REPORT NO. R-16

HYDRAULIC CHARACTERISTICS Of CHISHTIAN SUB-DIVISION, FORDWAH CANAL DIVISION

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He it is who sendeth down water from the sky, whence ye have drink and whence are trees on which ye send your beasts to pasture. Therewith He causeth crops to grow for you and the olive and the date-palm and grapes and all kinds of fruit. Lo! herein is indeed a portent for people who reflect.

(Al-Quran - Sura Al-Nahal - 10-11)

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FOREWORD

In 1989, the Secretaries Irrigation and Agriculture (Punjab) requested the International Irrigation Management Institute (IIMI) to initiate activities in the Fordwah/Eastern Sadiqia Area on inter-related aspects of irrigation, salinity and agricultural production. The objective of the study was to suggest management interventions in the canal irrigation system that would lead to prevention of further land degradation and would mitigate the effects *of* salinity on crop production. The underlying hypothesis of the studies was that a modified access to fresh canal water would help farmers in managing salinity and sodicity.

IIMI activities in the area have focussed on different levels of the irrigation system, from farmers' fields up to the river diversions at Head Suleimanki, where Fordwah and Eastern Sadiqia Canals offtake from the left abutment of the barrage. At the main canal level, activities have been undertaken jointly with the Punjab Irrigation & Power Department (PIPD). The focus of these joint activities has been to develop tools to assist the irrigation managers in taking better decisions on the operation and maintenance of this large-scale gravity irrigation system.

Activities were first started in the Chishtian Sub-division, located the lower end of the Fordwah Canal Division, and were later extended to the Malik Sub-division of the Eastern Sadiqia Canal Command on the request of the Chief Engineer, Bahawalpur.

The present study documents the experiences and knowledge gained by IIMI's field staff that have been working in the Chishtian Sub-division since 1990. The author of this study, Anwar Iqbal, has made a lot of efforts to collect and synthesize the material contained in this report. The hydraulic network, canals and structures, is described in detail and the management of activities of PIPD staff to allow the functioning of this network is reported.

These reports will be a useful reference for future activities and provide insights in the many facets of canal irrigation management in the Indus Basin.

Marcel Kuper

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Last but not least, I am greatly indebted to my parents, for their love which heartened me to achieve success in every sphere of life and whose hands always rernained raised in prayer for me.

CONVERSION OF UNITS

1 Length

1 inch = 0.0254 m = 25.4 rnrn
1 foot = 0.3048 m
1 yard = 0.9144 m
1 mile = 1609.3 rn

2. Surface or Area

1 square foot = 0.09290 m^2
1 square mile = 259 ha
1 acre = 43,560 ft^2 = 4,047 m^2 = 0.4047 ha

3. Capacity

1 cubic foot = 0.028317 m^3 = 28.317 l
1 acre-foot = 1233.5 m^3
1 acre-inch = **102.8** m^3

4. Discharge

1 cubic foot per secondlcusec or cfs) = 0.028317 m^3/s = 28.317 l/s

Per Surface:

1 cfs per 1000 acre = 0.6 rnrnlday = 0.07 l/s/ha
1 l/s/ha = 8.64 mm/day

CHAPTER 1: INTRODUCTION

1.1. Background

Pakistan possesses one of the largest continuous irrigation systems in the world. The Indus Basin Irrigation System irrigates an area of more than 14 million hectares, diverting some 125 billion m^3 to 43 canal systems.

The development of the irrigation system in the subcontinent started about **150** years ago, during the time of the British rule. After independence in 1947, disagreement arose with India about the rights to the waters in the border-crossing rivers. The crisis arose at the beginning of the kharif season in 1948, which after years of negotiation, was culminated with the Indus Waters Treaty in 1960. Since then, huge investments have been made for constructing large link canals to transfer water from the western rivers to the eastern rivers to replace water supplies being diverted upstream for use in India. About the same time, groundwater development was undertaken to provide for the steadily increasing demand *for* water. New areas and new crops had to be supplied with irrigation water and the distribution system had to be enhanced.

Present estimates *of* system efficiencies in the Indus Basin Irrigation System range from 30 to 50 percent. These low values can be attributed to various factors such as the physical infrastructure. deferred maintenance and weak implementation of water allocation and distribution. Due to the increased demand for canal water resulting from cropping intensities becoming increasingly greater than design, it is a need of the time to enhance the system to meet the demands of a growing population. There is, therefore, a growing need to manage the available (scarce] water resources in an increasingly more optimal way. which increases the demands upon the irrigation system managers in the allocation, scheduling and distribution *of* canal water supplies.

1.2. Irrigation in Pakistan

Irrigation along the rivers of Pakistan has been practiced for centuries. The present irrigation system was constructed during the period of British colonization. The Indus Water Treaty of 1960 between India and Pakistan arranged through the World **Bank** now determines the water allowance in the subcontinent (India and Pakistan). The water from the three eastern rivers (i.e., Ravi, Sutlej and Beas) is allocated to India while the water supply for Pakistan is assured by the western rivers of Indus, Jehlum and Chenab. This treaty led to an important reorganization **of** the water distribution in Pakistan with the construction of link canals and barrages. Two major dams (i.e, Mangla Dam on the River Jehlum and Tarbela Dam on the Indus River) were built in the 1960s and 1970s to regulate the water distribution in the irrigation network and to assure the water supply throughout the year. The general layout of the Indus Basin Irrigation System is shown in Figure 1.

The irrigation system was designed to command the maximum area possible, spreading the available resources equitably across vast tracts of land. There are two irrigation seasons: (1) kharif, the summer season, from mid-April to mid-October, and (2) rabi, the winter season covering the rest of the year. The canal water supplies are interrupted for one month during December-January for the maintenance of the canals (closure period).

1.3. Canal Water Distribution System

Generally, an irrigation canal offtakes directly from the river at the canal headworks just upstream from a barrage (Figure 2). Primary canals and branch canals convey the water with cross-regulators spaced along these canals to control the water levels. Then, distributaries (secondary canals) offtaking from the primary canals distribute the water through uncontrolled outlet (mogha) structures, with each outlet supplying water to a watercourse (tertiary) command area. In theory, the system is operated to run the secondary channels at their full supply levels (FSL is a design water level at one place in a canal, channel or outlet expressed by a water height) in order to distribute the water equitably. Downstream of the head regulating structure of the distributary, there are usually no flow control structures to regulate water levels.

Finally, the water conveyed through an outlet, locally named as mogha, is distributed to a group of farmers. The Punjab Irrigation and Power Department (PIPD) is responsible for providing a share of water to the group of farmers at the mogha, then it is there responsibility to distribute this water among themselves; however, if the farmers request, PIPD will provide technical assistance in preparing an official warabandi, which is a time schedule for each landowner to receive the full water supply during a rotation period of usually one week. The mogha[1] or outlet is not equipped with a regulation device. This structure is designed to provide a specified quantity of water when the distributary is at its full supply level. The distributary is operated as a proportional flow distribution system with the water quantity supplied to each tertiary unit fluctuating according to the water levels in the secondary channel.

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[1] The masonry structure in a canal bank to provide an opening to allow flow of water from the canal to the watercourse is known as an outlet or mogha.

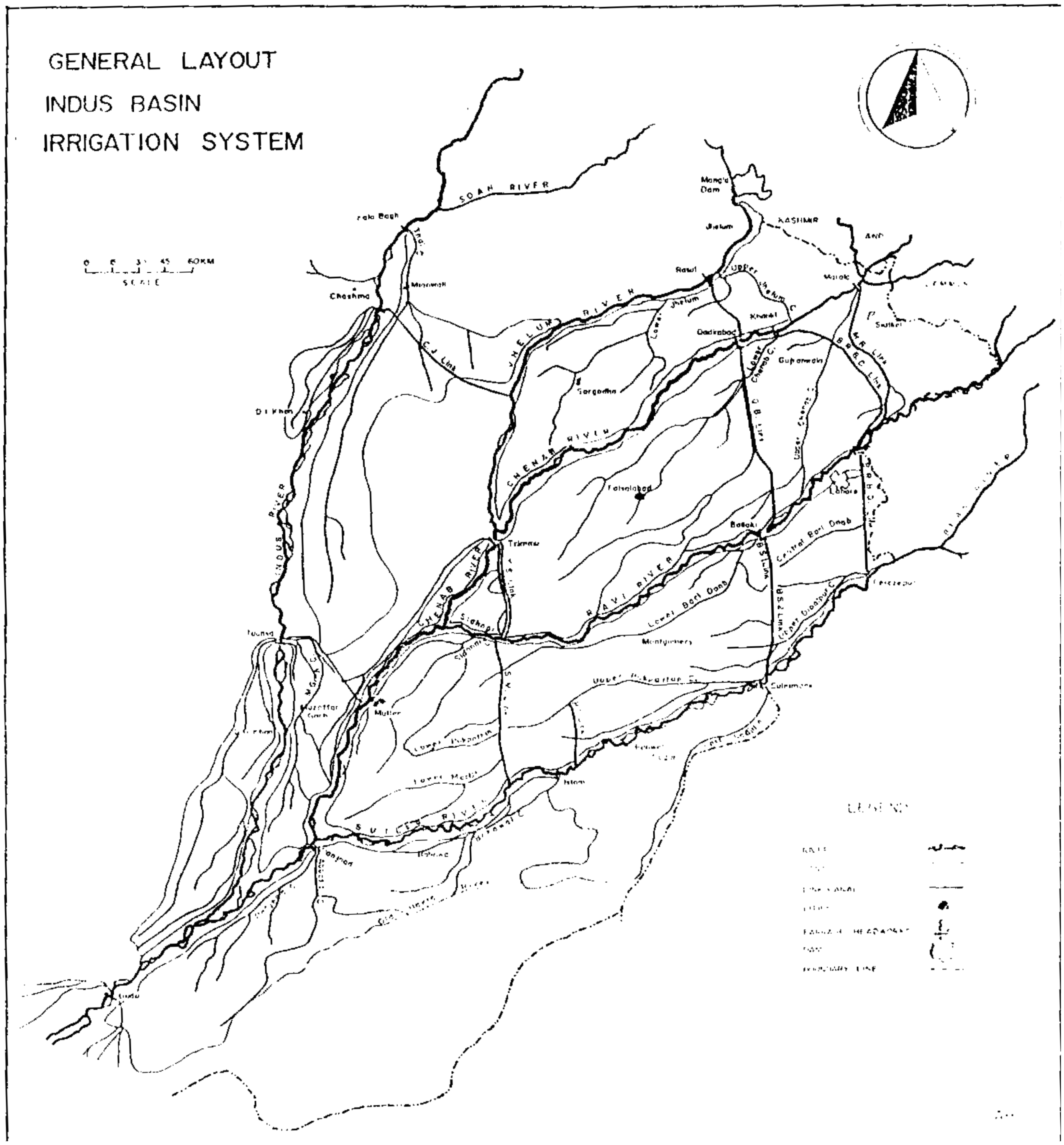
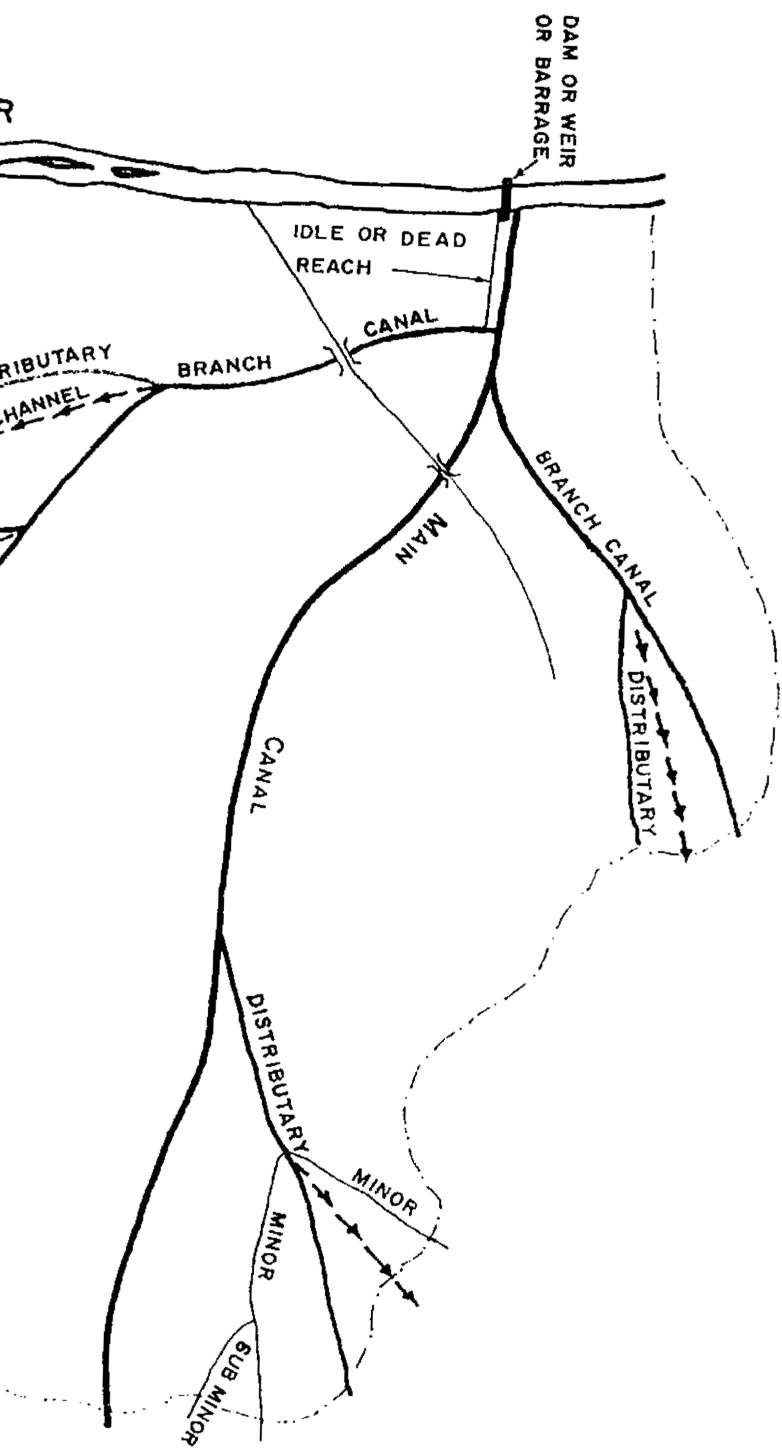


Figure 1.   General Layout of the Indus Basin Irrigation Sys

NAL SYSTEM



Canal water distribution system

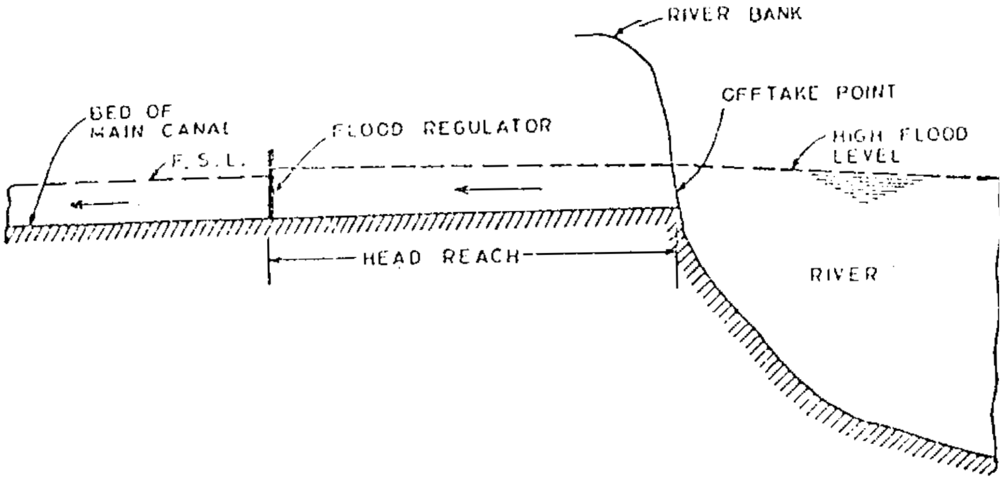


Figure 3. Inundation canal.

