through each bay should be more or less equal when number of bays is more than one. Suitable silt / control measure should be introduced where excessive silt is likely to be drawn by distributors.

Standing regulation orders for all important main canals and branches and critical works there on should be framed and observed to ensure safety of works and proper utilization of water. These regulation orders should be action oriented specifying the duties of various categories of staff connected with the regulation work and should be in possession of all the concerned staff looking after the maintenance.

No regulator should be planked up higher than is necessary for regulation, or kept planked up

after the necessity no longer exists.

The staff-in-charge of a canal regulator or distributors head should always have written instructions about the gauges to be run, the maximum and minimum permissible being clearly stated therein: A line marking the full supply level should be painted on the upstream face of every structure. If there is no structure in a considerably long reach, full supply level should be marked on the profile walls specially constructed for this purpose such that it is conveniently visible from the inspection bank.

6.5 Cross Drainage Works

6.5.1 Inspection

Regular inspections of cross drainage works on major rivers and drains are necessary every year before the floods to ascertain/examine their state of condition and after the floods to ascertain actual functioning and damage: if any, during the floods. Certain inspections are to be carried out during the canal closure. All inspections shall be directed to the following aspects:

- To see that the cross drainage and appurtenant works are in good operating conditions and to make them operable if they are not so.
- To determine after the floods the repairs or remodeling measures required; to see if any leakage from the canal is taking place at vulnerable locations;
- To investigate for presence of any unusual phenomenon in respect of boils, piping, sweating of bank or saturation of substratum etc or cracks in the structure;
- To check any changes in the design features in the field, and to restore it to the original design and to redesign the hydraulic structures after the floods, if so warranted. To study the behavior of pressure relief valves, weep-holes, and filters, if any, installed in the floors/retaining walls of cross drainage works;
- To study the water levels recorded and the quantum of flood discharge passed through the cross drainage work for evaluating its performance. In case of excessive rise of levels, investigations have to be carried out and remedial action taken to improve the conditions, if necessary, also during canal closure. If it is due to blocking of passage, the works may have to be de-watered for inspection; and

- To study the longitudinal section of drainage to see whether aggradation and degradation are taking place, endangering the safety of the structure.

In addition to the above, the inspection shall include investigation of the following aspects to guard against damages occurring to the cross drainage work:

- Investigate if any meandering of the drainage channel in the vicinity of the structure or change of flow pattern has occurred during the previous rainy season period;
- Investigate whether new streams have been diverted into the main stream for which the work has been constructed, resulting in inadequate capacity of the cross drainage work;
- Investigate if any obstruction has been created in the drainage higher up or lower down and ascertain if such obstruction has affected the functioning of the cross drainage structure;
- Investigate whether the tanks on the upstream of the structure are in good condition; and
- Investigate the construction of bridge or other structures, with fewer waterways, which may increase the H.F.L.as a result of afflux.

Cross drainage works shall be inspected periodically, the inspection shall be not less than twice every year, at least once before rainy season and once immediately after rainy season. In addition, whenever a flood exceeding the design flood or the previously recorded highest flood passes the cross drainage works, the structure shall be inspected to study the effects of the flood and suitable ameliorative measures shall be taken.

Upstream and downstream floods, loose aprons and filters, if any, of cross drainage works require particular attention during inspection. Any damage or settlement in them shall require special investigation to initiate timely and adequate measures for restoration to avoid further damage during subsequent floods. Likewise, training works such as groynes, flood protection works, spurs, etc shall also receive special attention during inspection regarding their stability and upkeep, so that any damage and/or settlement of pitching and loose apron may not result in shifting the course of the stream and attack the banks of the canal and sides of cross drainage works.

Faithful record of history of behavior of structures and damage to important structures during rainy season or otherwise and repairs carried out shall be maintained in the log books of damage and repairs for the major structures. Such record shall be made available during inspection by inspecting officers for their remarks.

An inspection register shall be maintained for all cross drainage works. Its first few pages shall contain the hydraulic and structural design details of the cross drainage works in the Performa given in Appendix A. A few pages for the inspection reports of the inspecting officers for each

year shall be maintained using the Performa given in Appendix B.

6.5.2 Damages to Cross Drainage Works and Remedial Measures

Damages to cross drainage works are manifested by the following:

- Silting and/or berming / choking in the drainage channel;
- Seepage, piping, scour and/or undermining;
- Sloughing and/or caving;
- Uplift and/or upheaval;
- Structural cracks;
- Out flanking/over-topping;
- Sinking and/or differential settlements;
- Growth of shrubs and other vegetation in the drainage barrels;
- Meandering of u/s reach and/or change in the drainage course in the vicinity of cross
- drainage work;
- Choking of pressure relief valves/filters;
- Bearings not functioning properly;
- Malfunctioning of gates; and
- Leakage through joints, seals and water stops.

Remedial measures for the damages to cross drainage works are mentioned below.

a) Silting is a common feature observed in cross drainage works. Silting takes place in the bed of the approach channel, drainage events and exit channel, resulting in reduction of effective area for passage of water causing heading up of water to levels higher than designed, thereby over-topping the cross drainage works and canal banks. A meandering drainage course is likely to deposit silt in a disproportionate manner in the drainage course. Regarding de-silting of the bed and training of the drainage course can be considered. If choking due to debris has taken place, this shall be immediately cleared.

b) Undermining of the structures by deep scours during flood is one of the serious dangers to be guarded against. The actual condition cannot be inspected during floods as the damage done cannot be seen or nothing comes to light as the scour pit gets filled up during receding floods.

i. The waterway of the cross drainage works shall be kept free from any obstruction by

regular clearance of. Sediment deposits, debris, trees, stumps of wood, etc found therein;

ii. To replenish concrete blocks/stone apron provided in front of upstream and downstream cutoffs as a regular maintenance measure;

iii. Need to provide deeper cutoff or increasing length of existing floor may have to be examined and adequate remedial' measures taken in case piping has set in, as evidenced by cavities detected under floors; and/

iv. To prevent such cavities in the floor, provision of compacted filter material to form sub grade shall be made. Where cavities have been noticed, the floor shall be removed above it, the cavities filled with compacted 'filter material and the floor repaired in addition to taking up the measures mentioned in item (iii) above.

c) Sloughing and/or caving of the guide banks of approach and tail channel and canal banks at the junctions of cross drainage works are to be prevented. Sloughing of guide banks may obstruct the water passage, causing heading up of water with consequential over-topping of structure or undermining and scour downstream. Adequate, timely steps shall be taken after inspection to prevent sloughing or caving of banks, if anticipated.

d) The barrel portion, the exit and entry points shall be rendered free of shrubs and vegetation to avoid obstruction to the drain flow.

e) A meandering water course in the vicinity of the cross drainage structure may result in embayment or endanger the downstream protection work. Suitable training works may have to be provided at such locations.

6.5.3 Maintenance of Cross Drainage Works

Before Rainy season

- The approach and exit channels in the vicinity of cross drainage work shall be cleared of silt debris stumps branches of trees etc before the rainy season.
- Any cracks and holes in upstream and downstream floors of the cross drainage work shall be duly repaired.
- It shall be ensured that water seals or asphalt joints are intact. Leakage if any shall be corrected by use of proper filler material.
- Concrete blocks or stone apron provided in front of upstream and downstream cutoffs may be replenished as a regular maintenance measure.

During Rainy Season

- During rainy season, a vigilant watch is required in major cross drainage work. Adequate gauge readings must be recorded during rainy season. Return flow and eddies near the cross drainage works need be watched.
- All fallen out or disturbed pitching mat be made good.

Post Rainy season

- The top levels of structure should be recorded for getting information if there are any settlements.
- If any gully or any caving is seen in canal banks or at the junction it should be treated with suitable selected soils.
- If hair cracks are noticed in the reinforced concrete slab or beams, they shall be carefully pressure-grouted with neat cement grout after thorough investigation of the cause. If wider cracks are noticed, they shall be grouted with mortar grout of rich mix of cement and sand. If peeling off of concrete is noticed, exposing reinforcement, the damage may be repaired by Grunting or shot-creting with B.R.G. fabric, after chiseling out the loose portions of concrete or mortar around the reinforcement and pre-wetting the surface with cement slurry. To prevent leakage, appropriate sealant compound may be provided at all edges.
- The gauges provided shall be repainted periodically to make them legible. It would be preferable if enamel gauge plates are provided, as markings done on these plates do not fade out for a long time. The gauges shall be checked for correctness.
- Any damage to the bed and sides is to be recorded on the appropriate register and arrangements made to prepare it. Implementation of Maintenance

General Maintenance of Canals, Drains will be done manually as the canal system has got small canals. The canal system will be closed when there is no need of Irrigation and as it is possible to maintain it manually. Main Canal will not need any de-silting normally. The tertiary canals are small one which will be easier to maintain manually.

7. Equipment Required for Maintenance

7.1 General

The maintenance of canals, drains, in the Omo valley Irrigation Project is simple affair as the canals will remain closed for some periods and hence maintenance can be done during closure periods and as the canals are small sized, the maintenance will be done mostly manually. However some machinery will be kept for some emergency.

7.2 Machinery for Maintenance Embankment and Side Slopes

The side slopes of the embankment of canals and drains have to be kept smooth to prevent erosion and to allow mechanized weed control. The best choice for this operation is the motor grader and consists of a hydraulically operated mould board of 3.00 m width.

