Watercourses Losses In Sahiwal Teksil

On Farm Water Management
Training Institute Punjab
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Pakistan

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LAHORE—PAKISTAN

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Preface

Water is the limiting factor in the economy of most of the developing countries and Pakistan is no exception. Huge loss of water in the Irrigation System of the Indus Basin has resulted in the menance of water logging and salinity whereas there is less water available at farmers fields than the actual crop water requirements.

There is a considerable amount of losses in watercouse conveyance system resulting more than 30 million acre feet of water loss annually in 87,000 watercourses of the Indus Basin. It is the need of the time to make the farmers aware of the extent of water course delivery losses for effective implementation of watercourse improvement programmes.

The present study on the determination of watercourse delivery losses in Sahiwal Tehsil will go a long way in further planning and effective implementation of existing watercourse improvement programme under On Farm Water Management Development Project.

The assistance and valuable suggestions made by Dr. S.A. Bowers and Mr. Tom Trout of Colorado State University in computations and data analysis of the present study is very much acknowledged. The co-operation of the Executive Engineers Irrrigation Sahiwal and Khanewal for supplying the Mouza Mapa of watercourses is appreciated.

The efforts of Mr. Mushtaq Ahmad Gill, Deputy Director (Training & Research) and other Training Institute's staff in conductiag this valuable study are commendable.

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I. Introduction

Back Ground :

Water, which is the life blood of plants and animals, is a limiting factor in the expansion of irrigated acreage and in the production of food. As the population increases, greater competition for the water supply makes conservation and efficient use of water imperative. Where water is plentiful it is often wasted. Where there is a diminishing supply of water, or it is scarce and expensive, conservation methods are most apt to be practiced. The purpose of irrigation is to provide an optimal water supply, avoiding shortage and excess of water.

More than one hundred years of irrigation development in the Indus valley have resulted in the world's largest integrated irrigation system. There are an estimated 60,000 miles of canals which command a gross area of 83 million acres of fertile soils. About 1,30.000 tubewells are supplementing the Indus Basin irrigation system and providing water to an additional 8 million acres. Water flows from the main canals through distributories to minor canals and then outlets through a mogha into a watercourse, which supplies water to the command area through field ditches. The net work of canals, distributories and minors deliver water to more than 80,000 watercourses. More than 4 milllon farmers with an average farm size of 8 acres are dependent on this system.

The Indus Basin irrigation system was designed mainly to fight against the famines during the light or un-seasonal rainfall. The famines occured in Indus Basin during 1783, 1812, 1824, 1833 and 1937. Erratic monsoons again caused serious famines in 1851-52, 1860. 1868-69 and 1877 (Thompson, 1925). However, since 1877, famines have not reached serious proporations because of the expension of the canal irrigation system. The canal system of Indus Basin was designed in the second half of the 19th century during the British regime, with the objective of extensive irrigation to bring more areas under irrigation in order to settle more people without considering the crop water requirements. The perennial canal system, therefore, was not designed for maximum production on irrigated land but only to eliminate the possibility of famines. In order to maintain a cropping intensity of 75% the canals in the Punjab were generally allocated one cusec of water for every 333-350 acrss of culturable commanded area.

Watercourse System :

The average irrigated acreage on a watercourse is about 400 acres with an average of 50 farmers.

The usual layout of the watercourse is that a main ditch starts from the outlet of the distributory or minor serving the main and sub-branches leading to farmers fields. This main ditch (Sarkari Khal) for which a 16 feet right of way is usually reserved is under the jourisdiction of the Provincial Irrigation Department but owned by the farmers collectively.

The water flows through the mogha and down the watercourse continuously for about 340 days in the perennial canal system. The irrigation rotation (Wara Bandi) period is usually seven days when every farmer receives water alloted to his land. The water is not applied to each acre each week but is distributed on the cropped fields as the farmer determines the need. However, given the magnitude of the delivery and application losses in the unlinned watercourses and poorly managed fields, the average farmer loose more than half of the water before it reaches the rootzone of his crops (Freeman and Lowder-milk 1976).

The farmers at the tail loose more than the farmers at the head of the watercourse. Table-I presents representative resnlts to illustrate the effects of location on the watercourse.

TATLE 1

*DISTRIBUTION OF AVERAGE YIELD ALONG THE WATERCOURSE

Crops	Head	Middle	Tail
	(Tons/acre)	(Tons/acres)	(Tons/acre)
(i) Wheat	1.94	1.19	1.00
(ii) Rice	0.84	0.57	0.58
(iii) Cotton	0.36	0.25	0.21
(iv) Sugarcane	16.5	9.75	10.4

*Hussain et al. (1976). Socio econmic bench mark survey TW-56 Mona Reclamation Project, Publication No. 58 Bhaiwal (Sargodha).

Purpose of Study :

The main purpose of the study was to know the extent of watercourse losses during conveyance of water from mogha to the farmers fields. It was also envisaged to find the problem watercourses in Sahiwal Tehsil in order to assign the priority for their improvement under On-Farm

Water Management Development Project. The second purpose of the study was to determine the average delivery efficiency of watercourses in an area with progressive farmers like Sahiwal Tehsil. The ultimate aim of the study was to get the farmers and the water management programme implementation agencies realise about the magnitude of watercourse delivery losses for starting watercourse improvement/renovation programmes on large scale.

Scope of Study :

The scope of the study under report was limited to the measurement of watercourse delivery losses in Sahiwal Tehsil through stratified random sampling of the total population of 1405 watercourses in Sahiwal Tehsil. Due to the limitation of time, transport and trained personnel for water loss measurement the study was confined to Sahiwal Tehsil only. The other criterian for selection of Sahiwal Tehsil or watercourse loss measurements was to consider their improvement programmes since the said tehsil lies in the On-Farm Water Managent Dev. Project area.

