Report No: R-39.4

PILOT PROJECT FOR FARMER-MANAGED IRRIGATED AGRICULTURE UNDER THE LEFT BANK OUTFALL DRAIN, STAGE-I PROJECT

MONITORING AND EVALUATION OF IRRIGATION AND DRAINAGE FACILITIES FOR PILOT DISTRIBUTARIES IN SINDH PROVINCE, PAKISTAN

Volume Four
Heran Distributary, Sanghar District

Interim Report

by

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1. INTRODUCTION

1.1 BACKGROUND

Tlic International Irrigation Management Institute (IIMI) is implementing three pilot projccts on Farmer-Managed Irrigated Agriculturc since July 1995, in collaboration with tlic Agricultural Engineering and Watcr Management Dircctoratc of tlic Department **of** Agriculturc, Covcrnnicnt of Sindli. Tlic tlirce pilot projects selected from tlic LBOD projcct arca, onc from each of the tlirce districts of Nawabsliah, Sangliar and Mirpurkhas, arc to assist farmers **in** undertaking Operation and Maintenance (O&M) of thc combined irrigation and drainage facilities. This would bc achicved through assisting faniicrs to organize themselves into Watcr Uscrs Associations (WUAs) at tlic watercourse level and into Watcr Uscrs Fcdcration (WUF) at tlic distributary Icvcl. Tlic expericncc gained from these pilot command areas **would** also help in identifying and developing an appropriate institutional process, along with legal requirements, for effective implementation on a broader scale for all of thc distributaries in a **canal** command arca.

1.2 PURPOSE

The purpose underlying these pilot projccts is that **the** WUAs **and** WUFs would eventually bc accountable for the water reccivcd at **the head** of tlic distributary, responsible for watcr distribution **among** tlic members, collection of watcr charges, **along with** operation **and** maintenance (O&M) **of** tlic combined irrigation **and** drainage facilities in their distributary command arca. They niay **also** adopt rcviscd proccdurcs **on** watcr allocation, distribution, watcr charges assessment and collection with the agrecmcnl of their members. WUFs would bc cxpcctcd to enter into agreements with their own members **and** the Sindh Irrigation **and** Drainage Authority (SIDA) for implementation of the proposed activities. **The** broad purpose of these pilot projects is two fold:

(i) to test tlic viability of farmers' **managing** parts of irrigation systems, niorc specifically distributary/minor canals, so **that** more efficient and equitable distribution of water can be achieved; and

(ii) to make recommendations related to future extensions **on** tlic basis of results from thc **pi**lot projccts

1.3 ACCOMPLISHMENT IN HERAN DISTRIBUTARY COMMAND AREA

Tlie Heran Distributary command area, Sangliar District, is one of tlic three pilot projccts. Considerable progress **lias** been made in thc implementation **of** projcct activities at this site. Tlic project staff **lias** assisted farmers to organize tlicmsclvcs into Watcr Uscrs Organizations (WUAs) in all of tlic 31 watcrcoursc commands. Using tlic WUAs **as** basic organizations, a Watcr Uscrs

Federation (WUF) has been formed at the distributary level. At present, a Joint Management Agreement **(JMA)** is being negotiated between the Sindh Irrigation & Drainage Authority (SIDA) and the Heran WUF. According to this agreement, the Heran WUF **would** undertake operation of the combined irrigation and drainage facilities including collection of water charges, improving water management and drainage practices, and carry out other related activities, including the maintenance of irrigation and drainage facilities in the Heran Distributary command area.

The main purpose of this effort is the involvement of farmers in operation and maintenance of the combined irrigation and drainage systems, which **has** never been successfully accomplished before in the country. Therefore, there is a strong need and justification for monitoring the process employed and its impact towards achieving the objectives.

1.4 MONITORING AND EVALUATION OF HERAN DISTRIBUTARY

The Monitoring and Evaluations (M&E) would help in at least two major ways:

(i) allow the SIDA **and** WUFs to adjust their activities to the needs and constrains of the irrigation and drainage management turnover projects; and

(ii) provide policy-makers and planners with up-to-date information about the consequences of appropriate management changes for planning new projects that could be extended to other distributary command areas.

As a first step, Monitoring and Evaluation (M&E) of the irrigation delivery and drainage disposal systems was undertaken to document the on-going situation before the management turnover of the Heran Distributary command area to the WUF. **A** detailed methodology **was** developed for data collection **and** analysis. Actual field data collection **was** started in April 1997. This is an interim report that summarizes the results and findings of the M&E activities undertaken so Far.

2. DESCRIPTION OF HERAN DISTRIBUTARY

2.1 LOCATION

The Heran Distributary takes off from tlic right bank of Nara Canal at KD 129, then flows from East to West from the Nara Canal. The command area is situated to the north of Sanghar City. The road from Sangliar to Gujri crosses the Heran Distributary at RD 11. The tail of the distributary lies in between Chak No. 9 and Chak No. 11. The Heran Distributary also has a minor known as Khadwari Minor. The Khadwari Minor takes off from tlic left bank of the Heran Distributary at RD 10 and flows from North to South (parallel) to the Sangar-Gujri Road, whereas the tail is near Chak No. 10. A location map of the project area is shown in Figure 2.1 and a command map of the distributary is presented in Figure 2.2.

2.2 SALIENT PHYSICAL FEATURES

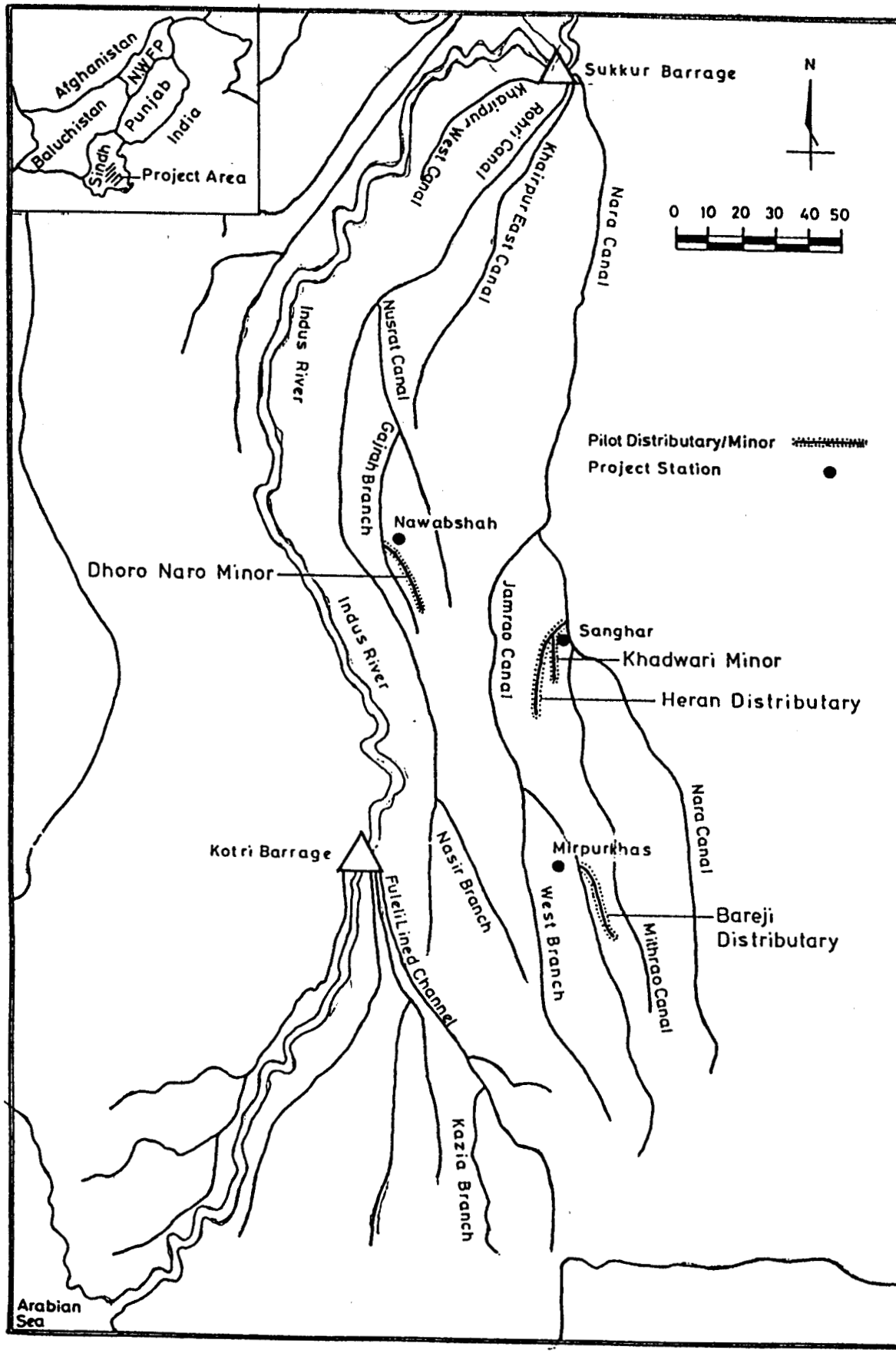
The head regulator consists of three gates. Two of them are closed and the middle one is functional. The cross regulator at RD 10 is dysfunctional. The distributary channel has a turn of about 65 dcgrcc at KD 19. The inspection path is in good condition. The distributary has one minor called Khadwari Minor which offtakes from it at RD 10. The head regulator of the minor is functional. The salient fcaturcs of the Heran Distributary are shown in Table **2.1.**

2.3 CLIMATE

The climate is arid sub-tropical with very hot summers and mild winters. The mean daily maximum temperatures in summer ranges from 39°C to 41°C and the mean monthly maximum temperature is about 43°C to 45°C. In wintcr, the mean daily minimum temperature is about 7^0C with tlic mean monthly minimum tcmpcraturc falling to 2.5^0C. The mean monthly summer rainfall varies from 32 mm in the North to 46 mm in the South. The wintcr is practically rainless. In general, the climate is typically desert type with very hot days in the summer and cold nights in wintcr with frost and fog frequently appearing. Dust storms arc common during the summer.

2.4 IRRIGATION SYSTEM

The climax in the development of the canal irrigation system in Sindh was achicvcd in 1932 when tlic Sukkur Barrage, the largest canal irrigation system in the world, was commissioned. The Sukkur Barrage proved to bc a great success. The Nara canal command area has a gravitational system (canal water). This system consists of main canals, branch canals, distributaries and minors. The Heran Distributary offtakes from the Nara Canal. The Nara Canal is part of an old river, which was an inundation canal with its source of supply from the foot of the Punjab hills.



Figute2.1. Location map of the three pilot distributaries in Sindh Province.

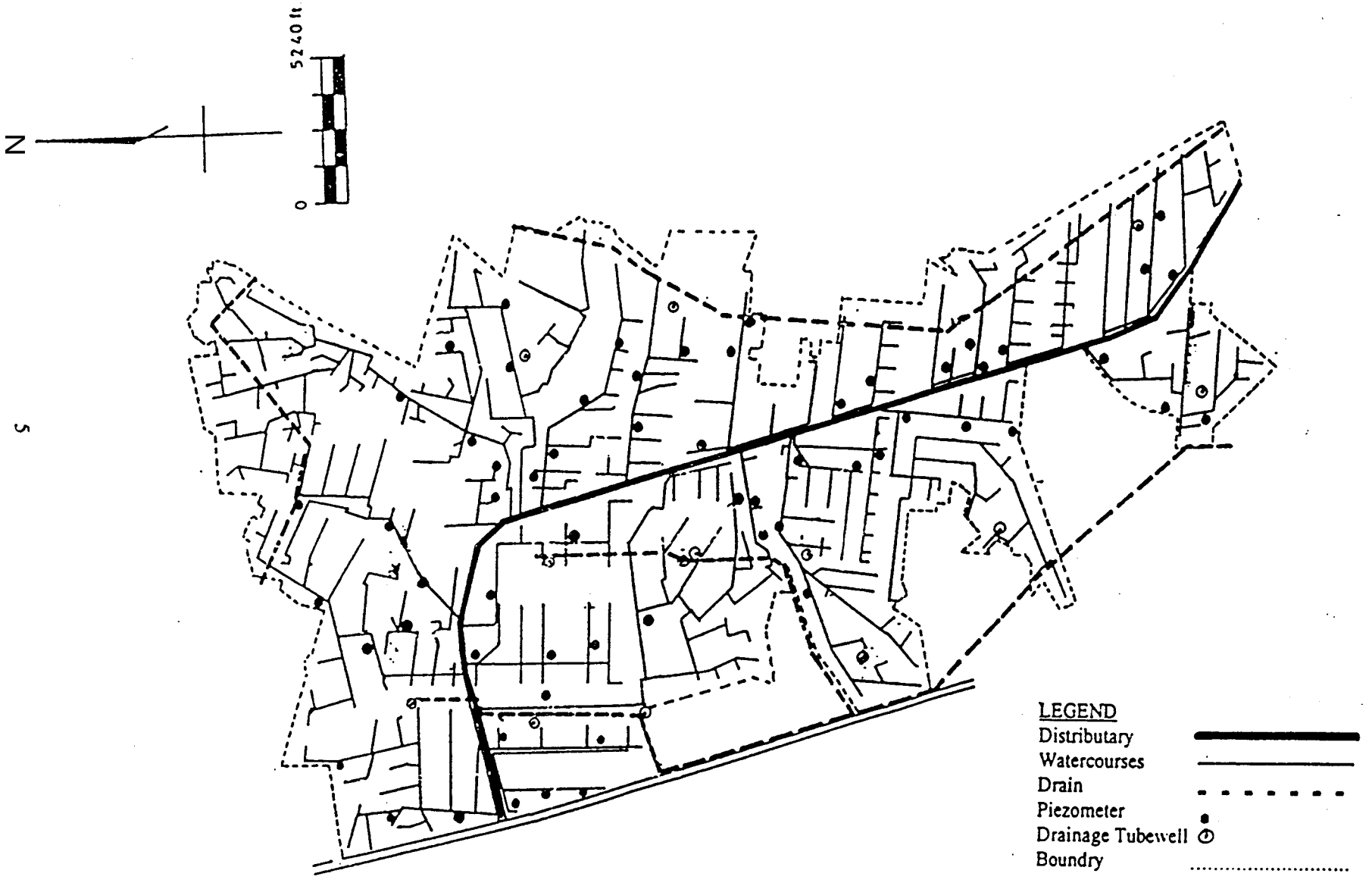


Figure 2.2 Layout plan of the Bareji Distributary command area.

Table 2.1. Salient fcaturcs of the Heran Distributary, Sangliar.

Description	Detail
Length	10.6 km
Old dcsign discharge	58.0 cfs
Old design depth **at** the head	2.6 feet
Old design depth **at** the tail	1.1 feet
Number of outlets	24
Lined watercourses	**23**
APM outlets	**20**
Open flume outlets	**4**
Culturable Command Area (CCA)	12, 326 Acres.

Tlic salient fcaturcs of tlic minor arc given in Table **2.2.**

Table **2.2.** Salient fcaturcs of the Khadwari Minor (Heran Distributary), **Sangliar.**

Dcscription	Detail
Length of minor	5.12 km
Old dcsign discharge	10.62 cfs
Number **of** outlets	7
Lined watercourses	**4**
Unlined watercourses	**3**
Cultureable Command Area (CCA)	**3,065** Acres

Tlic Sukkur Barrage scrvcs to maintain water lcvcls in the Indus River in order to permit adequate irrigation flows to bc diverted into a total of seven canals offtaking on both sides of the Borragc. The Nara **Canal is** the largest offtaking canal of the Sukkur Barrage. Nara **Canal** is irrigating three districts: Sangliar, Mirpurkhas **and** Thurparkar. The Heran Distributary **was** constructed during the construction period of Sukkur Barragc. Prior to its construction, **most** of the **area** was barren **land.** When the British Government distributed the **land** of this area to the Ex-Army pcoplc, then cultivation started.

Application of irrigation water from the Heran Distributary to the farm fields is through watercourses which are controlled by outlets (moghas). Within a watercourse command area, which is ranging from 200 to 700 acres in size, the shareholders receive a supply of water proportional to their land holding size. This is accomplished by assigning the entire flow of the watercourse, usually between one and three cusecs, to one farm for a specified time period on a seven-day rotation. The rotation schedule, called the warabandi, was established by the Irrigation Department, if not mutually agreed by the farmers.

2.5 DRAINAGE SYSTEM

Land is said to be waterlogged when its productivity or fertility is affected by high water table. The adverse effects of high water table upon the yield of crops also depends upon the nature of the crop grown. If the water table is in a state of equilibrium naturally, the amount of inflow is practically equal to the amount of outflow. This equilibrium is upset by the huge flow of water in the Nara Canal and construction of new branch canals, which contributed to the water table through seepage and deep percolation. Hence, the water table has risen to a significant level. In the pilot command area, the LBOD spread a network of surface drains and saline and scavenger tubewells, but the tubewells are still under the process of installation. The following are the components of the scheme to combat the problem of waterlogging and salinity in the area:

A network of surface drains discharging to the sea via a spinal drain and tidal link.

- Deep tubewells to intercept seepage water and control the ground water table by pumping ground water into the surface drainage network.
- Special wells to scavenge fresh water lenses for use in irrigation.Buried interceptor drains beside canals to recover fresh water seepage for use in irrigation.
- On-farm water management to improve watercourses and water use practices.

The drains which cover the Heran Distributary command area are given below.

Name of drain	Design discharge (cfs)	Total length (km)	Length in command area (km)
MBD	96.6	20.73	9.75
M-IRA	17.60	7.10	3.70
M-IR	79.50	23.29	3.66
S-1R	43.00	11.30	11.21

The subdrain M-1RA discharges into the branch drain M-1R and this branch drain discharges into MBD. The MUD enters into Sangliar Main Drain, while S-1R directly disposes

into Sanghar Main Drain. Under the LBOD project, the saline and scavenger tubewells are being installed and linked with these subdrains and branch drains for the purpose of disposal. Their detail is presented in Table 2.4.

Table 2.4. Salient features of tubewells in the Heran Distributary command area.

Name of drain	Type of tubewell	Number	Capacity (cfs)
MBD	Drainage	07	2.0
M-1R	Drainage	01	2.0
M-IRA	Scavanger	02	2.0
S-1R	Scavanger	17	2.0
S-IR	Drainage	08	2.0

2.6 LAND USE

Most of this area comprises arable irrigated land, with small patches of unused land that has become saline and alkaline. There are distinct cropping patterns that emerge in accordance with the varying availability of water.

Irrigated agriculture is the predominant land use of the area. Mostly, soils are loamy and sandy loam soil. About 85% of the land is used for growing crops, 3% of the land is used for gardens, while 12% of the land is not used for any purpose and remains fallow land.

2.7 CROPS

The climatic conditions and soil structure both are favorable for cultivating different crops. The major crops in the distributary command area are cotton, wheat, sugarcane, oil seed, berseem, maize, vegetables, rice and groundnuts.

2.8 GROUNDWATER

In the command area of the Heran Distributary, the canal water is being used for irrigation purposes. The ground water had been exploited but not found fit for irrigation purposes. Nevertheless, the canal water is available in sufficient quantity and therefore, groundwater is not in demand.

2.9 IRRIGATIO N PRACTICES

Efficient management of irrigation water is important for boosting the agricultural economy. The proper application of irrigation watcr plays an important role in watcr savings and increasing agricultural productivity. The Hcran Distributary command area is mostly being irrigated by the basin irrigation method, which lias traditionally been in existence since the functioning of tlic distributary. This method is being used for all crops, cxccpt vegetables.

At present, the cotton crop is being cultivated on ridges (furrow method), with this practice being initiated during the lust two or three years. The main reason for cotton crop cultivation on ridges / furrows is to avoid salinity and waterlogging problems.

Lift irrigation for cultivation of crops wiis not seen in tlic area. I Iowcvcr, it lias been reliably determined that sonic farmers use lift irrigation to fetch watcr from drains during the periods of watcr shortage.

3. RESULTS AND DISCUSSION

Tlic results of the monitoring and evaluation activities undertaken in tlic I Icran Distributary command area since April 1907 arc discussed below. The focus was on capturing the on-going conditions and practices (phase I of the monitoring and evaluation process) which represents the status of "before" the irrigation management turnover.

3.1 IRRIGATION DELIVERY SYSTEM

3.1.1 Operations of Irrigation Delivery System

Tlic most important operational objective of an irrigation delivery system is considered to be the provision of reliable arid equitable irrigation water supplies to all of the secondary and tertiary units served by that systciii. Having this in mind, operations of the Heran Distributary wcrc monitored to determine tlic nature and extent of fluctuations occurring in canal water supply and their effects on watercourscs. Flows were measured twice a week on the same days at the head regulator as well as at all of the outlets of the Heran Distributary.

3.1.1.1 Irrigation Supplies at Head Regulator of tlic Heran Distributary

Avcragc monthly values for dischargc at tlic head regulator of tlic Mcran Distributary from April to September 1997 arc presented in Figure 3.1. The results show that the avcragc monthly discharge received at tlic licad of the Heran Distributary was much more as compared with its old design dischargc, which would bc cxpcctcd. Tlic discharges wcrc also not very different from one month to tlic other except for tlic month of April, when the avcragc dischargc was significantly lower than tlic other months. Tlic reason for the low supply in April could bc related to a transition between the rabi and kharif seasons.

The average temporal coefficients of variability calculated for the monthly supplies at tlic head regulator arc presented in Figure 3.2. They wcrc found within acccptablc range i.e. being in the fair to good category according to Molden and Gates (1990) criteria. This means that the variations observed in the irrigation supplies at the licad of the Heran Distributary wcrc acccptablc and the main systciii operations wcrc found to bc rcliablc.