This blade will level and grade the side slopes of canals, dykes, roads, ditches, etc with the grader travelling alongside. The soil or silt is brought on the bank or road and is moved further with the regular blade in a following pass.

The grader and sloper can also be used for de-silting small canals like field drains, provided there is path alongside. Under these conditions, this motor grader can obtain high outputs. After experience gained, more motor graders can be procured if they prove to be useful in comparison of manual labor.

7.3 Machinery for Control of Grasses and Weeds

Control of grasses and weeds can on the embankment and slopes is necessary to discourage development of pests, shrubs and trees which could damage the banks and to encourage soil binding grasses.

Mowing can be done by a flail mower at the end of a hydraulically operated boom. This can be a special attachment to an agricultural tractor. With such a tractor the maximum reach would be about 5.0 m and working speed about 4.0 km per hr resulting in a net production of 2.0 km.

7.4 Machinery for Maintenance of Flood Protection Embankments and River Course

Dykes or embankments require close supervision and routine maintenance to strengthen weak reaches each year. Major maintenance is required at least once in 5 years to raise and strengthen eroded sections.

Removal of the obstructions in the river course has to be performed as and when required. Normally it is not required. These activities can be performed by a Bull Dozer with scraper box and wheel loader.

7.5 Machinery and Equipment required

Equipment	Number
• Excavator	R
• Tractor with mower	R
• Bulldozer with scraper box	R
• Motor Grader	R
• Roller	R
• Generator 33 kva	R
• 5 HP Pump For dewatering	R
• Truck dumpers	R
• Field equipment (measuring instruments)	R
• Surveying equipment	R

8. Manpower Required for Operation & Maintenance

8.1 General

The number of manpower required and the skill needed depend on the size of the scheme, the method of water distribution and the number and size of the farms. The proposed manpower for Omo valley irrigation project is, therefore, might be revised and amended based on the above operational requirements during the actual operation and maintenance.

Irrigation operation staffs commonly required in large irrigation projects are Gate Operators, Pump Operators (when water pumps are used), Water Guards, Irrigation Assistants (Super-intendents), and Irrigation Engineers. As large scale irrigation farms are new to Ethiopia, there is no domestic experience to be used as a base for estimating the manpower requirement. According to literature1, however, each Water Guard can look after 100 to 150 ha or more, depending on the type of system and the size and number of farms. An Irrigation Assistant can supervise four or more Water Guards covering about 500 ha. An irrigation Engineer, on the other hand, could be responsible for up to 2000 to 2500 ha or more.

8.2 Job Description of Various Staff required for operation & maintenance

8.2.1 Project Manager

Project Manager will be responsible for overall Administration. Planning, Maintenance of Structures, Operation of various structures and Water Management and Agricultural Extension.

8.2.2 Maintenance Engineer Civil and His Teams

- Plan, organize and supervise the required maintenance activities periodically.
- Plan, organize and supervise the proper state of functioning and maintenance of all Equipment and machinery of the PMU.
- Administer all activities in maintenance and report to the Central Administration Unit, water management unit through the Project Manager anything relevant in terms of requirement of laborers', machinery, materials and the like, according to the established procedures of the PMU.
- Estimate requirement of labor etc and material in advance of the rainy season for proper maintenance of all the Canal and Drainage System and Dykes etc.

8.2.3 Mechanical Engineer

Duties of this engineer are detailed here under:-

- Inspect Maintenance of all gates of Outlet, under sluices, head Regulators, all canal structures etc are in good order
- Carry out Inspection of all gates regularly
- Maintenance of workshop and its equipment
- Maintenance of Vehicles
- Maintenance of all Machines

8.2.4 Mechanical Foreman

- Maintenance of Gates in good order
- Inspection of all gates regularly

8.2.5 Water Management Engineer

The Water Management Engineer is responsible for the operation of the whole irrigation system. In particular he/she will perform the following:

- Supervising irrigation assistants
- Preparing irrigation plans
- Working closely with agricultural staff to plan the supply and demand for water
- Reporting all maintenance needs to the maintenance department
- Reporting to the general manger on the irrigation system and its future needs

8.2.6 Monitoring Technicians Groundwater

- Acquaint him with the location and characteristics of each observation well in the project area.
- Compile, analyze and evaluate the field data.
- Report to the Water Management Engineer any abnormal observation in connection with the fluctuation of water levels or salts in water samples of the each individual well.
- Identify water logging or drainage problems existing or that may exist within the developed area
- Develop Ground Level contours and determine the direction of water movement

- Plot ground water electrical conductivity contours Maintain and be responsible for the instruments issued to him.

8.2.7 Irrigation Assistants

The task of Irrigation Assistants will be to coordinate the work of water Guards which include:

- Collecting information from water guard on water requirements, maintenance needs and land preparation and passing this to the Irrigation Engineer
- Passing instructions on water allocations from the Irrigation Engineer to the water Guards
- Organizing training courses for Water Guards, Gate Operators and irrigators.

8.2.8 Gate Operators for Head Regulator

- Work in 8 hour shift to cover 24 hr per day. The shifts will be from 6.00 AM to 2.0 PM., 2.0 PM to 10 PM and 10PM to 6.0 AM.
- Not leave their place of work unattended during their 8 hr shift.
- Record accurately on the form provided the gauges, gate openings etc
- Learn thoroughly how to adjust the gates
- Not entertain outsiders in the gate operation cabins
- Keep all forms, Registers and Graphs and tables, stage discharge curves in proper order.
- Be attentive to the security of gates operating equipment etc and rechargeable torches in their custody
- Report any damage to the gates or scouring of Banks of canal in the near vicinity of the Head Regulator

8.2.9 Other gates

Similar as above, but operation shall be as ordered by the Project Manager

8.2.10 Water Guards

Water Guards are the main link between the engineers who operate the system and the irrigators in the field. Their major jobs will involve the following:

- Helping irrigators with water management problems
- Passing instructions to gate Operators

- Collecting requests for water from irrigators
- Reporting problems on land preparation and canal maintenance

In addition to the above job description details, the employee to operate and maintain the structures under this project have to acquire knowledge and skill regarding the plan and function of different component of the scheme for its proper management, operation and maintenance therefore, they have to be given training at site, on field or workshop program. Communication system with in the Project Management Unit (PMU) for sending progress reports, emergency calls, consultations etc. has also an important role therefore, to accomplish the optimum results of the completed system there should be a regular communication route with in the project.

9. References

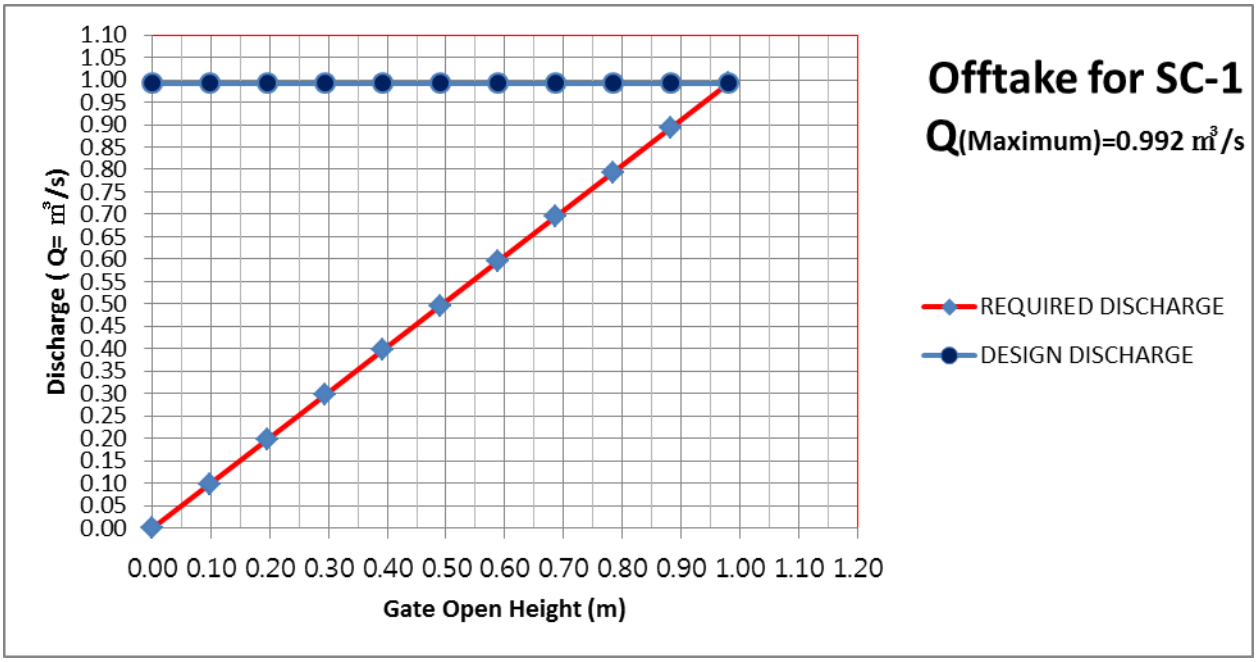
1. Arjo Dedessa Irrigation and Hydro power project Detail Design Report Volume II part II Operation and Maintenance Manual for irrigation and Drainage system, WWDSE, Addis Ababa, June, 2010.