II. Literature Review

During early 70's extensive research on watercourse losses was started by Punjab Agriculture Department under Water Mangement Research Project in collaboration of Colorado State University Field Team in Pakistan. Similar research studies were also started by CSU with Master Planning Division of WAPDA, Mona Reclamation Project and University of Agriculture, Faisalabad. These studies indicate watercourse conveyance losses ranging over 40 percent (Clyma and Corey, 1974) which is highest figure in this regard as compared to that of 10% loss rates previously assumed (Hazara, 1963) The extent of watercourse conveyance losses as determind by other agencies than Harza is much more as indicated in the table given below :—

TABLE 2

WATERCOURSE DELIVERY EFFICIENCIES IN INDUS BASIN

Reference Source	Watercourse conveyance efficiency%	Remarks
(I) Expert committees on water losses in the Irrigation System (1972).	85	No measurements taken. Took centain references outside Pakistan.
(2) The importance of Farm Water Management in Pakistan, Corey and Clyma Sept. (1974).	50—80 (Average-60)	SCARP Command Area.
(3) USAID, Pakistan Economic Development Data, Aug. (1974).	70	Based on CSU Reseach Work.
(4) IBRD, Irrigation & Drainage Sector Report, May (1974).	75	No specific recommendations but suggests urgency for work.
(5) Irrigation practices and application and efficiencies in Pakistan, Clyma CSU/WAPDA, April (1975)		
(6) Watercourse Losses as related to composition and condition of banks, Kemper et al. CSU/ WAPDA April (1975).		50% suggested for seasonal efficiency.
(7) IBRD, Agricultural Sector Survey.	75	
(8) Watercourse command survey in Pakistan's Punjab & Sind, System Constraints and Farmers Responses (Technical Report No. 45, Forthcoming early et al. (1977).	52	Results of 40 watercourse survey measurements taken over 14 month period.

Clyma (1974) and Clyma et al. (1975) provided their observations on watercourse losses and invited the attention of the Government of Pakistan, which ultimately resulted in launching of different programmes under the Water and Power Developmeat Authority (WAPDA) and Punjab Government to further investigate the extent of watercourse improvement programmes like On-Farm Water Management Development Project under Punjab Agriculture Department. Because the water-losses reported by Clyma et. al. (1975) were about four times than those assumed previously, they received much criticism from different agencies. The data gathered recently (i.e., Clyma et al. 1975, Early et al. 1976) on watercourse losses has shown that previous assumptions and research substainiatlly underestimated the extent of delivery losses.

III. Materials and Methods

The basic secondary data like names and number of watercourse/distributories alongwith their sanctioned discharge, length and command areas etc. for all the water courses in Sahiwal Tehsil was collected from the Irrigation Department. This basic data was compiled and tabulated according to the command areas and distributories for making statified random selection. The satisticatian of Agriculture Department was consulted in order to get expert advice on sampling the population. 5% sample was considered representative under the circumstances and accordingly the selection of 66 watercourses in total was made by consulting random tables. A list of these setected watercourses was prepared and their sites were located from Mouza maps obtained from Irrigation Department for the purpose (Annexture-I).

Seven Survey Teams consisting of trained personnel of On-Farm Water Management Training & Research Institute and field staff of the Project were constituted to undertake the water loss measurements of the randomly selected watercourses scattered through out the Tehsil areas. Each Survey Team consisted of one Agricultural Engineer and 2 trained Officers of the Project alongwith 2 field-men to carry the flumes from one place to another on watercourses. The teams were provided with the lists of the watercourses alongwith their basic secondary data and muoza plan of the selected watercourses. Before approaching to the work sites, the members of the Survey Teams were adequately trained in undertaking watercourse loss measurements on watercourses and the use of cutthroat flumes. Data Collection Proformas for each watercourse were provided to each Survey Team indicating the steps to be followed for collection of data. A specimen of the Data Collection Proforma is given at Annexture-VI. Each Survey Team was provided with one Pick-up, camping equipment, 4 cut throat flumes, 2 measuring tapes, 3 sprit levels and spades. Irrigation Rest Houses were got reserved for stay of field teams during the study period. The Survey Teams recorded the discharge observations at 3 places on each watercourse viz head, middle and tail for a considerable period of time till the constant reading of the flume achieved at that place. The observation period was 3 to 4 hours on an average on each site. However, on some of the watercourses, the middle flumes observation could not be recorded completely due to the limitation of the Wara Bandi schedule on these watercourses at the time when the study was being conducted. Therefore, head and tail observations were taken for the purpose of computing loss and delivery

efficiencies. The water loss measurements on the randomnly watercourses were completed in 3 weeks due to the limitation of Wara Bandi schedule specially at the tail of the watercourse. The actual discharge measurements were made at different sites of the watercourse during last 3 days of each week since the water was available at tail end of the main watercourse at that time. Adequate supervision was made by the Principal staff on the On-Farm Water Management Training and Research Institute to ensure the better quality of data being collected on watercourse sites.

IV. Discussion on Results

The analysis of the data collected by the seven Survey Teams on 66 watercourses was done at "On-Farm Water Management Training & Research Institute". The services of CSU Computor were utilized for computation of results.

Discharge of the head and tail flumes was computed using the reference tables designed for the size of the flume used.

Cut throat flumes of size 8" × 18" × 36"" were used at all points on the watercourses under study. The delivery efficiencies computed in respect of each watercourse on the basis of head and tail discharge are given at Annexure-II.

The annexture shows a range of 51 to 87% delivery efficiency on the 66 randomly selected watercourses on the basis of their length and discharge. Average delivery efficiency on these watercourses comes out 70 percent.

Water losses on each watercourses in terms of liters per second per watercourses. liters per second per unit length of watercourse and also perceneage losses on each watercourses have been computed as given at Annexure-III. Average losses on each watercourse come to 18.30 liters per second or 29.93 percent on each watercourse.

Weighted average loss rates. percentage losses and unit distance loss rates were computed by giving the weightage to the length of watercourse only. Since there were wide variations in length as compared to discharge. Similarly weighed average delivery efficiencies were also computed. The weighted average losses per watercourse are 210 32 liters per second per watercourse. Whereas weighed average percentage losses are 33.20 percent and losses per 100 meters of the watercourse length are 0.8 liters per second.