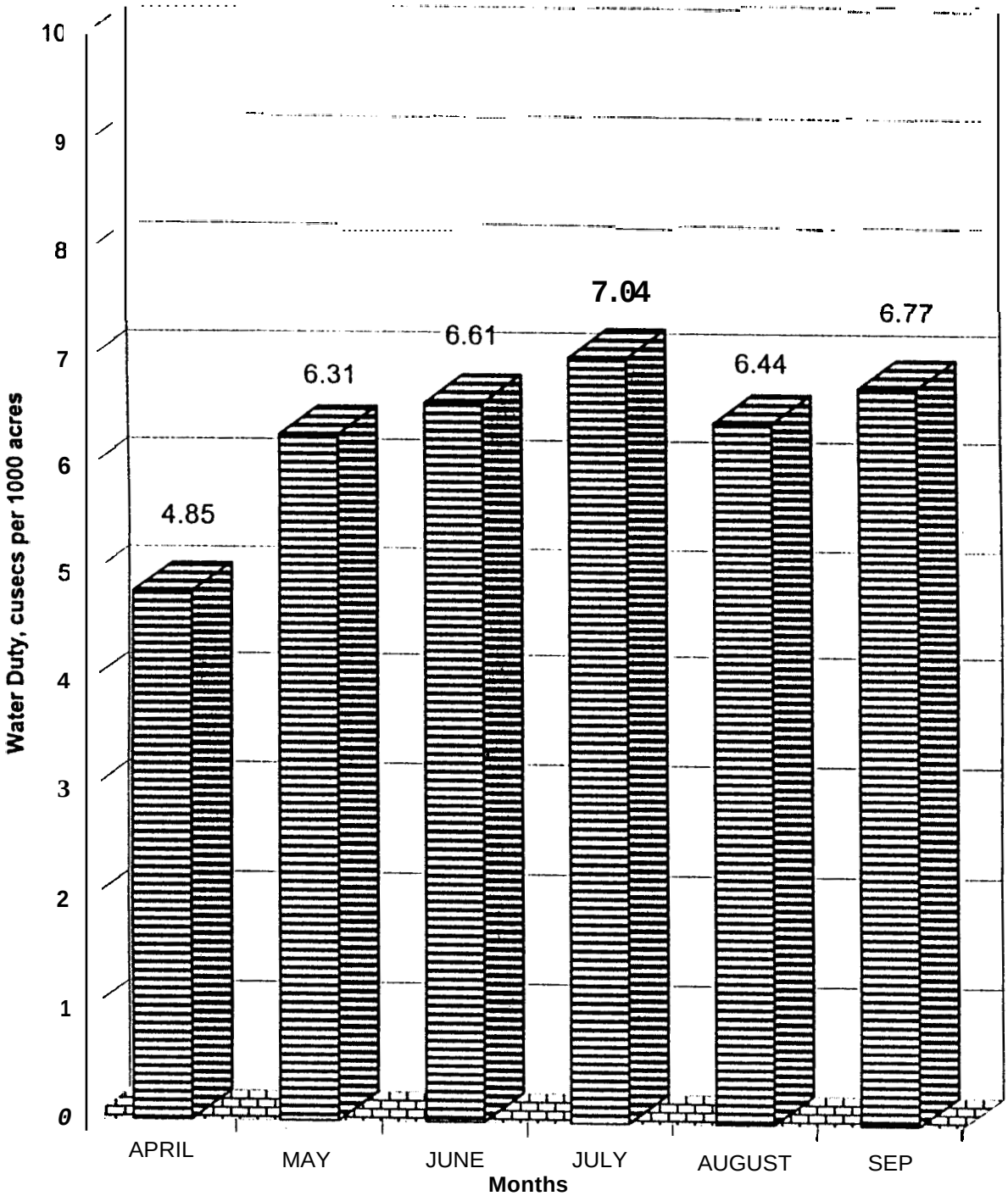


Figure 3.1 **Monthly average discharge entering Heran Distributary for Kharif 1997.**

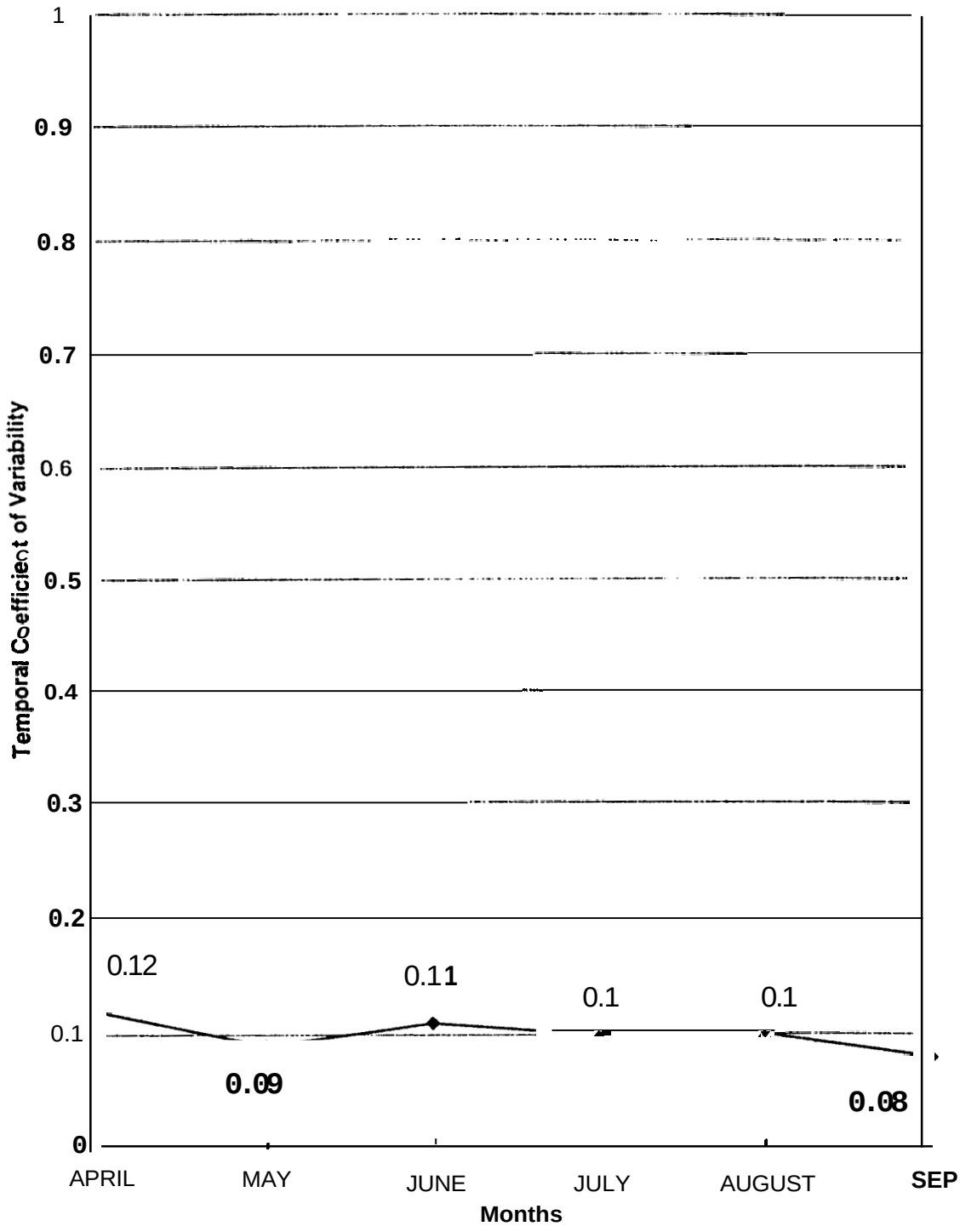


Figure 3.2 Temporal Coefficient of Variability at head regulator of the Heran Distributary for Kharif 1997.

3.1.1.2 Irrigation Supplies at Watercourse Outlets

The type of outlet and its operating condition for all of the outlets from the Heran Distributary are shown in Table 3.1.

Table 3.1 Types of outlets and their operating condition (Heran Distributary).

S.#	OUTLET #	TYPE OF OUTLET	FLOW CONDITION
	1-L	APM	Submerged Orifice
2	2-R	APM	Free Orifice.
3	3-L	APM	Submerged Orifice
4.	4-R	APM	Submerged Orifice
5.	5-L	APM	Free Orifice.
6.	6-L	APM	Submerged Orifice
7.	7-L	APM	Free Orifice.
8.	9-AR	APM	Submerged Orifice
9.	8-L	APM	Free Orifice.
10.	9-R	APM	Free Orifice.
11.	10-R	APM .	Submerged orifice
12&13	11+12-R	APM	Submerged Orifice
14.	13-R	APM	Free Orifice
15.	14-L	APM	Free Orifice
16.	8-AL	APM	Free Orifice
17.	15-L	APM	Free Orifice
18.	16-K	APM	Submerged Orifice
19.	17-AL	APM	Free Orifice
20.	16-AR	Open Flume	Submerged
21.	17-BL	APM	Free Orifice
22.	18-R	Open Flume	Submerged
23.	17-T	Open Flume	Submerged
24.	18-T	Open Flume	Free Flow

Tlic type of outlet **and** its operating **condition** for **all** of tlic outlcts **from** tlic Kliadwari Minor arc shown in Table **3.2.**

Table **3.2** Types of outlcts and their operating condition (Kliadwari Minor).

S.#	OUTLET #	TYPE OF OUTLET	FLOW CONDITION
1.	1-Al	Open Flume	Free Flow.
2.	1-L	Open Flume	Free Flow.
3.	2-R	Open Flume	Submerged.
4.	3-L	Open Flume	Free Flow.
5.	4-R	Open Flume	Submerged.
6.	5-T	Open Flume	Free Flow
7.	6-T	Open Flume	Submerged.

Irrigation supplies at watcrcoursc outlcts wcrc measured **at** the same time **as** tlic discharge measurements **at** tlic head regulator. Tlic monthly **data** (eight observations in **each** month) wcrc normalized on tlic basis of watcr duty in cfs/1000 acres. Tlic average monthly discliarge value for each outlet is presented in Figures 3.3 through **3.8.**

Figurc **3.3** shows that there is no pattern of watcr distribution among tlic outlcts. Two watcrcoursc outlcts (Outlets 7-L and 10-R) arc drawing exceptionally high discliargcs. **About** half of tlic outlcts wcrc drawing liiglicr dischargcs compared with the rcst. Wlicrcas two watcrcoursc outlcts (Outlets **2-K** and 3-L) wcrc drawing significantly low discliargcs when comparcd **with** tlic rcst. This trend more or less continued during other months as well. From these figures, it is clear **that** there **was a** large variation in **amounts** of watcr being drawn by different outlcts.

The distribution of watcr among the outlcts **is** the main concern of the watcr users / farmers. Tlicreforc, the distribution of watcr among the outlcts was cvaluatcd using tlic term "equity", which indicates **the** ability of a systcni to distribute water uniformly over space. The distribution of watcr is usually influenced by **a** number of potential factors, which cause a non-uniform watcr distribution **along a** parent clianncl. They niay include lack of proper maintcnancc, scdimcnt deposition, tampering of outlcts, and illegal watcr abstractions.

Tlic data wcrc analyzcd to determine the spatial coefficient of variability for each month. Tlic results arc shown in Figurc 3.9. Figurc 3.9 shows **that** the **spatial** coefficient of variability for the outlcts ranged from 0.39 (39%) to 0.48 (48%) which implied that tlic watcr distribution along tlic outlcts was in tlic "poor" category according to Molden **and** gates (1990).

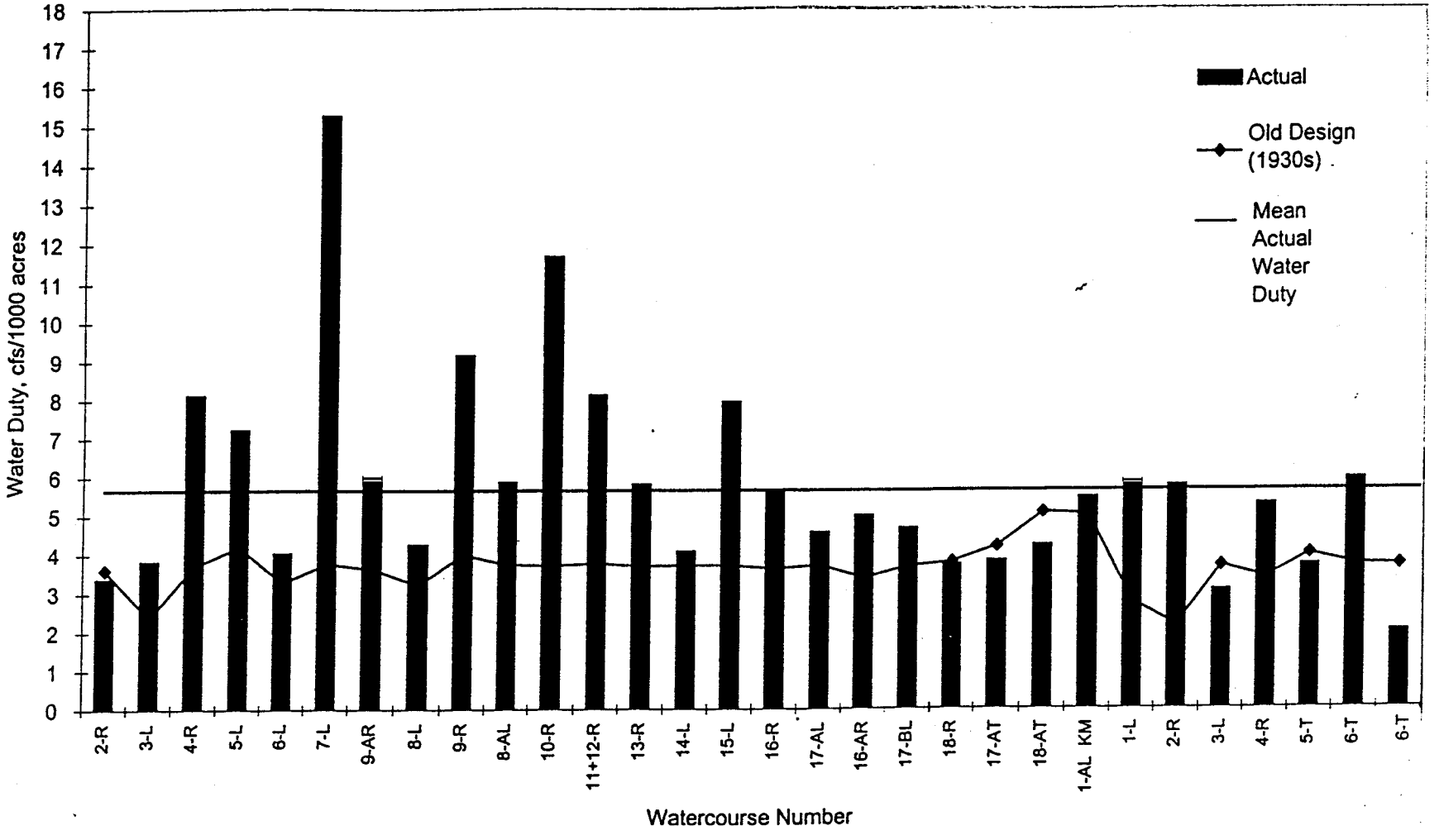


Figure 3.3 Normalized water discharge of outlets from Heran Distributary for April 1997.

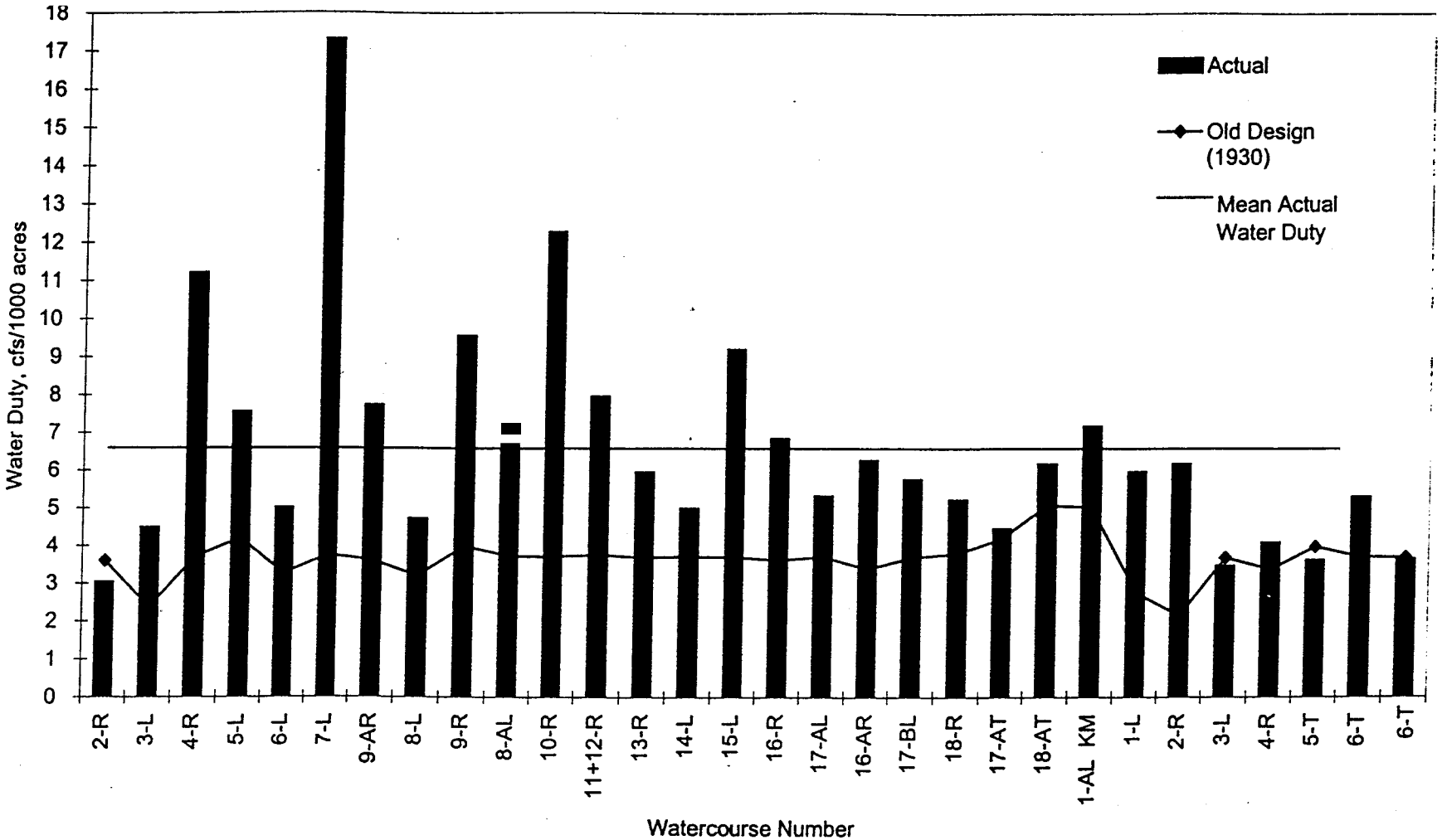


Figure 3.4 Normalized water discharge of outlets from Heran Distributary for May 1997.