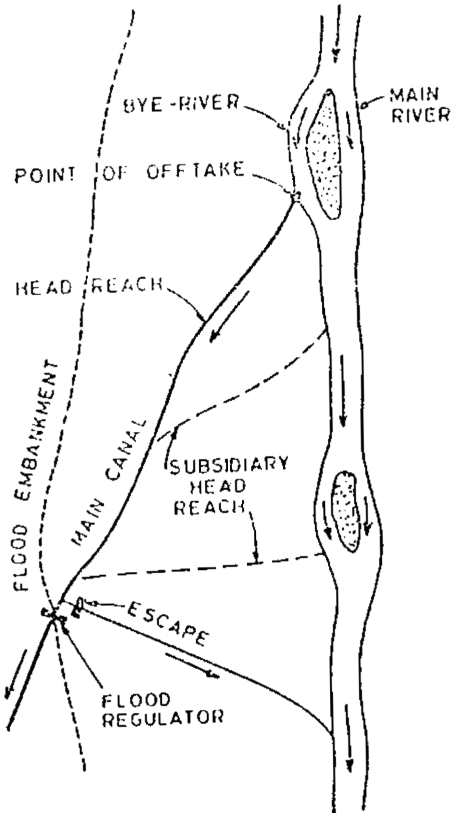


Figure 4. **Head** of inundation main canal.

d) **If** shoals are present in the river bed, the site of the offtake point should be in front of the shoal as shown in Figure 4. The shoal will create a pocket in front *of* the offtake point of the canal. The formation of the pocket will create a stilling pond, which will help to reduce the amount of sediment entering the canal.

e) At the offtake point, the width of the river and its velocity should **be** normal *so* that it **is** not affected by fluctuations in the water level.

f) If a river bye-pass is available, the offtake point should be located on the bye-pass, because this will cause a minimum *of* sediment entering the canal.

g) When the offtake point becomes unserviceable, there should **be** *no* difficulty in locating another offtake point.

2.1.3. Considerations in the **design of** inundation canals

The main difficulty with an inundation canal is that of sediment deposition (silt and fine sand) and the formation of a bar at its mouth when a sudden fall in the river level occurs, which results from the lack of water level control at the head of the canal. Further, during floods, more water may find its way through the canal and submerge vast tracts of land on both sides. Thus, in order to safeguard against future difficulties, the following considerations should be considered in the design of an inundation canal.

a) A flood regulator (Figure 5) can be provided on the main canal 5 to 6 km downstream from the offtake point. If the flow regulator is provided at the offtake point, there is a danger of the same being washed away during floods. The main function of this regulator *is* to regulate the flow of water in the main canal and also to prevent heavy river floods from entering the main canal.

b) The flood regulator can be provided with canal vertical lift gates in tiers (Figure 5) *so* as to exclude heavy sediment bed loads from entering the main canal.

c) A canal escape should be provided just on the upstream side of the flood regulator (Figure 4), through which surplus flood water, during the closure of the flood regulator, will be disposed off into the river via a channel.

d) The full supply level (FSL) of the main canal should be fixed **as** the level at which water in the river is more or **less** steady for a certain maximum number of days (about 40 to 50 days) during the inundation season.

e) The canal bed level at tlie offtake point should be as low as practicable *so* that canals rnay get water for a longer time period.

f) Full supply discharge of the canal is fixed on the basis of the requirements of rabi and kharif crops.

g) The cross-section of the canal **is** kept liberal because the time factor in inundation irrigation is very low and uncertain. Further, the inundation main canal is made deeper and narrower (i.e, the B/D ratio is small) than other types of irrigation canals.

h) The bed slope of the canal is fixed depending upon the slope of the country, keeping in view that excessive velocities causing scour should not be allowed. In general, the bed slope provided for the canal is in the range of 0.1 to 0.25m/km.

2.1.4 Maintenance **of** inundation canals

As sediment control devices are not provided for in the inundation canals. there is an acute sediment problem (usually called silting in Pakistan) in the main canal as well as other channels ***of*** an inundation irrigation system. In the head reaches of the main canal, usually heavy deposition of sediment takes place, which rnay vary from 0.30 to 1.75 meters in one season. Sediment deposition usually results in reduced discharge capacity **of the** channel.

Every year, after the end of the inundation season, the removal of sediment deposits in irrigation channels are undertaken, which forms the major maintenance work for these canals. Moreover, certain provisions are made during the construction *of* the inundation canals for their proper maintenance which are described below.

a) In addition to the main head or offtake point, subsidiary heads (Figure 4) may be provided which will admit water in the canal, in case the main offtake point has too much sediment deposition.

b) A flood regulator, along with a canal escape, may be provided a few kilometers downstream of the offtake point. This will regulate the supply of water as well as control the entry of sediment into the canal as explained earlier.

c) If there are a number of main inundation canals [say 3 or 4) taking off at different points from the same river, a feeder canal taking off from the same river may be constructed as shown in Figure 6, which links all of the main canals and maintains supplies in these canals in case their head reaches become filled with sediment. The provision of a feeder canal avoids the necessity of constructing a number of subsidiary heads; also, the other canals receive their supplies under a higher head.

2.1.5. Advantages of inundation canals

The various advantages of inundation canals are as follows:

a) The overall cost of construction of an inundation canal system is low because no diversion headworks are constructed;

b) The water supplied by these canals contain sediment, which helps to improve the soil fertility of the agricultural fields; and

c) Since the canals do not supply water throughout the year. the problem of waterlogging usually does not arise. Further, there is less possibility of overirrigation in this case; hence, the bad effects of overirrigation are reduced.

2.1.6. Disadvantages of inundation canals

The various disadvantages of inundation canals are as follows:

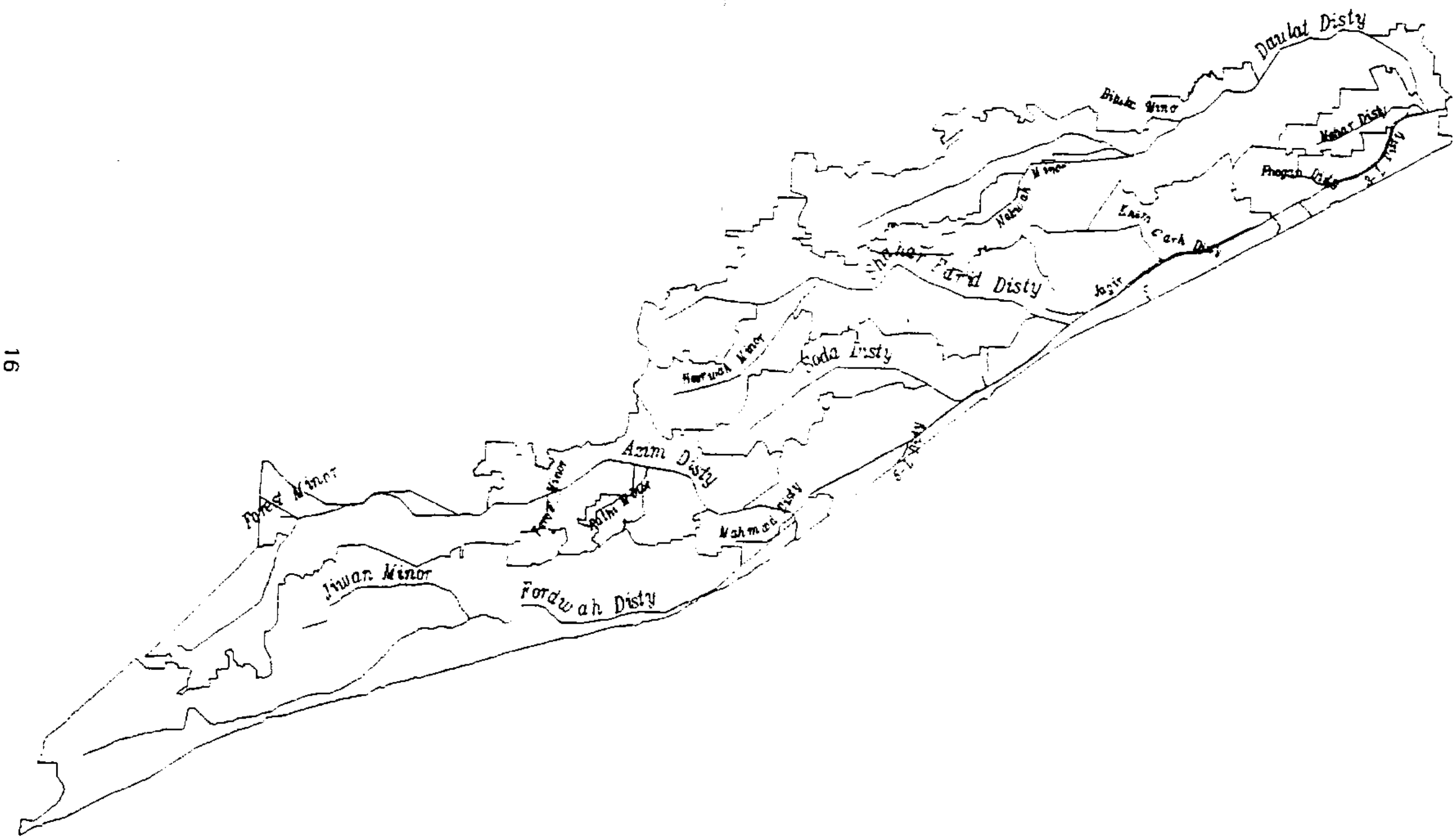
a) the water supply available from these canals is variable and unreliable;

b) As there are no headworks, the offtake point or the head of the canal are liable to be damaged during floods;

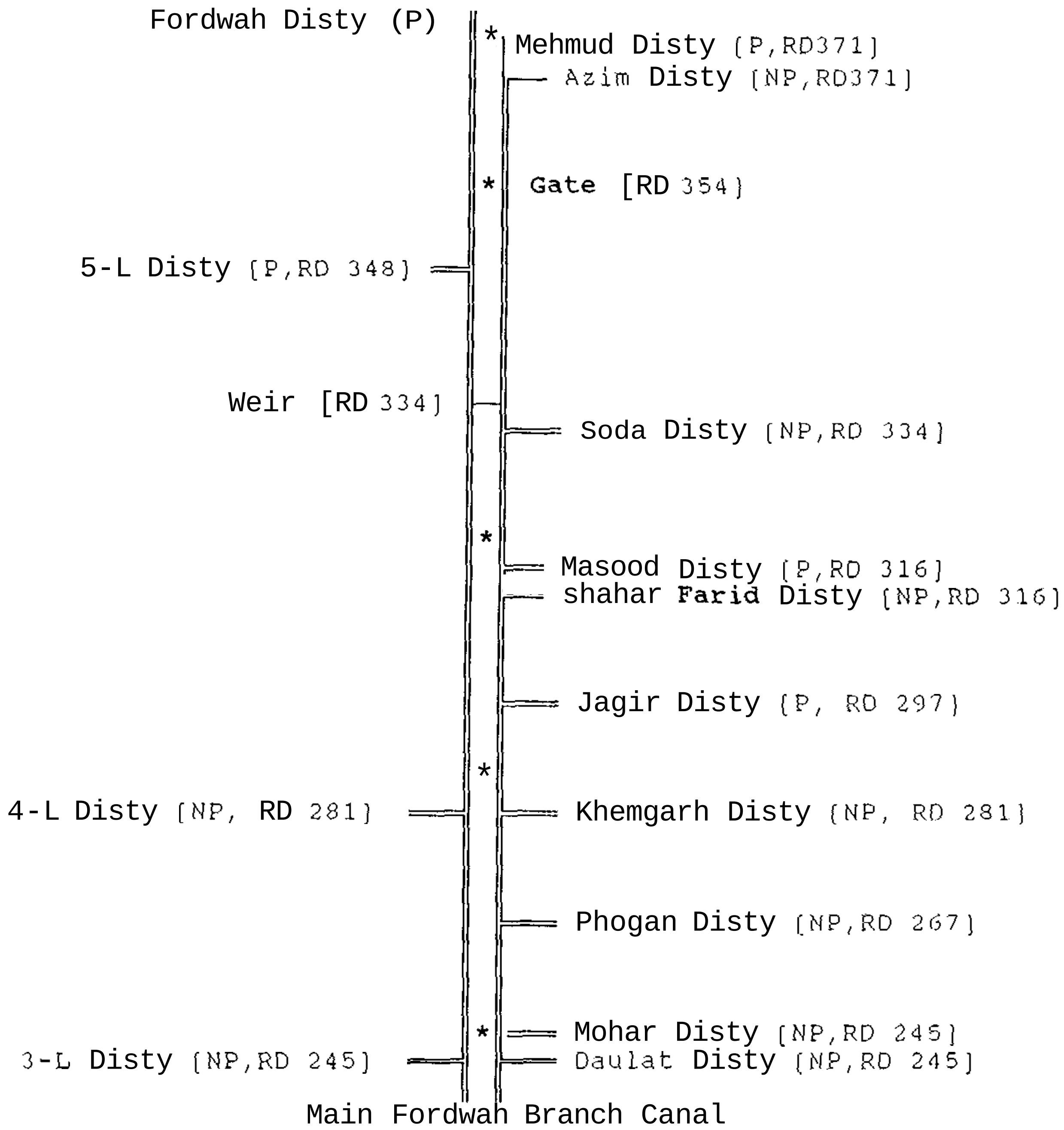
The location map for Fordwah/Eastern Sadiqia is shown in Figure 7. Fordwah Branch Canal has a total length of 123 km, 38.4 km of which are in the Chishtian Sub-division frorn RD-245 to RD-371 (tail of this branch canal). The design discharge at RD-199, the indent point for the Chishtian Sub-division, is 1282 cusecs. The bed width is about 115 feet at RD-199, and 50 ft at the tail (RD-371). The average **slope** is 0.02% (1/5000). Water is distributed to secondary channels (distributaries) through 14 offtakes having vertical sliding gates, culverts or open flumes.