The summary of watercourse loss and delivery efficiency is given in Table-3.

TABLE 3

SUMMARY OF RESULTS OF WATERCOURSE LOSS MEASUREMENT IN SHIWAL TEHSIL

A. LOSSES :

1.	Average Delivery Losses on Water Course	=	18 30 LPS/Sec or 0.65 cusecs

TABLE 3—Contd.

2. Weighted Average Delivery losses on Watercourse

$$= L = \frac{\Sigma(L_1 \times D_1)+L_2 \times D_2}{\Sigma D}$$

$$= \frac{3427249.9-}{168646} \qquad \underline{20.32 \text{ LPS}}$$

3. Weighted Average percentage Losses

$$= \frac{\Sigma\ (\%\ Loss_1 \times 1/D_1)+(\%Loss_2 \times 1/D_2)}{\Sigma\ 1/D}$$

$$= \frac{1.0263}{.00393} = \underline{33.20\%}$$

4. Delivery Losses per unit Length of Watercourse per 100 meter

$$= \frac{\text{Loss}}{\text{distance}} \times 100$$

$$= \frac{20.30}{2552.23} \times 100$$

$$= \underline{0.8 \text{ LPS}}$$

Where

L = Weighted Average loss in Liters/Sec

L = Loss in liters/Sec

D = Distance between Head and tail flumes in Meters

LPS = Liters/Sec

B. DELIVERY EFFICIENCY :

1. Average Delivery Efficiency

$$= \frac{\text{Av. inflow-Av. Loss}}{\text{Av. Inflow}} \times 100$$

$$= \frac{61.15-18.30}{61.15} \times 100$$

$$= \underline{70.70\ \%}$$

2. Weighted Average delivery efficiency

$$= \frac{\text{Av. Inflow-Weighted Av. Loss}}{\text{Average Inflow}} \times 100$$