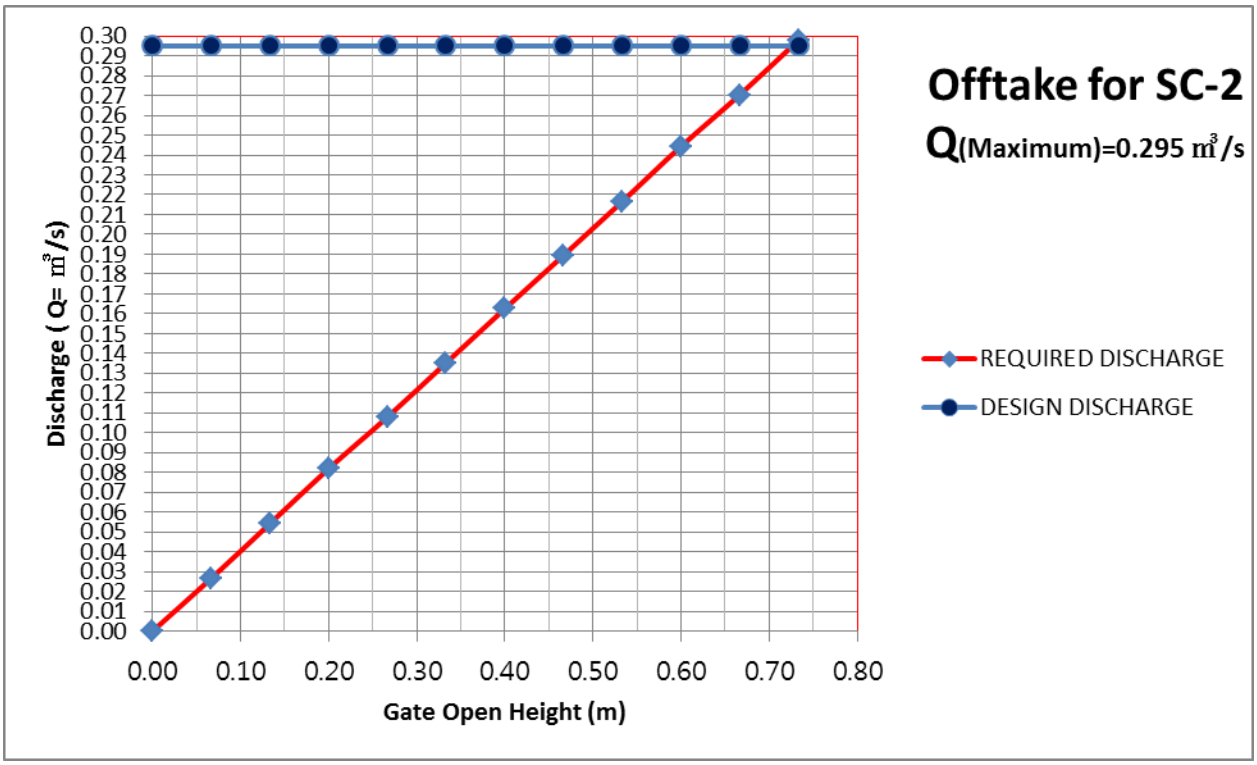
2. Gumara Dam and Irrigation system Detail Design Report Volume – V – Pt 2 Operation and Maintenance Manual for Structure, Canal and drainage system, WWDSE, Addis Ababa, March, 2010.

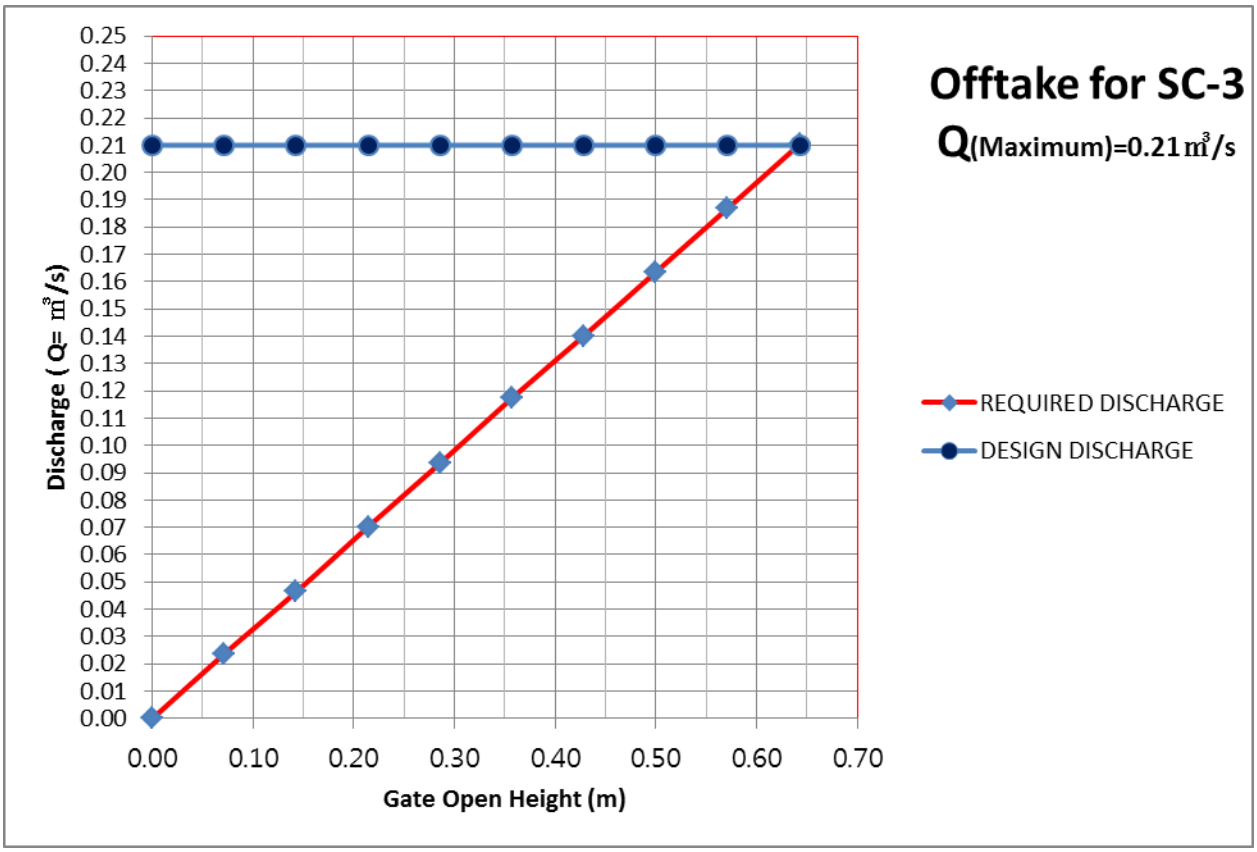
3. Irrigation Water Management Training Manual 10, Irrigation Scheme Operation and Maintenance Manual, FAO, Rome, 1996.