The white marks which were established to calibrate all flow control structures in Chishtian Sub-division are given in Annex 1, together with the elevations of these white marks. The locations of these white marks are given in Annex 2. There are 21 direct outlets (Pipes, APM and OCOFRB) along Fordwah Branch Canal in Chishtian Sub-division. Their size and corresponding coefficient of discharge are give in Annex 3. The total GCA (gross command area) of Chishtian Sub-division is 1,81,369 acres and CCA (cultural command area) is 1,63,635 acres (Litrico, 1995). Of the 14 distributaries, nine are non-perennial, which means that they are entitled to draw water during the kharif season only, and five are perennial, which draw water all year (Table 1).

The command area of each distributary in Chishtian Sub-division is shown in Figure 8, while a schematic of Fordwah Branch Canal is provided in Figure 9. The water levels are maintained along the canal by means 01 five gate cross regulators and two weirs. Most of the distributaries offtake Just upstream of a cross regulator; only three of them (Phogan, Jagir and Soda) are not under the direct control of a regulator. The seepage in this canal, measured using the inflow-outflow method, is about 9.3 cusecs per million square feet of wetted perimeter (Calibration of Structures, IIMI, 1995).



Command area map of distributaries in the Chishtian Sub-Division.



Lagend:
* = Gate structure
- = Weir
NP= Non perennial
P = Perennial

Design discharge (Cusecs):
Daulat=209,Mohar=38,3-L=18
Phogan=18,Khemgarh=24,4-L=14
Jagir=28,Shahar Farid=153
Masood=35,Soda=77,5-L=4,Mehmud=9
Fordwah disty=158, Azim=244
Total discharge=1029

Figure 9. Layout of Fordwah Branch Canal in Chishtian Sub-division.

2.3. Reasons for Perennial and Non-Perennial Channels

The Fordwah Division is a mixture of perennial and non-perennial channels. The non-perennial channels get water only in the kharif season (from mid-April to mid-October) through the Fordwah Canal from Suleimanki Head Works. But perennial channels, which are located only in Chistitian Sub-division, also obtain water through the Sadiq Ford Feeder offtaking from Sadiqia Canal during the rabi season (from mid-October to mid-April). The different reasons for this are given below:

a) There is not enough water available during the rabi season to supply all distributaries;

b) The ground water quality along perennial distributaries was not good;

c) Along non-perennial distributaries, there were a lot of open wells and ground water quality was comparatively good; and

d) Non-perennial distributaries were having a waterlogging problem, so not having canal flows during the rabi season helped to relieve this problem.

CHAPTER 3: ORGANIZATIONAL ARRANGEMENTS

3.1. Organization of Bahawalnagar Circle

There are different levels of management units in the Punjab Irrigation System. The Zone is the biggest unit, and a Chief Engineer is incharge of it. The Circle is the next unit, headed by a Superintending Engineer (SE). Then comes the Division, which is the basic irrigation unit. headed by an Executive Engineer (XEN). A Division is divided into Sub-divisions, headed by an Assistant Executive Engineer called Sub-divisional Officer (SDO).

Actually, Bahawalnagar Circle is a mixture of perennial and non-perennial units of the Sutlej Valley Project. There are three divisions in Bahawalnagar circle namely as; (1) Eastern Sadiqia Division[2], (2) Hakra Division, (3) Fordwah Division. The organizational chart of Bahawalnagar Circle is given in Figure 10. The total GCA and CCA for each Division is given in Table 2, while total GCA and CCA for each Sub-division in Fordwah Division is given in Table 3. There are a total nine Sub-divisions in Bahawalnagar Circle:

1) Jalwala Sub-division (mixture of perennial and non-perennial channels) of Eastern Sadiqia Division;

2) Malik Sub-division (totally perennial channels) of Eastern Sadiqia Division;

3) Dahranwala Sub-division (totally perennial channels) of Eastern Sadiqia Division;

4) Haroonabad Sub-division (totally perennial channels) *of* Hakra Division;

5) Faqirwali Sub-division (totally perennial channels) of Hakra Division;

6) Fort Abbas Sub-division (mixture of perennial and non-perennial channels) of Hakra Division;

7) Minchinabad Sub-division (totally non-perennial channels) of Fordwah Division;

8) Bahawalnagar Sub-division [totally non-perennial channels) of Fordwah Division; and

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[2] SDO drainage *is* also working under the supervision of the XEN Sadiqia.

3.2. Organization **of** Chishtian Sub-division.

The Sub-division is headed by an Assistant Executive Engineer called Sub-divisional Officer (SDO). Chishtian Sub-division is divided into five operating and maintenance (sub-engineer's) sections, each of them headed by a Sub-engineer. These Sub-engineers provide help to the SDO in technical and other related matters. And it is also divided into three Zilladari [revenue) sections, each of them headed by a Zilladar. These Zilladars provide help in the matters related to the revenue and agricultural tasks. The complete details about operating & maintenance and revenue sections are given below. The organizational chart for Chishtian Sub-division is shown in Figure **11,** while the detailed list of the regular establishment **of** Chishtian Sub-division is shown in Table 4.

Operating and Maintenance (Sub-engineer's) sections *of* Chishtian Sub-division are:

1. Operating and Maintenance (Sub-engineer's) Takhat Mahal Section;
2. Operating and Maintenance (Sub-engineer's) Khemgarh Section;
3. Operating and Maintenance (Sub-engineer's) Chak Abdullah Section;
4. Operating and Maintenance (Sub-engineer's) Chishtian Section: and
5. Operating and Maintenance (Sub-engineer's) Hasilpur Section.

Revenue (Zilladari) sections of Chishtian Sub-division are:

1. Revenue (Zilladari) Kherngarh Section;
2. Revenue (Zilladari) Chishtian Section; and
3. Revenue (Zilladari) Bakhshan Khan Section.

According to the Table 4, the Chishtian Sub-division is having a number of staff involved in different activities related to administrative matters, operating & maintenance work, agriculture tasks and revenue. There arc five sections related to operating & maintenance. Each section is headed by a Sub-engineer.

A Sub-engineer *is* an important person, who is related more with field activities at the section level. The Sub-engineer visits his assigned area by using his own personal motor bike or car (if he belongs to a rich family). He also visits the SDO office to get instructions from the SDO related to his section or about the visits of XEN or SE and Chief Engineer etc. for preparing various things accordingly. He also reports lo the SDO about all kinds of maintenance & operating work in advance with all details like installation **of** gauges, berm cutting & silt clearance, rehabilitation work in different reaches of different channels, checking side erosions, repairing the head regulation points and slabs, painting oiling & greasing regulation gates, repairing pilchi pitching & killa hushing in different channels, steel lining & repairing of tampered outlets and employing workcharge seasonal establishment with estimated amounts. The SDO also checks at the site and sends it for approval to the XEN. When the XEN approves the amount, then PIPD get this work done through any Government Contractor. The SDO can approve a certain amount of money in case of emergency for spending for closing & strengthening sudden breaches etc.

There are only 5 Gauge Readers in Chishtian Sub-division. Actually, the Gauge Readers are mostly local (belonging from the same area in which they have to work). The Gauge Reader is having an important role to run the irrigation system. The Gauge Readers at cross regulators live at the same place to take care of canal water 24 hours. Most of the Gauge Readers are experienced in their related work. Although in Chishtian Sub-divisiori, there is a lack of communication, but these Gauge Readers can understand just by looking at the type of fluctuation, what is happening in upstream reaches of a channel. The Gauge Reader keeps the record of daily discharge positions (according to the discharge tables provided him through the SDO or Sub-engineer and approved by the XEN) in his reach and tries to handle the available water according to the instructions made by the SDO or Sub-engineer. But sometimes, when a breach occurs in any offtaking channel (dire to sudden excess of water without any information, or weakness of the bank of a channel), the Gauge Reader also tries to handle and to satisfy the farmers (who become emotional due to damaging of their crops and property with the water from the breach) and also sends someone to inform the SDO office and the Signaller for further action.

There are 4 Mates (considered more responsible as compared to the Beldars), who supervise the Beldars (uneducated persons but work like labourers) which are a total of 33 in Chishtian Sub-division. The Mate and the **Beldars** (also local people) take care of the channels. Beldars put soil or tree branches at weak berms, banks and broadcast canal water **on** the canal bank due to dust in his assigned area. The Mate and the Beldars also get the help of farmers in case of a breach in order to close it. The Mate also looks after the maintenance & repair work according to the orders of the Sub-engineer. The SDO also sends the Beldars of one section to another section for working according to the situation.

There are 3 Signallers in the Chishtian Sub-division. The Signaller is also an important person, who keeps an eye through the Telegraphic System about the activities in the field. He also conveys the messages of the SDO's to other related staff in a very short time, but only if the Telegraphic System works in a good way. He also receives daily gauges & discharges position of all cross regulators and offtaking channels with their tail positions (depth *of* water at tail in feet). He also records all of these collected information (from the field) in a official Gauges Register. Then he shows to the SDO how much water they are receiving (from RD-199+812. the indent point of Chishtian Sub-division) and how it is distributed within the Chishtian Sub-division. The Signaller also receives by hand the gauges & discharge positions of each cross regulator and offtaking channels, due to any fault in the old Telegraphic System. He also keeps a record of the visits of their senior staff. He also informs (in the main Telegraphic Office Bahawalnagar) about reducing the discharge from upstream in case of a sudden breach or heavy rain in the Chishtian area.

The Sub-divisional Clerk (SDC), Sub-divisional Reader (SDR) and Assistant Vernacular Clerk (AVC) are support staff. They keep the records (of whole Sub-division) of the salaries of staff, letters from higher officials, other revenue matters related to farmers and also keep the records of official warabandi *of* each individual outlet (watercourse) along each channel *in* Chishtian Sub-division. They also tell *to* the farmers (who do not know how to write an application to the SDO) for changing the warabandi time within a watercourse due to an increase in the GCA (of the said watercourse). complaining *to* the SDO about the theft of water within a watercourse by the tenants & servants *of* big or influential farmers during their water turn (of those farmers who are complaining) for whole sub-division and then the SDO sends someone to check physically the site and take necessary action according to his powers, or send that case to the XEN for further action.

There are 3 Zilladars for the whole Chishtian Sub-division. The Zilladar is the person incharge of the revenue section related to agricultural tasks. Each Zilladar supervises 9 or 10 Patwaris. It is the responsibility of the Zilladar to check the accuracy of the work, like the area map of each chak boundary, warabandi schedule of each Farmer according to the land holding at each watercourse or outlet, Khasrah Register and Thur Girdawari Khasrah register which has already been updated by his Patwaris, as well as all other related matters. He also helps the new Patwaris who work under his supervision.

All of the other staff members are support staff, who take care the office, the equipment used for different kinds of work, mail and other official works assigned by the SDO.

3.2.1 Operation and Maintenance Section

The Chishtian Sub-division is divided into five operating sections. For each section, there is a Sub-engineer who is responsible for operation and maintenance of his section. Each concerned Sub-engineer visits his area of responsibility and tries to provide the canal water according to the schedule made by the SDO in his sub-division. Sometimes, the Sub-engineer makes changes in the schedule after discussing with the SDO regarding the supply of water for his section due to heavy rains, repairing of broken outlets, unexpected breaches, etc. The SDO sends a weekly program to the Executive Engineer (XEN) about the demand for water (total discharge) through the Signaler for his sub-division after discussing with all of his Sub-engineers.
The total lengths of all five operating & maintenance sections are:

1) Sub-engineer Takhat Mahal Section, total length is 200+780 feet;

2) Sub-engineer Khemgarh Section, total length is 194+530 feet;

3) Sub-engineer Chak Abdullah Section, total length is 176+790 feet;

4) Sub-engineer Chishtian Section, total length is 194+040 feet; and

5) Sub-engineer Hasilpur Section, total length is 174+300 feet.

The farmers located in the tail reach of Fordwah Distributary visited the PIPD Chief Engineer's office at Bahawalpur about the shortage of canal water at the tail of Fordwah Distributary because of being a perennial channel. So, due to this reason, the Chief Engineer visited at the beginning of rabi 1995-96 the tail area of Fordwah Distributary in the presence of the Superintending Engineer (SE) and all other PIPD staff. The Chief Engineer officially handed over the control of Fordwah Distributary from head to tail, together with its Jiwan

Minor, to the Sub-engineer (Hasilpur) for taking responsibility to overcome tail shortages. Previously, the head area of Fordwah Distributary was under the control of the Sub-engineer (Chishtianl. The details about the operating and maintenance sections of all five sub-engineer's are given in Table 5.