$$= \frac{61.15-2032}{61.15} \times 100 = \underline{66.7\ \%}$$

(b) = 100—Weighted Average per cusecs Loss

$$= 100-33.20 = \underline{66\ 80\ \%}$$

* Weighted both on the length of Watercourse & its reciprocal

FIG. 1 RELATIONSHIP OF WATER LOSS WITH W/C DISCHARGE FOR CONSTANT LENGHT

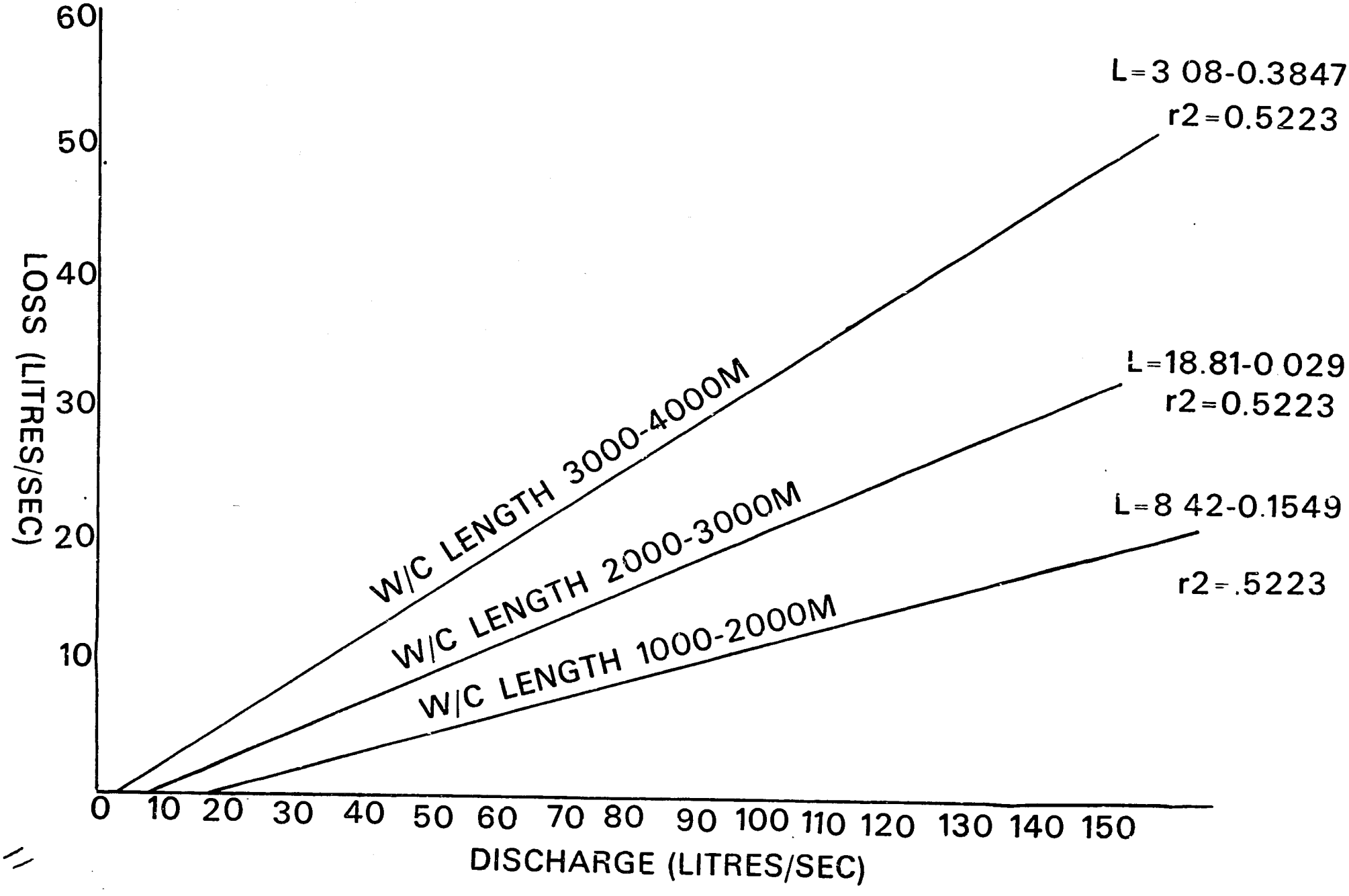


FIG. 2. RELATIONSHIP OF W/C LOSS WITH LENGTH OF W/C

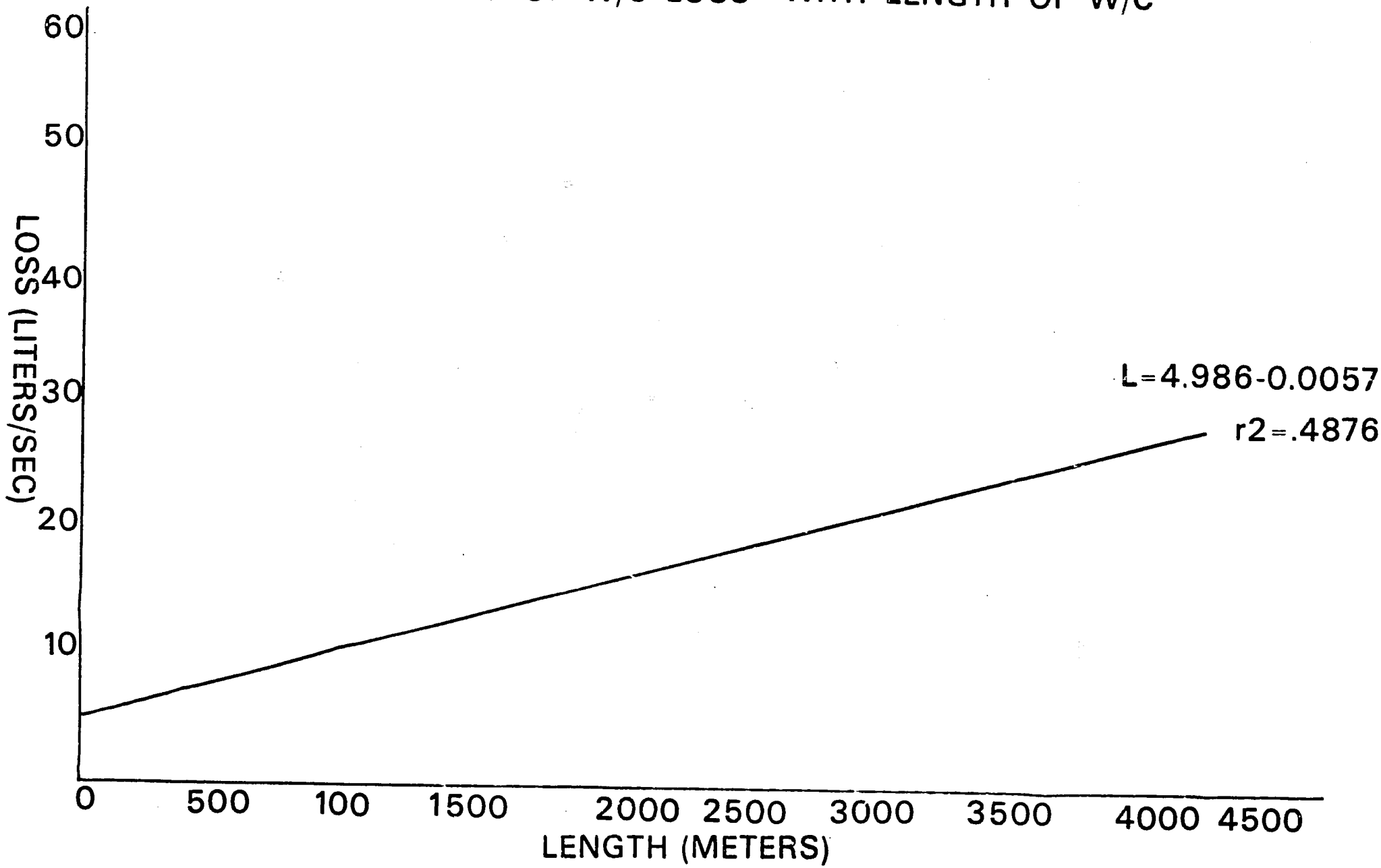


FIG-3 RELATIONSHIP OF DELIVERY EFFICIENCY WITH DISCHARGE OF W/C

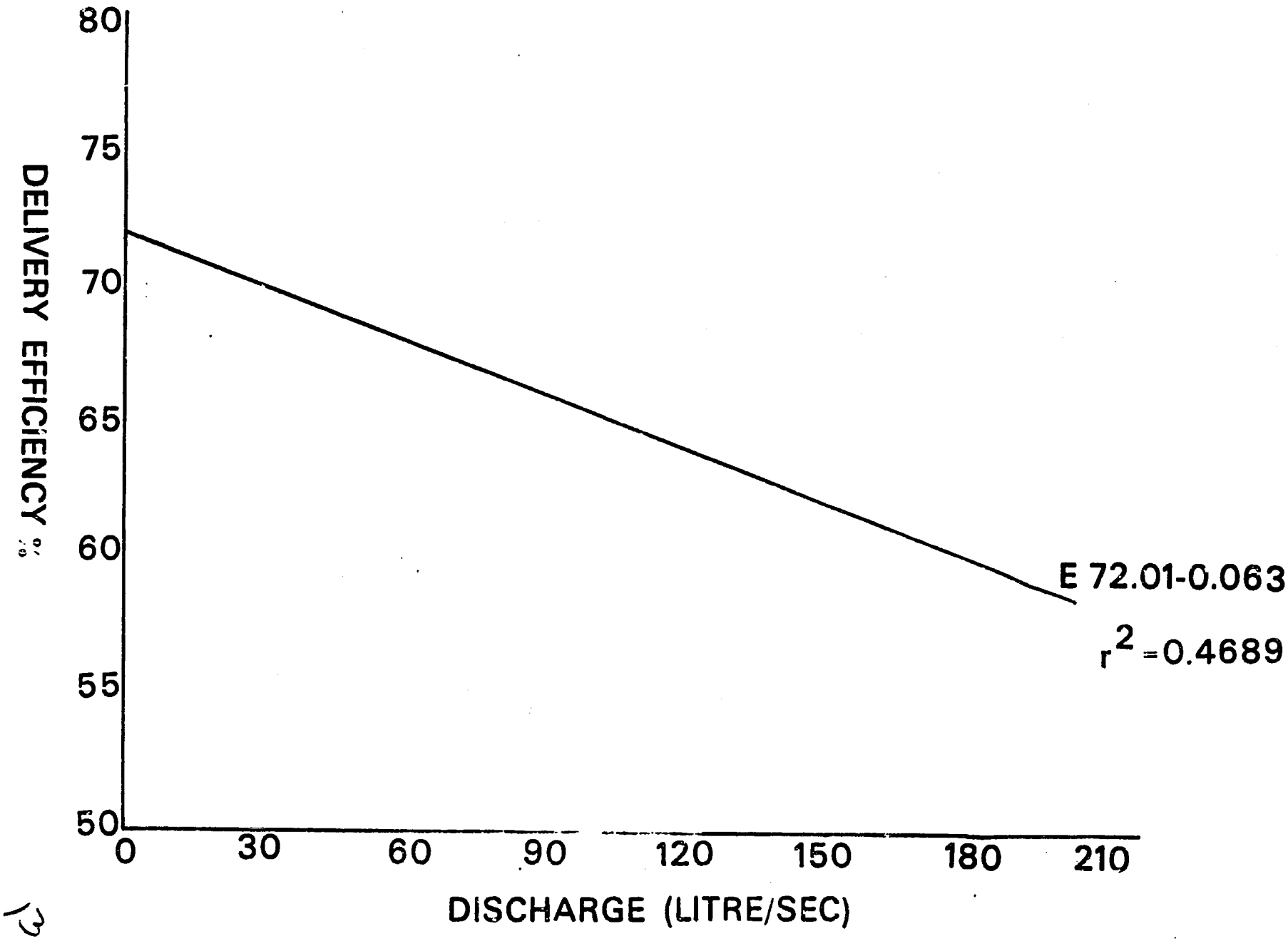
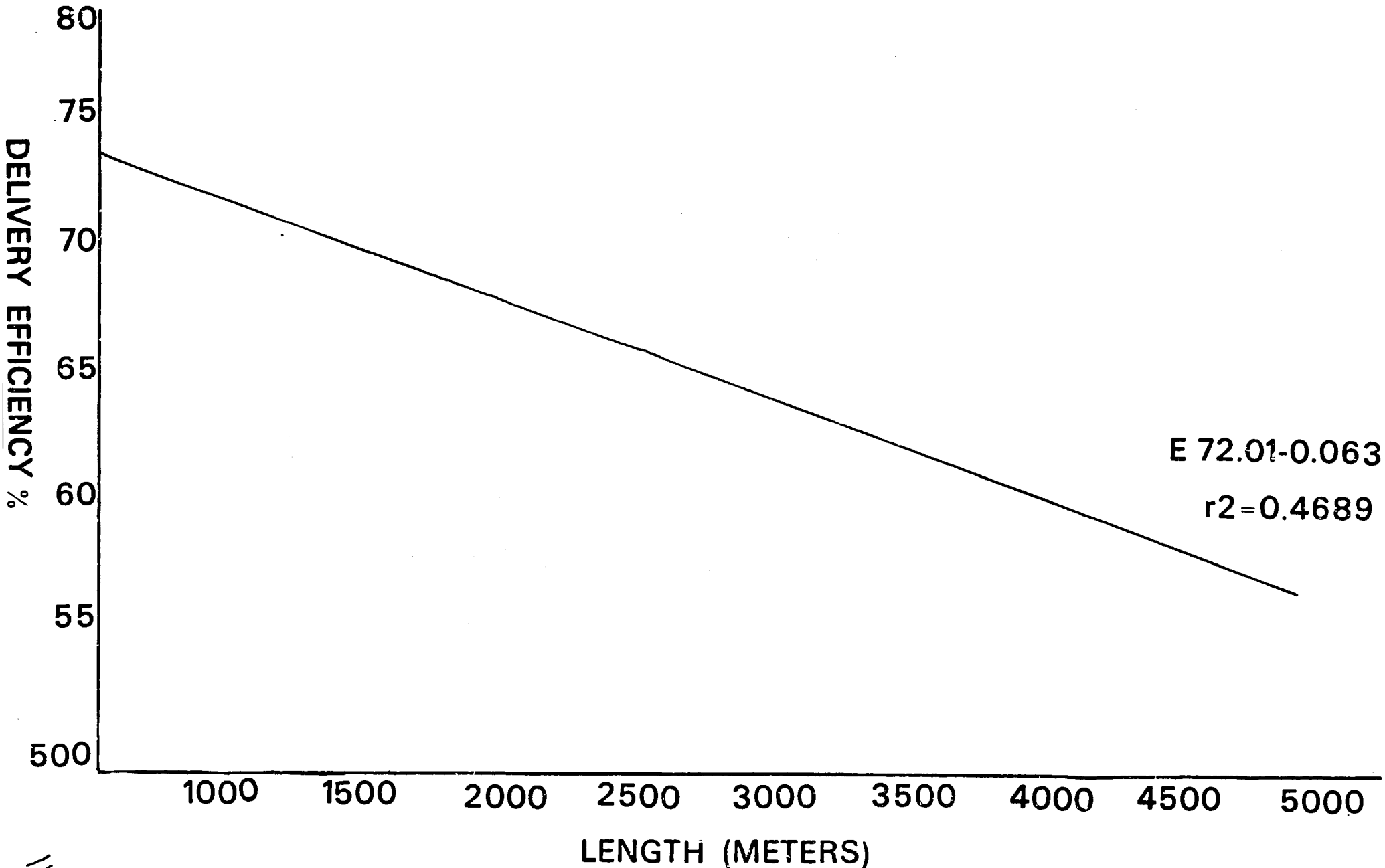


FIG 4. RELATIONSHIP OF AVERAGE DELIVERY EFFICIENCY WITH LENGTH OF W/C



The computation of watercourses losses and delivery efficiencies indicated their relationship with Moga discharge and length of the watercourse. Figure-I shows the variation of water loss with varying discharge keeping the length of watercourse constant. The increased loss rate with higher discharge of the watercourse indicates that most of the watercourses are carrying more water than their capacity. This emphasizes the importance of renovation/improvement of these water courses.