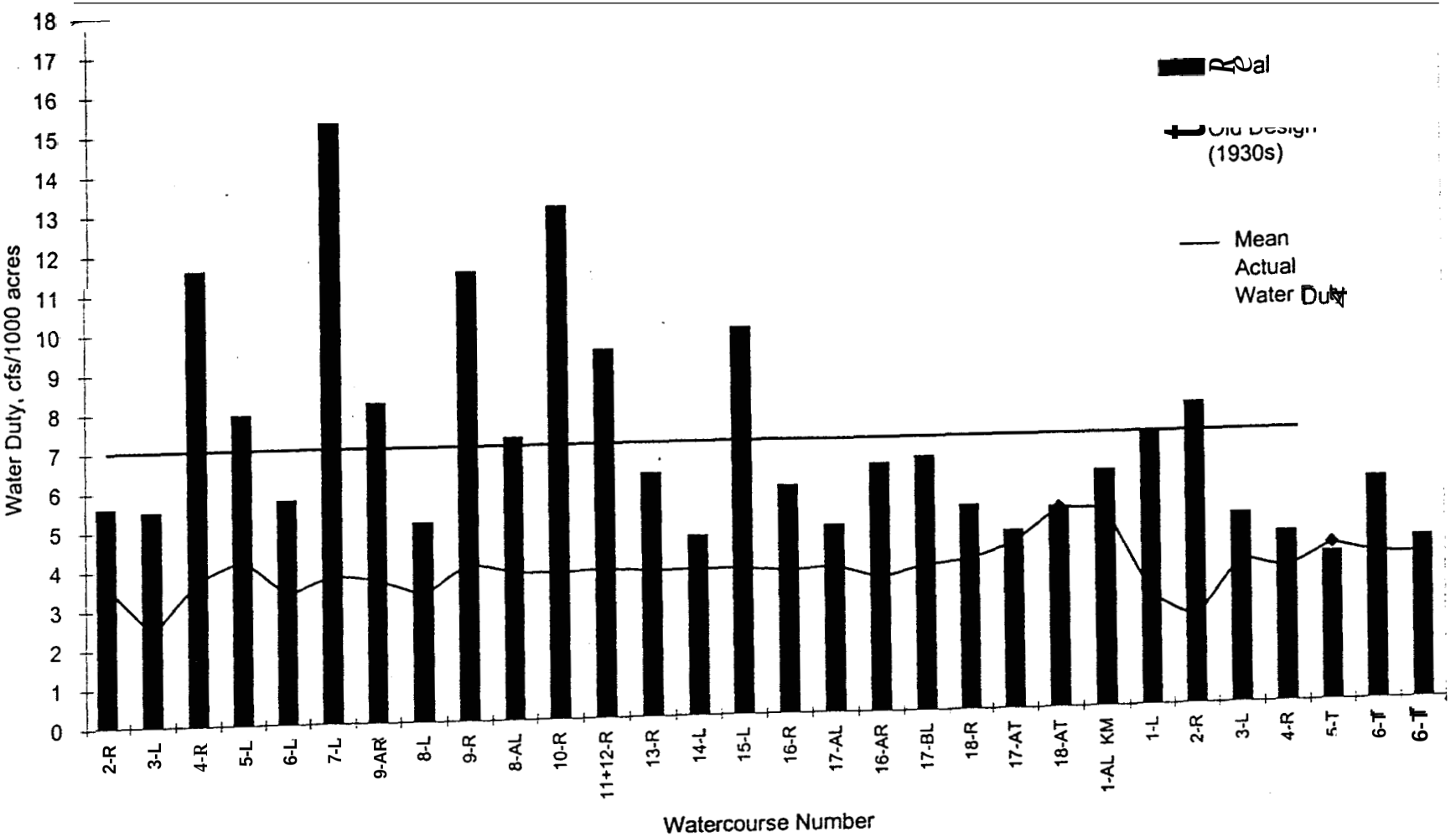
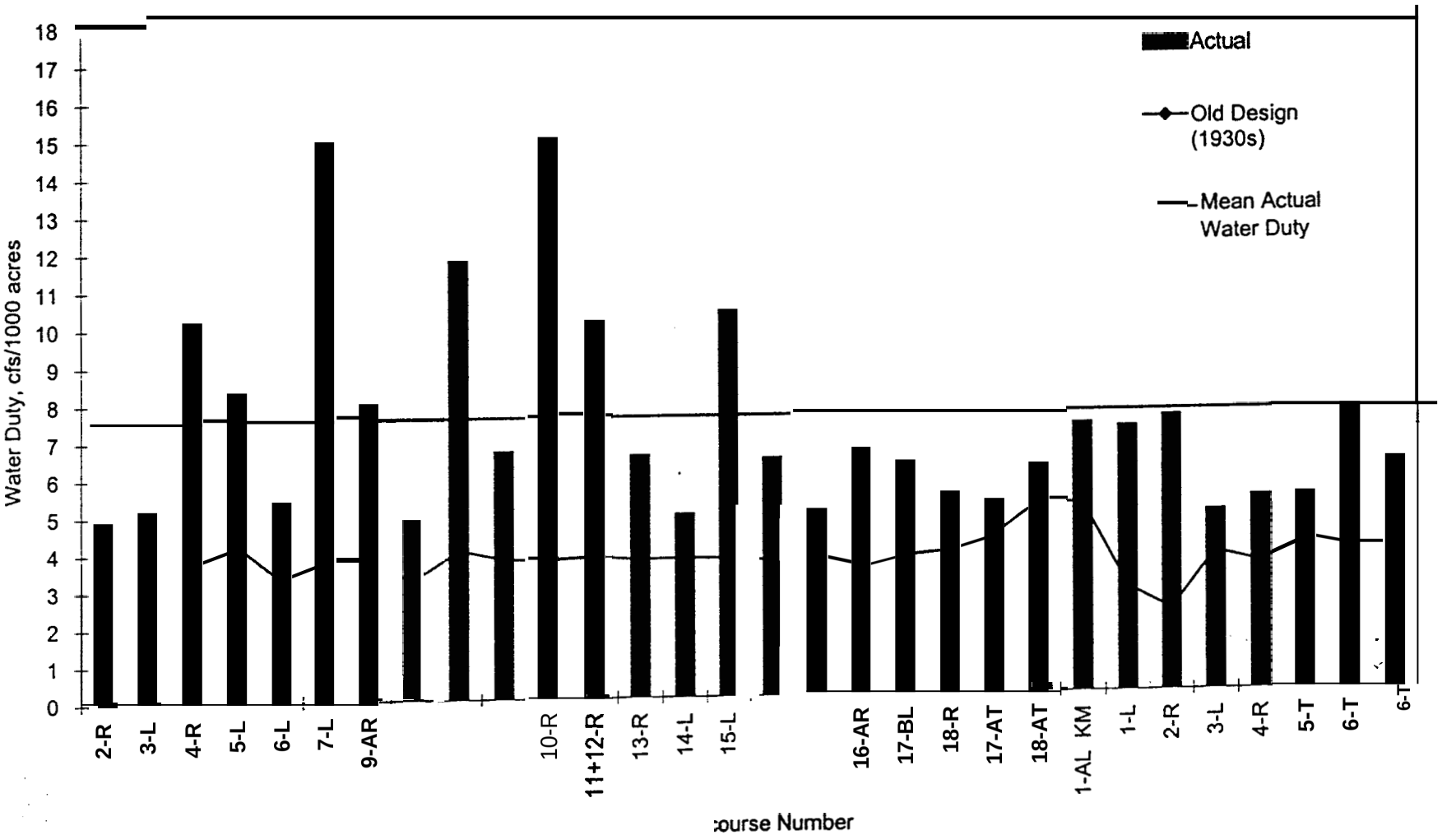


Figure 3.5 Normalized water discharge of outlets from Heran Distributary for June 1997



ig ure3.6 vater a outlets from Heran Distributary for July 1997.

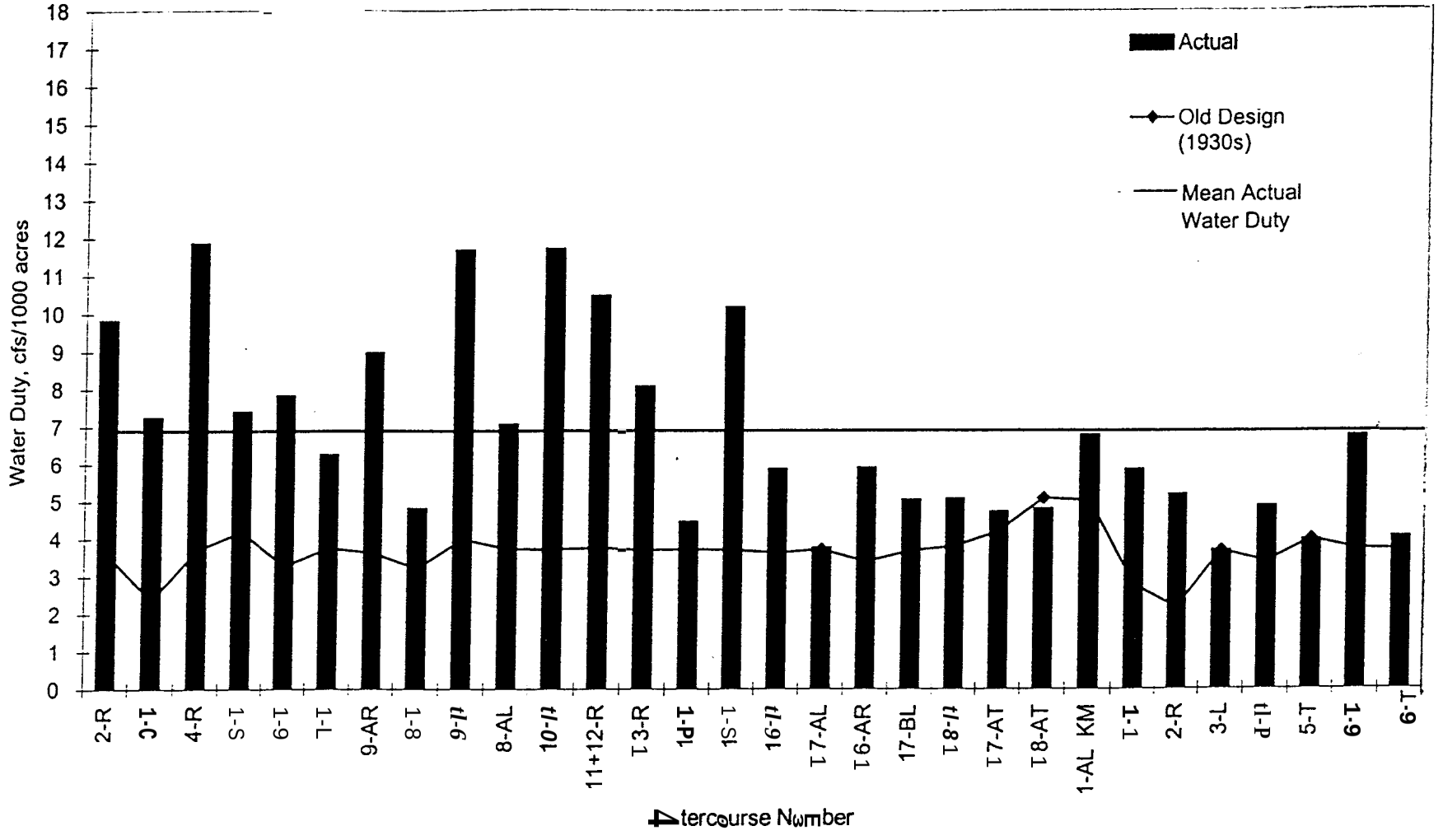


Figure 3.7 Normalized water discharge of outlets from Heran Distributary for August 1997.

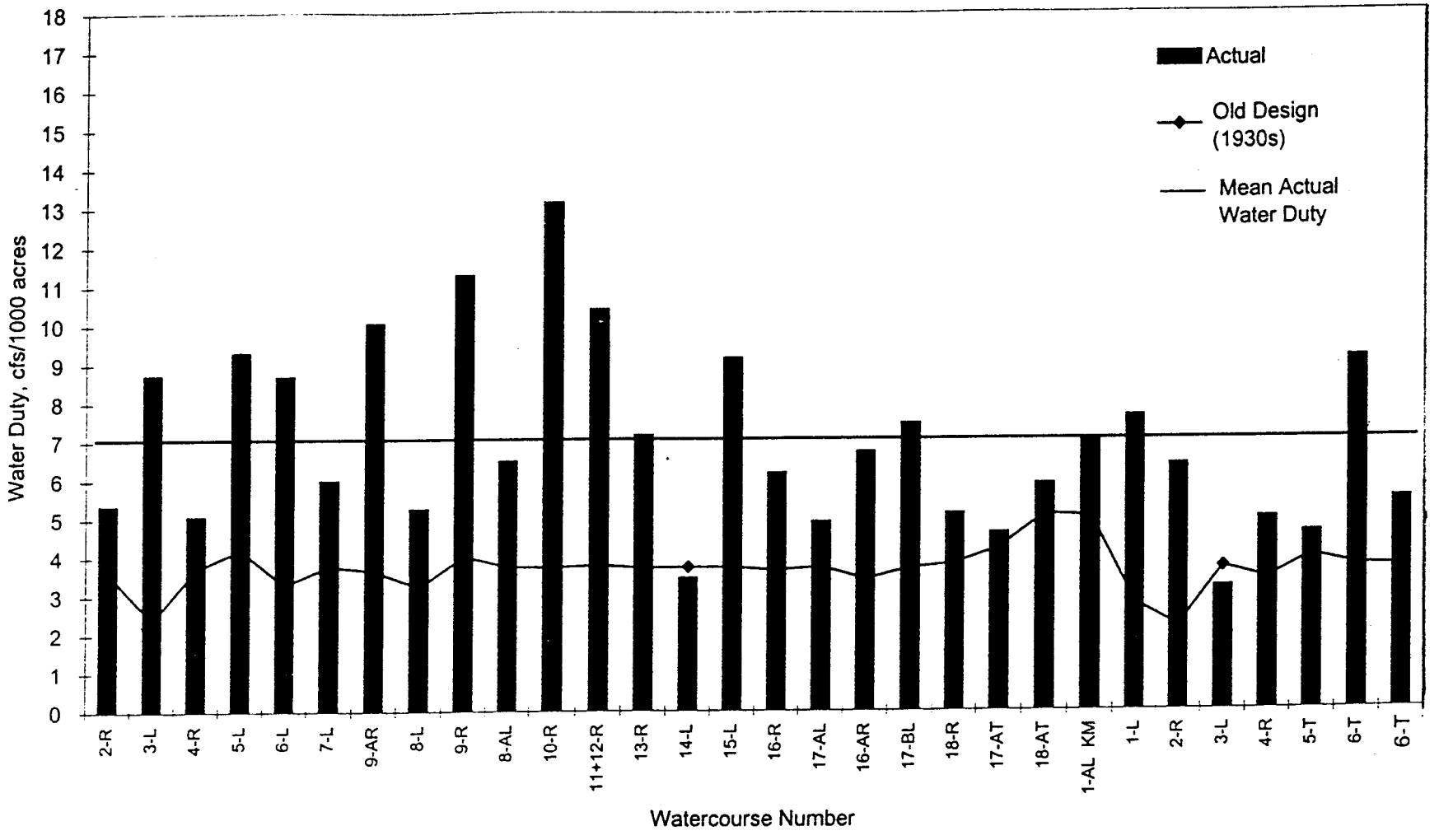


Figure 3.8 Normalized water discharge of outlets from Heran Distributary for September 1997.

Temporal coefficients of variability at outlets were calculated to see the fluctuations over time. These are presented in Figure 3.10. The temporal coefficient of variability varied from 0.18 (18%) to **0.24 (24%),** which is comparatively small, thereby implying that each outlet was drawing proportionally **the** same amount whether the distributary had increased or decreased irrigation water supplies.

The results presented above imply that the water distribution was not equitable and, therefore, equity may be rated as poor. Details of the discharge measurement data are presented in Annex **A.**

3.1.1.3 Fluctuations in Watercourse Supplies

Flow measurements on sample watercourses selected from the head, middle and tail portions of the distributary were undertaken continuously for 6 days to determine the fluctuations in the watercourse supplies. The resulting **data** are presented **in** Figures 3.11 through 3.16 for the Heran Distributary and Figures 3.17 through 3.22 for the Khadwari Minor.

The figures show that there were relatively small variations in irrigation supplies during the measurement period. Also, variations between the day and the night irrigation supplies were not significant.

Coefficients of temporal variation for day **and** night discharge measurements were calculated for the head regulator, **as well as** for the three sample watercourses. They are presented **in** Table **3.3.**

Table **3.3.** Coefficient of temporal variation for day and night discharge measurements of Heran Distributary, Sanghar.

Date	2R Night	2R Day	11+12R Night	11+12R Day	18R Night	18R Day	HR Night	HR Day
18-19	0.000	0.002	0.010	0.024	0.050	0.030	0.000	0.000
19-20	0.004	0.008	0.018	0.032	0.025	0.050	0.000	0.006
20-21	0.002	0.005	0.041	0.011	0.066	0.049	0.001	0.001
21-22	0.004	0.004	0.041	0.021	0.056	0.021	0.001	0.001
22-23								
23-24								

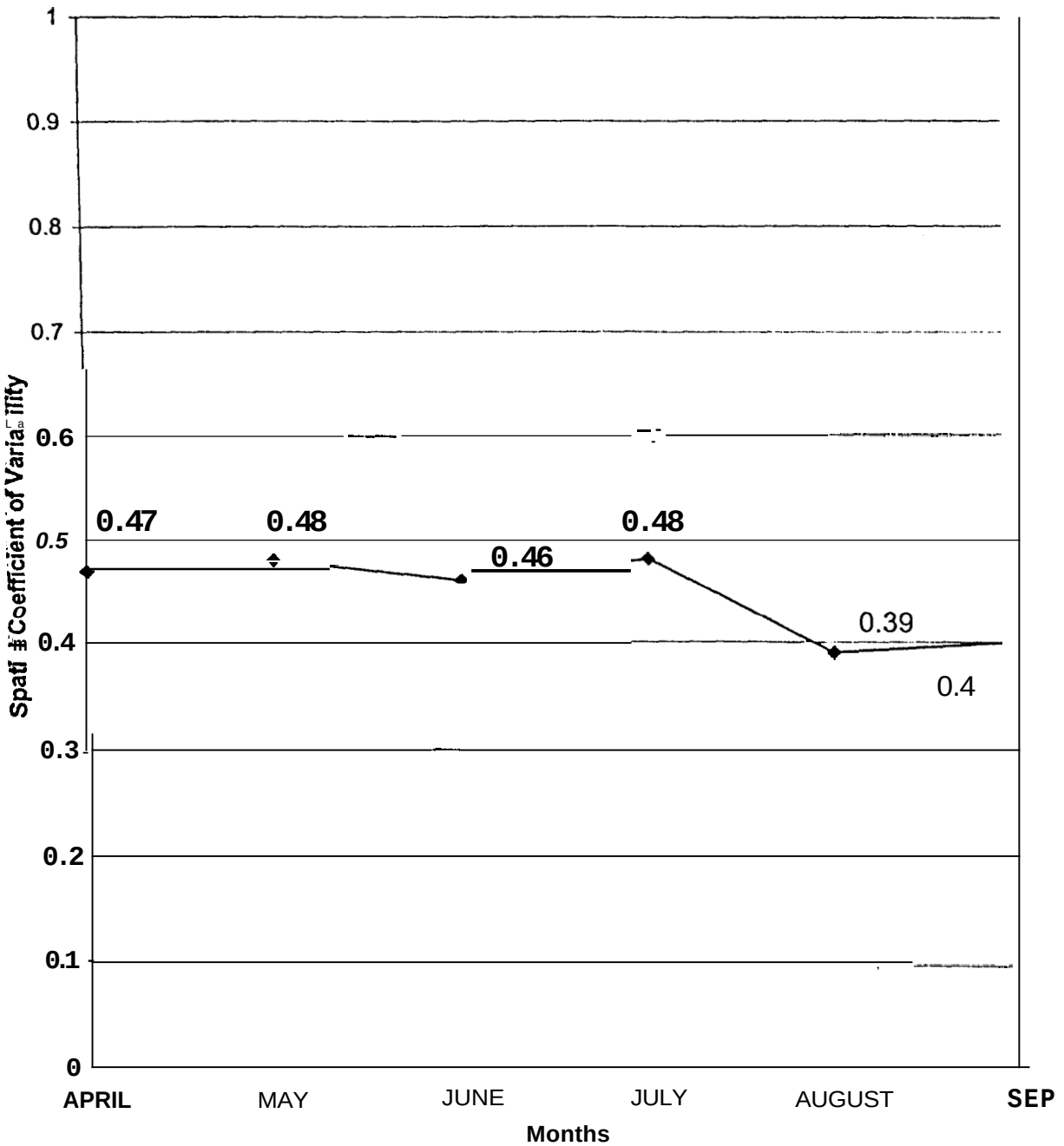


Figure 3.9 Spatial Coefficient of Variability among the outlets from the Heran Distributary for Kharif 1997.

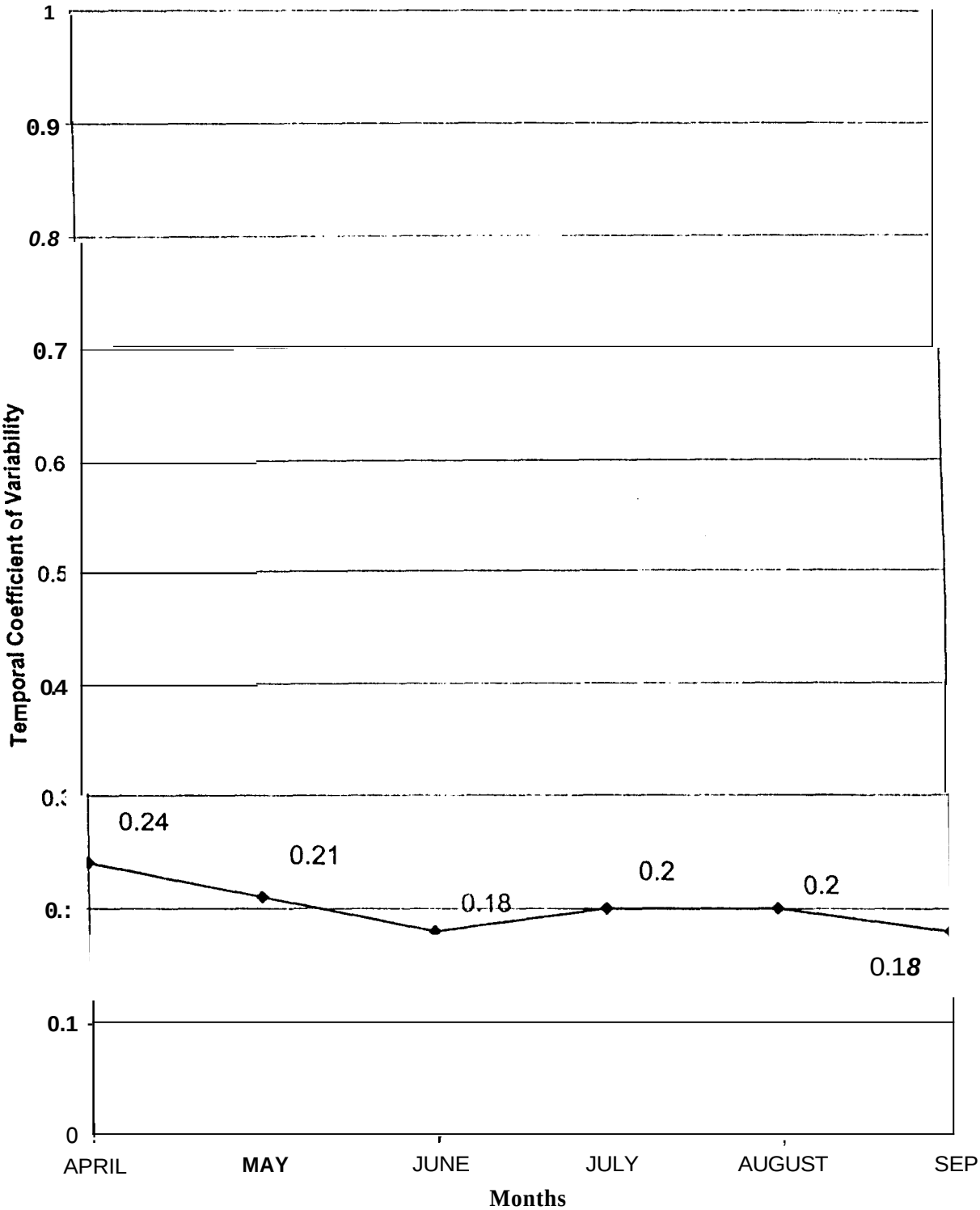


Figure 3.10 Temporal Coefficient of Variability at outlets from the Heran Distributary for Kharif 1997.