Table 5. Operating and maintenance sections of Chishtian Sub-division

Sections	Branch/Distributary/Minor	Reach (from and uptill) in feet	Total length in feet
Sub-Engineer, Takhat Mahal Section	Fordwah Branch Canal	RD-245 + 500 to 297 + 000	51 + 500
	Daulat Distributary	RD-0 to 55 + 000	55 + 500
	Mohar Distributary	RD-0 to 20 + 240 (tail)	20 + 240
	Hussain Abad Minor	RD-0 to 8 + 840 (tail)	8 + 840
	3-L Distributary	RD-0 to 23 + 100 (tail)	23 + 100
	Phogan Distributary	RD-0 to 8 + 750 (tail)	8 + 750
	4-L Distributary	RD-0 to 17 + 350 (tail)	13 + 750
	Khemgarh Distributary	RD-0 to 15 + 500 (tail)	15 + 500
Sub-Engineer, Khemgarh Section	Fordwah Branch Canal	RD-297 + 000 to 352 + 000	55 + 500
	Jagir Distributary	RD-0 to 13 + 830 (tail)	13 + 830
	Shahar Farid Distributary	RD-0 to 47 + 000	47 + 000
	Masood Distributary	RD-0 to 35 + 000	35 + 000
	Soda Distributary	RD-0 to 43 + 700 (tail)	43 + 700
Sub-Engineer. Chak Abdullah Section	Daulat Distributary	RD-55 + 000 to 115 + 150 (tail)	60 + 150
	Billuka Minor	RD-0 to 12 + 780 (tail)	12 + 780
	Nakewah Minor	RD-0 to 43 + 800 (tail)	43 + 800
	Shahar Farid Distributary	RD-47 + 000 to 74 + 880 (tail)	27 + 880
	Hayerwah Minor	RD-0 to 32 + 180 (tail)	32 + 180
Sub-Engineer, Chishtian Section	Fordwah Branch Canal	RD-352 + 000 to 371 + 650 (tail)	19 + 650
	5-L Distributary	RD-0 to 11 + 300 (tail)	11 + 300
	Masood Distributary	RD-35 + 000 to 45 + 950 (tail)	10 + 950
	Mehmud Distributary	RD-0 to 11 + 860 (tail)	11 + 860
	Azim Distributary	RD 0 to 11R + 980 (tail)	1R + 980
	Rathi Minor	RD-0 to 10 + 000 (tail)	10 + 000
	Feroze Minor	RD-0 to 8 + 000 (tail)	8 + 000
	Forest Minor	RD-0 to 3 + 300 (tail)	3 + 300
Sub-Engineer, Hasilpur Section	Fordwah Distributary	RD-0 to 139 + 780 (tail)	139 + 780
	Jiwan Minor	RD-0 to 34 + 520 (tail)	34 + 520

CHAPTER 4: COLLECTION OF INFORMATION

There are different kind of information, which are being collected by the field staff of PIPD. The information being discussed in this chapter are:

- Gauges (water levels);
- Khasrah (crops survey);
- Thur Girdawari Khasrah (visual observation of salinity for each field);
- Outlet Register (GCA, CCA, size, location, design discharge and crest reduced level (CRL) etc. of each outlet in the Sub-division);
- 'H' Register (data about water level of each outlet etc.);
- Sub-engineer's Outlet Note Book (GCA, CCA, size, location, design discharge and crest reduced level (CRL) etc. of each outlet in his section); and
- Communication System (backbone of the Punjab Irrigation System but not in good working condition).

4.1. Gauges

The Punjab Irrigation and Power Department (PIPD) staff are using gauges for periodically (once a day or more often) reading water levels (discharge position) of cross-regulators (CR) along Fordwah Branch Canal and for the head regulator (HR) of each distributary and minor including their tail gauges. The present position of gauges in Chishtian Sub-division is given in Table 6.

Table 6 shows the present condition and positions of gauges at all of the cross regulators, head regulator of offtaking channels and their tails in the Chishtian Sub-division. At some places, there are no gauges.

The total height of the gauge is 9 feet which is installed on the left wall, upstream of the cross regulator of Fordwah Branch Canal at RD-245+500. This gauge is installed with reference of the crest of the cross regulator. The total height of the downstream gauge is 8.5 feet, which is installed in a well downstream of the cross regulator at RD-245+500 of Fordwah Branch Canal. This downstream gauge is buried 5.5 feet in the sediment. So, if the depth of water at this point is less than 5.5 feet, then it is not easy to read the gauge accurately. The gauge installed about 200 feet downstream (left side of the

S.No.	Designation of Staff	Partal quota of Khasrah for Rabi Khaam/Pukhta (acres)	Partal quota of Khasrah for Kharif Khaam/Pukhta (acres)
1	Executive Engineer (XEN)	5001300 (for the entire division)	500/300 (For the entire division)
2	Sub Divisional Officer (SDO)	150011000 (For the entire sub-division)	1500/1000 (For the entire sub-division)
3	Deputy Collector	*600014500* (For the entire division)	6000/4500 (For the entire division)
4	Zilladar	400013000 (For the entire section)	4000/3000 (For the entire section)

4.2.2. Thur Girdawari **Khasrah**[3]

The Thur Girdawari Khasrah is a printed register provided by the Divisional office through the Zilladar to each concerned Canal Patwari for visual observation of salinity for each field in his assigned halqa. The Canal Patwari visits his halqa for Thur Girdawari Khasrah once a year in December, January or February when salinity is most visible. He notes the salinity according to specific classes as defined in Table ***8,*** for each single field (acre[4]). After completing the Thur Girdawari Khasrah from each field, the Canal Patwari submits the Thur Girdawari Khasrah to the concerned Zilladar, who makes a complete statement for each channel in his section and sends this to the SDO and then the XEN. The Thur Girdawari Khasrah can be checked physically by the XEN, SDO, LRO (Land Reclamation Officer), ALRO (Assistant Land Reclamation Officer). Zilladar Reclamation and Zilladar from their normal partal quota (checking about 20% of the quantity of work). Then, the Assistant Land Reclamation Officer sends the Reclamation Zilladar and Patwari to physically check the Thur Girdawari Khasrah (which has already been done by the Canal Patwari). Both the Reclamation Zilladar and Patwari prepare a statement (based on the collected visual observation of salinity) regarding strongly saline fields for each outlet (watercourse command area) and submit this list to the Land Reclamation Officer for further action. Then, the *LRO* visits the XEN's office and shows the list of demand for extra water supply channel wise under each outlet. The XEN approves some extra water according to the capacity of each selected channel. After getting the approval from the XEN, the LRO sends his Reclamation Zilladar and Patwari to have a meeting with the farmers of the selected outlets in their halqa about the rules regarding extra water supply using seasonal pipes. The rules are:

a) The farmer will use the extra canal water only for selected saline fields.

b) The farmer will sow rice in saline fields for which the Land Reclamation Directorate has approved extra canal water (with a ratio of one cusecs for 45 acres for three months from the 15th of July to the 15th of October).

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[3] Salinity assessment made through visual **soil** salinity surveys undertaken during the months of December, January and February when the salinity is most visible.

[4] The basic administrative unit of the irrigation system with dimensions 67m x 60m

c) The farmer will get this opportunity for a maximum of three years (that is three months during kharif every year up to three years).

d) The farmer will pay a "leaching" (reclamation) fee of 35 rupees/acre for using this extra canal water for three months together with abyana for the kharif season.

e) If at one outlet there is more than one farmer, they will get warabandi time (total time of each farmer for using canal water) for that seasonal outlet according to the land holding made by the Canal Patwari. The Patwari (Land Reclamation) will check during these three months, that farmers are using the water from the seasonal outlet on selected saline fields.

f) Alter the 15th of October, the seasonal pipe will be removed by PIPD staff and will be installed again in the second year on the 15th of Julv.

The purpose of Thur Girdawari Khasrah is: (i) to assess the extent of salinity ano waterlogging in canal command areas: and (ii) to plan, organize and monitor the allocation of extra canal water supplies (or reclamation shoots) to salinity affected areas, in coordination with the operating staff of the Punjab Irrigation & Power Department. The ALRO makes a statement showing how much area has been improved due to providing seasonal outlets for reclaniation shoots) in his circle.

One year before, The former Chief Minister *of* Punjab stopped providing seasonal pipes/outlets saying that "Some farmers are misusing this opportunity". But now, from kharif 1996, it has again started. An example of Thur Girdawari Khasrah is shown in Annex 5.

Table ***8.*** Salinity classes used for Thur Girdawari Khasrah.

Salinity and land status	Salinity class (local name)	Characteristics of the salinity class
Uncultivated and saline	Thur Kohna	Saline area that has never been cultivated since the advent of canal irrigation system.
Formerly cultivated and saline	Thur panjsala	Saline area that has gone out of cultivation more than 5 years ago.
	Thur Nau	Saline area that has gone out of cultivation within the past 5 years.
Cultivated and saline	Thur Juzvi	Visually salinity affected area with more than 20 percent affected by salinity but still under cultivation.
	Thur Tark	Salinity not visible but affecting cotton crop (incomplete opening of balls).

4.2.3. Outlet Register

A printed outlet register is supplied by the concerned division to the concerned sub-division and retained by the revenue clerk at the division office, while the SDO maintains the outlet register by himself. The outlet register contains the following data: the name of distributary: supply factor; intensity; kharif rabi ratio; serial number; location (RD) of outlet; side of outlet (left or right or front etc.); name of village (chak); GCA of outlet; CCA *of* outlet; date of construction or alteration; authorized discharge; type of outlet; reduced level (RL) of crest of outlet; description and reduced level of referring bench mark; size of outlet that is "B" (width), "Y" (height); "H" (depression head of outlet); working head and setting of outlet ('H' of outlet/full supply depth in distributary • 100).

The Sub-engineer obtains a copy through his SDO about outlet changes in his section and updates his own outlet note book. The Sub-engineer has **to** compare his outlet note book with the outlet register *of* the sub-division once a year. Then, the Sub-divisional Reader will compare the outlet register of his sub-division with the divisional outlet register. An example of an Outlet Register is shown in Annex. 6.

4.2.4. 'H' Register

The 'H' Register is a printed register designed for water level (called head) 'ti' observations by the Sub-engineer in his section, which is supplied by the divisional office through the head clerk. The 'H' observations are observed and measured in February, May, August and November of each year. After observing the heads 'H', of the outlets and structures for all *of* the channels in his section, the Sub-engineer submits his 'H' Register to the Sub-divisional office. Then, the SDR (Sub-divisional Reader) also enters the observed H's in his register for all of the channels in the sub-division and returns the 'H' Register to the concerned Sub-engineer. The SDO may check these recorded measurements during his inspection of the channels. The supply at the head of a channel must be run constant with its design discharge, or indented discharge 24 hours before the 'H' observations. After placing the H's in the Register for the entire Sub-division, the SDR sends the 'H' Register to the Division Office for their entering the H's. After completing the 'ti' Register, the XEN sends the divisional 'H' Register to the Circle Office for entering the H's in the Circle Office 'H' Register. After completing the 'H' Register of tho Circle Office, the divisional 'H' Register is sent back to the concern division. But nowadays. the 'H' Register is not maintained in Chishtian Sub-division.

4.2.5. Sub-engineer's Outlet Note **Book**

The Sub-engineer Outlet Note Book is supplied from the Division Office by the head clerk to the concerned Sub-engineer, which he maintains. **All** outlet alteration forms are entered in the Outlet Note Book after making any changes, such as the size of outlet, with dated signature. The Sub-engineer will compare his Outlet Note Book with the sub-divisional Outlet Register once a year and to record his certification about the comparison made on such a date. **A** Sub-engineer has to keep the Outlet Note Book in his basta (bag) during the inspection of his section, as well as for officers inspecting in his section. The Outlet Note Book is maintained as a measurement book, which is a very important record for the section. In this Outlet Note Book is recorded: the name of distributary; serial number; location (RD) of outlet; side of outlet (left or right or front etc.); name of village (chak); CCA of outlet; authorized discharge **of** outlet; date of construction or alteration; type of outlet; reduced level (RL) of crest of outlet; size of outlet that is **"B"** (width), "Y" (height); **"H"** (depression head of outlet); working head of outlet; remarks column to include sanctioning authority and date, signature of subordinate carrying out the work. **An** example is shown in Annex. 7.

4.3. Communication System

The communication system for Chishtian Sub-division is depicted in Figure 12. This figure is marked with (a), (b), (c),...(i) and the text below has been written in accordance with this notation. Thus, the text can be related to Figure 12.

a) There is an old telegraphic system located at RD-199+812 of Fordwali Branch Canal in the room of the Gauge Reader. He is taking gauge readings twice a day at morning and evening, and recording them in an ID register. The Gauge Reader transmits the discharge position twice a day this place to the main telegraph office in Bahawalnagar. The Gauge Reader states how much water is being received from upstream and how this water is being subdivided to other offtakes according to the orders of his SDO or XEN. The Gauge Reader stated that this telegraphic system is riot reliable because sometimes it works and sometimes it does not work.

b) The main telegraph office at Bahawalnagar has four telegraphic sets which are connected with all of the Bahawalnagar Circle telegraph offices. The main office receives daily discharge positions along the entire Fordwah system, including **all** offtakes in the various sub-divisioris, and compares with the Rotation Schedule (see Annexure 8) for that season. Here, they are maintaining a Register including daily discharges, which they receive from the field offices through the telegraphic system or from other different sources. From this office, they convey information about the field visits of senior staff along any offtake, other orders about closing or opening the distributaries, and about increasing or decreasing the discharge during any emergency. But this communication system is not working very well due to some faults.

c) The Signaler at the SDO Chishtian office disclosed that about **14** years ago tho telegraphic system at this place (Takhat Mahal Sub Rest House) was in working order and a person was working there as a signaler of Takhat Mahal Section. And he was receiving gauge readings of Cross Regulator at RD-245+**500** of Fordwah Branch Canal, along with daily discharge positions of Daulat, Mohar and **3-L** distributaries, through a telephone which was installed in the room of the Gauge Reader at RD-245+500 of Fordwah Branch at that time. The Signaler of Takhat Mahal was receiving the discharge readings about Phogan Distributary which offtakes from RD-267+725 of Fordwah Branch Canal, through the beldars of that area. And this Signaler was also receiving the discharge readings of Khemgarh and **4-L** Distributary which offtake from RD-281+000 of Fordwah Branch (and also the discharge of Cross Regulator at **RD-281**+000), through any responsible person. So, the Signaler of this area was covering from **RD-245+500** to **RD-281**+000 of Fordwah Branch Canal, including all offtakes, and was always getting in touch with the Signaler of Chishtian to inform him about the water situation in his reach. He was also conveying all instructions to the related staff after receiving them from the Chishtian SDO office.

d) At this point, there was also a telegraphic system, which is not working anymore. Now, this Gauge Reader is sending daily data to the Chishtian SDO from different sources about his reach. So, if any breach occurred in his reach in any distributary, the Gauge Reader closes any distributary which will be affected due to the breach because of stress from the farmers. Then, that water will be released into the main branch without informing any downstream gauge reader, who may not be able to handle this emergency situation. This is all due to not having proper communication among the gauge readers and the responsible staff in the offices.

e) At this time, the Signaler gets the daily gauges from the Gauge Reader at RD-316+380 of Fordwah Branch Canal. The Signaler collects the information through a telegraphic system to the Chishtian ID office. But, sometimes, when the telegraphic system at this point has problems, then the Gauge Reader sends the gauges data **to** the ID Office, Chishtian by any means in order to inform them about the discharges in his reach.