Figure-2 illustrates the relationship of water course loss with its length. There is a linear relationship between the water losses and the watercourse length.

Figure-3 reflects the change in delivery efficiency with relevant change in Moga discharge. There is decrease in delivery efficiency with the increase in discharge. This also explores the fact that most of the watercourses are carrying more water than their present capacities.

Figure-4. shows the linear relationship of delivery efficiency with length of the watercourse. The longer watercourses have comparatively less delivery efficiency than the smaller watercourses.

Table-4 shows the summary of statistics about average length, command areas. discharge, losses and efficiency for watercourses in Sahiwal Tehsil. The economic analysis of the watercourse loss and delivery efficiency data in Sahiwal Tehsil reveals that certain watercourse improvement with partial linning is much feasible in that area giving the cost benefit ratio of 1 : 1.58. The table also indicates the increase of delivery efficiency upto 85%. Through water course renovation, improvement programme, 242 acre ft of water can be saved annually on each watercourse at an average. Which could improve the cropping intensity/resulting increased agri-production.

TABLE 4

RESULTS SHOWING THE COMPOSITION OF SAHIWAL TEHSIL IN RELATION TO WATER RESOURCES DEVELOPMENT

EXISTING POSITION :

(1)	Average length per watercourse,	= 2552 meters.
(2)	Command area per watercourse.	= 485 acres, 196 ha
(3)	Average discharge per watercourse.	= 61.15 LPS 0.31 l/s/ha
(4)	Annual available water per watercourse.	= 1468 Ac, ft.
(5)	Delivery efficiency.	= 66.80 %.
(6)	Loss rate	= 33.20% or 20,30 LPS or 0.65 cusec or 438.3 Ac. ft per year per watercourse.

TABLE 4—(Contd.)

IMPROVEMENT POTENTIALS (COST BENEFIT RATIO)

(1) Anticidated water saving per watercourse with earthen improvement at 85% Delivery Efficiency.	= 242 Ac. ft.
(2) Value of water saved (assuming water rate @ Rs. 10 per hour for one cusec tubewell water.)	= Rs. 120.00 = Rs. 38, 280,00
(3) (a) Cost of Earthen Improvement with partial lining per watercourse @ Rs. 15.00 per running meter for 2552 meters av8rage length of watercourse.	
(b) Assuming life of watercourse for 5 years and interest rate @ 12%, total amoratised annual cost.	Rs. 10, 619, 23
(4) Total per year investment on water course improvement.	Rs. 18, 275. 25
(5) Total Annual Benefit i.e. water savings 242 Ac. Pt @ Es. 120/.	Rs. 29, 040,00
Benefit ; Cost Ratio.	= 1 : 1.58

V, Conclusions and Recommendations

The watercourse delivery losses study on watercourses in Sahiwal Tehsil has led to the following conclusions and recommendations :

(1) There are considerable water conveyance losses in the watercourse i.e. 33.20% on an average per watercourse in a progressive tehsil like Sahiwal. These losses indicate the steady state condition of flow in the watercourse. The operational losses on watercourse will be higher than those of the present study. This emphasizes the need for the renovation and improvement of watercourses.

(2) More than 50% of the watercourses in Sahiwal Tehsil are carrying more water than their capacity which results in high delivery losses. Re-construction of these watercourses is needed.

(3) There is a great potential for watercourse improvement in Sahiwal Tehsil as it will save about 242 Acre feet of water annually per watercourse on an average even with earthen improvement and partial linning having 85% delivery efficiency. This can suecessfully help to grow an additional of about 125 acres of wheat and about 100 acres of cotton per watercourse command annually.

(4) The existing watercourse improvement programmes under On-Farm Water Management Dev. Project has created an awareness about the extent of watercourse losses amongst the farming community. Farmers have also shown their anxiety for their watercourse improvement during the watercourse.

(5) Large scale watercourse improvement programme should be launhced with active involvement of farmers and close coordination of the concerned departments.

~ 33 acres/cusec.

ANNEXURE I

RANDOMLY SELECTED WATERCOURSE IN SHAHIWAL TEHSIL FOR W/LOSS MEASUREMENTS

S. No.	Chak No.	Water course No.	*Designed discharge** Cusecs	Liters/Sec.	Command Area Acres).
1	2	3	4	5	6
1.	70/4R	66379 R	1.43	40.1	429
2.	65/5L	29303 R	1.75	50.0	526
3.	65/4R	29303 L	1.33	37.7	400
4.	73-A/5L	45302 L	1.88	53.2	535
5.	44/46-5L	73490 L	0.85	24.1	400
6.	47/5L	60100 R	1.69	47.9	505
7.	60/5L	10240	1.68	47.6	495
8.	56/5L	25768 R	2.01	56.9	598
9.	61/4R	42670 R	1.34	35.1	442
10.	6/11L	6072 L	1.45	41.0	434
11.	8/11L	35507 L	1.47	41.7	431
12.	1/10L	8500 L	1.06	30 0	479
13.	Dada Sehu/2L	12000 L	1.45	41.0	435
14.	14/11L	25562 R	1.66	47.0	499
15.	105/108/7R	15085 L	1.38	30.1	415
16.	9/11L	14640 R	1.30	36.8	390
17.	109/7R	19360 R	3.05	86.4	914
18.	6/11L	3100 L	2.56	72.5	467
19.	Dad Buluch	24600/R	1.02	28.5	339
20.	Akbar Shah	25917 R	1.33	37.7	399
21.	82/6R	6820/R	0.85	24.0	256
22.	82-94/6R	11200/L	1.95	55.3	583
23.	50 G-O	225668/L	1.08	29.0	360
24.	65 A G	215110 L	2.27	64.3	749
25.	59 G O	871467 L	1.19	33.7	397
26.	Kutab Shahana	56724 R	1.34	36.9	446
27.	90/6R	28000 R	1.57	44.5	464
28.	Khod pur	288519 L	1.38	28.1	459
29.	127/9L	48450 L	1.49	42.2	444
30.	107/9L	40667 R	1.45	41.0	435
31.	151/9L	31750 R	1.46	41.3	529
32.	104/9L	13874 R	1.76	49.8	529