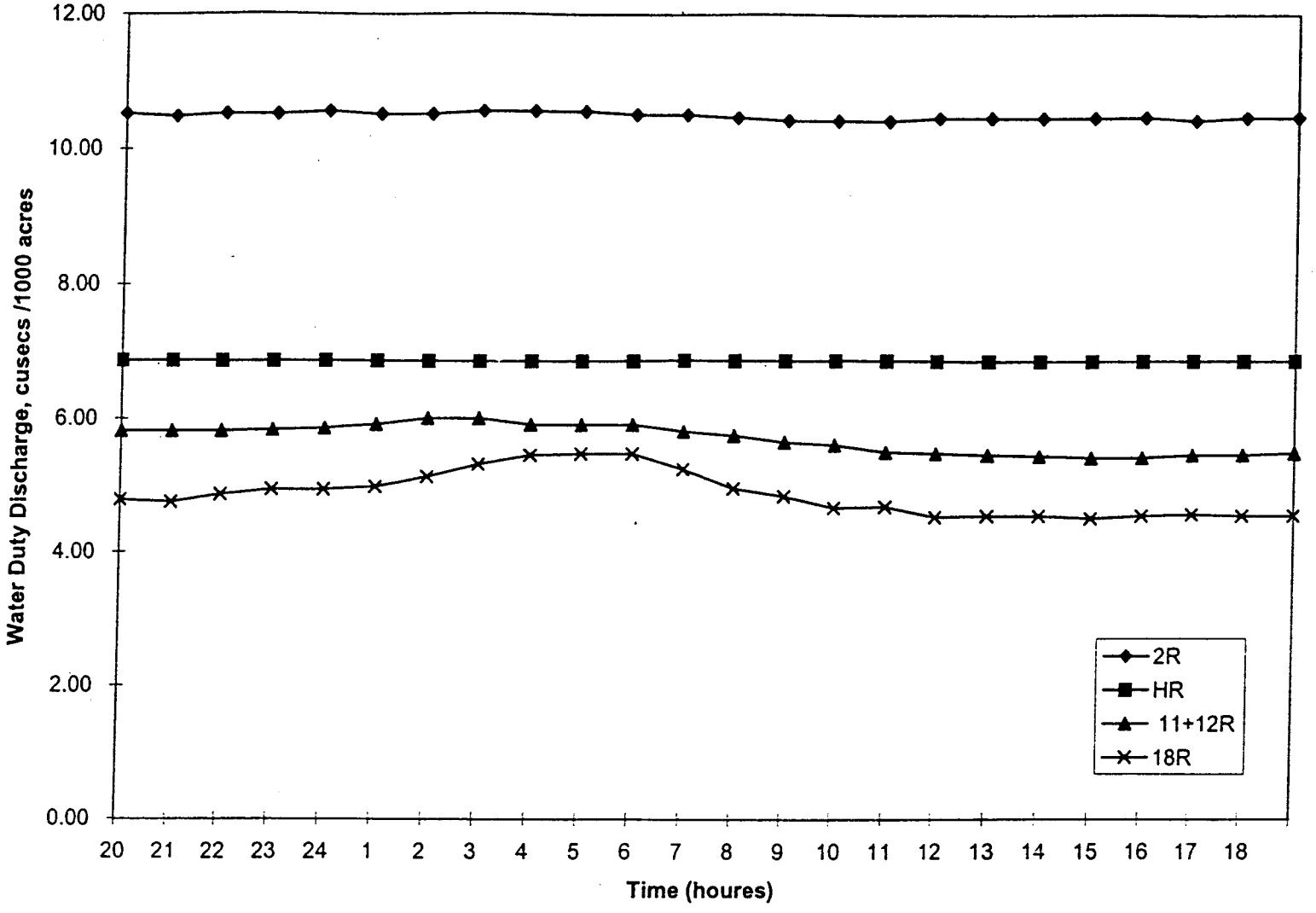


Figure 3.11 Discharge of Heran Distributary and some sample outlets (August 18/19, 1997).

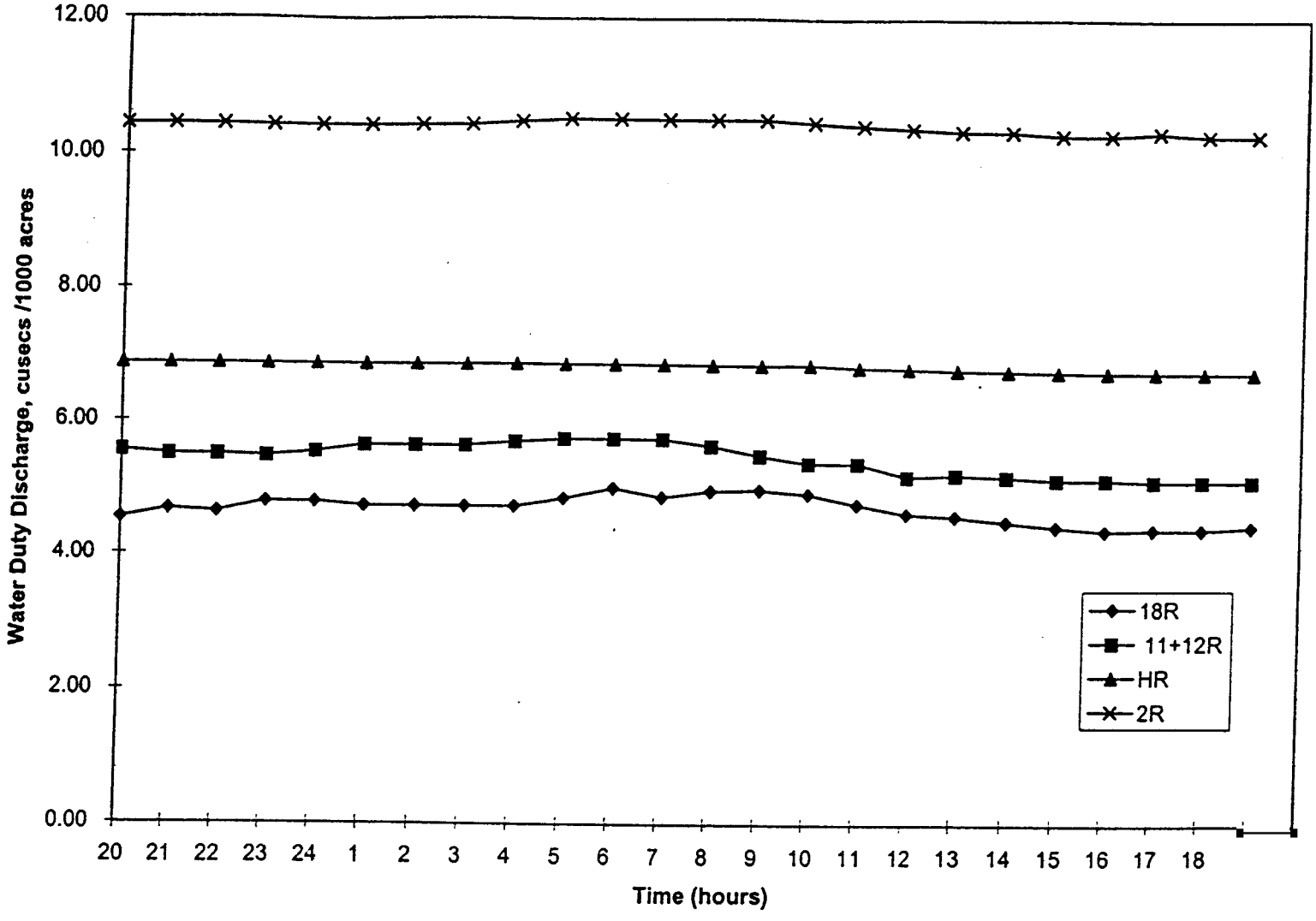


Figure 3.12 Discharge of Heran Distributary and its sample outlets (August 19/20, 1997).

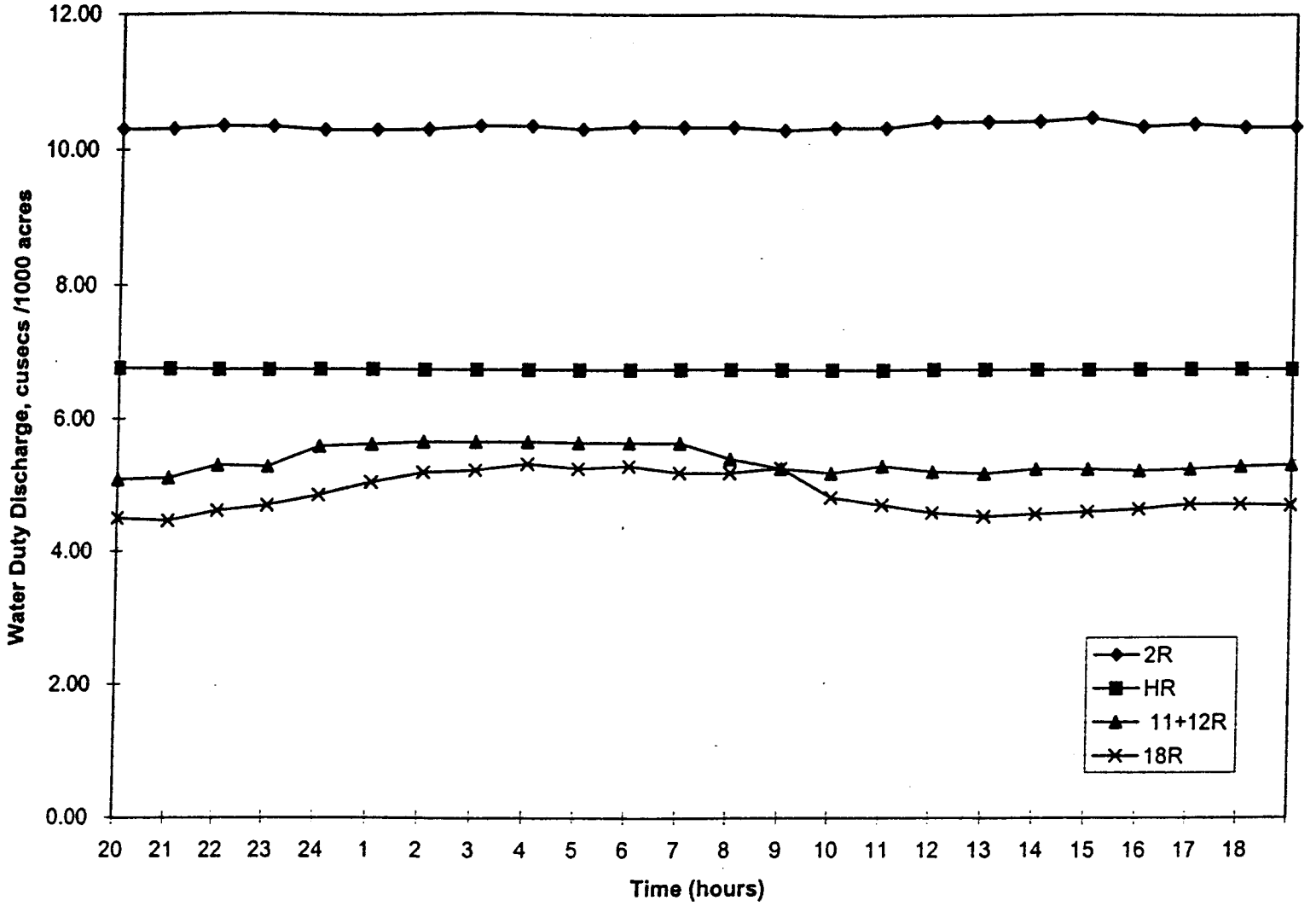


Figure 3.13 Discharge of Heran Distributary and its sample outlets (August 20/21 1997).

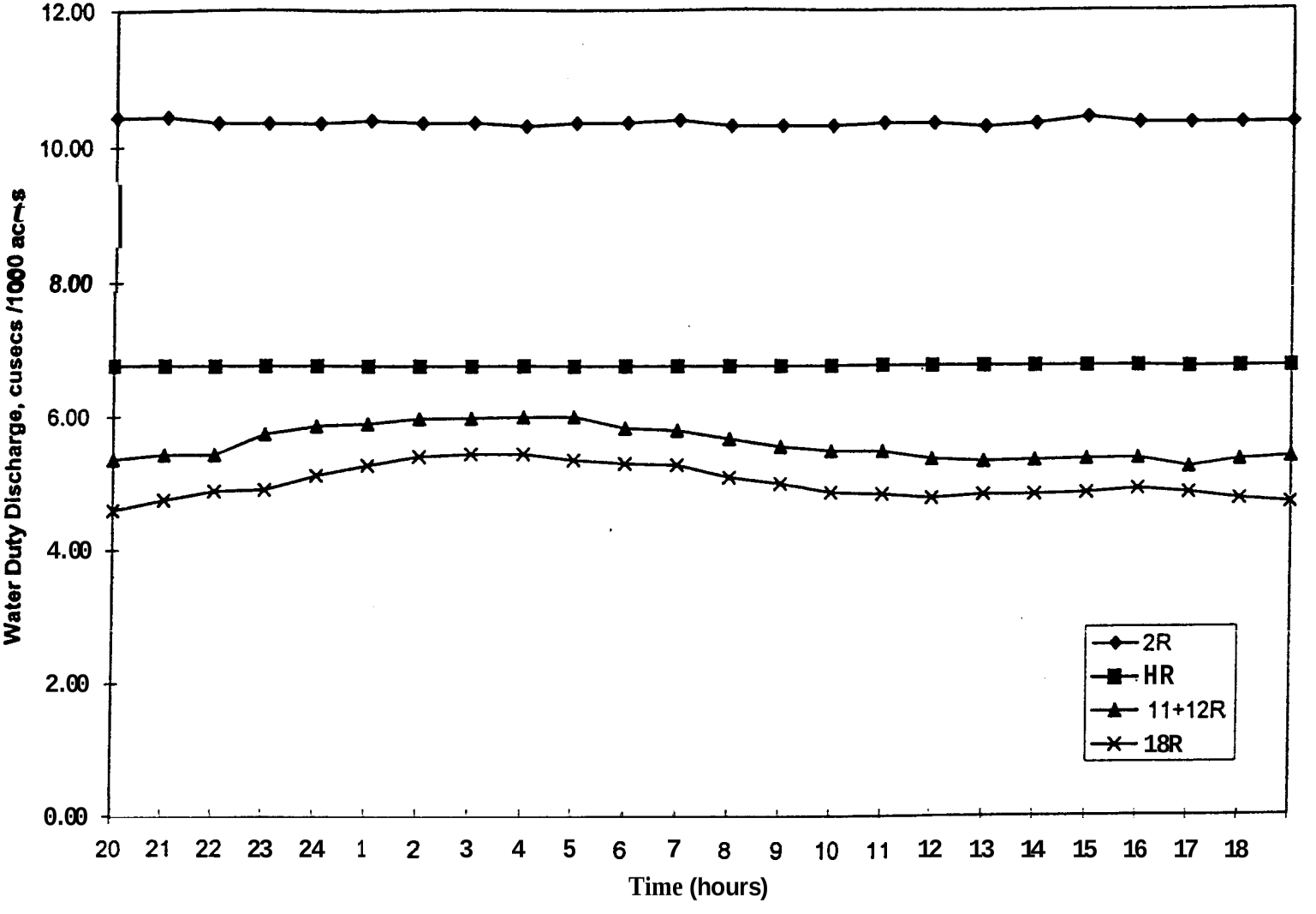


Figure 3.14 Discharge of Heran Distributary and its sample outlets (August 21122,1997).

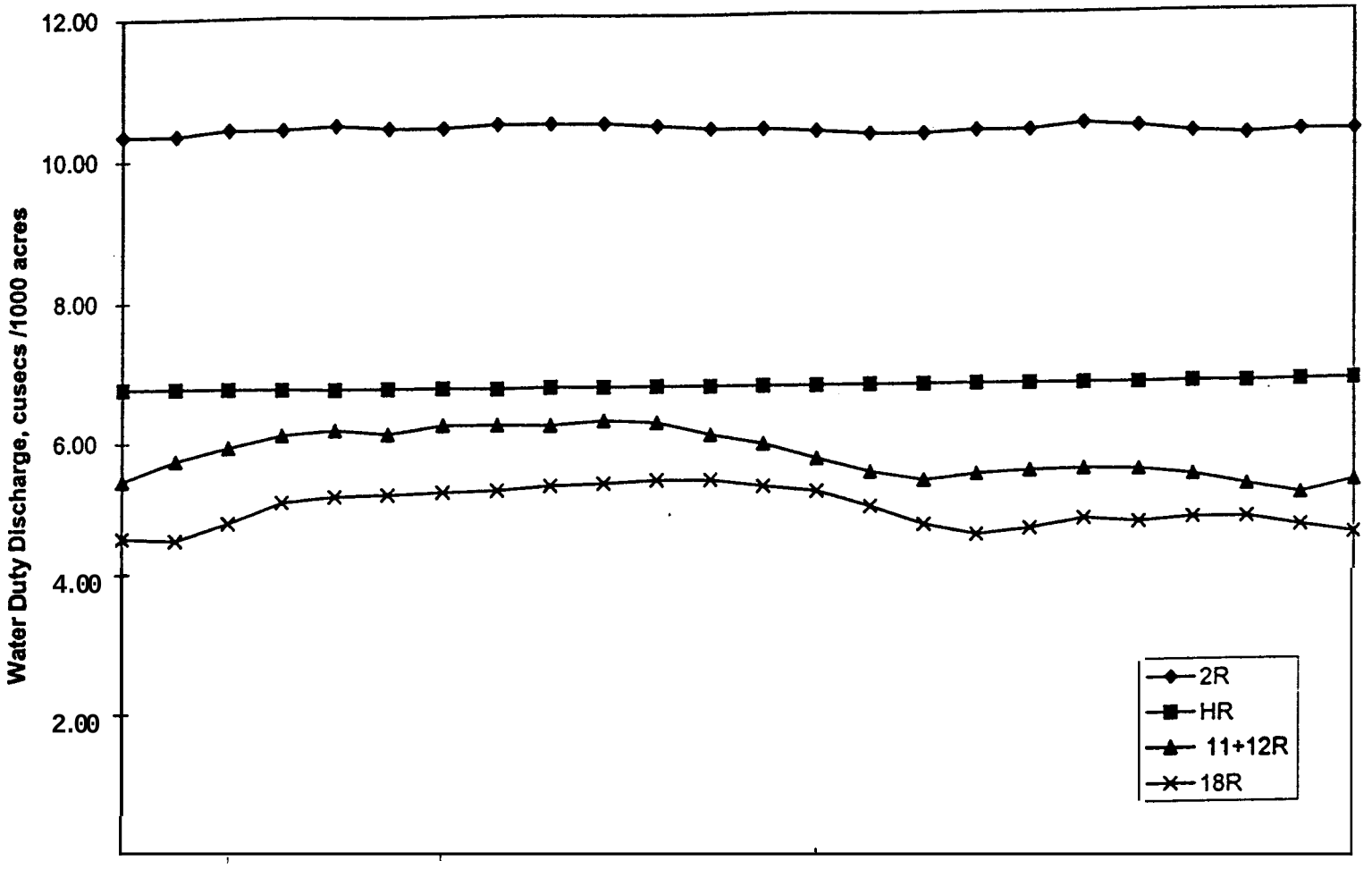


Figure 3.15 Discharge of Heran Distributary and its sample outlets (August 22123,1997).

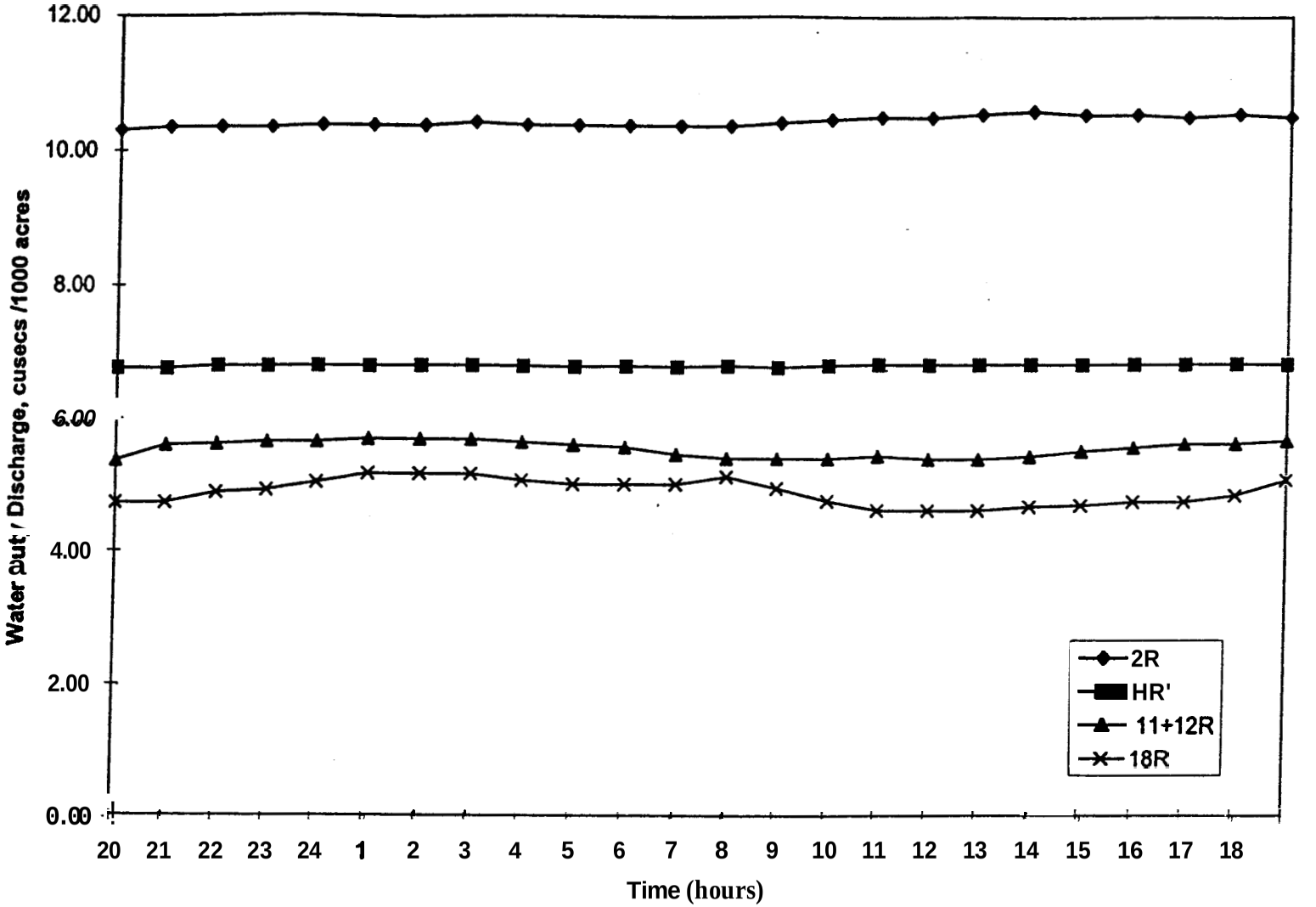


Figure 3.16 Discharge *of* Heran Distributary and its sample outlets (August 23124,1997).