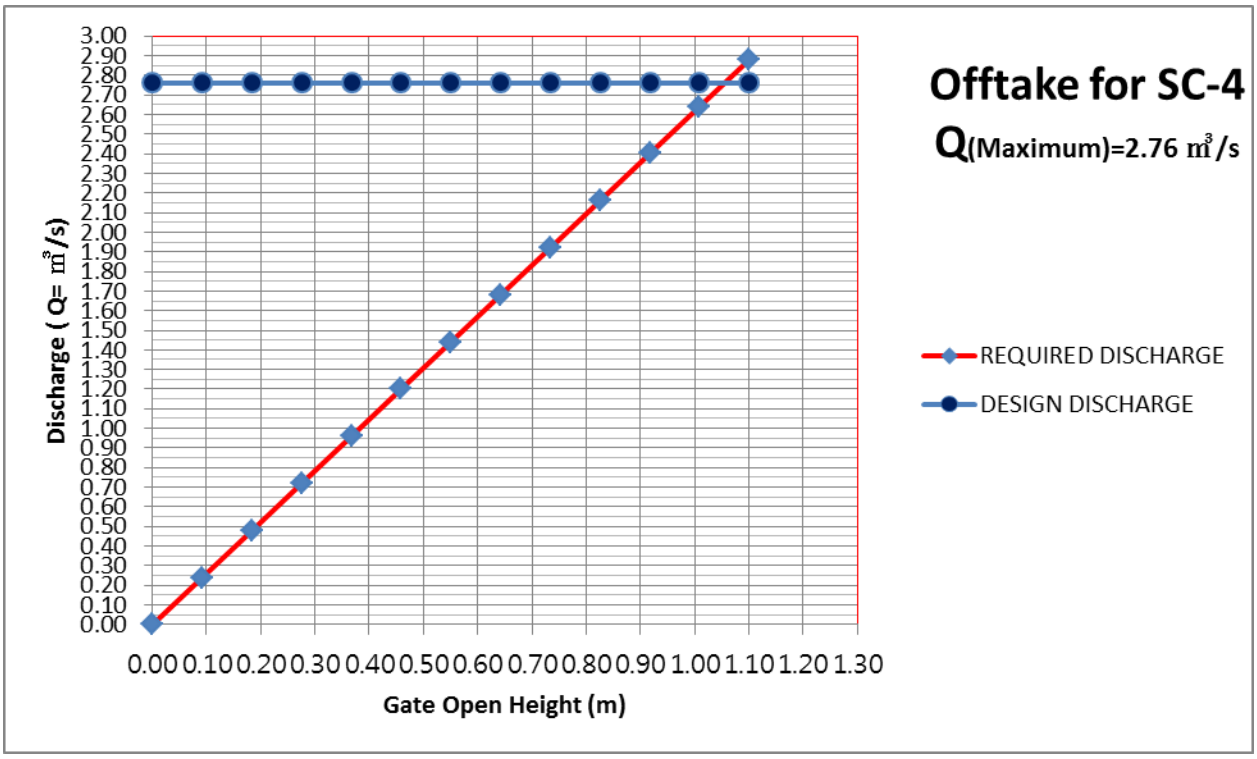
10. Annex-I

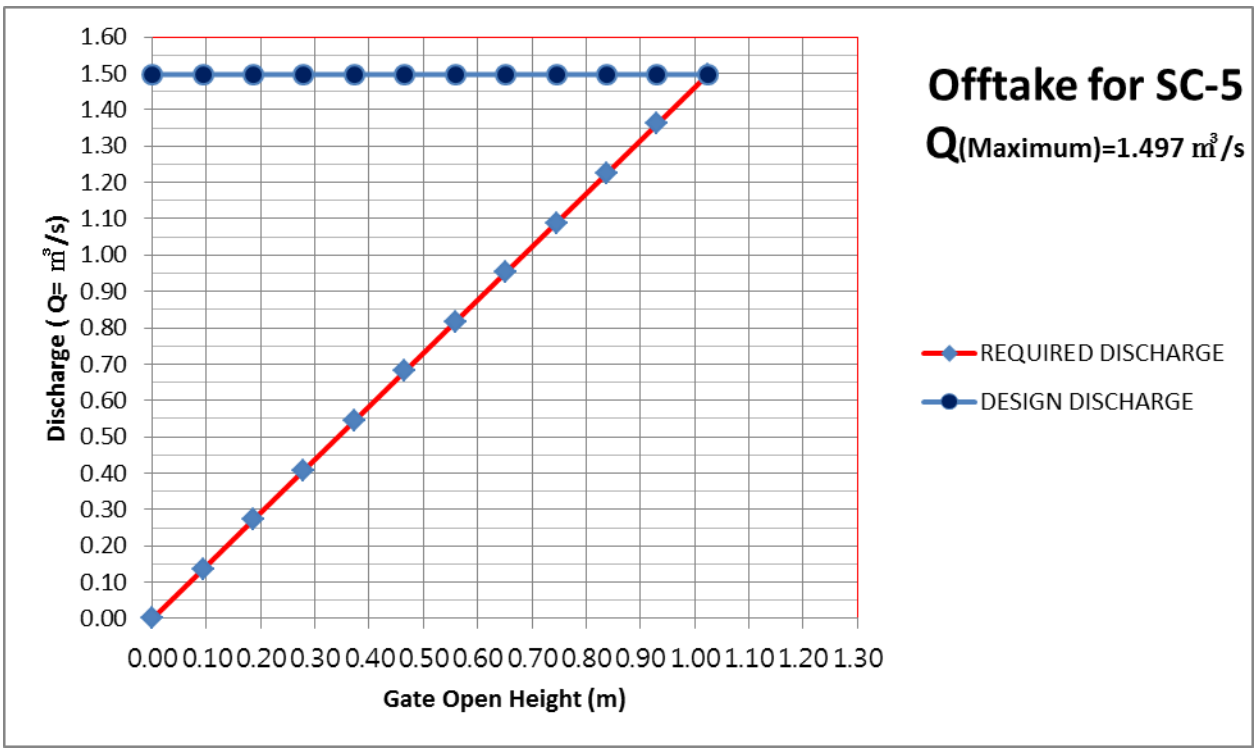
Rating Curves of Off Takes and Cross Regulators of Main and Secondary Canals Detail:

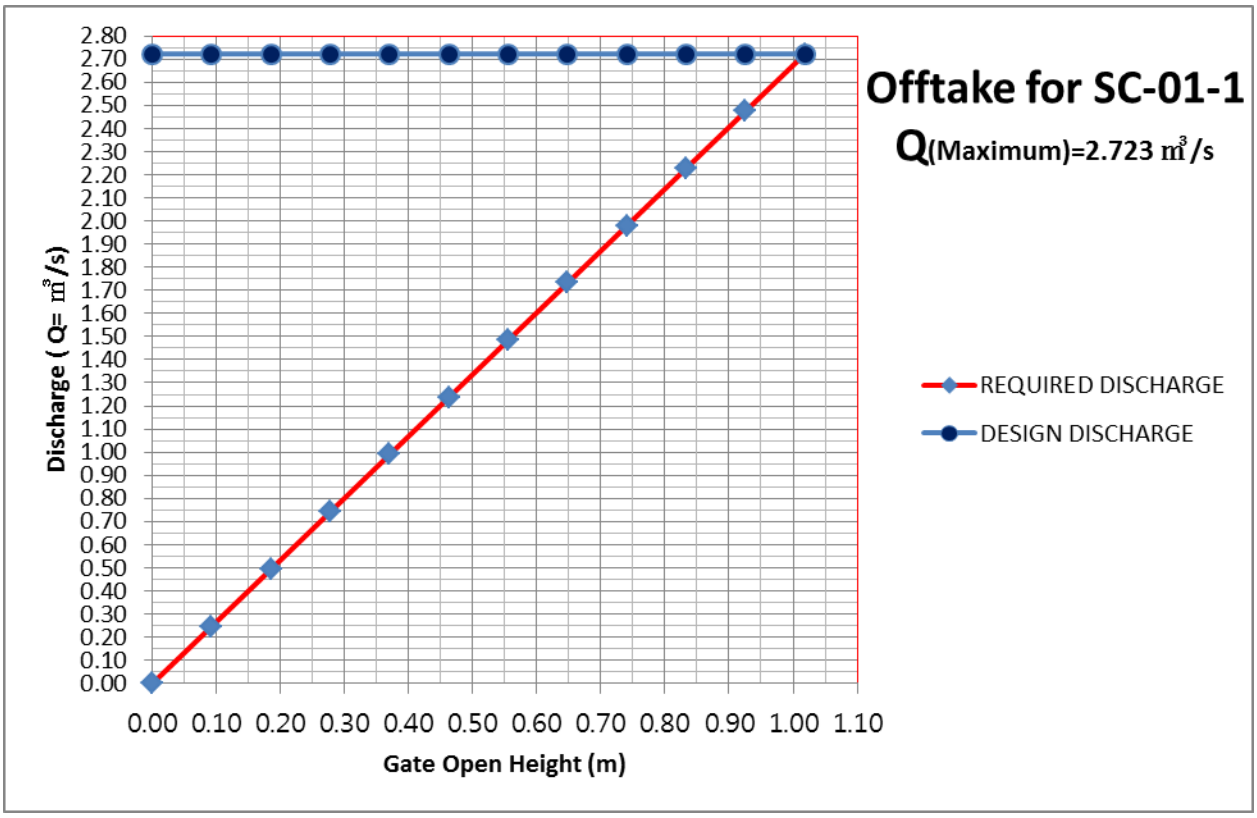


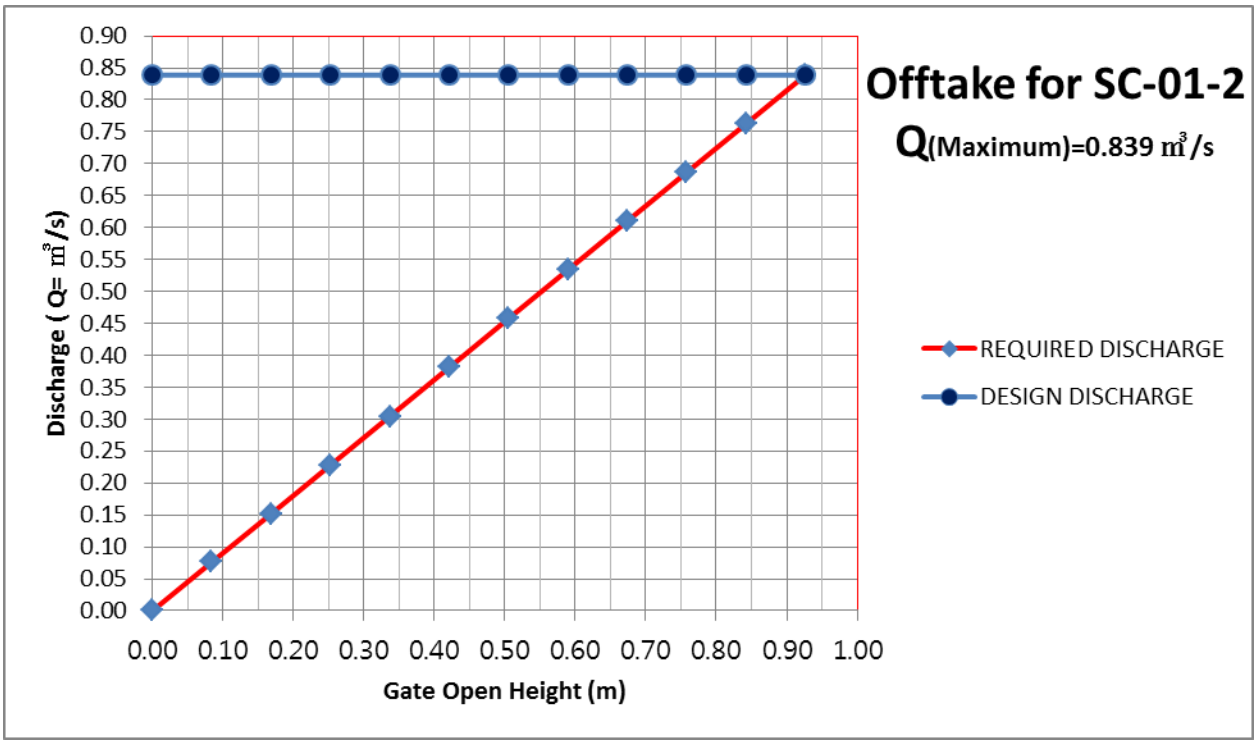

Offtake for SC-2
Q(Maximum)=0.295 m³/s
Discharge (Q= m³/s)
0.30
0.29
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.20
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
Gate Open Height (m)
REQUIRED DISCHARGE
DESIGN DISCHARGE