ANNEXTURE I—(Contd.)

RANDOMLY SELECTED WATERCOURSES IN SAHIWAL TEHSIL FOR W/LOSS MEASUREMENTS

S. No.	Chak No.	Waterrcouse No.	Designed dischgared*		Command Area
			Cusecs	Liters/Sec.	Acres.
1	2	3	4	5	6
33.	123-9L	63637 R	2.14	60.6	643
34.	156-9L	36580/TL	3.90	110.4	1173
35.	121-9L	82420 TR	1.37	38.8	410
36.	140-9L	32000 L	1.53	43.3	559
37.	107/9L	45170 R	0.87	24.6	257
38.	19/11L	4260	1.33	37.7	399
39.	145-9L	97780 L	1.75	49.6	515
40.	112/9L	126807/TL	1.85	52.4	556
41.	163/1	156480	1.74	49.5	494
42.	164/9L	184991 R	1.33	37.7	398
43.	169-A/9L	225850 L	1.28	36.2	473
44.	168/9-L	276250 R	1.62	45.9	487
45.	4/10L	50085	1.58	44.7	474
46.	3/10L	15175 R	0.92	26.1	275
47.	109/7R	28800 R	1.02	28.9	303
48.	109/12L	29085 L	1.91	54.1	573
49.	109/12L	83725	1.52	43.0	455
50.	54/12L	9821 L	1.92	54.4	577
51.	65/12L	39225 L	1.48	41.9	443
52.	60/12L	59400 L	1.98	56.1	595
53.	70/12L	178550 L	1.33	37.7	398
54.	77/12L	26200 L	1.94	54.9	573
55.	105/12L	66900 L	1.53	43.3	458
56.	40/12L	17690 L	0.63	17.8	126
57.	1/14L	4468/R	1.29	36.5	387
58.	33/1L/14L	29250 TR	1.36	38.51	407
59.	94/12L	96025/L	1.69	47.9	346
60.	93/12L	19686/L	1.54	43.6	463
61.	4/13L	8505/L	1.92	54.4	576
62.	3/13L	25330/R	3.12	88.4	936
63.	4/13 L	23720/R	3.31	93.7	993
64.	26-28/14L	73330/L	1.20	34.0	361
65.	39/12L	5750	0.93	26.3	280
66.	30/14L	23045/R	1.69	47.8	508

*Mogha Discharge in cusces from Irrigation Department record.

ANNEUTRE II

WATERCOURSE FLOW MESUREMENTS AT HEAD & TAIL

*W.C. S. No.	Head Flume		Tail Flume		W. course Convey-ance Efficiency
	Measured discharged liters/Sec.	Distance from Mogha (Meters)	Measured discharge liters/Sec.	Distance from Head flume (Meters)	
1.	28.7	2	18.6	3015	64.8
2.	73:9	25	41.4	2655	56 0
3.	74.5	10	40.6	4010	62.5
4.	55.5	7	30.3	7028	54 6
5.	42.5	30	25.3	2315	59.5
6.	58.7	20	38.0	2825	64 7
7.	84 7	5	52.4	3345	62.0
8.	108.7	30	58.4	3320	53.7
9.	110.1	5	77.2	3847	70.1
10.	84.7	10	44.9	3340	53 0
11.	74.0	33	55.3	3320	74.72
12.	61.9	5	50.2	1603	81.07
13.	40.3	50	30.2	2375	75.18
14.	62.0	20	49.0	2325	79.0
15.	98.2	20	73.7	2660	75.0
16.	41.1	100	25.5	2245	62.0
17.	87.4	60	74 0	1070	84.66
18.	83.9	10.0	60.1	4814	71.63
19.	33 7	10	24.9	995	73.8
20.	50 61	83	42 4	2800	83.7
21.	21.4	31	14.6	1409	68.3
22.	70.5	79.5	59.8	1400	84.8

*For details of Watercourse data see Annexture-I.

ANNEXTURE II--(Contd.)

W.C. S. No.	Head Flume		Total Flume		Watercourse
	Measured Discharge Liters/Sec.	Distance from Mogha (Meters)	Measured Discharge Liters/Sec	Distance from Head Flume (Meters)	Conveyance Efficiency
23.	62.0	15.0	42	1782	69.74
24.	72.1	6.0	35.2	3344	54.4
25.	41.3	67.0	21.1	1933	53.5
26,	28.5	15.0	22.7	1258	79.6
27.	87.20	31.0	73.0	1781	83.7
28.	63.50	58.0	53.7	1282	84.8
29.	138.1	33.0	116.6	1177	86.4
30.	69.1	33.0	50.6	159J	56.6
31.	66.9	30.0	41.1	3015	60.5
32.	67.9	60.0	40.5	2455	59.6
33.	144.7	151.0	100.5	1970	87.6
34.	66.8	83	36.4	8209	64.5
35.	64.3	30	54.70	1180	75.0
35.	76.8	33	47.30	3710	61.50
37.	33.2	23	28.2	1563	75.80
38.	56.0	10	40.4	3825	72.0
39.	62.0	25	36.0	3225	58.0
40,	52.4	30	31.6	2750	60.3
41.	62.3	30	37.6	1640	60.0
42.	53.0	15	36.7	1965	69.2
43.	26.4	40	15.70	2600	59.46
44.	60.2	20	55.9	3000	59.6
45.	39.3	15	21.8	3335	55.4
46.	69.9	15	59.0	2315	84.0

(Contd.)