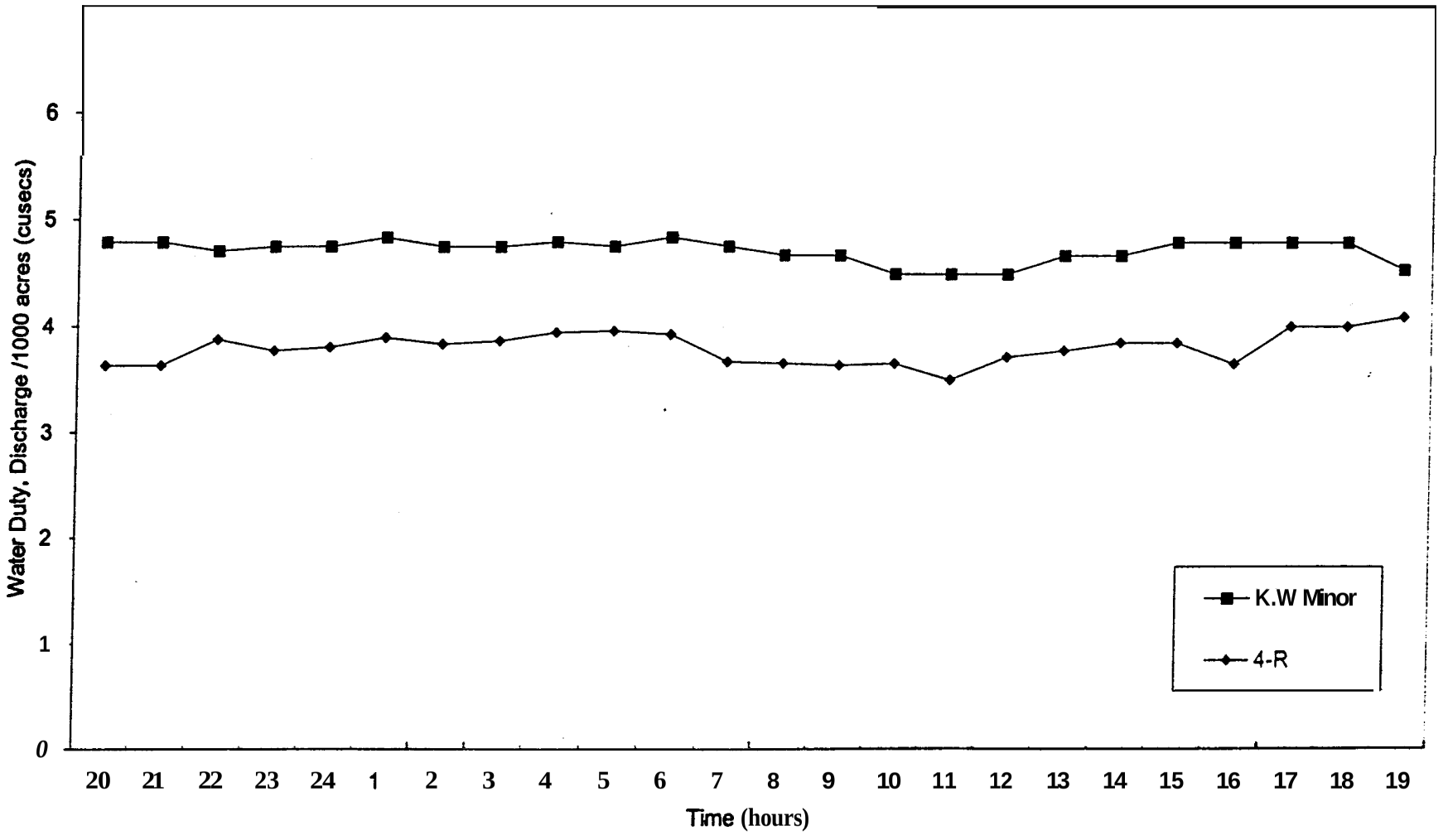


Figure 3.17 Discharge of Khadwari Minor and a sample outlet (18/19 Aug. 1997).

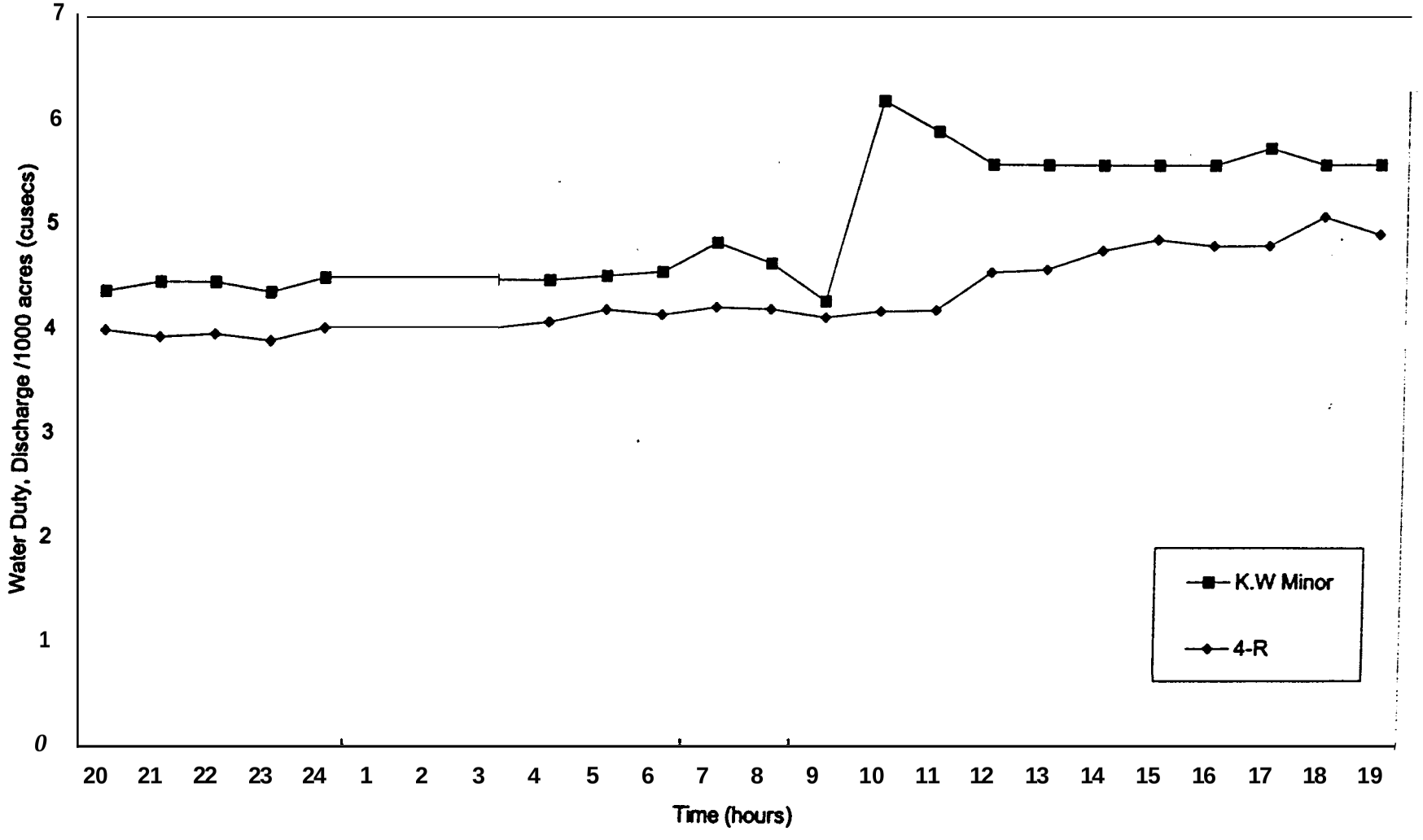


Figure 3.18 Discharge of Khadwari Minor and a sample outlet (19/20 Aug. 1997).

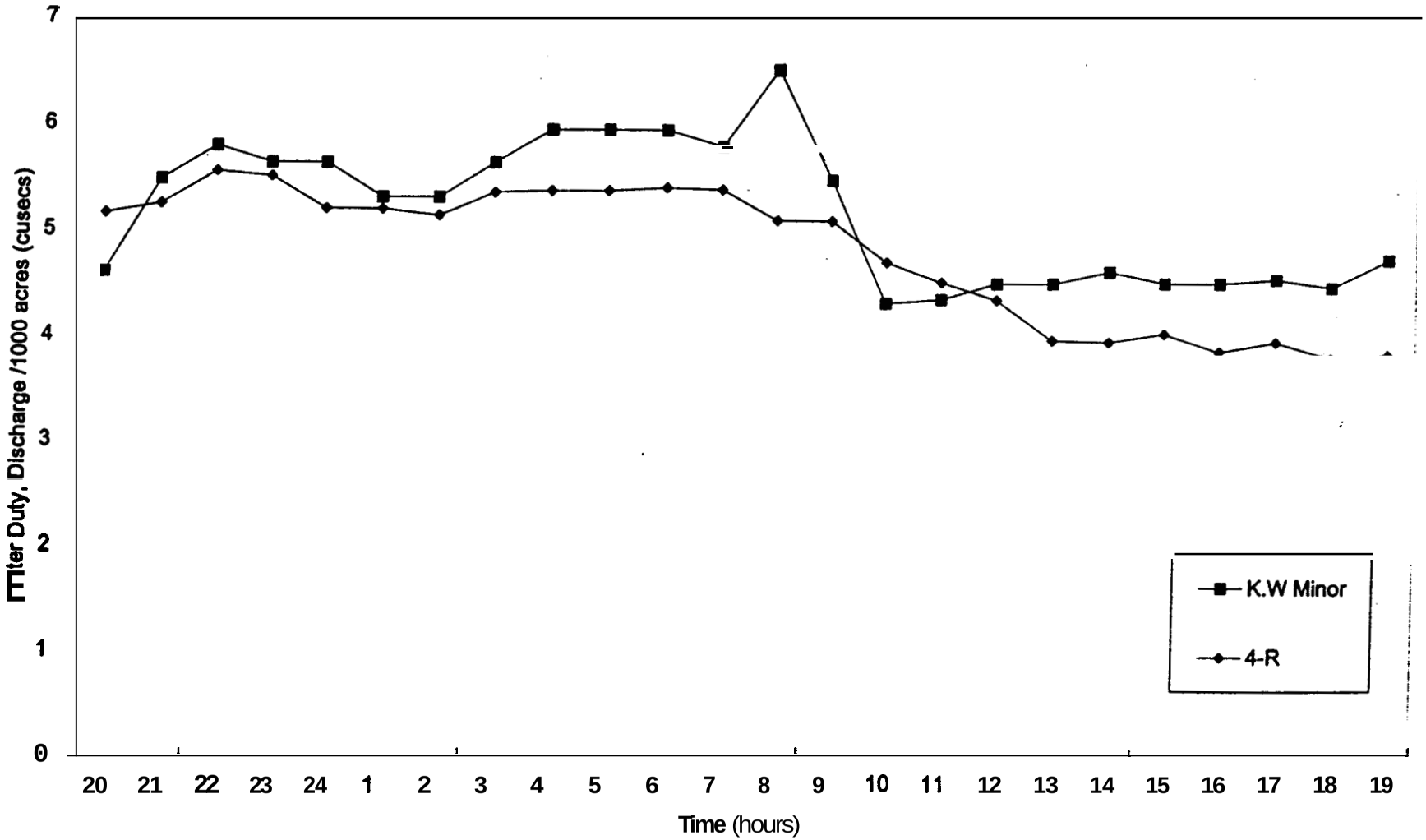


Figure 3.19 Discharge of Khadwari Minor and a sample outlet (20/21 Aug. 1997).

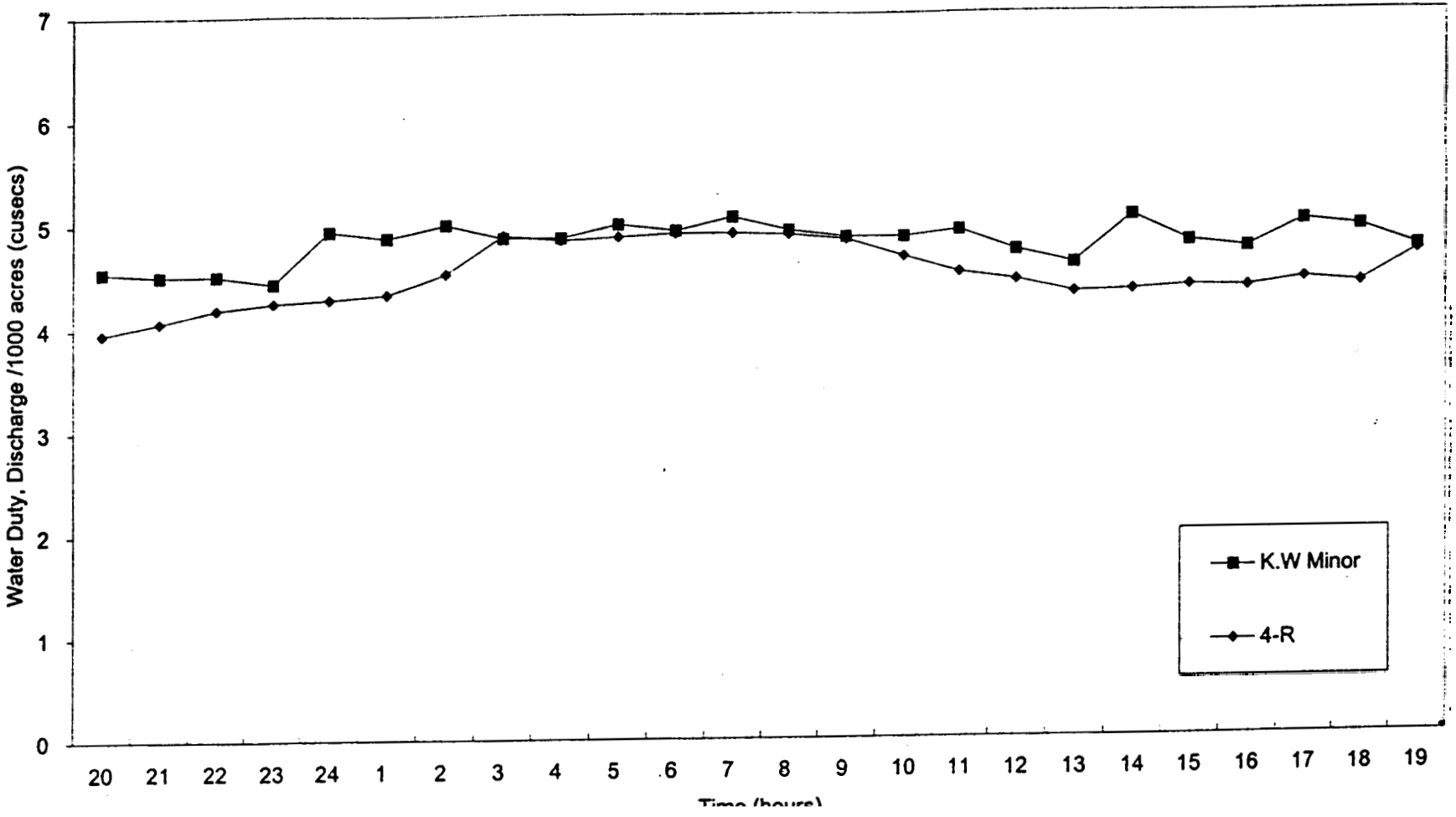


Figure 3.20 Discharge of Khadwari Minor and a sample outlet (21/22 Aug. 1997).

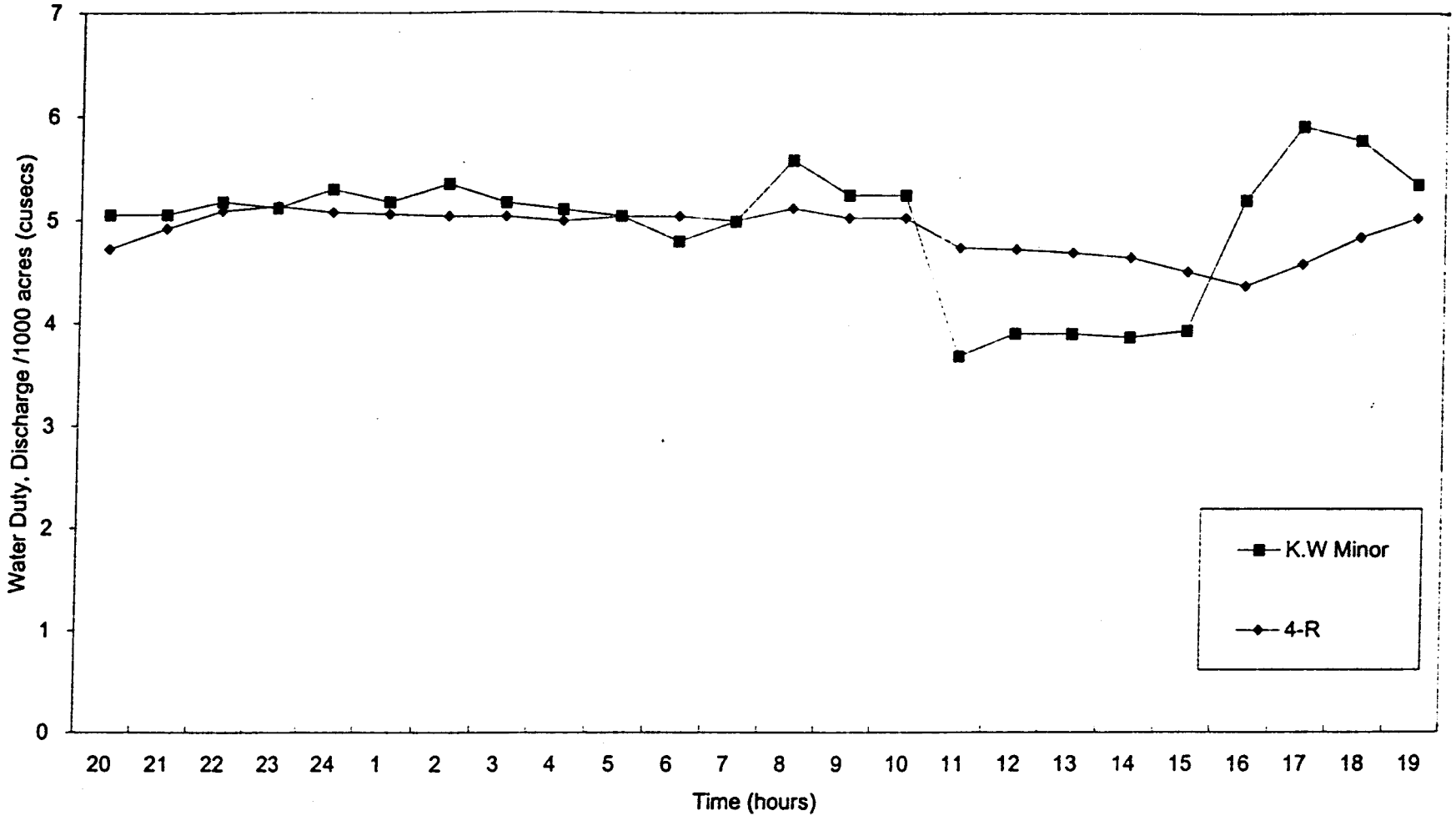


Figure 3.21 Discharge of Khadwari Minor and a sample outlet (22/23 Aug. 1997).

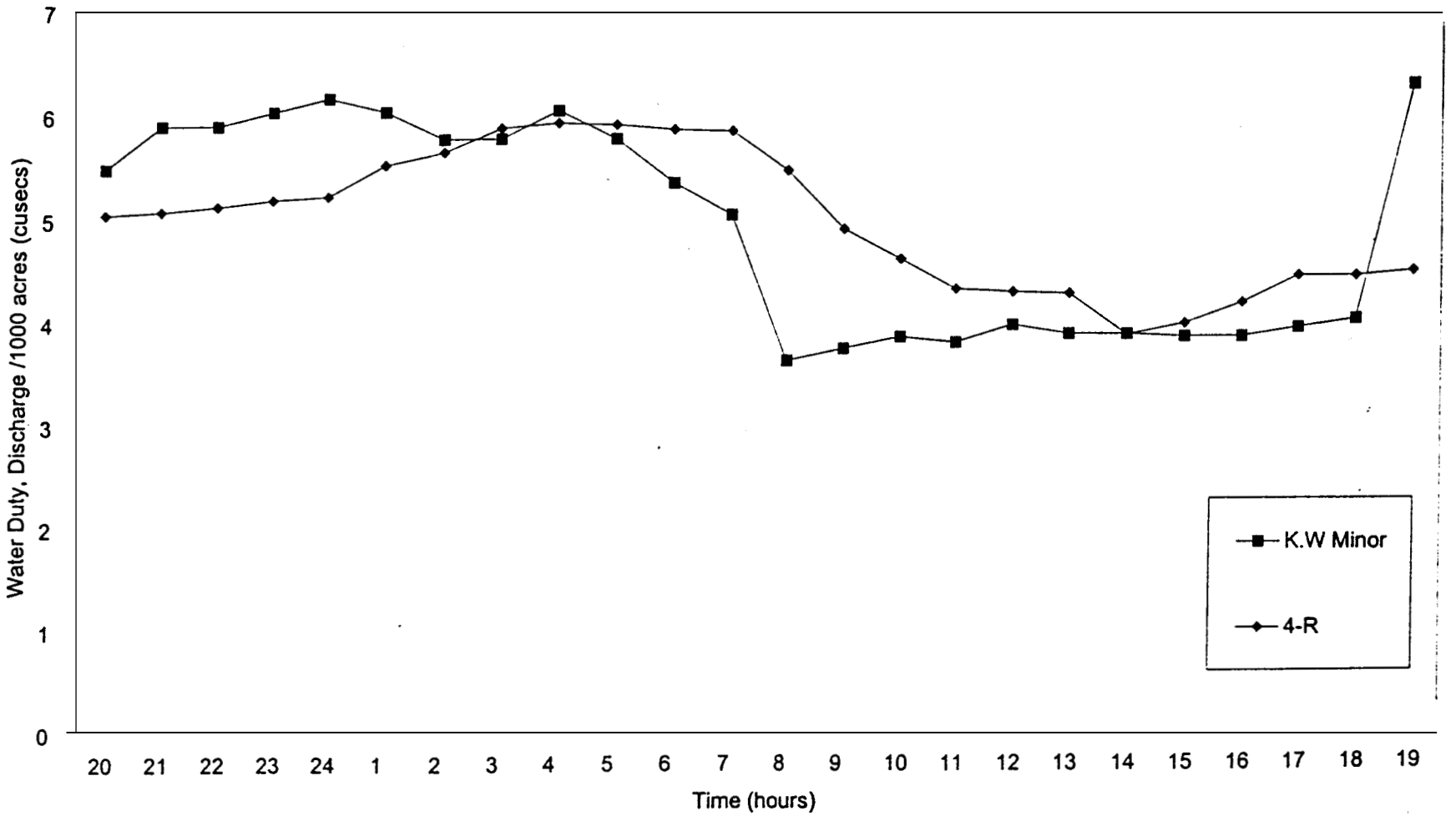


Figure 3.22 Discharge of Khadwari Minor and a sample outlet (23/24 Aug. 1997).