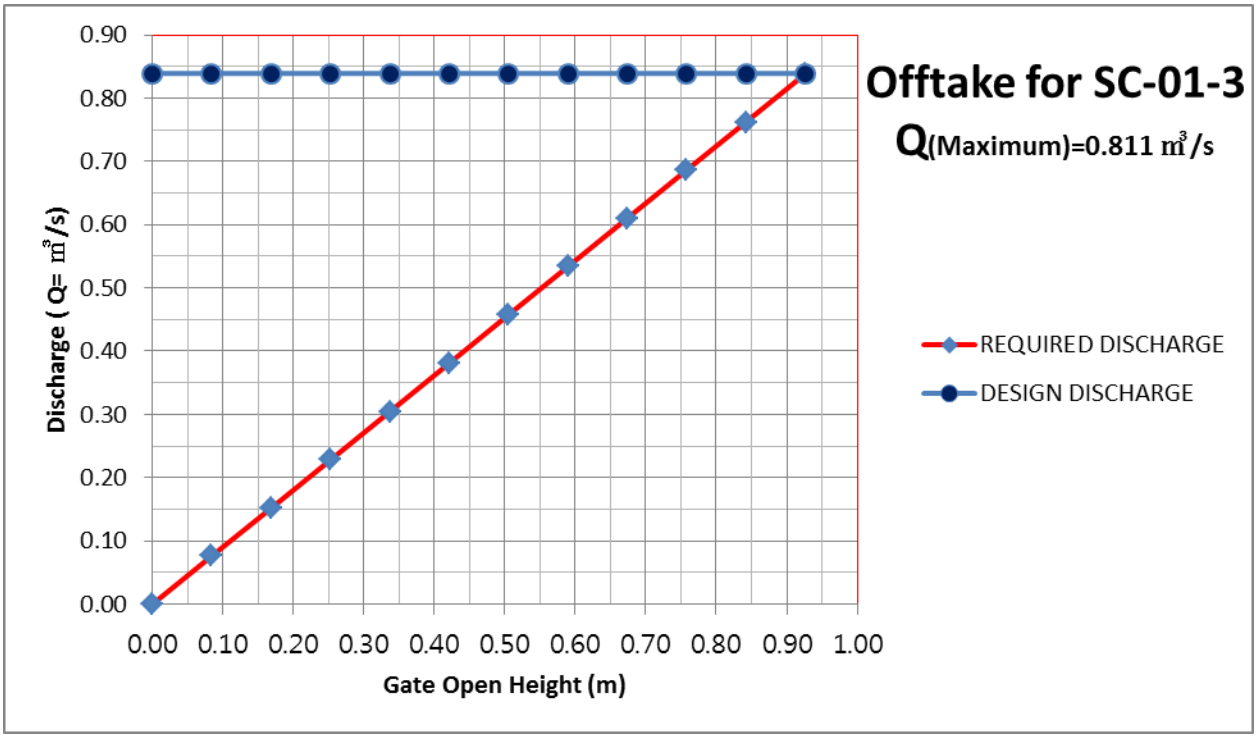

Offtake for SC-3
Q(Maximum)=0.21 m³/s
Discharge (Q= m³/s)
Gate Open Height (m)
0.25
0.24
0.23
0.22
0.21
0.20
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
REQUIRED DISCHARGE
DESIGN DISCHARGE

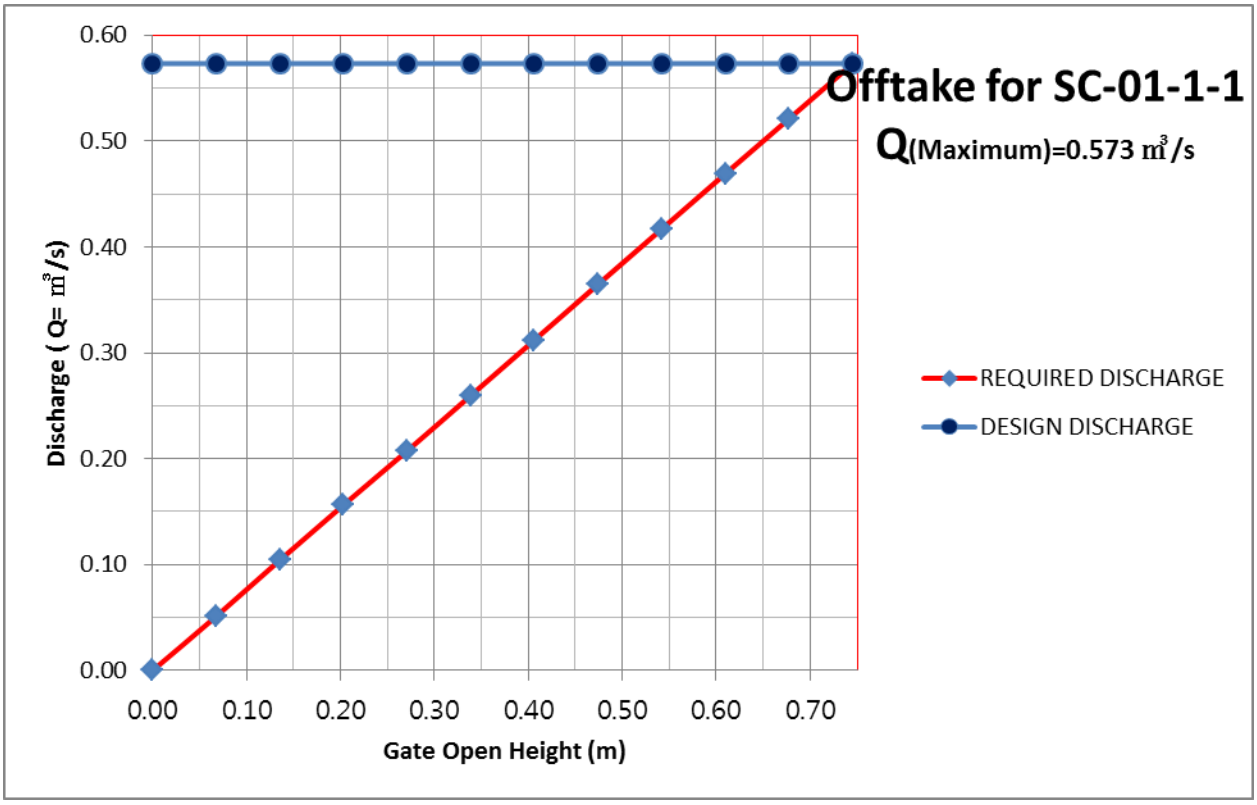

Offtake for SC-4
Q(Maximum)=2.76 m³/s
Discharge (Q= m³/s)
Gate Open Height (m)
REQUIRED DISCHARGE
DESIGN DISCHARGE