ANNEXTURE II—(Contd.)

W.C. S, No.	Head Flume		Tail Flume		Watercourse
	Measured Discharge Liters/Sec	Distance from Mogha (Meters)	Measured discharge Liters/Sec.	Distance from Head flume (Meters)	Conveyance Efficiency
47.	8.45	10	6.7	1350	79.0
48.	78.0	30	49.4	3170	63.3
49.	57.75	20	35.6	2482	61.64
50.	120.62	30	96.70	3772	80.0
51.	61.3	30	41.10	2147	67.0
52.	42.0	26	33.40	4072	79.5
53.	28.2	30	20.40	1062	72.0
54.	53.9	30	38.2	2965	70.0
55.	70.1	30	57.9	3652	82.6
56.	10.8	20	3.92	300	36.29
57.	33.0	5	26.6	2405	80.5
58.	37.5	10	24.9	3990	66.4
59.	42.1	10	21.79	2390	51.88
60.	44.7	20	30.8	3162	68 99
61.	45.4	3	41.1	666	90.0
62.	101.5	5	78.1	2500	76.80
63.	105.1	10	88.6	990	84.0
64.	51.8	10	40.5	2300	78.1
65.	24.7	10	15.3	1500	61.0
66.	31.08	10	18.67	3000	59.0

48/66 (73%) higher than nominal
17/66 (26%) lower " "
1/66 (1%) same as "

ANNEXTURE III

MEASURED WATER LOSSES ON INDIVIDUAL WATERCOURSES*

W.C. S. No.	Losses Liters/Sec./100 Meter	Losses in Litters/Sec.	Percentage Losses on watercourse
1.	0.33	10.1	35.19
2.	1.22	32.5	43.97
3.	0.6	27.9	37.44
4.	0.35	25.2	45.40
5.	0.74	17.2	40.47
6.	0.73	20.7	35.26
7.	0.96	32.3	38.13
8.	1.5	50.3	46.27
9.	0.85	32.9	29.88
10.	1.19	39.8	46.98
11.	1.56	18.7	25 27
12.	0.72	11.7	18.90
13.	0.41	10 1	25.06
14.	0.55	13.0	20.96
15.	0.92	24.5	24.9
16.	0.69	15.6	37.95
17.	0.68	13 4	15.33
18.	0.49	23.8	28.36
19.	0.88	8.81	26.11
20.	0.3	8.21	16.22
21.	0.48	6.8	31.77
22.	0.76	10.1	15.20
23.	1.11	30.1	30.26
24.	0.98	32.9	45.63
25.	0.99	19.2	46.48
26.	0.46	5.8	20.35
27.	0.79	14.2	16.28
28.	0.76	9.8	15.43
29.	1.08	21.5	15.56
30.	0.97	18.5	26.77
31.	0.88	26.8	39.46
32.	1.11	7.4	10.89

* Percentage Water Losses $= \frac{\text{Loss in liters/Sec.}}{\text{Distarage of Head Flume}} \times 100$

ANNEXTURE III—(Contd)

W.C. S. No.	Losses Liters/Sec./100 Meter	Losses in liters/Sec.	Percentage Losses on Watercourse
33.	0.72	14.2	12.38
34.	0.72	30.7	45.51
35.	0.81	9.6	14.93
36.	0.32	27.3	48.41
37.	0.60	19.0	24.169
38.	0.42	15.6	27.85
39.	0.8	26.0	41.93
40.	0.75	20.8	39.69
41.	1.80	24.7	40.0
42.	0.80	16.3	30.75
43.	0.47	10.7	40.53
44.	0.81	24 4	40 36
45.	0.82	17.5	44 52
46.	0.47	10.9	15.59
47.	0.12	1.75	20.71
48.	0.89	28.6	36.66
49.	0.89	22.15	38.35
50.	9.62	23.72	19.66
51.	0.14	20.8	32.95
52.	0.21	8.6	20.45
53.	0.39	7.8	27.66
54.	0.53	15.7	29.13
55.	0.32	12.2	17.40
56.	2.75	6.88	63.70
57.	0.26	6.4	19.39
58.	0.40	12.6	33.60
59.	0.84	20.31	48 24
60.	0.43	13.9	31.99
61.	0.64	4.3	09.47
62.	0.74	23.4	23.05
63.	I.66	16.5	15.70
64.	0.49	11.3	21.81
65.	0.63	9.4	38.05
66.	0.42	12.41	39.93

ANNEXTURE—IV

ON FARM WATER MANAGEMENT DEVELOPMENT PROJECT PUNJAB
DATA SHEET

WATERCOURSE LOSSES SURVFY IN TEHSIL SAHIWAL

Name/Number of Watercourse————————Distriibutory————————

Irrigation Sub Division————————————Village————————————

Command Area————————————

... ...

Date———————————— Party————————————

Whether————————Flow position in Watercourse————————————

Length of Watercourse————————————Soil Type————————————

... ...

Conveyance Efficiency

AVERAGE DISCHARGE

(a) Head————————————Distance————————————

(b) Middle————————————Distance————————————

(c) Tail————————————Distance————————————

Conveyance efficiency

I Section————————————

II Section————————————

Average Losses/100m—III Overall———————— conveyance efficiency

Average Losses/100 meters.————————————

... ...

ON-FARM WATER MANAGEMENT DEVELOPMENT PROJECT PUNJAB

Discharge Mensurements

Flume 1 Head						Flume 2 Middle					Flume 3 Tail				
Station _____						Station _____					Station _____				
Date	Time	Ha	Hb	Q	Remarks	Time	Ha	Hb	Q	Remarks	Time	Ha	Hb	Q	Remarks