Also, coefficients of temporal variation **on an** hourly basis were calculated for the head regulator, **as** well as for the three sample watercourses. They are presented in Table 3.4.

Date	2R	11+12R	18R	HR
18-19	0.000	0.010	0.060	0.000
19-20	0.007	0.041	0.041	0.007
20-21	0.005	0.037	0.061	0.001
21-22	0.004	0.046	0.052	0.001
22-23	0.007	0.065	0,062	0.001
23-24	*0.009*	0.021	0.038	0.005

3.1.1.4 Irrigation Delivery Performance

The summary of irrigation delivery performance is given in Tables 3.5. The summary indicates that the most serious problems are at tertiary level rather than at the **main** system level. These problems can successfully **be** resolved through the cooperation of concerned farmers and their WUAs.

Table 3.5. Performance summary **of** irrigation delivery system of the Heran

Months 1997	Average Discharge at **head** regulator (cfs/1000 acres)	Temporal coefficient of variability at head regulator	Spatial coefficient of variability at outlets	Temporal coefficient of variability at outlets
April	4.85	0.12	0.47	0.24
May	6.31	0.09	0.48	0.21
June	6.61	0.11	0.46	0.18
July	7.04	0.10	0.48	0.20
August	6.44	0.10	0.39	0.20
September	6.77	0.08	0.40	0.18

3.1.2 Maintenance of ti elivery System

3.1.2.1 General Maintenance

The Heran Distributary was monitored periodically for documenting the maintenance conditions and practices. The monitoring of general maintenance activities revealed that the only maintenance activity undertaken was "desilting" which was done during the annual canal closure period. No other maintenance activity was undertaken subsequently. Most of the outlets were found tampered and, therefore, draw more water than their due share.

3.1.2.2 Physical Conditions

The physical condition of a channel has considerable bearing on the conveyance and distribution of water among the outlets. Walk-thru surveys and farmers' interviews were undertaken to assess the physical condition of the channel. During these surveys, efforts were made to record vegetation growth, weak points of banks and berms, condition of the inspection path (bcnn used for travelling) and non-inspection path (berm on opposite side of the channel from the inspection path), and physical condition of the outlets.

Presence of vegetation in the irrigation system is a niajor source for disturbing the flow of water. This also leads to changes in flow conditions such as from free-flow to submerged-flow. The vegetative growth was classified as follows:

Class I : Clean (vegetation less than 1 foot high)

Class II : Very little (Vegetation between 1-2 feet high)

Class III : Little (Vegetation between 2-3 fcet high)

Class IV : Moderate (Vegetation between 3-5 fcet high)

Class V : Thick (Vegetation greater than 5 feet in height)

The average physical conditions observed during the surveys are presented in Table 3.6. The data on vegetative growth show that the Heran Distributary has high vegetative growth at some locations on both sides of the channel. This disturbs the smooth flow of water by decreasing the velocity and consequently, sediment deposition takes place. The banks were observed to bc in good physical condition except at a few places.

Table 3.6 Vegetative growth and weak-portion survey of the Heran Distributary and Khadwari Minor, Sanghar.

Distance (RD)	Vegetative Growth			Condition (G=good and W=weak)			
	Right	Bottom	Left	Banks		Berm	
				Left	Right	Left	Right
0 to 6.56	1	1	5	Good	Good	Good	Good
6.57 to 8.53	1	1	5	Good	Good	Weak	Good
8.53 to 15.10	1	1	1	Good	Good	Weak	Good
15.10 to 16.73	1	1	3	Good	Good	Weak	Good
16.73 to 20.0	1	1	1	Good	Good	Good	Good
20.0 to 21.65	1	1	3	Good	Good	Good	Good
21.65 to 24.93	2	1	1	Good	Good	Weak	Good
24.93 to 26.57	1	1	3	Weak	Good	Weak	No berm
26.57 to 32.80	1	1	5	Weak	Good	Weak	No berm
32.80 to 32.82	2	1	5	Good	Good		No berm
Khadwari Minor							
0 to 0.33	5	1	5	Poor	Good	Poor	Poor
0.33 to 6.56	5	1	5	Poor	Good	Poor	Poor
6.56 to 12.46	1	1	1	Good	Good	No berm	No berm
12.46 to 13.45	1	1	5	Good	Good	No berm	No berm
13.45 to 16.4	1	1	5	Good	Good	No berm	No berm

3.2 DRAINAGE DISPOSAL SYSTEM (DDS)

The Heran Distributary command area has a network of surface drains. In addition to the drains, the compound (scavenger) tubewells and drainage tubewells have been installed in the command area. Specific details on drainage facilities are provided in Table 2.4.

3.2.1 Operations of Drainage System

3.2.1.1 Drainage Effluent

The tubewells are not yet operational. The surface drains are functioning and contributing drainage effluent to the drainage disposal system. The network of surface drains in the Heran Distributary command area were identified. The inflow (source) and outflow (disposal) points of the drainage effluent were located. The term **"source"** indicates the inflow of drainage effluent from the upstream command **arca** entcrs into the **Hcran** Distributary command area and the term "disposal" indicates the outflow of the drainagc effluent leaving from the Hcran Distributary command arca (inflow **at** sourcc subtracted from outflow at disposal, gives the net drainage effluent from the command arca). The discharge **of** the drainage effluent **was** measured **at** the source and disposal points by current metering once cvcry month. The results arc prcscntcd in Table **3.7.**

Table **3.7.** Contribution of the surface drains in Heran Distributary command arca, Sangliar.

Month 1997	Total Contribution in Percentage		
	M-1RA	M-1R	MBD
April	20	22	6
June	4	6	6
July	12	4	2
August	11	2	3
September	7	5	2

Tlic results show that the drainagc effluent is very small. This will bc increased when the drainage tubewells become operational.

3.2.1.2 Water Table Depth

There were 86 piezometers installed in **the** conimand arca of tlic Heran Distributary to monitor watcr tablc fluctuations. The watcr tablc fluctuations were observcd on a monthly basis. **Tlic** avcragc monthly **watcr** tablc depths **arc** shown in Figure **3.23.**

As shown **in** the figure, the avcragc watcr table depth in the Heran Distributary command area is high (about **2.6** feet). This certainly **has** detrimental cffccts on crop production. No significant variation in the water table depth **was** observed during the kharif season. With commissioning of the drainagc tubewells, the watcr tablc will movc downwards.

The piezometer location and average watertablc depth in each piezometer is shown in Figure 3.24.

3.2.1.3 Groundwater Quality

To monitor groundwater quality, water samples were collected from each piezometer on **a** monthly basis and the electrical conductivity was measured. **Also, a** detailed chemical analysis of these samples was done on a quarterly basis. The results arc presented in Table 3.8. The results of the water quality analysis indicate that most of the water samples wcrc in the range of marginal quality to hazardous. Therefore, tlic ground water cannot bc used directly for irrigation purposes. Even after mixing, or treating, care **has** to be taken for its long term effects on the soils and crop production.

3 Maintenance of Drainage Sy

The surface drains lying in the command area were surveyed. The observations have been summarized in Table 3.9. The physical condition of the drains was found satisfactory. The only major problem identified was tlic vegetative growth.

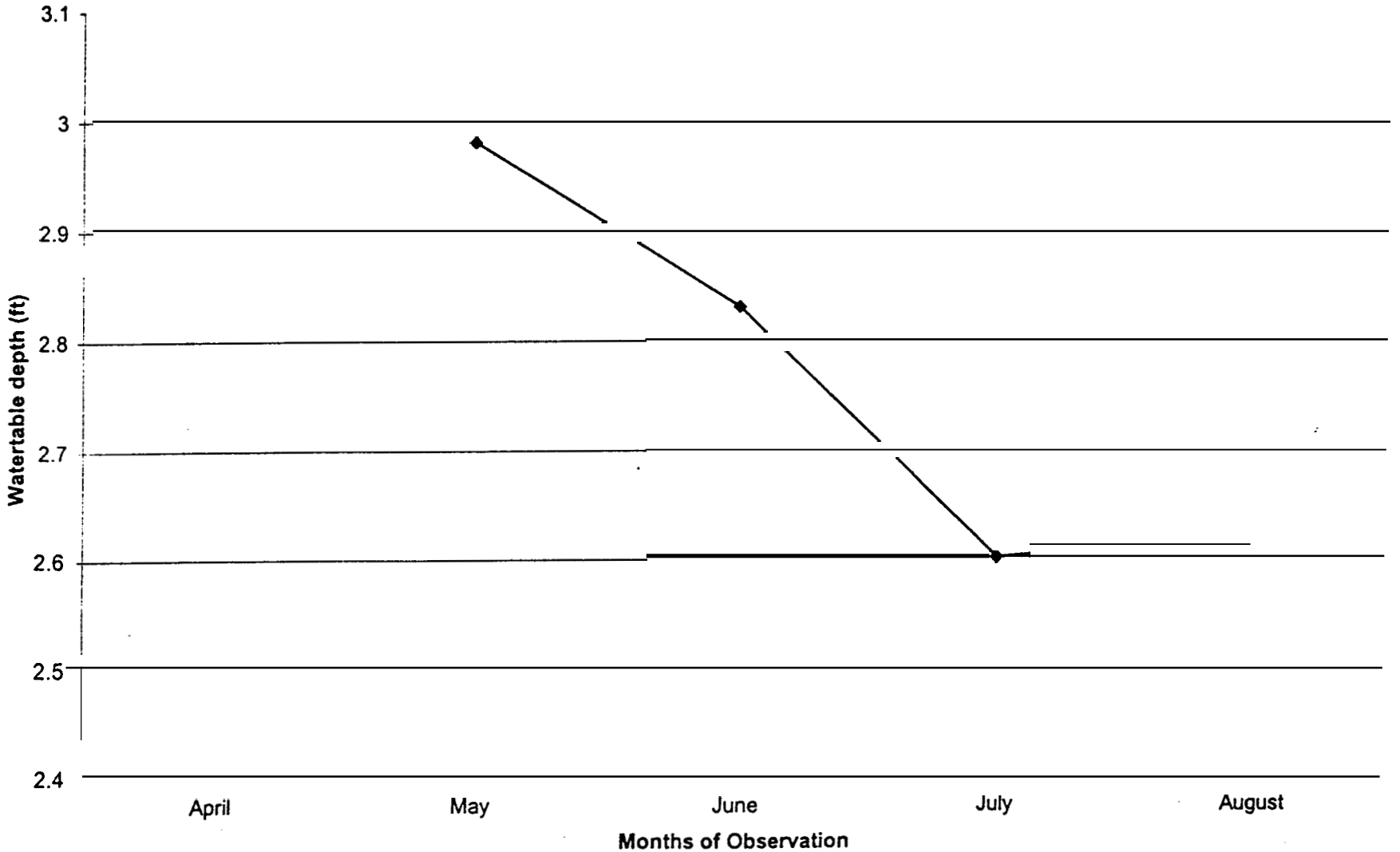


Figure 3.23 Average watertable depth in Heran Distributary command area for Kharif 1997.

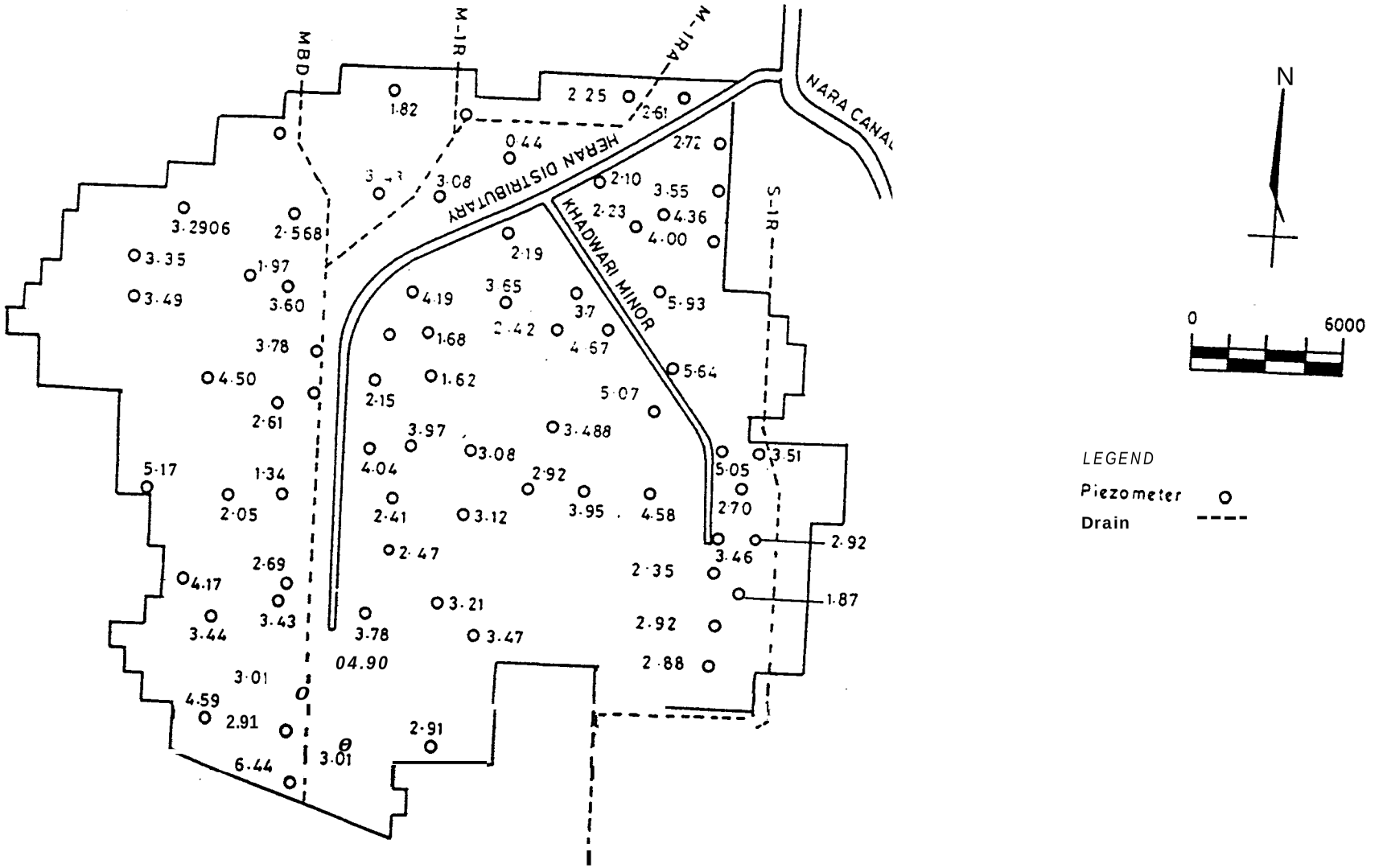


Figure **3.24** Piezometer location and average watertable depth for Kharif 1997 in the command area of Heran **Distributary,** Sanghar.

Table 3.8. Water quality in the Heran Distributary command area, Sanghar.

WC No.	Head				Middle				Tail			
	EC dS/m	PH	SAR	SSP	EC dS/m	PH	SAR	SSP	EC dS/m	PH	SAR	SSP
1L	1.24	7.3	14.56	87	1.80	7.4	16.55	72	0.67	8.0	1.59	34
2R	2.80	8.0	15.46	77	-	-	-	-	1.24	7.9	4.69	63
3L	0.99	7.5	6.62	72	2.29	7.5	8.01	63	2.25	8.1	4.30	45
4R	6.90	7.8	14.80	68	1.01	8.1	-	59	1.12	8.5	8.67	77
5L	5.30	7.5	18.21	77	1.35	7.5	5.72	63	1.90	7.6	6.37	66
6L	1.82	7.7	3.35	48	2.08	8.0	6.24	60	2.80	8.4	20.41	83
7L	1.90	7.6	3.60	45	1.30	7.4	15.67	88	1.35	7.7	8.96	73
8AL	0.85	8.1	10.55	81	1.05	7.7	4.76	63	0.70	8.4	1.51	38
8L	0.75	7.4	1.31	36	3.15	7.6	0.55	6	0.95	7.8	4.13	61
9AR	3.00	7.3	6.10	56	0.70	7.7	1.41	35	-	7.2	48.44	80
9R	1.10	7.5	1.88	42	0.81	7.6	8.09	78	0.60	7.4	1.69	39
10R	0.82	7.4	1.59	35	0.80	7.2	3.45	55	0.99	7.5	3.25	69
11-12R	1.75	7.3	4.08	48	1.03	7.3	2.58	46	1.10	7.1	3.23	53
13R	1.23	7.3	5.61	66	2.35	7.2	3.32	45	0.80	7.4	2.16	48
14L	1.38	7.0	2.03	33	-	-	-	-	1.05	7.2	2.69	47
15L	1.27	7.2	2.24	40	0.77	7.3	2.41	50	0.85	7.5	2.35	44
16AR	1.02	7.2	4.10	55	0.78	7.1	9.36	82	0.77	7.8	4.55	57
16R	0.98	7.3	1.76	36	1.75	?	51.21	74	5.20	7.2	27.22	88
17AL	1.37	7.3	4.18	52	0.95	7.0	8.33	76	0.77	7.4	47.61	93
17AT	1.77	7.3	4.63	53	1.25	7.5	6.90	65	3.05	7.4	0.77	9
17BL	0.65	7.5	1.21	29	1.15	8.3	3.25	43	1.33	?	5.80	64
18AT	0.73	8.1	1.50	83	0.73	8.4	2.12	46	1.54	7.8	6.44	65
18R	5.05	7.2	0.83	9	0.99	7.7	4.55	59	3.50	?	10.92	66
SIRH-R	16.83	7.7	29.37	75	16.0	7.7	30.78	76	-	-	-	-
Khadwari Minor												
1AL	0.75	7.5	2.11	43	1.10	0.61	2.36	43	0.61	7.4	1.74	38
1L	0.94	7.1	2.20	40	0.57	7.3	1.50	34	0.56	7.8	1.40	34
2R	3.50	7.1	10.71	67	1.20	7.5	4.06	55	0.90	7.5	2.22	42
3L	1.06	8.0	2.49	46	1.22	7.8	1.95	35	1.47	8.0	10.44	78
4R	-	-	-	-	0.61	7.7	2.29	48	1.01	8.1	3.98	57
5T	-	-	-	-	3.02	?	8.56	60	1.20	8.0	4.46	56
6T	1.25	7.7	11.01	76	1.20	8.3	8.39	74	1.47	8.0	5.58	60

Table 3.9. Vegctative growth anti wcak-portion survcy of surface drains in the Hcran Distributary command.area, Sanghar.

Distance RD	Vcgetativc Growth			Comments
	Right	Bottom	Left	
S-1R Drain				
0 to 6.56	1	5	1	Bank & Berm almost good all along its length
6.56 to 9.84	1	1	1	do
9.84 to 13.12	1	5	1	do
13.12 to 16.4	1	5	1	do
16.4 to 19.68	1	5	1	do
19.68 to 22.90	1	5	1	do
22.96 to 26.24	1	5	1	do
0 to 6.56	1	5	1	do
6.56 to 8.2	1	2	1	do
0 to 6.56	1	5	1	do
6.56 to 11.81	1	5	1	do
0 to 9.84	1	5	1	do
9.84 to 14.76	1	5	1	do
14.76 to 18.37	1	5	1	do

4. CONCLUSIONS

From the results and discussions presented in Sections 2 and 3, the following conclusions were reached.

- The actual irrigation water supplies at the head regulator of the Heran Distributary are more than the old designed discharge (1930s). Their "reliability" at the head regulator is within an acceptable range according to Molden and Gates (1990) criteria. Therefore, the main system performance is rated as satisfactory.

- Irrigation water distribution among the outlets (equity) is found to be very poor according to the criteria of Molden and Gates (1990). This situation needs to be improved through cooperation and concerted efforts to be made by the water users thorough their WUAs and WUF.

- Due to a lack of proper maintenance, uniform water distribution is greatly affected. Particularly, the presence of high vegetation on the banks of the Heraii Distributary reduces the velocity of flow and increases sediment deposition. Because of this silt deposition, the flow depth (head) increases and more water is drawn by the surrounding outlets.

- The water table depth has gone high and needs immediate attention. Commissioning of the drainage tubewells may be undertaken quickly to lower the water table.