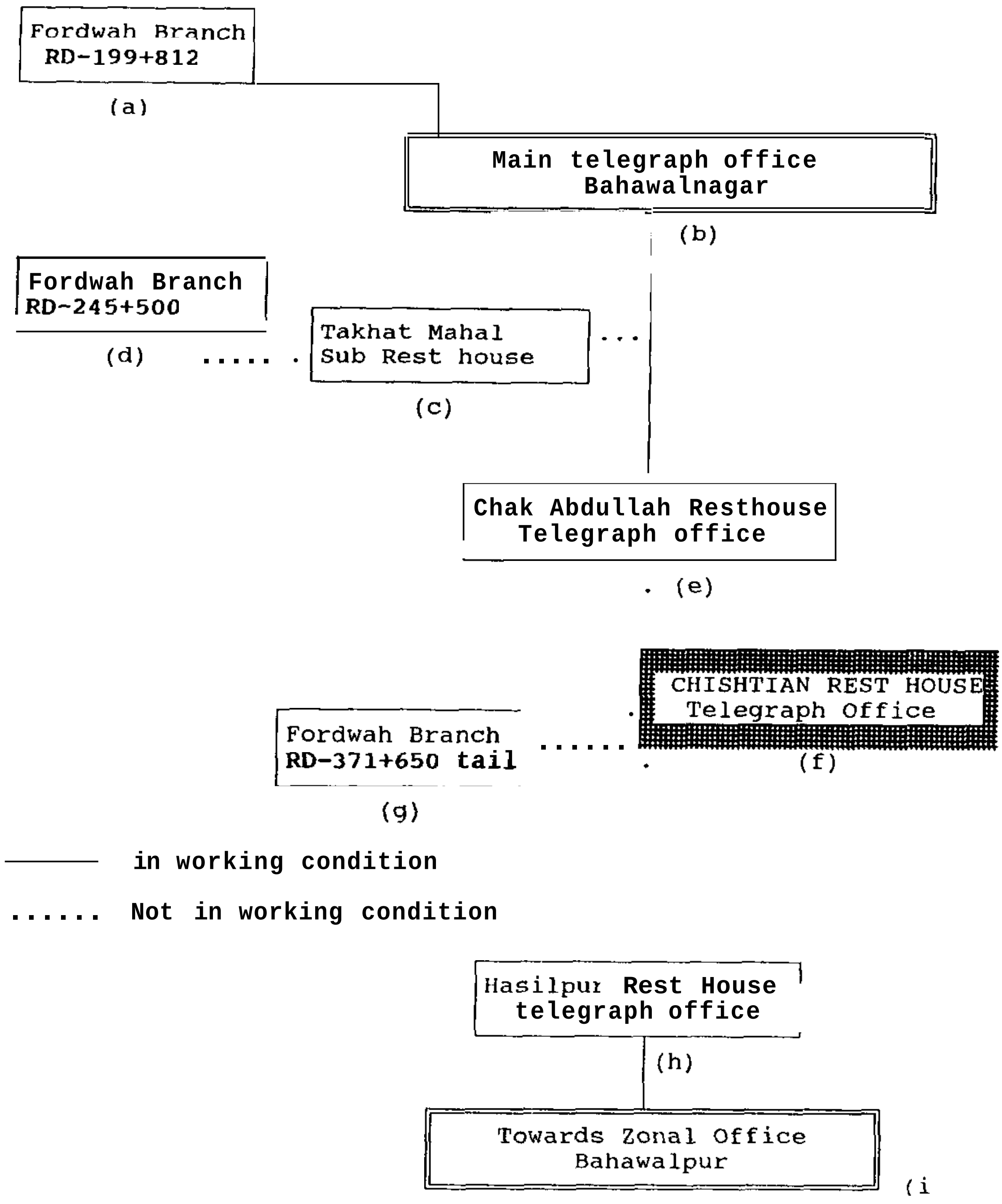


Figure 12. Communication System in Chishtian Subdivision.

f) The Signaler obtains discharge positions daily through the telegraphic system and by other sources in Chishtian Sub-division. The Signaler conveys messages to the Gauge Readers on behalf of the SDO Chishtian for controlling water deliveries in a better way due to his experience. The Signaler also enters these daily discharges for all offtakes in a register. The Signaler writes the information received from the Gauge Readers, so the reliability of the field data depends on these Gauge Readers. The Signaler also informs the SDO about daily discharge positions and also requests to the Bahawalnagar ID office, on behalf of the SDO, for the total indent of Chishtian Sub-division. But. this old wire system also has problems sometimes.

g) There was also an old telegraphic system in working order at RD-371+650 (tail of Fordwah Branch Canal). So, the Gauge Reader at this point was bound to inform daily to the SDO office about the discharge position in his reach. But, for more than ten years, this wire system is also not working and the Gauge Reader is visiting daily the SDO office to inforrn about the discharge in his reach. The Gauge Reader of this point stated that, for more than fifteen years, the tail is receiving a lot of problems due to excess water from upstream without any information. Fifteen years earlier, the Bahawal Ford Feeder Canal was working and anytime when excess water was received from upstream, he was passing that water into the Feeder Canal to save the other distributaries from a sudden breach. But now, the Feeder Canal is not working; therefore, many times when excess water reaches the distributary, there are breaches. Especially Azim Distributary has breaches due to a periodic excess of water at the tail of Fordwah Branch Canal.

h) At this point there was also an old telegraphic system in the rest house and the Signaler of this point was receiving the gauge positions of Jiwan Minor, and RD-64+050 (fall structure) of Fordwah Distributary (and its tail) and the tail of Azim Distributary together with its minors through ID Gauge Readers and Beldars. He was conveying this field information to the Chishtian Signaller office daily. But now, this telegraphic system is also not working anymore since fourteen years ago. But ID staff are recording the gauges for these points from other sources.

i) There is also an old telegraphic system in the Zonal Office at Bahawalpur, which is in working condition. At this office, the Head Signaller was receiving discharge readings from Suleimanki Headworks, main canals and branches from the main telegraph office in Bahawalnagar for keeping his records updated. He was also informing the PIPD Chief Engineer, Bahawalpur at his office. Sometimes, the farmers of the tail reach visit the Chief Engineer, Bahawalpur to claim about tail shortages. So, due to the visits of farmers, the Head Signaller of the Zonal Office sends a copy of the written orders of the Chief Engineer to Bahawalnagar for the SE, **XEN** and **SDO** Chishtian through the telegraphic system *(if* it works, otherwise through the mail).

Note: Now the PIPD staff can use the telephone for different messages in case of problems in the old telegraphic system. They have this facility in Bahawalpur, Bahawalnagar and Chishtian. Otherwise, they are communicating through the mail.

CHAPTER 5: DESCRIPTION OF STRUCTURES

5.1. Types of Structures

The structures constructed to regulate the discharge, full supply level or velocity of flow in a channel are known as regulation works. Such structures are necessary for the efficient working and safety of the channel. The various regulation works discussed in this chapter are as indicated below.

5.1.1. Falls or Drops

A fall is a structure constructed across **a** channel to permit lowering of the water level and dissipate the surplus energy possessed by the falling water, which may otherwise scour the bed and banks of the channel. However, there are different types of fall structures. Complete drawings and the longitudinal section for the fall structure at RD-334+040 of Fordwah Branch Canal is shown in Figure 13.

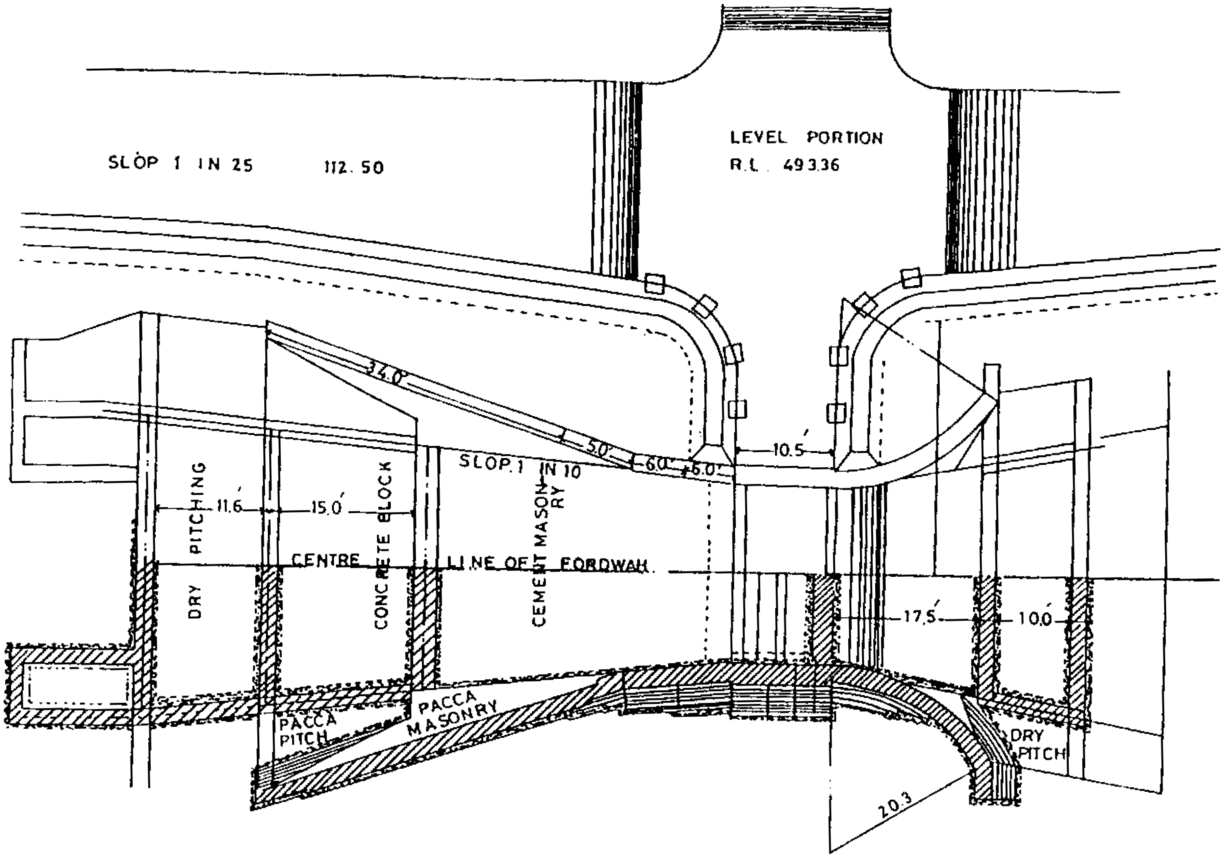
5.1.2. Cross Regulators and Distributary Head Regulators

Cross regulators and distributary head regulators are provided to control the supplies moving down the parent channel and the offtaking channel, respectively (Figure 14). **A** cross regulator is provided on the parent channel at the downstream side of the offtake to head up the water level and to enable the offtaking channel to draw the required supply. **A** head regulator is provided at the head of the offtaking channel (e.g. distributary) to control the supplies entering the offtaking channel. Complete drawings and longitudinal section of the head regulator (controlled with karries) of 3-L Distributary are shown in Figure 15, while the longitudinal section of the entire **3-L** Distributary *is* shown in Figure **16.** Complete drawings and longitudinal section of the head regulator (controlled with gate) of Masood Distributary is shown in Figure 17 and a complete longitudinal section of the entire Masood Distributary is shown in Figure 18.

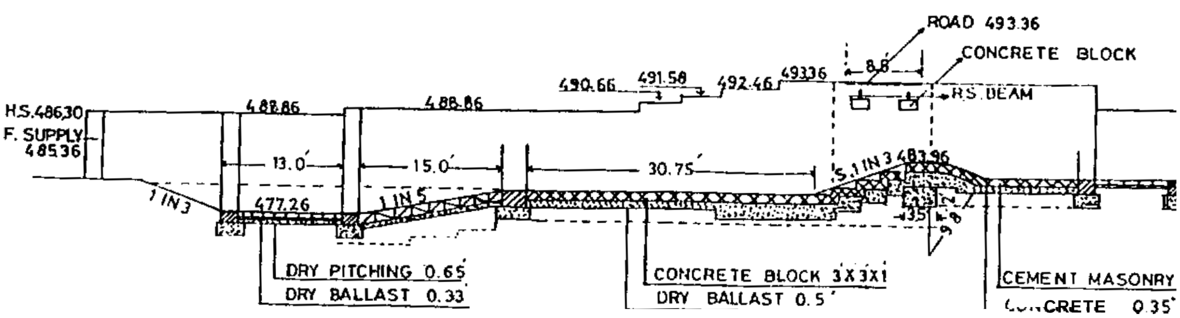
The functions of cross regulators are listed below.

a) A cross regulator enables the effective regulation of the water level upstream from the structure.

b) When the water level in the parent channel is low, they help to raise the 'water level and feed the upstream offtaking channels to meet their full water demand.



DETAIL OF FALL STRUCTURE AND VILLAGE ROAD BRIDGE AT RD- 334+040 FORDWAH BRANCH CANAL



LONG SECTION OF FALL

Figure **13.** Drawings *of* fall structure, village road bridge and longitudinal section of fall at RD-334+040 of Fordwah Branch Canal.