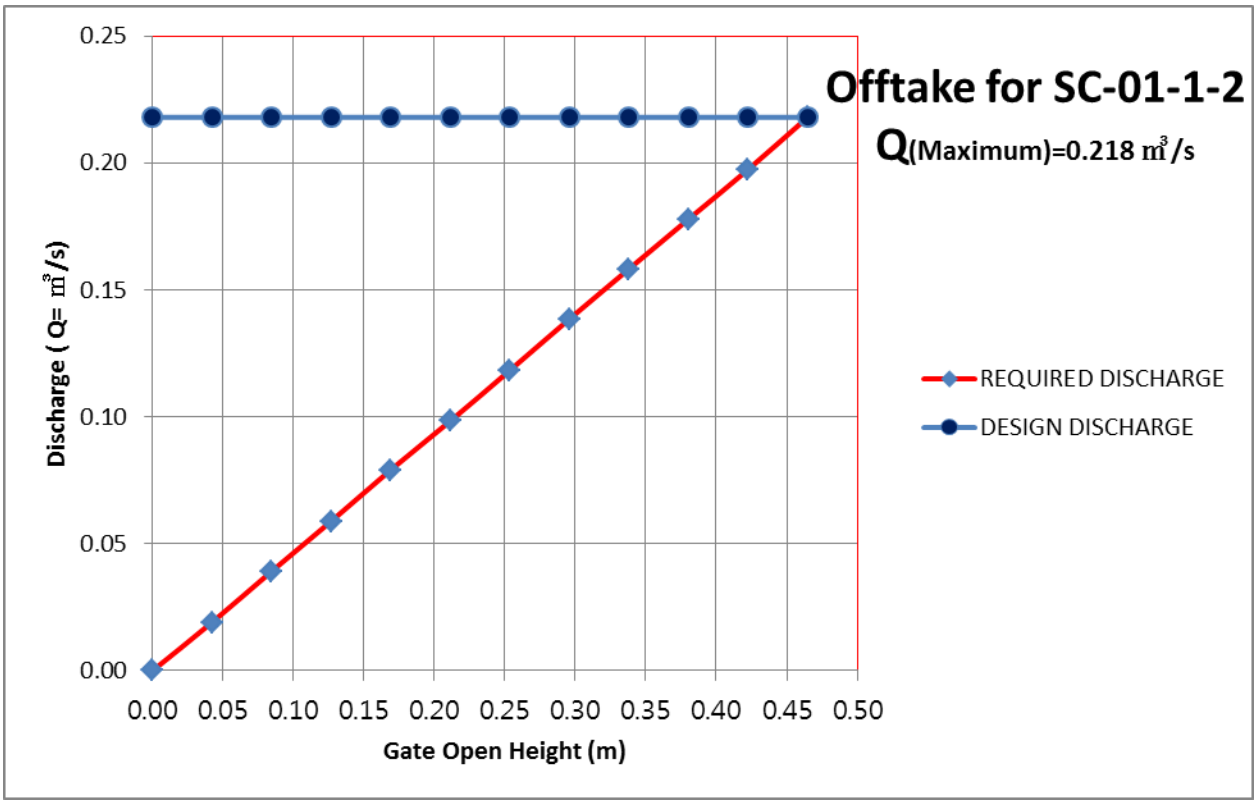

Offtake for SC-5
Q(Maximum)=1.497 m³/s
Discharge (Q= m³/s)
Gate Open Height (m)
REQUIRED DISCHARGE
DESIGN DISCHARGE

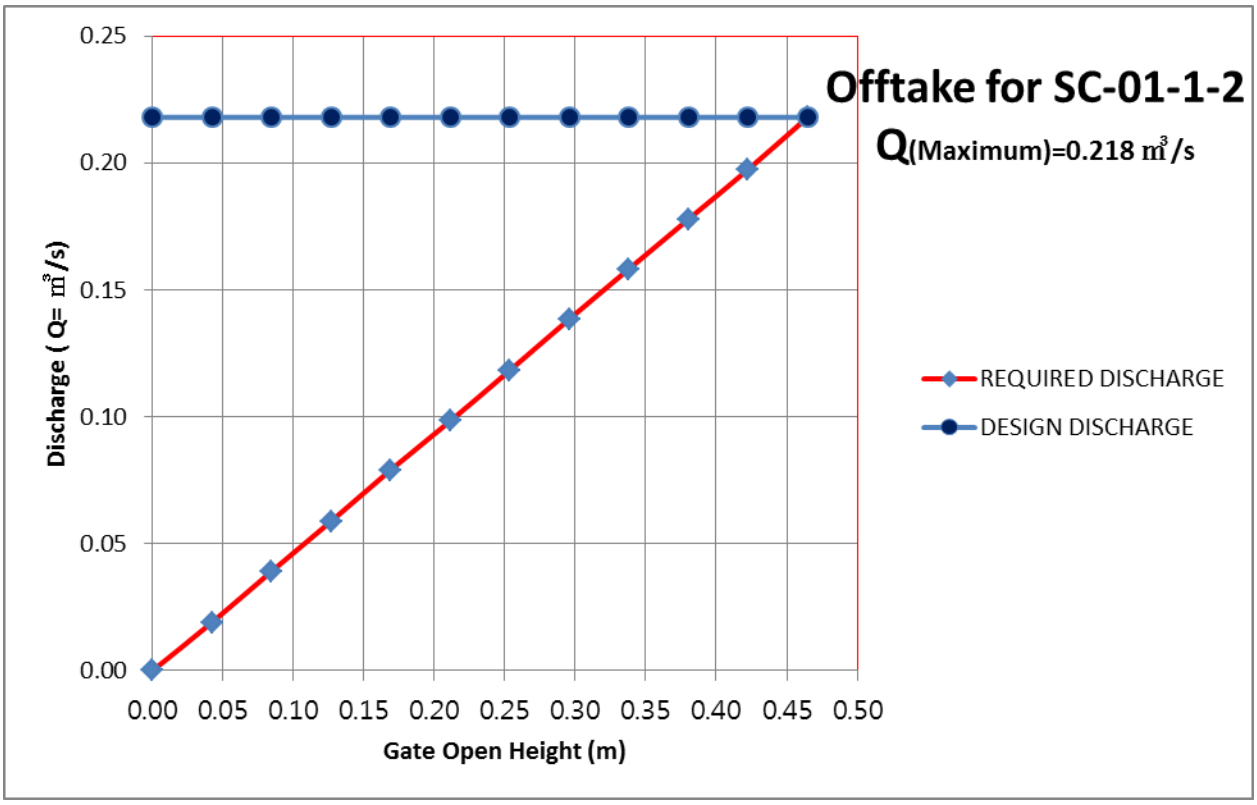

Offtake for SC-01-1
Q(Maximum)=2.723 m³/s
Discharge (Q= m³/s)
Gate Open Height (m)
REQUIRED DISCHARGE
DESIGN DISCHARGE
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10 1.20 1.30 1.40 1.50 1.60 1.70 1.80 1.90 2.00 2.10 2.20 2.30 2.40 2.50 2.60 2.70 2.80

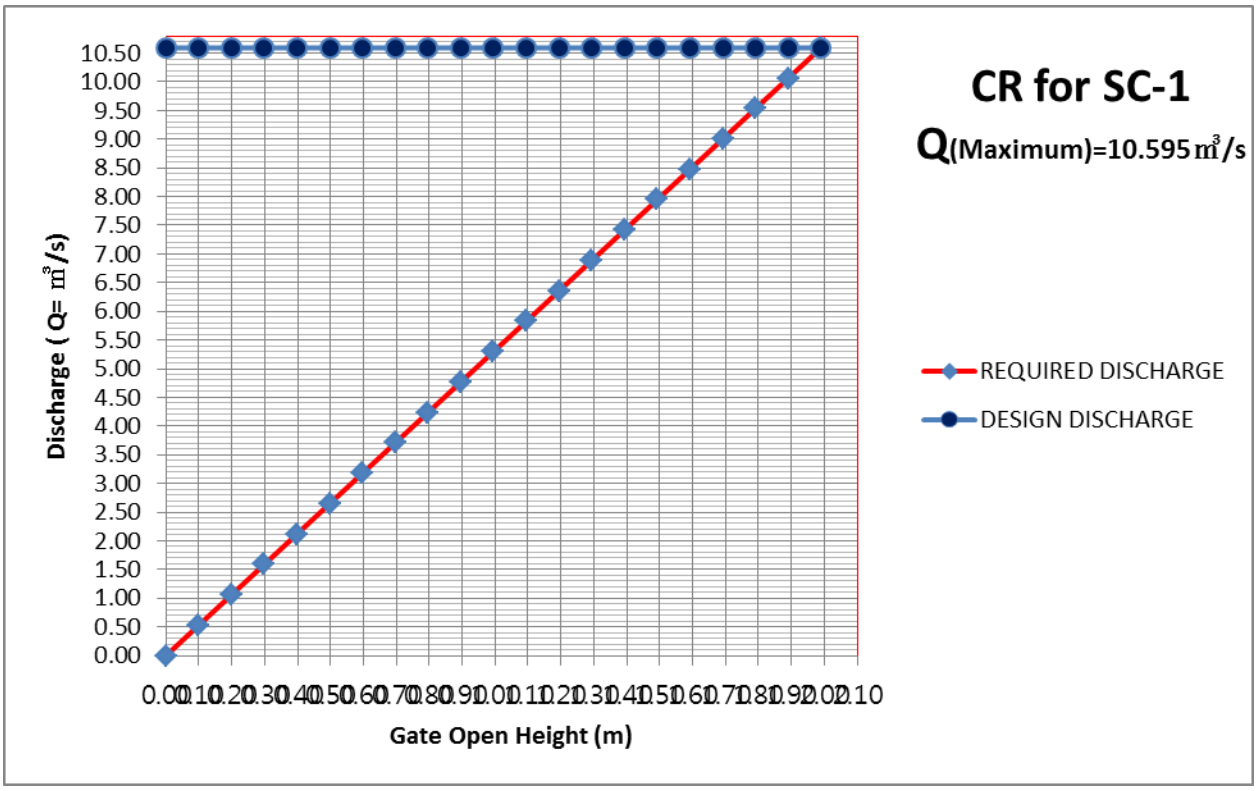

Offtake for SC-01-2
Q(Maximum)=0.839 m³/s
Discharge (Q= m³/s)
Gate Open Height (m)
REQUIRED DISCHARGE
DESIGN DISCHARGE
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