- The ground water quality is brackish as the water samples collected from the piezometers were in the marginal and hazardous range. Hence, this groundwater cannot be used for irrigation purposes.

- The surface drains were in good physical condition. However, vegetative growth needs to be checked for their efficient functioning.

REFERENCES

Molden, D. and Gates, T. K. 1990. Measures of Evaluation of Irrigation Water Delivery Systems. In Journal of Irrigation and Drainage Engineering, Volume 116, No. 6, ASCE, USA.

4. CONCLUSIONS

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- The actual irrigation water supplies at the head rcgulator of the Hcran Distributary arc more than the old designed discharge (1930s). Their "reliability" at tlic hcad regulator is within an acceptable range according to Moldcn and Gates (1990) criteria. Therefore, the main system pcrformancc is rated as satisfactory.

- Irrigation water distribution among the outlets (equity) is found to bc very poor according to the criteria of Moldcn and Gatcs (1990). This situation nceds to bc improved through cooperation and concerted efforts to be made by tlic watcr users thorough thcir WUAs and WUF.

- Due to a lack of proper maintenance, uniform watcr distribution is greatly affected. Particularly, the presence of high vegetation on the banks of tlic Heran Distributary rcduccs the velocity of flow and increases sediment deposition. Bccausc of this silt deposition, the flow depth (hcad) increases and more watcr is drawn by the surrounding outlets.

- The watcr table depth has gone high and needs immediate attention. Commissioning of the drainage tubcwclls may bc undertaken quickly to lower the watcr table.

- The ground water quality is brackish as the watcr samples collcctcd from the piezometers were in the marginal and hazardous range. Hence, this groundwatcr cannot be used for irrigation purposes.

- The surface drains wcrc in good physical condition. However, vegetative growth nceds to bc chcckcd for their efficient functioning.

KEFERENCES

Moldcn, D. and Gates, T. K. 1990. Mcasurcs of Evaluation of Irrigation Watcr Delivery Systems. In Journal of Irrigation and Drainage Engineering, Volume 116, No. 6, ASCE, USA.

ANNEX A. DISCHARGE MEASUREMENTS

Table A1. Actual Discharge at the head of Heran Distributary and Khadwari Minor.

Measuring Date	Head of Heran cfs	Head of Khadwari Minor cfs
8.4.97	73.91	-
9.4.97	08.95	-
10.4.97	67.5	-
16.4.97	54.29	18.93
22.4.97	84.17	18.7
213.4.97	84.15	16.15
310.4.97	106.55	16.15
2.5.97	108.191	17.85
9.5.97	110.27	17.33
6.5.97	89.47	12.98
9.5.95	90.32	15.08
14.5.97	110.84	16.09
16.5.97	110.4	16.64
21.5.97	97.12	10.03
24.5.97	103.43	14.58
2.6.97	97.86	15.98
6.6.97	103	15.6
9.6.97	89.47	13.6
13.6.97	111.35	15.69
18.6.97	08.93	15.9
21.6.97	113.75	19.5
26.6.97	116.88	17.97
28.6.97	124.99	19.03
2.7.97	114.06	17.54

Table A1. (Complete)

7.7.97	114.21	16.92
11.7.97	115.39	16.97
16.7.97	124.27	22.74
18.7.97	118.55	19.35
21.7.97	122.37	16.12
26.7.97	113.99	21.37
29.7.97	86.86	16.39
2.8.97	111.1	15.65
5.8.97	98.5	20.38
8.8.97	111.15	15.78
11.8.97	116.2	17.83
15.8.97	107.03	17.65
24.8.97	110.92	12.25
28.8.97	79.94	9.49
30.8.97	100.14	15.01
1.9.97	106.37	15.96
5.9.97	106.85	17.99
8.9.97	117.35	17.18
13.9.97	95.12	22.26
15.9.97	106.12	16.56
20.9.97	121.79	21.88
22.9.97	106.51	15.27
27.9.97	116.31	22.04

Table **A2.** Design and avcragc existing duty at licad regulator of I-Icran Distributary and Khadwari Minor.

Month	Hcran Distributary		Khadwari Minor	
	Design Duty (cfs/1000 acrc)	Avcragc Existing Duty (cfs/1000 acrc)	Design Duty (cfs/1000 acrc)	Avcragc Existing Duty (cfs/1000 acrc)
April 97	3.75	5.27	3.43	5.70
May 97	3.75	6.64	3.43	4.93
June 97	3.75	6.90	3.43	5.43
July 97	3.75	7.36	3.43	0.01
August 97	3.75	6.76	3.43	5.02
September 97	3.75	7.09	**3.43**	0.02

Table A3. Discharge measurement at each outlet through tape readings for the month of April 1997.

W\C NO	April 8	April 10	April 16	April 22	April 30	Mean cfs
1-L	0.58	0.44	0.40	0.68	1.25	0.67
2-R	0.91	0.56	0.78	0.88	0.87	0.80
3-L	2.38	2.22	2.25	2.23	2.65	2.35
4-R	6.19	5.85	7.19	7.03	7.27	6.71
5-L	1.45	1.66	1.22	1.21	2.28	1.56
6-L	7.08	6.32	8.28	7.88	8.63	7.64
7-L	2.72	2.25	2.40	2.41	4.48	2.85
9-AR	1.88	1.35	1.75	1.88	2.09	1.79
8-L	2.56	2.86	3.64	3.68	4.51	3.45
9-R	3.88	2.87	4.98	5.33	5.89	4.59
8-AL	3.00	2.28	3.11	2.76	3.95	3.02
10-R	3.75	3.34	4.02	5.34	4.90	4.27
11+12-R	6.45	5.88	6.33	7.56	7.27	6.70
13-R	1.98	1.72	2.02	2.23	2.20	2.03
14-L	1.88	1.85	2.22	2.45	2.89	2.26
15-L	1.78	1.66	1.62	1.85	1.89	1.76
16-R	2.77	2.86	3.02	3.84	4.34	3.37
17-AL	1.03	2.23	2.85	2.77	3.67	2.51
16-AR	2.34	1.06	2.22	2.05	2.20	1.97
17-BL	1.03	1.33	1.05	1.35	2.48	1.45
18-R	1.85	1.38	1.66	1.85	2.31	1.81
17-AT	1.32	1.00	2.43	3.85	3.89	2.50
18-AT	2.63	2.45	2.53	3.45	4.08	3.03
1-AL KM	1.92	0.98	2.54	2.19	2.30	1.99
1-L	1.45	0.87	1.32	1.87	2.88	1.68
2-R	1.36	1.02	1.23	1.02	2.21	1.37
3-L	1.87	1.82	2.03	1.22	2.15	1.82
4-R	1.82	2.02	2.65	1.08	2.85	2.08
5-T	1.92	2.26	2.87	1.05	3.21	2.26
6-T	0.00	0.66	1.02	0.00	0.00	0.34
					Total	80.61

Table A4. Discharge measurement at each outlet through tape readings for the month of May 1997.

W\C NO	May 2	May 3	May 6	May 9	May 14	May 16	May 21	May 24	Mean cfs
1-L	0.80	2.02	0.30	0.50	0.44	0.34	0.74	0.54	0.71
2-R	1.08	1.19	0.97	1.08	1.09	0.97	0.77	1.05	1.03
3-L	2.71	4.02	3.25	3.25	3.99	3.37	4.39	2.85	3.48
4-R	7.49	7.53	6.37	7.41	7.48	7.49	7.16	7.18	7.26
5-L	2.32	2.33	2.22	2.31	2.32	2.31	2.21	2.25	2.28
6-L	9.59	9.56	8.28	9.17	9.17	9.25	8.42	8.55	9.00
7-L	4.71	4.70	3.51	4.60	4.65	4.65	4.38	4.43	4.45
9-AR	2.33	2.40	1.74	2.21	2.21	2.20	1.87	1.89	2.11
8-L	4.70	4.73	4.37	4.64	4.65	4.68	0.00	4.47	4.03
9-R	6.15	6.21	5.97	6.10	6.14	6.31	5.87	5.87	6.08
8-AL	4.16	4.19	3.88	0.00	4.20	4.19	4.00	4.01	3.58
10-R	5.07	1.13	4.61	5.50	4.61	5.53	5.61	4.06	4.51
11+12-R	7.86	7.88	6.31	6.30	7.27	7.88	6.91	6.16	7.07
13-R	2.28	2.28	2.09	2.42	2.47	2.45	4.49	2.25	2.59
14-L	2.92	2.92	2.69	2.99	3.11	3.00	1.92	2.87	2.80
15-L	1.91	1.91	1.73	1.99	2.06	2.00	3.88	1.89	2.17
16-R	4.01	3.80	3.06	4.10	4.91	5.46	3.79	3.30	4.05
17-AL	3.76	3.76	3.44	3.88	3.98	3.88	3.20	3.71	3.70
16-AR	3.30	3.36	2.25	0.23	3.62	3.52	2.56	4.29	2.89
17-BL	2.56	2.61	2.11	2.69	2.73	2.75	2.54	2.60	2.57
18-R	2.32	2.44	1.89	2.43	2.53	2.53	2.43	2.12	2.34
17-AT	4.30	4.47	2.48	4.86	4.73	4.92	4.96	4.32	4.38
18-AT	4.63	4.80	2.56	5.05	5.16	4.74	4.87	4.63	4.55
1-AL KM	2.38	2.30	1.69	2.33	2.47	3.35	1.08	1.99	2.20
1-L	3.20	3.13	2.47	2.30	3.20	2.30	0.42	2.02	2.38
2-R	1.99	2.56	2.24	1.22	1.98	1.99	1.89	1.67	1.94
3-L	1.90	1.99	1.11	1.56	1.76	1.86	0.56	1.56	1.54
4-R	2.85	2.71	1.70	1.54	2.43	2.56	2.54	2.77	2.39
5-T	3.12	3.01	1.91	1.59	2.54	2.76	0.84	2.93	2.34
6-T	0.89	0.88	1.09	1.00	1.00	1.08	1.56	0.97	1.06
								Total	101.48

Table A5. Discharge measurement at each outlet through tape readings for the month of June 1997.

W\C NO	June 2	June 6	June 9	June 13	June 18	June 21	June 26	June 28	Mean cfs
1-L	1.50	1.90	0.30	0.88	1.56	0.80	2.35	1.08	1.30
2-R	1.05	1.12	0.97	1.19	1.20	1.27	1.29	1.87	1.25
3-L	2.67	3.09	3.25	3.11	2.76	4.87	4.86	3.97	3.57
4-R	7.35	7.46	6.37	7.49	8.00	8.00	7.92	7.86	7.56
5-L	2.32	2.35	2.22	2.44	2.40	2.50	2.47	3.97	2.58
6-L	8.86	9.07	8.28	8.28	0.00	10.00	9.45	9.98	7.99
7-L	4.50	4.58	3.51	4.90	4.90	4.87	4.99	5.10	4.67
9-AR	1.91	1.98	1.74	2.47	2.43	2.30	2.48	2.65	2.25
8-L	4.55	4.60	4.37	4.95	4.90	4.90	4.98	5.14	4.80
9-R	5.92	5.56	5.97	5.51	6.41	6.36	6.58	6.75	6.13
8-AL	0.00	4.00	3.88	4.86	4.32	4.25	4.38	4.54	3.78
10-R	4.86	4.89	4.61	5.44	5.52	5.47	5.48	6.08	5.29
11+12-R	6.81	7.22	6.31	7.46	8.13	7.68	7.69	7.23	7.32
13-R	2.21	2.21	2.09	2.52	1.99	2.37	2.73	2.75	2.36
14-L	2.83	2.82	2.69	3.14	3.06	2.96	3.07	3.34	2.99
15-L	1.82	1.82	1.73	2.11	1.92	1.88	1.28	2.09	1.83
16-R	2.73	3.33	3.06	4.16	3.76	3.59	3.85	4.52	3.63
17-AL	3.58	3.56	3.44	3.98	3.70	3.54	3.81	4.07	3.71
16-AR	3.08	3.13	2.25	4.23	2.47	3.17	2.87	4.63	3.23
17-BL	2.32	2.27	2.11	3.55	2.36	2.35	2.57	2.82	2.54
18-R	2.88	2.01	1.89	2.82	2.22	2.18	2.20	2.64	2.36
17-AT	3.35	2.96	2.48	4.11	3.35	3.17	4.09	5.32	3.60
18-AT	3.27	3.02	2.56	4.59	3.57	3.34	4.23	5.83	3.80
1-AL KM	2.21	2.14	1.69	2.44	2.58	3.08	3.31	2.89	2.54
1-L	2.99	2.94	2.47	3.13	3.22	3.41	3.06	2.37	2.95
2-R	2.75	2.34	2.24	2.40	1.78	3.54	3.46	2.96	2.68
3-L	1.28	1.59	1.11	1.61	1.68	1.93	1.78	1.99	1.62
4-R	1.86	2.22	1.70	2.20	2.61	2.76	3.51	2.91	2.47
5-T	1.98	2.43	1.91	2.49	2.78	3.06	2.26	3.01	2.49
6-T	1.88	1.20	1.09	0.98	0.99	1.02	1.05	1.30	1.19
								Total	104.47

Table A6. Discharge measurement at each outlet through tape readings for the month of July 1997.

W\C NO	July 2	July 7	July 11	July 16	July 18	July 21	July 26	July 29	Mean cfs
1-L	1.88	1.02	1.17	2.31	closed	0.50	1.00	1.29	1.15
2-R	1.05	0.98	1.32	1.34	1.30	1.29	1.20	1.02	1.19
3-L	3.98	3.26	2.64	2.59	3.83	3.70	3.90	1.41	3.16
4-R	9.42	8.78	7.24	7.88	7.98	7.71	7.87	7.15	8.00
5-L	2.82	2.45	2.47	2.39	2.46	2.44	2.37	2.15	2.44
6-L	9.56	9.22	10.50	10.73	10.70	10.42	0.00	1.02	7.77
7-L	5.10	4.92	4.97	5.07	5.07	4.97	5.02	1.50	4.58
9-AR	0.00	2.86	1.89	2.81	2.84	2.65	2.70	1.72	2.18
8-L	5.28	4.97	5.00	5.06	5.06	4.94	5.04	4.40	4.97
9-R	0.00	6.54	6.57	6.71	6.71	6.50	6.63	5.76	5.68
8-AL	4.52	4.37	4.39	4.41	4.50	4.32	4.50	3.87	4.36
10-R	5.88	5.62	5.82	5.92	6.45	6.23	5.42	4.32	5.71
11+12-R	7.98	7.42	9.12	9.50	1.42	9.65	10.95	5.44	7.69
13-R	2.67	2.49	2.54	2.60	2.64	2.53	2.68	2.15	2.54
14-L	3.24	2.13	3.15	3.20	3.23	3.16	3.24	3.83	3.15
15-L	2.23	1.96	2.00	2.00	1.98	2.03	2.07	1.86	2.02
16-R	4.39	3.36	4.30	4.19	2.42	4.54	4.15	2.72	3.76
17-AL	3.97	3.75	3.87	3.92	3.91	3.89	4.01	3.62	3.87
16-AR	2.56	3.02	3.43	3.57	2.33	3.82	3.23	3.12	3.14
17-BL	2.77	2.49	2.65	2.63	2.65	2.88	2.63	2.41	2.64
18-R	2.58	2.41	2.23	2.43	2.77	3.93	2.97	2.11	2.68
17-AT	5.37	4.05	4.59	4.41	3.55	4.84	4.41	3.21	4.30
18-AT	5.30	4.34	5.03	4.76	4.47	4.49	4.75	3.27	4.55
1-AL KM	2.45	2.37	2.83	3.10	2.71	2.32	3.00	2.07	2.61
1-L	3.11	3.07	0.00	3.59	3.22	3.73	3.08	2.86	2.83
2-R	2.88	2.55	3.05	3.49	2.35	2.55	2.77	1.77	2.68
3-L	1.32	1.51	2.17	2.43	2.03	1.72	2.53	1.83	1.94
4-R	3.69	2.27	4.79	3.56	3.17	2.63	3.50	3.67	3.41
5-T	1.49	3.33	2.30	3.87	3.32	2.79	4.02	2.87	3.00
6-T	1.98	2.21	1.02	1.20	1.87	2.04	1.85	1.97	1.77
								Total	109.74

Table A7. Discharge measurement at each outlet through tape readings for the month of August 1997.

W\C NO	August	August	August	August 1	August 1	August 2	August 2	August 3	Mean cfs
1-L	2.61	2.00	2.58	2.84	1.82	2.89	1.49	2.10	2.29
2-R	2.29	0.99	2.20	2.54	0.00	2.56	1.12	1.53	1.65
3-L	4.52	3.77	4.41	3.16	3.52	3.19	2.92	3.95	3.68
4-R	7.28	7.35	7.29	7.37	7.32	7.40	6.02	6.92	7.12
5-L	4.11	2.44	4.30	3.95	2.56	3.89	3.36	3.87	3.56
6-L	3.60	3.73	3.52	3.21	3.47	3.16	2.62	2.78	3.26
7-L	5.62	3.25	5.49	5.86	5.45	5.82	4.41	5.41	5.16
9-AR	2.69	0.00	2.69	2.75	2.34	2.68	1.78	2.21	2.14
8-L	5.41	4.76	5.36	5.04	5.20	5.03	4.03	4.57	4.93
9-R	6.22	5.86	6.17	6.57	5.23	6.54	5.74	6.01	6.04
8-AL	4.51	3.05	4.43	0.00	4.10	3.92	3.39	3.91	3.41
10-R	6.56	5.32	6.49	6.61	5.12	6.42	5.12	5.87	5.94
11+12-R	9.93	7.23	9.89	12.54	9.65	10.81	7.35	9.06	9.56
13-R	2.32	2.37	2.26	2.80	2.58	2.60	1.54	2.01	2.31
14-L	3.41	2.85	3.30	3.40	3.53	3.09	2.25	2.92	3.09
15-L	2.09	2.02	1.93	2.07	2.30	2.12	1.02	1.32	1.86
16-R	2.50	3.32	2.42	4.02	3.48	3.99	1.15	2.03	2.86
17-AL	3.71	2.87	3.72	4.29	3.53	4.40	2.05	3.21	3.47
16-AR	2.32	2.85	2.20	3.16	2.87	3.20	1.61	1.98	2.52
17-BL	2.55	2.22	2.48	2.95	2.96	2.88	1.71	2.20	2.49
18-R	2.73	2.37	2.77	2.32	2.47	2.68	2.03	2.38	2.47
17-AT	3.78	2.84	3.69	3.85	3.65	3.91	2.32	3.16	3.40
18-AT	4.67	3.06	4.58	4.97	4.33	4.93	3.62	4.21	4.30
1-AL KM	2.12	2.88	2.20	2.60	2.38	1.87	1.09	2.09	2.15
1-L	2.09	2.98	2.13	2.15	2.22	1.42	1.01	1.96	2.00
2-R	2.17	2.76	2.30	2.20	2.40	1.58	0.99	2.07	2.06
3-L	1.89	2.33	1.86	1.92	2.40	1.33	1.11	1.82	1.83
4-R	2.67	3.65	2.71	2.91	3.20	1.20	1.97	2.55	2.61
5-T	2.84	3.02	2.81	3.77	3.25	3.62	1.78	2.72	2.98
6-T	1.02	1.76	1.11	1.39	1.20	0.97	0.87	1.02	1.17
								Total	102.32

Table A9. Average discharge measurement for Kharif 1997.

WUC NO	Sept 1	Sept 5	Sept 8	Sept 13	Sept 15	Sept 20	Sept 22	Sep 27	Mean cfs
1-L	1.34	0.99	1.40	1.03	1.36	1.20	1.34	1.29	1.24
2-R	2.33	2.25	2.43	2.02	2.24	2.35	2.29	0.00	1.99
3-L	0.41	1.99	1.99	1.71	1.71	1.79	1.27	1.69	1.57
4-R	8.00	6.79	8.54	10.21	8.67	9.13	11.68	8.54	8.95
5-L	4.11	3.80	4.14	3.80	3.85	3.96	3.93	3.98	3.95
6-L	3.15	2.92	3.33	3.07	2.96	3.19	3.09	3.20	3.11
7-L	5.82	5.55	5.98	5.75	5.65	5.88	5.79	5.89	5.79
9-AR	2.34	2.10	3.58	0.43	2.11	2.81	2.72	2.55	2.33
8-L	4.89	4.82	5.12	3.74	4.70	4.99	4.99	4.82	4.76
9-R	6.43	6.28	6.83	5.46	6.26	6.67	0.00	6.42	5.54
8-AL	4.25	4.28	4.43	0.00	4.28	4.55	4.47	4.39	3.83
10-R	5.97	5.61	5.87	4.57	5.97	6.41	6.52	6.30	5.90
11+12-R	7.40	**7.69**	8.71	8.24	7.30	9.86	9.40	9.09	0.47
13-R	2.45	2.33	2.74	1.64	2.46	**2.62**	0.00	0.00	**1.78**
14-L	3.14	3.01	3.29	0.00	3.09	3.18	3.26	3.20	2.78
15-L	1.95	1.94	2.05	1.63	1.98	1.99	2.00	2.04	1.95
16-R	3.33	4.11	3.92	3.02	3.22	4.27	3.64	4.20	3.71
17-AL	3.81	3.83	4.20	3.58	3.85	4.08	4.07	4.21	3.95
16-AR	3.46	3.45	4.08	3.32	3.51	3.95	3.89	4.15	3.73
17-BL	2.58	2.65	2.36	2.04	2.39	2.58	2.71	2.76	2.51
18-R	2.35	2.43	2.63	1.97	2.31	2.37	2.67	2.51	2.41
17-AT	4.33	4.06	4.89	2.15	3.93	4.32	4.66	4.95	4.16
18-AT	4.46	4.33	5.33	2.14	4.19	4.63	5.02	5.43	4.44
1-AL KM	2.34	2.80	2.81	3.00	2.47	3.01	2.74	3.28	2.81
1-L	2.16	2.38	2.42	2.74	2.20	2.79	2.30	2.63	2.45
2-R	1.47	1.63	2.08	1.48	1.23	2.47	1.58	2.27	1.78
3-L	1.34	1.99	1.60	2.95	1.44	2.26	1.21	2.16	1.87
4-R	2.24	3.48	2.68	3.68	2.40	3.49	2.43	3.73	3.02
5-T	3.53	3.17	3.97	5.55	3.58	4.90	2.55	4.90	4.02
6-T	1.58	1.50	1.52	1.52	1.52	1.66	1.58	1.76	1.58
								Total	106.37

Table A8. Discharge measurement at each outlet through tape readings for the month of September 1997.