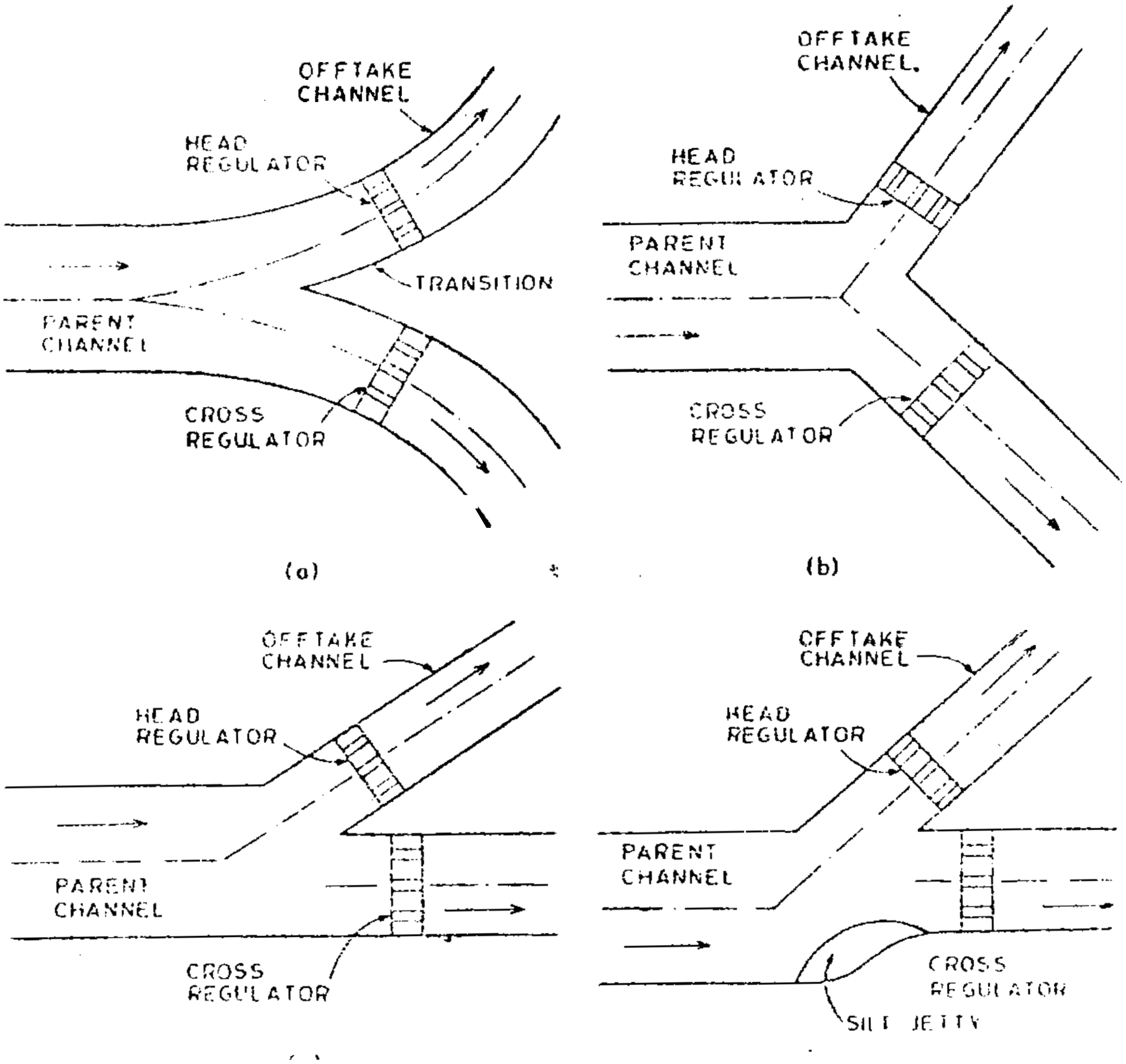


Figure 14. Offtaking alignments.

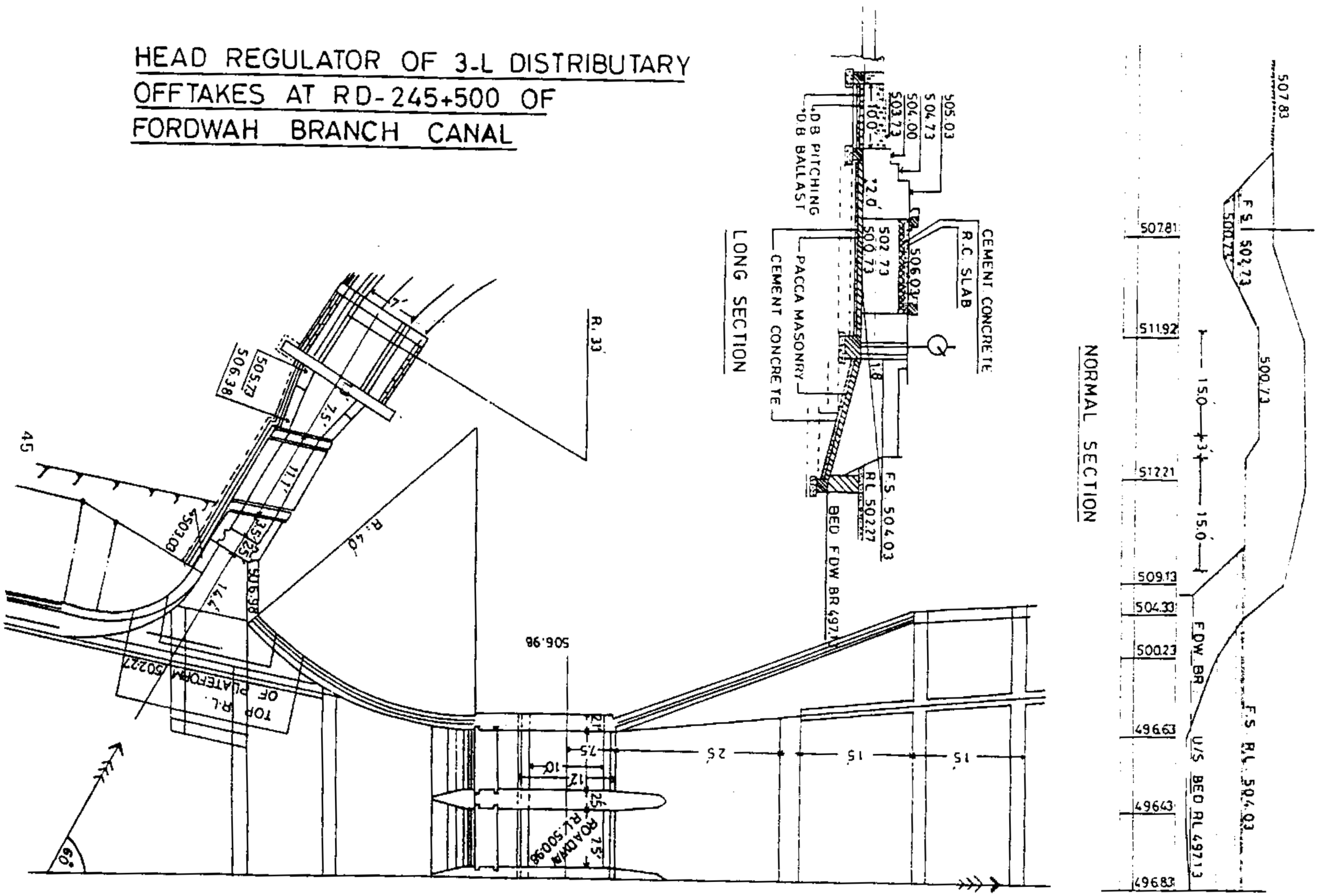


Figure 15. Drawings of the head regulator and longitudinal section of the head regulator of 3-L Distributary offtaking at RD-245+500 of Fordwah Branch Canal.

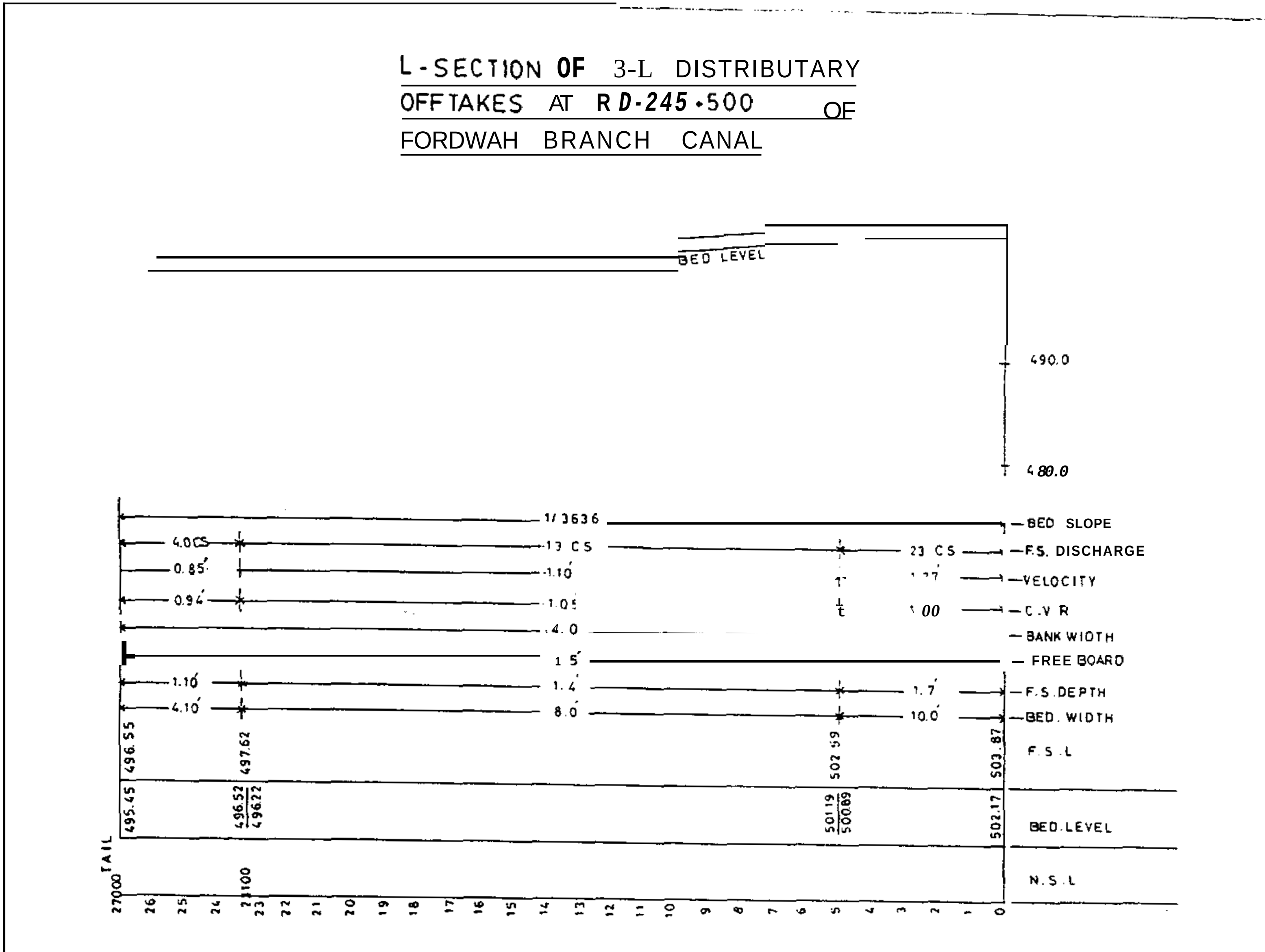
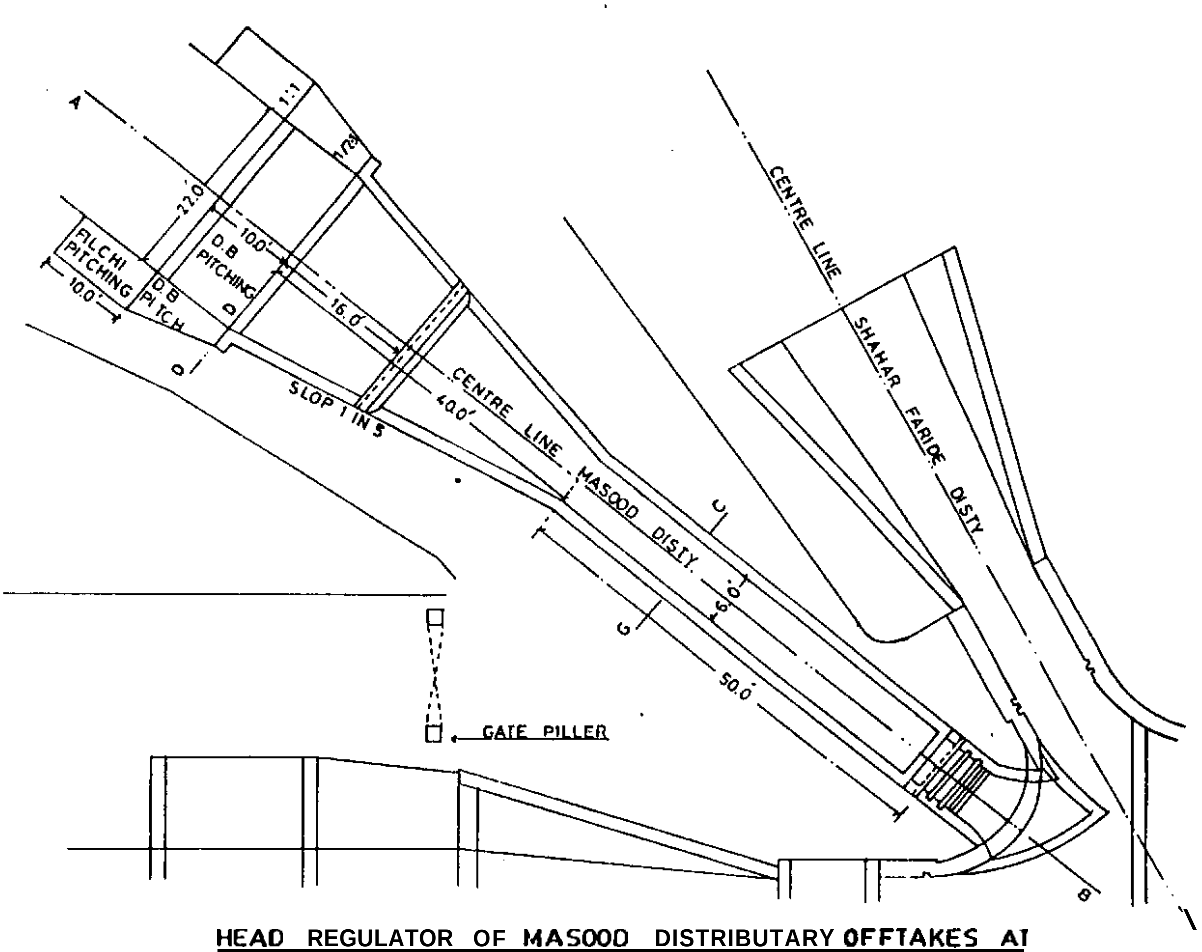
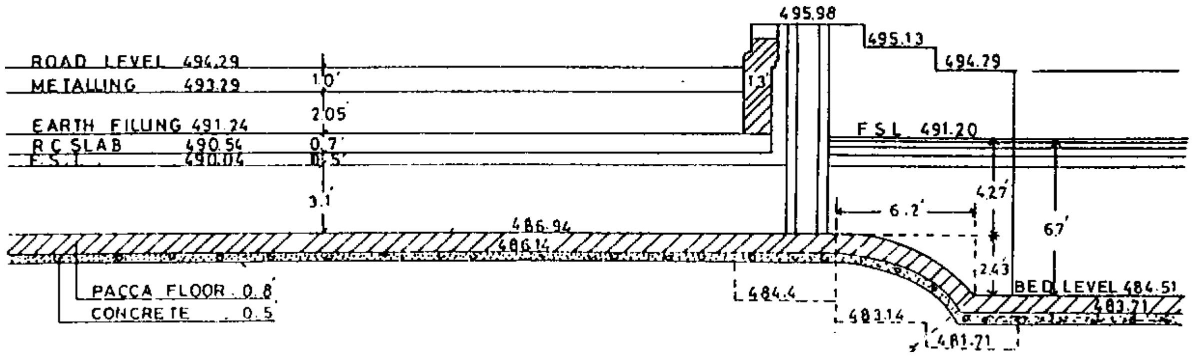