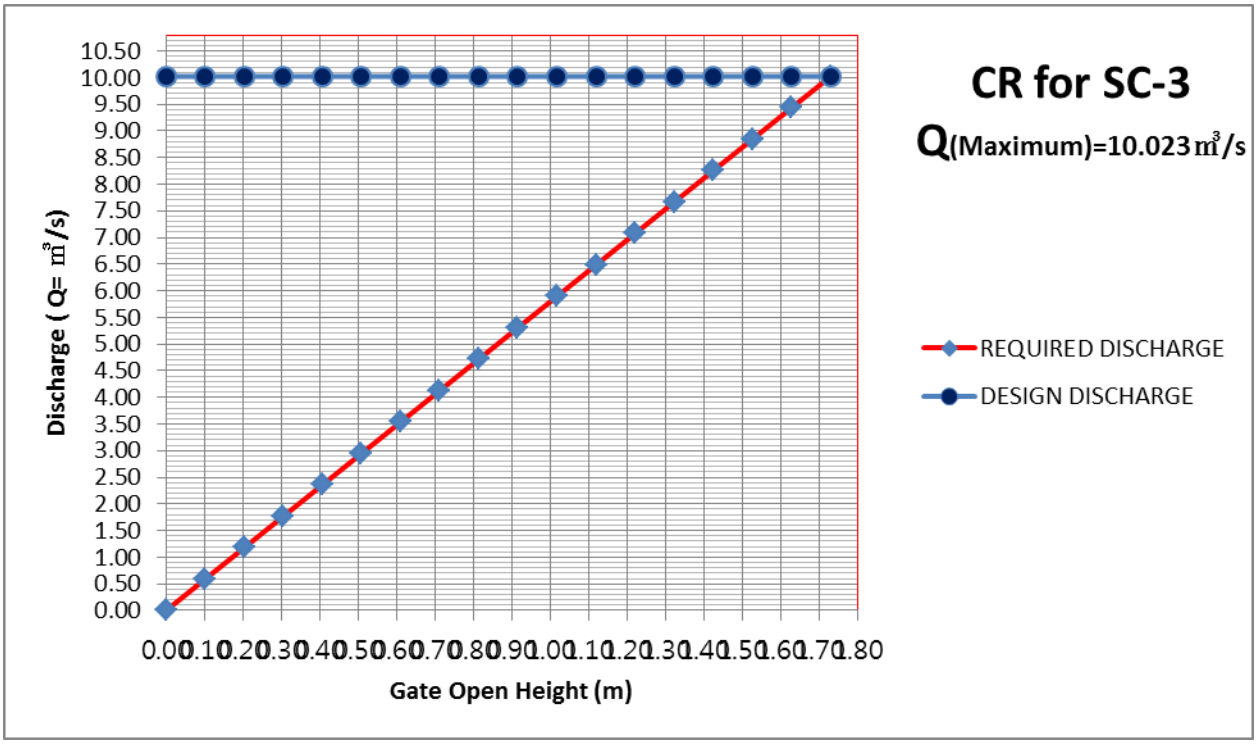

Offtake for SC-01-3
Q(Maximum)=0.811 m³/s
Discharge (Q= m³/s)
Gate Open Height (m)
REQUIRED DISCHARGE
DESIGN DISCHARGE
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

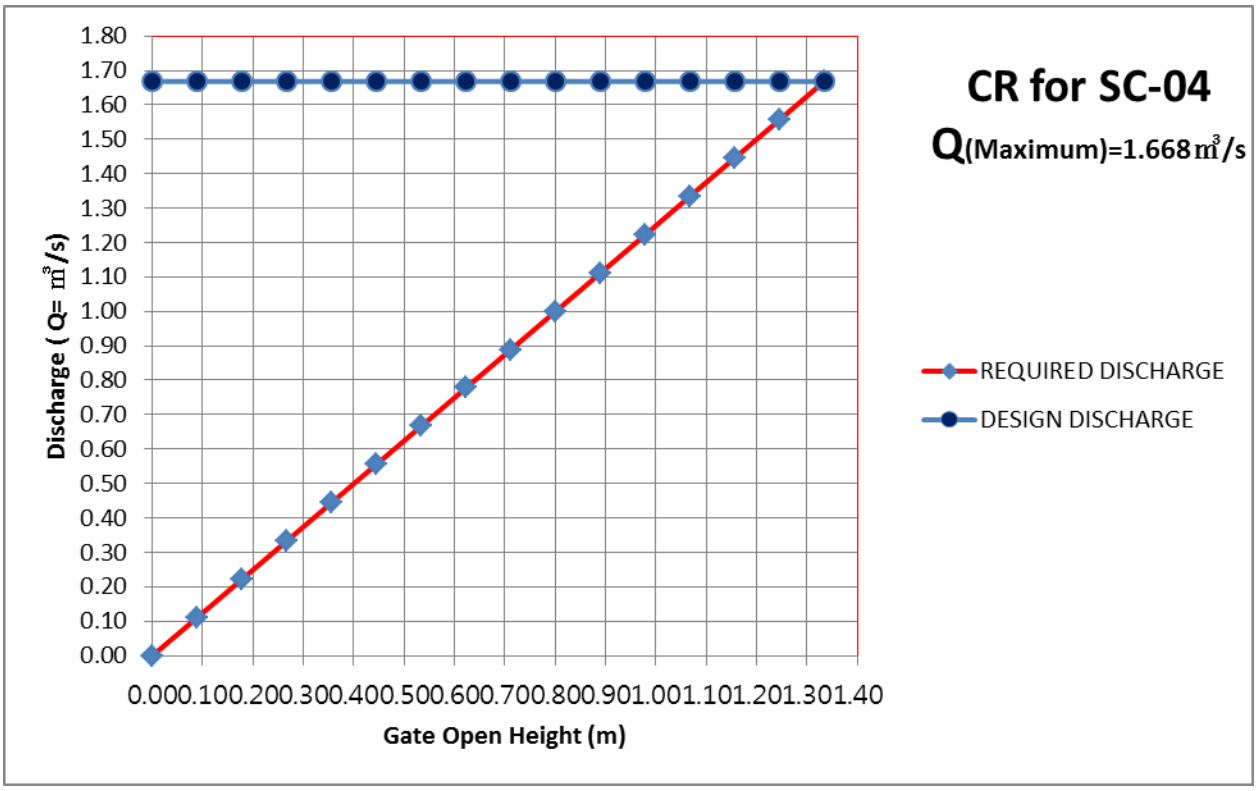

Offtake for SC-01-1-1
Q(Maximum)=0.573 m³/s
Discharge (Q= m³/s)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
Gate Open Height (m)
REQUIRED DISCHARGE
DESIGN DISCHARGE

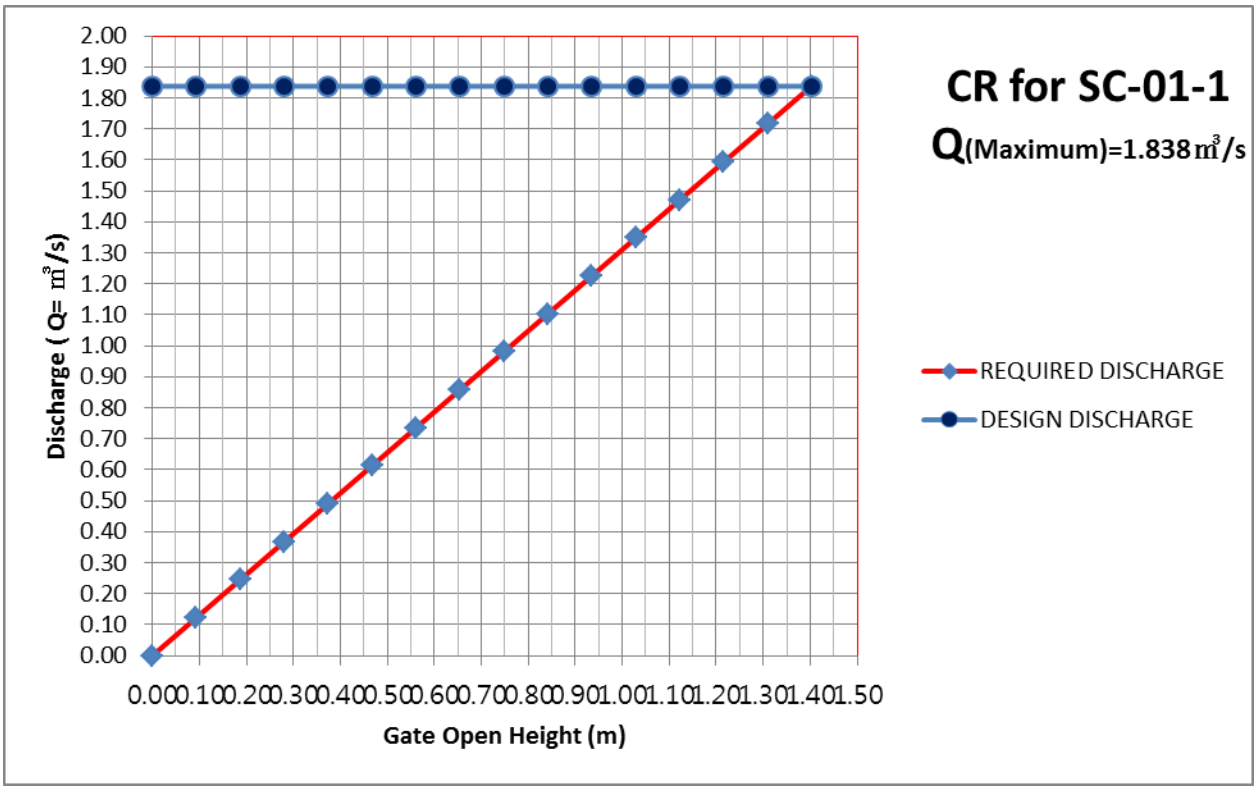

Offtake for SC-01-1-2
Q(Maximum)=0.218 m³/s
Discharge (Q= m³/s)
0.25
0.20
0.15
0.10
0.05
0.00
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Gate Open Height (m)
REQUIRED DISCHARGE
DESIGN DISCHARGE