W\C NO.	Average Apr 97	Average May 97	Average Jun 97	Average Jul 97	Average Aug 97	Average Sept 97	Q in cfs Average
1-L	0.67	0.71	1.30	1.15	2.29	1.24	1.23
2-R	0.80	1.03	1.25	1.19	1.65	1.99	1.32
3-L	2.35	3.48	3.57	3.16	3.68	1.57	2.97
4-R	6.71	7.26	7.56	8.00	7.12	8.95	7.60
5-L	1.56	2.28	2.58	2.44	3.56	3.95	2.73
6-L	7.64	9.00	7.99	7.77	3.26	3.11	6.46
7-L	2.85	4.45	4.67	4.58	5.16	5.79	4.58
9-AR	1.79	2.11	2.25	2.18	2.14	2.33	2.13
8-L	3.45	4.03	4.80	4.97	4.93	4.76	4.49
9-R	4.59	6.08	6.13	5.68	6.04	5.54	5.68
8-AL	3.02	3.58	3.78	4.36	3.41	3.83	3.66
10-R	4.27	4.51	5.29	5.71	5.94	5.90	5.27
11+12-R	6.70	7.07	7.32	7.69	9.56	8.47	7.80
13-R	2.03	2.59	2.36	2.54	2.31	1.78	2.27
14-L	2.26	2.80	2.99	3.15	3.09	2.78	2.85
15-L	1.76	2.17	1.83	2.02	1.86	1.95	1.93
16-R	3.37	4.05	3.63	3.76	2.86	3.71	3.56
17-AL	2.51	3.70	3.71	3.87	3.47	3.95	3.54
16-AR	1.97	2.89	3.23	3.14	2.52	3.73	2.91
17-BL	1.45	2.57	2.54	2.64	2.49	2.51	2.37
18-R	1.81	2.34	2.36	2.68	2.47	2.41	2.34
17-AT	2.50	4.38	3.60	4.30	3.40	4.16	3.72
18-AT	3.03	4.55	3.80	4.55	4.30	4.44	4.11
1-AL KM	1.99	2.20	2.54	2.61	2.15	2.81	2.38
1-L	1.68	2.38	2.95	2.83	2.00	2.45	2.38
2-R	1.37	1.94	2.68	2.68	2.06	1.78	2.08
3-L	1.82	1.54	1.62	1.94	1.83	1.87	1.77
4-R	2.08	2.39	2.47	3.41	2.61	3.02	2.66
5-T	2.26	2.34	2.49	3.00	2.98	4.02	2.85
6-T	0.34	1.06	1.19	1.77	1.17	1.58	1.18
Total	80.61	101.48	104.47.	109.74	102.32	106.37	100.83
Head	81.36	102.51	107.03	113.71	104.37	109.55	103.09
Losses	0.75	1.03	2.56	3.97	2.05	3.18	2.26

Table A10. Round-the-clock discharge measurements for six days at the Heran Distributary, Sanghar.

Date	Time	Water Duty (cfs/1000 acres)					
	(hours)	2-R	11+12R	18-R	HR	KD Minor	4-R
18-8-97	19	10.52	5.83	4.79	7.19	4.79	3.63
	20	10.50	5.83	4.79	7.19	4.79	3.63
	21	10.52	5.83	4.87	7.19	4.71	3.88
	22	10.54	5.85	4.94	7.19	4.75	3.77
	23	10.56	5.87	4.92	7.19	4.75	3.80
	24	10.52	5.93	4.98	7.19	4.83	3.89
19-8-97	1	10.54	6.03	5.13	7.19	4.75	3.83
	2	10.57	6.03	5.33	7.19	4.75	3.86
	3	10.57	5.93	5.46	7.19	4.79	3.94
	4	10.56	5.93	5.48	7.19	4.75	3.95
	5	10.54	5.93	5.48	7.19	4.83	3.92
	6	10.54	5.83	5.25	7.20	4.75	3.66
	7	10.49	5.77	4.96	7.20	4.67	3.65
	8	10.46	5.67	4.85	7.20	4.67	3.63
	9	10.45	5.63	4.67	7.20	4.49	3.65
	10	10.45	5.53	4.69	7.20	4.49	3.50
	11	10.50	5.51	4.54	7.20	4.49	3.71
	12	10.50	5.49	4.56	7.20	4.67	3.77
	13	10.50	5.47	4.54	7.20	4.67	3.85
	14	10.50	5.44	4.52	7.20	4.79	3.85
	15	10.48	5.44	4.54	7.20	4.79	3.65
	16	10.45	5.49	4.58	7.20	4.79	4.00
	17	10.48	5.49	4.56	7.19	4.36	3.98
	18	10.48	5.51	4.56	7.20	4.45	3.92
	19	10.44	5.57	4.54	7.20	4.45	3.95
	20	10.44	5.51	4.67	7.20	4.36	3.89
	21	10.44	5.51	4.64	7.20	4.49	4.02
	22	10.45	5.49	4.79	7.20	4.49	4.03
	23	10.45	5.55	4.79	7.20	4.49	4.08
	24	10.45	5.66	4.71	7.20	4.49	4.03
20-8-97	1	10.45	5.66	4.73	7.20	4.49	4.09
	2	10.45	5.66	4.71	7.20	4.54	4.21
	3	10.50	5.71	4.71	7.20	4.58	4.17
	4	10.52	5.76	4.85	7.20	4.86	4.24
	5	10.52	5.76	5.00	7.20	4.67	4.23
	6	10.52	5.76	4.87	7.19	4.31	4.15
	7	10.53	5.66	4.96	7.19	6.22	4.21
	8	10.52	5.51	4.98	7.19	5.93	4.23
	9	10.48	5.40	4.92	7.20	5.62	4.60
	10	10.44	5.40	4.77	7.16	5.62	4.63
	11	10.39	5.21	4.62	7.15	5.62	4.81
	12	10.35	5.23	4.60	7.13	5.62	4.92
	13	10.34	5.21	4.52	7.12	5.62	4.85
	14	10.31	5.16	4.44	7.10	5.78	4.85
	15	10.29	5.16	4.37	7.10	5.62	5.13

Table A10. (Continued)

	16	10.33	5.14	4.41	7.09	5.62	4.96
	17	10.29	5.14	4.41	7.09	4.59	5.15
	18	10.29	5.14	4.44	7.08	5.47	5.24
	19	10.30	5.87	4.50	7.09	5.78	5.54
	20	10.32	5.87	4.46	7.08	5.62	5.50
	21	10.36	5.85	4.60	7.07	5.62	5.19
	22	10.33	5.87	4.67	7.07	5.31	5.19
	23	10.29	5.88	4.85	7.07	5.31	5.13
	24	10.30	5.90	5.04	7.07	5.62	5.34
21-8-97	1	10.31	5.90	5.17	7.07	5.93	5.36
	2	10.36	5.90	5.23	7.07	5.93	5.36
	3	10.34	5.90	5.33	7.07	5.93	5.39
	4	10.32	5.90	5.44	7.07	5.78	5.37
	5	10.36	5.90	5.29	7.06	6.50	5.08
	6	10.34	5.88	5.19	7.07	5.47	5.08
	7	10.36	5.90	5.19	7.08	4.32	4.70
	8	10.32	5.88	5.27	7.08	4.36	4.52
	9	10.34	5.96	4.83	7.07	4.51	4.35
	10	10.36	5.96	4.71	7.07	4.51	3.97
	11	10.42	5.98	4.60	7.09	4.62	3.95
	12	10.42	6.00	4.54	7.09	4.51	4.03
	13	10.45	6.02	4.58	7.09	4.51	3.86
	14	10.49	6.00	4.60	7.09	4.54	3.95
	15	10.37	6.00	4.66	7.09	4.47	3.80
	16	10.38	6.02	4.73	7.09	4.73	3.83
	17	10.36	6.08	4.73	7.09	4.54	3.95
	18	10.37	6.08	4.71	7.09	4.51	4.06
	19	10.42	5.38	4.58	7.09	4.51	4.18
	20	10.43	5.44	4.75	7.09	4.43	4.24
	21	10.36	5.44	4.89	7.08	4.93	4.27
	22	10.36	5.76	4.90	7.09	4.86	4.32
	23	10.37	5.87	5.11	7.09	4.99	4.52
	24	10.38	5.91	5.27	7.08	4.86	4.89
22-8-97	1	10.37	5.98	5.40	7.08	4.86	4.84
	2	10.36	5.99	5.42	7.08	4.99	4.87
	3	10.32	6.01	5.42	7.08	4.93	4.90
	4	10.34	6.01	5.34	7.08	5.06	4.90
	5	10.36	5.83	5.33	7.08	4.93	4.89
	6	10.41	5.80	5.27	7.07	4.86	4.84
	7	10.32	5.67	5.08	7.08	4.86	4.67
	8	10.31	5.55	4.98	7.08	4.93	4.52
	9	10.31	5.49	4.83	7.08	4.73	4.44
	10	10.33	5.49	4.83	7.09	4.60	4.32
	11	10.34	5.38	4.75	7.09	5.05	4.34
	12	10.32	5.34	4.83	7.10	4.80	4.37
	13	10.34	5.36	4.83	7.10	4.73	4.35
	14	10.42	5.38	4.85	7.10	4.99	4.43
	15	10.34	5.38	4.90	7.09	4.93	4.38
	16	10.36	5.25	4.85	7.08	4.73	4.69
	17	10.36	5.36	4.75	7.07	5.05	4.72
	18	10.34	5.40	4.69	7.07	5.05	4.92
	19	10.36	5.47	4.64	7.10	5.17	5.08
	20	10.36	5.76	4.60	7.10	5.11	5.13
	21	10.43	5.95	4.85	7.10	5.29	5.07

Table A10. (Complete)

	22	10.43	6.12	5.13	7.08	5.17	5.05
	23	10.47	6.18	5.21	7.07	5.35	5.04
	24	10.46	6.12	5.23	7.08	5.17	5.04
23-8-97	1	10.44	6.25	5.27	7.08	5.11	4.99
	2	10.50	6.25	5.27	7.07	5.04	5.04
	3	10.50	6.20	5.34	7.08	4.80	5.04
	4	10.50	6.29	5.34	7.08	4.99	4.99
	5	10.42	6.25	5.40	7.07	5.58	5.11
	6	10.40	6.07	5.40	7.07	5.24	5.02
	7	10.38	5.09	5.31	7.07	5.24	5.02
	8	10.36	5.71	5.23	7.07	3.68	4.73
	9	10.31	6.36	5.00	7.08	3.90	4.72
	10	10.31	5.38	4.73	7.08	3.90	4.69
	11	10.37	5.47	4.58	7.09	3.87	4.64
	12	10.37	5.51	4.66	7.08	3.93	4.50
	13	10.42	5.53	4.79	7.08	5.20	4.37
	14	10.41	5.51	4.73	7.08	5.91	4.58
	15	10.31	5.43	4.79	7.09	5.77	4.84
	16	10.26	5.27	4.79	7.08	5.35	5.02
	17	10.29	5.14	4.66	7.09	5.49	5.05
	18	10.30	5.32	4.54	7.10	5.49	5.05
	19	10.32	5.38	4.73	7.08	5.91	5.08
	20	10.36	5.61	4.73	7.08	5.91	5.13
	21	10.36	5.63	4.89	7.12	6.05	5.19
	22	10.36	5.67	4.92	7.12	6.18	5.22
	23	10.40	5.67	5.04	7.13	6.05	5.53
	24	10.42	5.71	5.17	7.12	5.77	5.65
24-8-97	1	10.38	5.71	5.17	7.14	5.77	5.88
	2	10.17	5.71	5.17	7.14	6.05	5.92
	3	10.38	5.67	5.08	7.13	5.77	5.91
	4	10.42	5.63	5.02	7.12	5.35	5.86
	5	10.38	5.60	5.02	7.13	5.04	5.85
	6	10.38	5.49	5.02	7.12	3.63	5.47
	7	10.42	5.43	5.13	7.14	3.75	4.90
	8	10.45	5.43	4.98	7.12	3.86	4.61
	9	10.50	5.43	4.77	7.15	3.80	4.32
	10	10.54	5.47	4.64	7.17	3.97	4.29
	11	10.54	5.43	4.62	7.17	3.89	4.27
	12	10.58	5.43	4.64	7.17	3.89	3.88
	13	10.61	5.47	4.69	7.18	3.86	3.98
	14	10.58	5.55	4.71	7.18	3.86	4.18
	15	10.59	5.61	4.77	7.19	3.94	4.44
	16	10.54	5.67	4.77	7.19	4.02	4.44
	17	10.58	5.67	4.87	7.19	6.29	4.49
	18	10.54	5.71	5.10	7.18	10.54	5.71

ANNEX B. PIEZOMETER DATA

Table B1. Average watertable depth for Kharif 1997 in the command area of Heran Distributary, Sanghar.

	MAY	JUNE	JULY	AUGUST	SEP	OCTOBER	NOVEMBER
W/C#	MEASURED WATER TABLE DEPTH (ft.)						
1-L---H	2.75	2.226	3.14	3.01	2.5	1.996	1.256
1-L---M	4.512	2.702	3.69	3.58	3.31	3.262	2.512
1-L---T	4.185	3.49	4.43	4.012	3.89	3.47	3.39
2-R---H	2.611	.----------	.----------	.----------	.----------	.----------	.----------
2-R---M	.----------	.----------	.----------	.----------	.----------	.----------	.----------
2-R---T	2.291	1.164	2.54	2.5	2.8	3.12	2.51
3-L---H	4.033	3.56	5.36	5.25	3.62	2.16	-1.8
3-L---M	6.251	5.201	6.29	6.05	5.89	5.661	4.911
3-L---T	6.522	4.822	6.42	6.25	3.31	6.312	5.482
5-L---H	2.074	1.574	3	2.84	1.02	.-4.43	0.824
5-L---M	1.513	0.873	2.36	2.26	0.96	.-1.49	.-0.07
5-L---T	2.591	2.254	3.08	2.69	0.56	.0.83	0.674
4-R---H	1.777	-0.37	0.52	0.2	0.1	.-0.16	0.657
4-R---M	1.878	3.088	3.88	3.48	3.09	3.046	2.376
4-R---T	1.256	1.026	2.53	2.36	1.96	1.266	1.626
6-L---H	2.49	2.77	4.73	4.45	4.06	3.29	1.87
6-L---M	3.56	4	5.53	5.266	5	4.14	2.39
6-L---T	3.589	5.054	6.36	6.02	4.36	3.614	2.944
7-L---H	.----------	.----------	.----------	.----------	.----------	.----------	.----------
7-L---M	2.1	2.16	2.96	2.65	2.25	2.73	2.55
7-L---T	3.485	3.155	4	3.86	2.94	3.815	3.585
9-AR---H	.----------	.----------	.----------	.----------	.----------	.----------	.----------
9-AR---M	2.25	2.58	4.83	4.36	3.13	2.05	2
9-AR---T	2.6	2.51	3.58	3.46	3.48	2.43	2.35
8-L---H	2.815	-3.83	4.33	4.05	3.62	3.075	1.415
8-L---M	2.931	2.801	4.41	4.26	3.86	3.471	2.141
8-L---T	3.04	3.213	4	3.97	3.89	3.713	2.739
9-L---H	2.033	2.03	3.58	3.236	2.56	2.45	2.03
9-L---M	2.715	2.245	2.86	2.64	2.38	2.285	2.465
9-L---T	1.99	3.053	4.29	4.04	3.08	3.263	2.513
10-R---H	3.408	3.158	3.83	3.8	3.81	3.828	3.578
10-R---M	1.985	1.565	2.41	2.1	1.79	1.405	1.065
10-R---T	2.38	2.96	4.08	3.78	3.55	3.21	3.04
8-AL---H	3.935	3.435	4.5	4.5	4.6	4.594	3.344
8-AL---M	1.396	0.816	2.25	2.05	1.92	1.976	0.726
8-AL---T	.----------	.----------			.----------	.----------	.----------
11+12-R---H	3.587	4.417	5.33	5.02	4.153	2.667	2.337
11+12-R---M	3.438	3.108	4.08	3.59	3.27	2.938	2.608
11+12-R---T	3.525	3.025	3.75	3.65	2.15	2.855	2.605
13-R---H	.----------	.----------	.----------	.----------	.----------	.----------	.----------
13-R---M	3.204	3.034	4.83	4.63	3.21	1.784	1.864
13-R---T	2.151	1.731	3.33	3.21	2.65	1.901	1.41
14-L---H	2.099	1.609	2.63	2.29	2.15	2.099	0.789
14-L---M	.----------	.----------	.----------	.----------	.----------	.----------	.----------
14-L---T	1.346	1.206	1.89	1.72	1.984	2.536	0.886
15-L---H	4.133	3.733	5	4.11	3.24	0.89	2.23
15-L---M	4.387	3.137	4	4.13	4.21	4.64	1.84

Table B1. (Complete)

15-L---T	5.023	2.433	2.41	2.65	2.89	3.02	1.02
16-R---H	1.506	0.446	1.9	1.56	1.29	0.706	0.846
16-R---M	1.725	1.705	2.52	2.35	1.987	1.435	0.985
16-R---T	3.503	5.493	6.8	5.78	4.31	3.273	3.193
17-AL---H	2.403	1.9	3.08	2.621	2.054	1.65	1.15
17-AL---M	2.03	2.31	3.31	2.63	2.09	1.91	1.75
17-AL---T	3.028	2.975	3.53	3.156	2.954	2.355	2.115
16-AR---H	2.133	2.463	3.29	3.012	2.56	1.783	1.003
16-AR---M	3.624	3.819	4.875	4.265	3.86	3.624	2.444
16-AR---T	2.948	3.738	5.21	4.96	4.023	3.308	1.948
18-R---H	3	3.14	4.09	3.68	3.25	2.7	2.83
18-R---M	2.723	2.863	4.4	3.91	3.33	2.683	1.713
18-R---T	3.935	4.525	5.36	4.98	4.17	3.085	1.665
17-BL---H	1.411	3.741	5.33	4.775	3.658	2.911	2.741
17-BL---M	3.47	2.37	3.98	3.26	2.98	2.6	3.59
17-BL---T	3.863	3.313	4.28	3.54	2.36	1.863	1.033
17-AT---H	4.303	4.503	5.92	5.18	4.64	3.873	3.413
17-AT---M	2.835	3.905	4.75	4.01	3.287	2.325	0.825
17-AT---T	3.247	3.29	5.04	4.36	3.46	2.42	2
18-AT---H	2.675	2.765	3.72	3.231	2.68	2.175	0.715
18-AT---M	2.623	3.284	3.271	2.97	2.41	2.203	0.763
18-AT---T	5.813	5.973	7.77	6.987	5.68	4.503	3.703
1-AL---H	3.6	3.76	5.68	5.19	4.63	3.48	2.97
1-AL---M	3.38	2.03	5.48	4.59	3.96	3.01	2.65
1-AL---T	4.28	4.27	6.21	5.67	4.68	4.36	3.9
1-L---H	4.2	4.14	6.14	5.74	5.056	.----------	3.1
1-L---M	3.969	3.032	4.46	3.25	2.85	.----------	1.813
1-L---T	2.839	1.7	3.29	3.04	2.67	.----------	.----------
2-R---H	3.09	3.96	5.74	5.17	4.96	.----------	3.22
2-R---M	3.27	3.34	4.79	4.39	3.99	.----------	1.98
2-R--T	2.325	2.635	3.05	3.49	3.12	.----------	2.485
3-L---H	3.449	3.01	3.81	3.62	3.46	3.1	2.48
3-L---M	3.176	2.19	3.41	3.15	2.69	2.25	1.75
3-L---T	0.843	0.465	3.51	2.67	1.88	0.165	-0.59
4-R---H	.----------	.----------	.----------	.----------	.----------	.----------	.----------
4-R---M	2.05	2.45	3.71	2.58	2.589	1.75	1.84
4-R---T	2.44	2.49	3.74	2.56	2.04	1.34	1.35
5-T---H	.----------	.----------	.----------	.----------	.----------	.----------	.----------
5-T---M	3.03	2.6	3.92	3.27	2.05	2.28	3.12
5-T---T	2.499	2.81	4.59	3.69	2.58	1.75	1.76
6-T---H	2.144	1.788	3.22	2.87	1.76	1.088	0.468
6-T---M	2.181	2.045	4.72	3.47	2.21	1.975	1.325
6-T---T	2.885	.----------	.----------	.----------	.----------	.----------	.----------
Note: H= Head, M= Middle and T=Tail							

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RESEARCH REPORTS

Report No.	Title	Author	Year
R-1	**Crop-Based Irrigation Operations Study in the North West Frontier Province of Pakistan** Volume I: Synthesis of Findings and Recommendations	Carlos Garces-R D.J. Bandaragoda Pierre Strosser	June 1994
	Volume II: Research Approach and Interpretation	Carlos Garces-R Ms. Zaigham Habib Pierre Strosser Tissa Bandaragoda Rana M. Afaq Saeed ur Rehman Abdul Hakim Khan	June 1994
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R-2	Salinity and Sodicity Research in Pakistan - Proceedings of a one-day Workshop	J.W. Kijne Marcel Kuper Muhammad Aslam	Mar 1995
R-3	Farmers' Perceptions on Salinity and Sodicity: A case study into farmers' knowledge of salinity and sodicity, and their strategies and practices to deal with salinity and sodicity in their farming systems	Neeltje Kielen	May 1996
R-4	Modelling the Effects of Irrigation Management on Soil Salinity and Crop Transpiration at the Field Level (M.Sc Thesis - published as Research Report)	S.M.P. Smets	June 1996
R-5	Water Distribution at the Secondary Level in the Chishtian Sub-division	M. Amin K. Tareen Khalid Mahmood Anwar Iqbal Mushtaq Khan Marcel Kuper	July 1996
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