Figure 16 Longitudinal section of 3-L Distributary (from head to old design tail) offraking at **RD-245–500** *of* Fordwah Branch Canal



HEAD REGULATOR OF MASOOD DISTRIBUTARY OFFTAKES AT
R.D 316+380 OF FORDWAH BRANCH CANAL



LONG SECTION OF HEAD REGULATOR
OF MASOOD DISTRIBUTARY

Figure 17. **Drawings of the head regulator and longitudinal section of the head regulator of Masood Distributary offtaking at RD 31G-I 380 of Fordwah Branch Canal.**

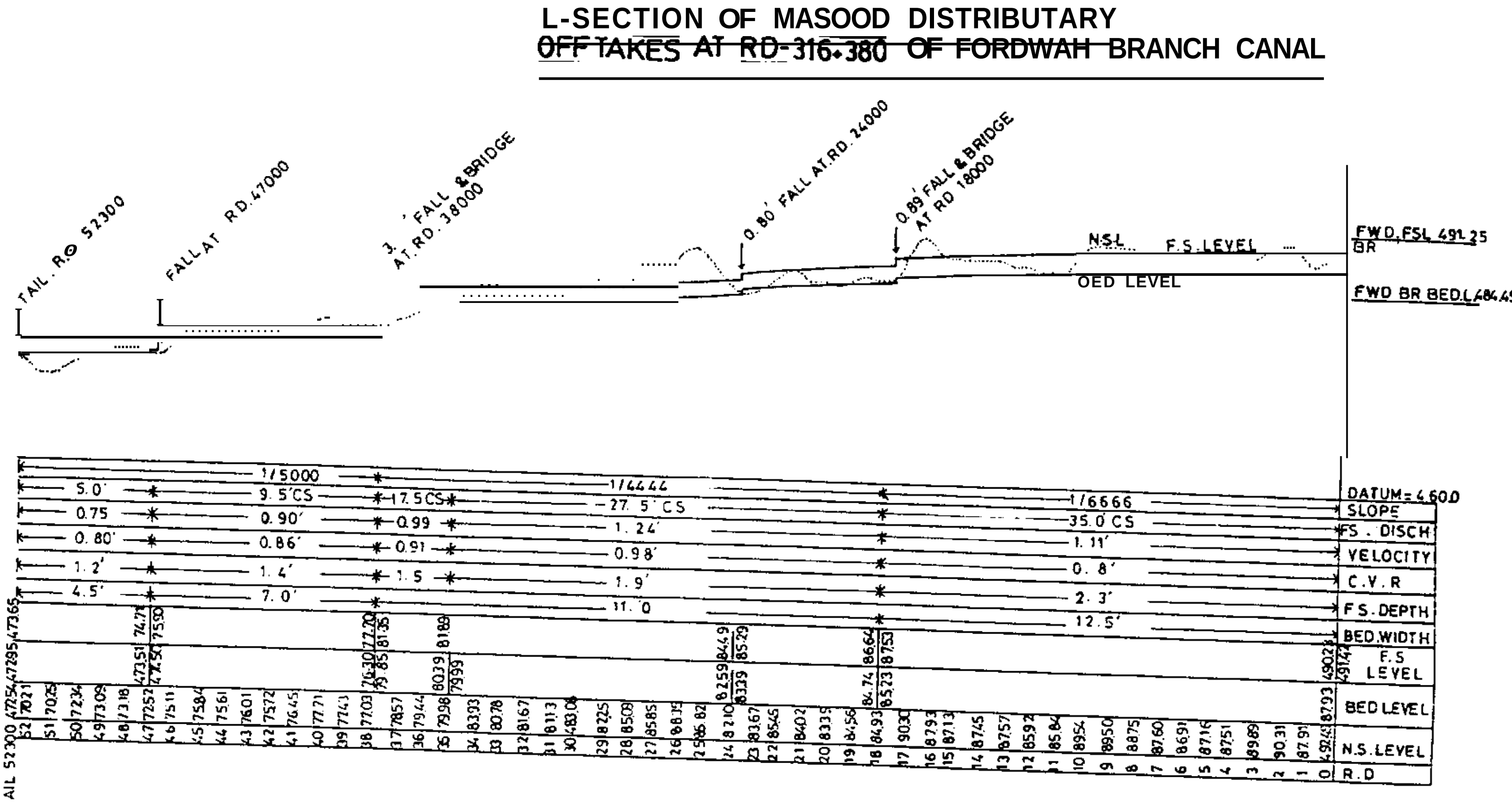


Figure 18. Longitudinal section of Masood Distributary (from head to old design tail) offtaking at RD-316 + 380 of Fordwah Branch Canal.

c) They help in closing the water supply to the downstream in the parent channel for the purposes of repairs and construction work.

d) In conjunction with escapes, they help water to escape from the channels.

e) They facilitate communication, since a road can be taken over them with a little extra cost.

f) They help to absorb water level fluctuations in the various sections of the canal system, and thus to prevent possibilities of breaches in the tail reaches.

g) They help to control the discharge at an outfall of the canal into another canal *or* lake.

h) In conjunction with falls, they help to control the water surface slope for bringing the canals to their regime slope and section.

The functions of distributary head regulators are listed below.

a) They regulate or control the supplies to the offtaking channel from the parent channel.

b) They control the entry *of* silt in the offtaking channel.

c) They serve as a meter for measurement *of* discharge entering the offtaking channel.

d) They help in shutting off the supplies when not needed in the offtaking channel, or when the offtaking channel is required to be closed for repairs.

5.1.3. Escapes

An escape is a structure constructed on the embankment of an irrigation channel for the disposal of surplus water from the channel. Hence, it is also called a surplus water escape, or canal escape, to distinguish it from the escapes provided for other purposes as indicated below.

Sometimes, escapes are provided in the head reaches of main canals to scour bed sediment deposited in the head reaches. The escape provided for this purpose is called a canal scouring escape.

In some cases, an irrigation channel ends in a natural drain or river; in such cases, an escape is provided across the channel at its tail or fag end. Such an escape is called a tail escape and is provided to maintain the required FSL (full supply level) at the tail end of the channel.

Surplus water may result at any point in an irrigation channel under the following circumstances:

a) Mistake or difficulty in regulation at the head of a channel;

b) Heavy rainfall in the upper reaches of a channel; and

c) Sudden closure of outlets by cultivators (farmers) due to a sudden cessation of demand, usually resulting from heavy rainfall, and sudden closure of any offtaking channel due to a breach.

If the surplus water is allowed to travel to the lower reaches, the water may overflow the banks, damage the embankment and spoil the surrounding crops. Although the supplies may be reduced from the head of the channel, but the effect of such reduction would be felt only after a certain time depending on the distance of the affected reach from the head. As such, immediate action is necessary to prevent damage and it is done by using an escape. This is particularly *so* in the case of a 'breach' or failure of channel bank somewhere. When a breach takes place, the channel has to be closed from the head and as soon as this information reaches the head, this is done. But, the channel from the head to the breach site is full of water, and if all the water was to rush out of the breach, it will widen and deepen the breach, delay closing operations, and cause widespread damage to land and property. If escapes of sufficient capacity exist on the upstream of the breach site, all of the water can be passed out through the escape, the regulator downstream of the lowest escape closed, and the channel dewatered quickly for repairing the breach. The surplus water escapes are therefore the safety valves of an irrigation channel system (Modi, 1988).

5.2. Calibration of Structures

Actually, IIMI was asked in 1989 by the Secretaries of Irrigation & Power and Agriculture of the Government of Punjab to commence work in the

Fordwah/Eastern Sadiqia area, given the fact that a number of development projects would be initiated in the area. The objective of IIMI's research is to develop and pilot test, in collaboration with national research and line agencies, alternative irrigation management practices to optimize agriculture production and mitigate problems of salinity/sodicity. The research is carried out at various levels of the irrigation system, from main system operation to field level irrigation application.

The main system component of the research is carried out in collaboration with the Punjab Irrigation & Power Department and aims to develop tools to assist irrigation managers to take better founded decisions on operations and maintenance. Within the framework of this programme, a field calibration training course was organized (from 28 May to 6 June in Bahawalnagar) in the Fordwah Canal Division on the request of the Secretary, Irrigation & Power Department, Punjab.

The training course had four main components:

1. Classroom and field site lectures on hydraulic principles for the use of current meter and rating of structures;

2. Rating of distributary head regulators by current meter (wading method);

3. Rating of major structures and cross-regulators by current meter (suspension method, boat); and

4. Inflow-outflow test to determine seepage losses.

The participants of the training course calibrated all hydraulic structures of Chishtian Sub-division (Fordwah Branch Canal RD 199-371). Component 3 was entrusted to the International Sedimentation Research Institute, Pakistan (ISRIP). Upon completion of the rating of structures fcomporients 2 and 3), an inflow-outflow test was conducted to estimate the seepage losses in Fordwah Branch Canal (RD 199-371). This work was done with joint efforts by the staff of the International Irrigation Management Institute (IIMI), the Punjab Irrigation & Power Department (PIPD), the International Waterlogging & Salinity Research Institute (IWASRI), Watercourse Monitoring and Evaluation Directorate (WMED) and the International Sedimentation Research Institute-Pakistan (ISRIP).

To develop the rating of hydraulic structures, measurements have to be taken with a range of discharge (e.g. 20%, 40%, 60%. 80%, 100% and 120% of the full supply discharge). Thus, the training course was organized during a period in which supplies were not at their maximum. During this ten-day period, 1-2 measurements were taken for each structure. Although this will give a good idea of the rating of these structures, more measurements will be required to develop full rating curves. For more details, see "Training Course on Field Calibration of Irrigation Structures, Fordwah Canal", IIMI, **1995.**

Before calibrating, all of the structures and the head regulators of offtaking channels of Chishtian Sub-division have been provided with benchmarks (so-called white marks (WM)) to measure h_u , h_l and G_o (see Figure' **19)** and the location (where WMs are located) of the white marks upstream and downstream at the structure are shown in Figure 20. The symbol 'X_u' is the longitudinal and 'Y_u' the latitudinal distance (on upstream side) in feet with reference to the center of the crest. Similarly, 'X_d' is the longitudinal and 'Y_d' the latitudinal distance (on downstream side) in feet with reference to the center of the crest. The term 'Z_u' is the vertical distance (of upstream WM) in feet above the crest and 'Z_d' is also the vertical distance (of downstream WM) in feet above the crest. However, the dimensions of the structures and reference levels are given in Annex **1,** while the white marks elevations and their locations (distance with reference to the center *of* the crest) are shown in Annex 2.