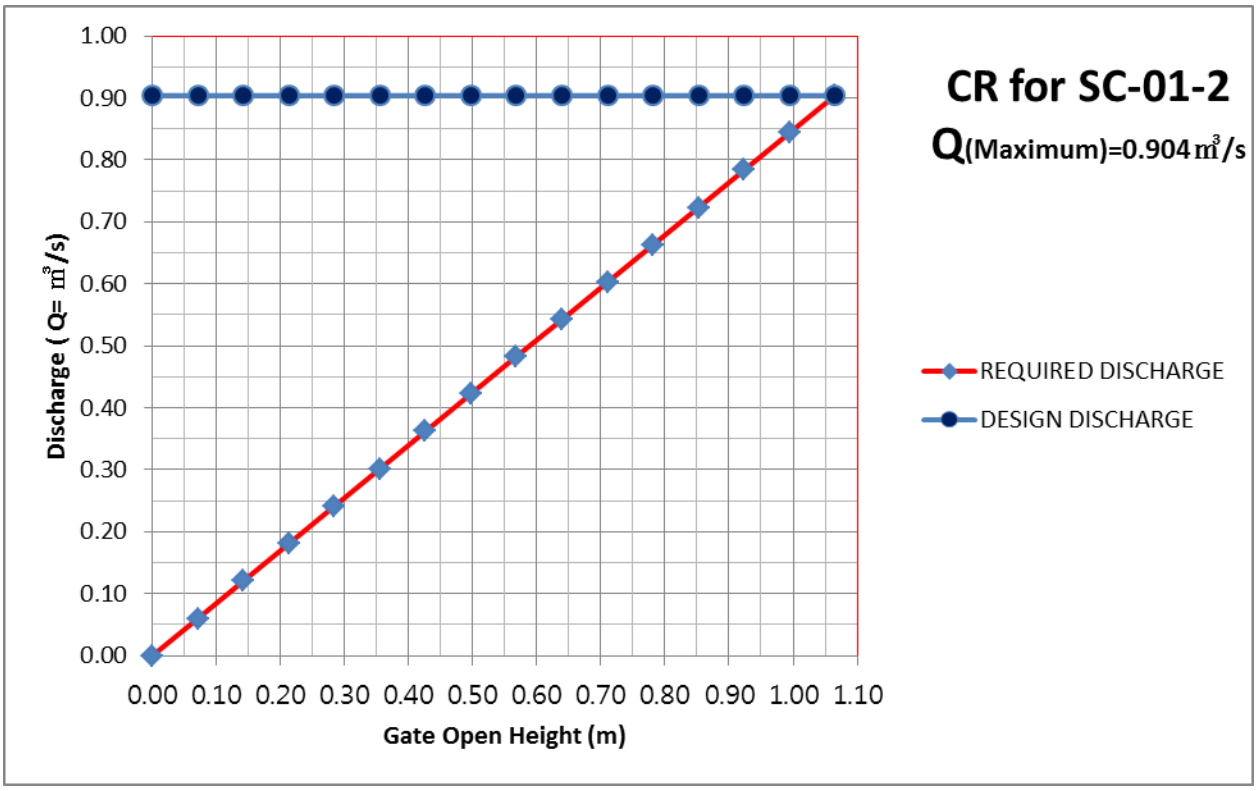

Offtake for SC-01-1-2
Q(Maximum)=0.218 m³/s
Discharge (Q= m³/s)
0.25
0.20
0.15
0.10
0.05
0.00
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Gate Open Height (m)
REQUIRED DISCHARGE
DESIGN DISCHARGE

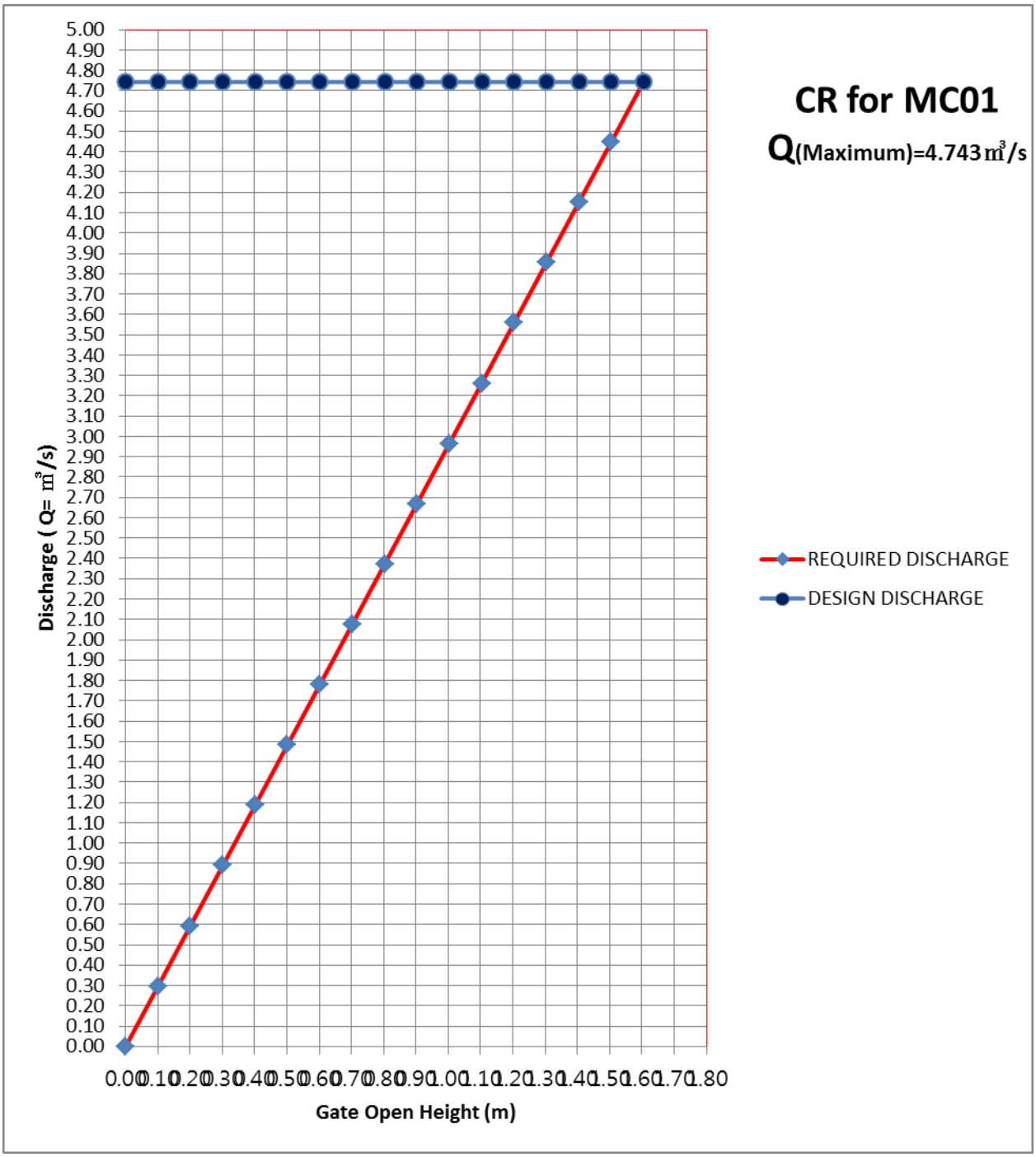

CR for SC-1
Q(Maximum)=10.595 m³/s
Discharge (Q= m³/s)
Gate Open Height (m)
REQUIRED DISCHARGE
DESIGN DISCHARGE


CR for SC-3
Q(Maximum)=10.023 m³/s
Discharge (Q= m³/s)
Gate Open Height (m)
REQUIRED DISCHARGE
DESIGN DISCHARGE


CR for SC-04
Q(Maximum)=1.668 m³/s
Discharge (Q= m³/s)
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.000.100.200.300.400.500.600.700.800.901.001.101.201.301.40
Gate Open Height (m)
REQUIRED DISCHARGE
DESIGN DISCHARGE


CR for SC-01-1
Q(Maximum)=1.838 m³/s
Discharge (Q= m³/s)
Gate Open Height (m)
REQUIRED DISCHARGE
DESIGN DISCHARGE
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10 1.20 1.30 1.40 1.50


CR for SC-01-2
Q(Maximum)=0.904 m³/s
Discharge (Q= m³/s)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10
Gate Open Height (m)
REQUIRED DISCHARGE
DESIGN DISCHARGE


CR for MC01
Q(Maximum)=4.743 m³/s
Discharge (Q= m³/s)
Gate Open Height (m)
REQUIRED DISCHARGE
DESIGN DISCHARGE
5.00
4.90
4.80
4.70
4.60
4.50
4.40
4.30
4.20
4.10
4.00
3.90
3.80
3.70
3.60
3.50
3.40
3.30
3.20
3.10
3.00
2.90
2.80
2.70
2.60
2.50
2.40
2.30
2.20
2.10
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10 1.20 1.30 1.40 1.50 1.60 1.70 1.80