The outlets were also calibrated (to determine the coefficient *of* discharge, C_d for calculating the discharge of outlets in Chishtian Sub-division) in **1995-96** by IIMI's trained staff. The results are presented in a report "Water Distribution at the Secondary Level in the Chishtian Sub-division" by Tareen et al IIMI, **1996.**

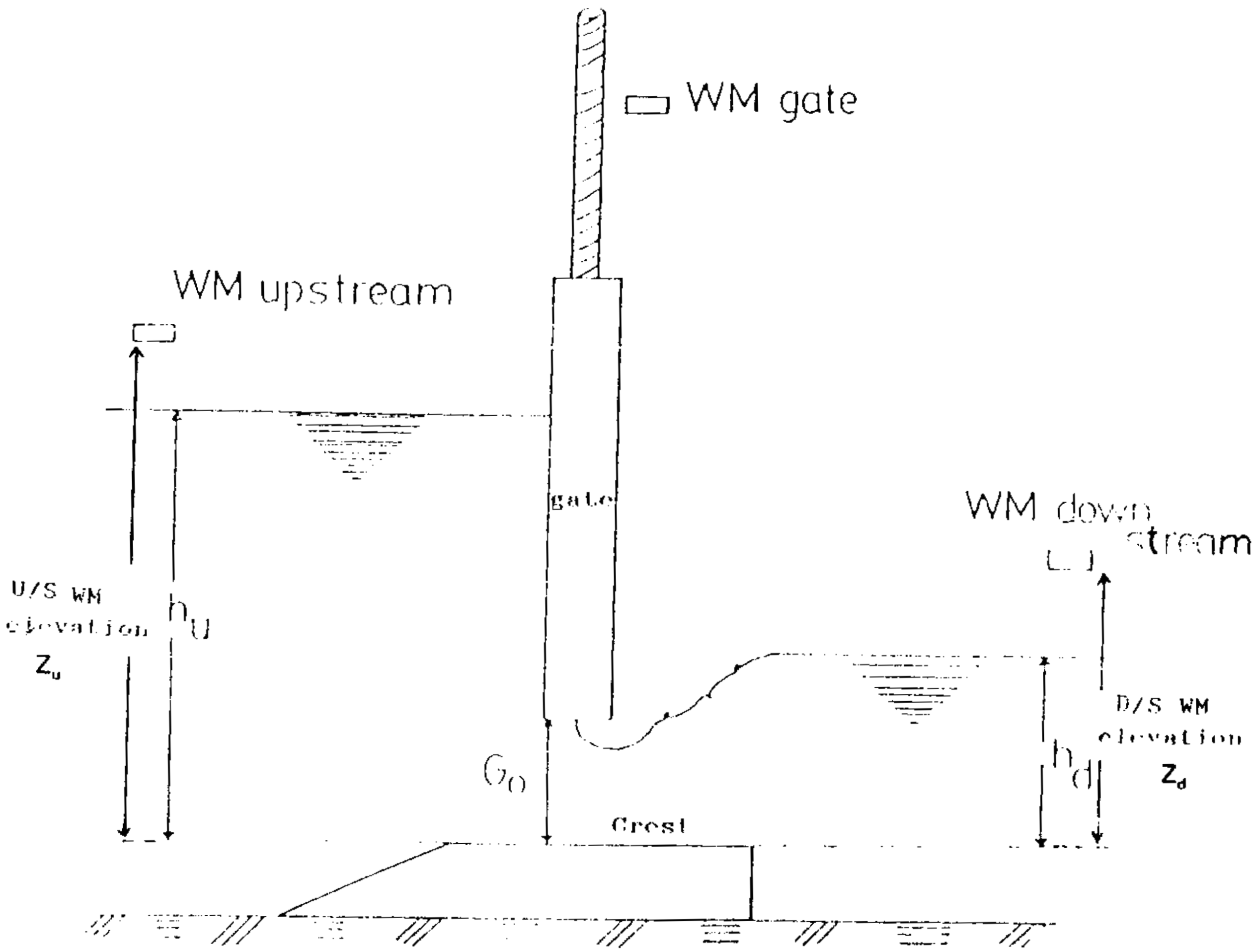


Figure 19. Location of white marks (upstream and downstream) at the gated head regulator of distributary.

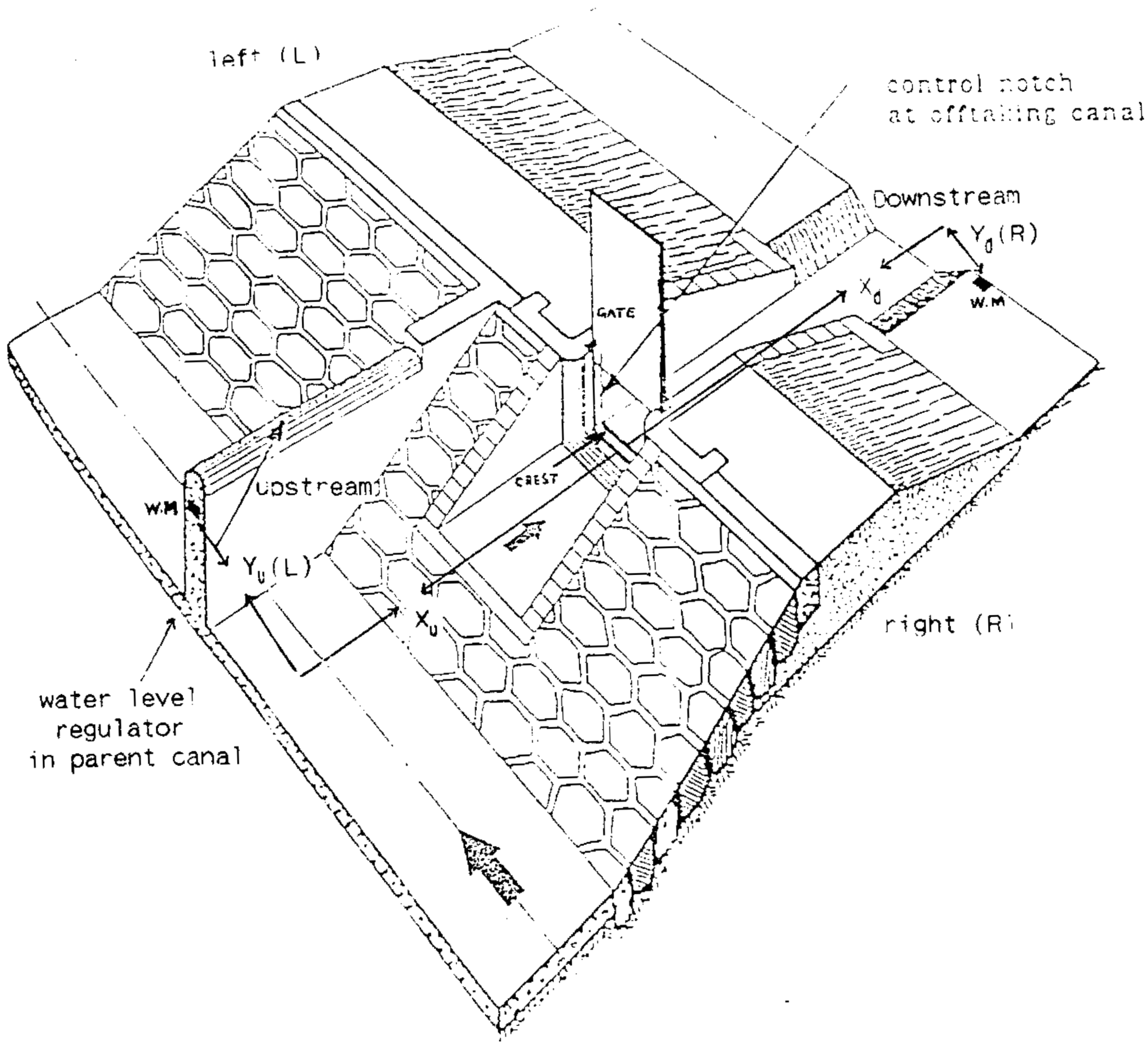


Figure 20. Longitudinal and latitudinal distance of white marks (upstream and downstream) on structure in Chishtian Sub-division.

CHAPTER 6: DESCRIPTION OF CHANNELS

6.1. General Characteristics

6.1.1. Daulat Distributary

Daulat Distributary offtakes from the right side of Fordwah Branch Canal just upstream from the cross regulator at RD-245 + 500. This is a non-perennial distributary having a total design discharge of 209 cusecs. The head regulator has two gates (gates need to be repaired). The flow condition at the head regulator is modular. Most of the time, this distributary runs less than the design discharge. Often, the tail has problems of water shortage due to illegal pipes and cuts in the upstream reaches and farmers blocking the water in the distributary. There is a fall structure at RD-21 + 273, which is highly submerged due to sediment deposition (although just upstream of the Daulat Distributary head regulator there is a silt ejector in the Fordwah Branch Canal as shown in Figure 21). At RD-63 + 630, there is a gated structure (Figure 22) which is also submerged. But, the fall structure at RD-99 + 800 is broken. There are two minors: (1) Billuka Minor which offtakes from RD-54 + 800 on the right side and the head structure is controlled with karries; and (2) the second minor Nakewah which offtakes from RD-63 + 630 on the left side just upstream from the gated structure shown in Figure 20 (the head structure of this minor is gated, but the gate does not work properly). There are no discharge rating tables for these two minors.

The physical characteristics of Daulat Distributary are given in Table 9, while similar data for Billuka Minor and Nakewah Minor are listed in Tables 10 and 11, respectively. Some additional information collected for Daulat Distributary are:

- Most all of the people are locals living in the Daulat Distributary command area;
- The electrical conductivity (EC) of the ground water was measured as 500 near the head, 475 in the middle and 1200 in the tail reach area;
- The ground water table is 5 feet below the ground surface at the head and 10 feet in the middle reach;

* Salinity is present along Daulat Distributary and the head reach area has problems of waterlogging during the rabi **season** (specially during the rainy season);

* The most common bore technology found in Daulat Distributary command area **is** filter.

* The bore depth for tubewells is 50 to 200 feet;

* Only the **farmers in** the head reaches can obtain sufficient water and tail farmers are not satisfied with the present canal water supply;

* List of a few large farms of Daulat Distributary;

S.No	Total **Land** (acres)	Reach
1	300	Head
2	150	Head
3	150	Middle
4	100	Middle
5	275	Tail
6	375	Tail

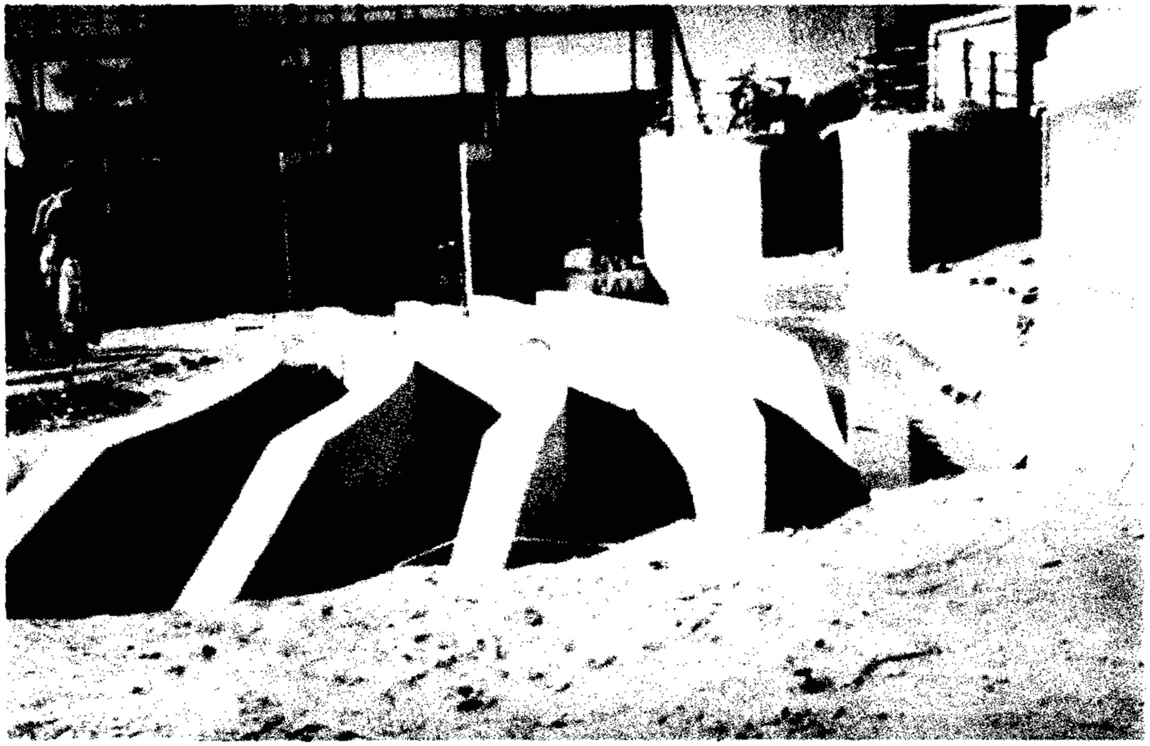


Figure 21. Picture showing silt ejector at the right side of Fordwah Branch Canal just upstream from the cross regulator at RD-245 + 500.

Figure 22. Picture showing gated fall structure (at the right) and the head regulator of Nakewah Minor (at the left) just upstream at RD-63+630 of Daulat Distributary.

Table **9.** Physical Characteristics of Daulat Distributary.

Status	Non-perennial
Off-taking RD of Fordwah Branch Canal	**245**+500
Length Design (ft)	115+150
Length Actual (ft)	115+150
Design Duty (cfs/1000 acres)	5 5
Design Discharge (cfs)	209
Maximum Discharge (cfs)	240
Minimum Discharge to feed the tail	-
Design Slope (ft)	0.28, 0.17 in 1000
Design Bed Width at head (ft)	31
Design Bed Width at tail (ft)	4.5
No. of Outlets	72
Type of Outlets	OCOFRB, OCAPM, OFRB, APM, OF, PIPE
No. of Drops	**3**
GCA (acres)	**36772**
CCA (acres)	**32690**

Structure	Type of Structure	RD	Design "Q" (cfs)	Flow Condition
Head of Distributary	Gated Orifice	0	**209**	Free Flow
Drop	Weir	21+**273**	**186**	Submerged
Drop	Gated Orifice	63+**630**	**74**	Submerged
Drop	Weir	**99**+800	30	Submerged

Name of Minor	Off-taking RD	Design "Q" (cfs)
Billuka Minor	**54+800**	**8**
Nakewah Minor	**63+630**	**39**

Status	Non-Perennial
Off-taking RD of Daulat Distributary	54+800
Length Design (ft)	12+780
Length Actual (ft)	12+780
Design Duty (cfs/1000 acres)	5.5
Design Discharge (cfs)	8
Maximum Discharge (cfs)	13
Minimum Discharge to feed the tail	+.-
Design Slope (ft)	0.30. 0.275 in 1000
Design Bed Width at head (ft)	5
Design Bed Width at tail (ft)	3.5
No. of Outlets	7
Type of Outlets	OFRB,OF,PIPE
No. of Drops	0
GCA (acres)	1448
CCA (acres)	1320

Structure	Type of Structure	RD	Design "Q" (cfs)	Flow Condition
Head of Minor	Weir	0	8	Submerged

Status	Non-Perennial
Off-taking RD of Daulat Distributary	63+630
Length Design (ft)	43+800
Length Actual (ft)	43+800
Design Duty (cfs/1000 acres)	5.5
Design Discharge (cfs)	39
Maximum Discharge (cfs)	40
Minimum Discharge to feed the tail	• --
Design Slope (ft)	0.265 in 1000
Design Bed Width at head (ft)	12
Design Bed Width at tail (ft)	3
No. of Outlets	28
Type of Outlets	OFRB,OF,PIPE
No. of Drops	0
GCA (acres)	7861
CCA (acres)	6910

Structures

Structure	Type of Structure	**RD**	Design "Q" **(cfs)**	Flow Condition
Head of Minor	Gated Orifice	0	39	Submerged

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