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Annual Report
1992–93

Drainage & Reclamation Institute of Pakistan

Tando Jam
1993

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DRAINAGE AND RECLAMATION INSTITUTE OF PAKISTAN

ANNUAL REPORT

1992-93

1. INTRODUCTION

Drainage and Reclamation Institute of Pakistan (DRIP) conducts and promotes research in drainage of waterlogged areas, reclamation of salt affected soils, groundwater resources development, and related soil and water management aspects. It conducts scientific, technological and economic research on problems related to irrigated agriculture which have seriously damaged the agricultural production of the Indus plain soils. The Institute is an Autonomous Research and Training Organization and is governed by a Board of Governors. The Chairman Pakistan Council of Research in Water Resources (PCRWR) is the President of the Board.

2. This annual report highlights the research and development efforts of the Institute for the year 1992-93. During this period the Institute mainly focussed on conduct of research on tile drainage, a horizontal method of drainage, monitoring of installed drainage projects, skimming well modelling for irrigation and drainage of agricultural lands, water management aspects related to drainage, and reclamation of salt affected soils. New projects on irrigation management and drainage were planned and implemented.

3. DRIP has been successful to introduce tile drainage technology amongst the progressive farmers with their collaboration

for reclamation of waterlogged and saline soils. Farmers have shared upto 60 per cent of the capital cost and full responsibility of the operation and maintenance cost. Research on tile drainage has lowered the drainage cost to Rs. 18000/ha. Similarly the farmers have benefitted from the skimming well technology by increasing irrigation water supplies by skimming fresh water from shallow layer, floating over native saline groundwater. Monitoring and evaluation of installed drainage projects have generated scientific data for planning of future drainage projects. Research in water management, specially on innovative irrigation techniques have created an added interest. The research advanced by DRIP has been highly useful to understand the problems of waterlogging and salinity and finding their appropriate solutions. The report gives information on functions of DRIP, research activities, preparation of new research and development projects, soil and water analysis, documentation and dissemination of research results, important meetings and visits, financial statement, staff of the Institute, training received by the staff members, and DRIP publications.

2. FUNCTIONS OF DRIP

4. The Institute performs the following primary functions:

Research

i) Drainage of agricultural lands
ii) Salinity control
iii) Land reclamation
iv) Irrigation practices and water management

Monitoring of Drainage Projects

i) Technical evaluation of drainage and reclamation methods

ii) Detailed hydro-chemical monitoring of installed drainage projects
iii) Cost benefit analysis for various drainage and reclamation methods under different agro-hydro-geological conditions

Documentation and Dissemination

i) Document research results on problems similar to those of Pakistan agriculture

ii) Disseminate research results for application by prospective users.

3. RESEARCH ACTIVITIES

5. In Pakistan water resources are limited as compared to land resources. Therefore, horizontal expansion of agriculture can not be achieved. On the other hand, the population growth rate is the highest amongst the developing countries. It necessitates that food production must commensurate with population increase. One possibility to increase food is the vertical expansion of agriculture viz. by increasing production per unit of land through intensification. Again the vertical expansion of agriculture is constrained with the serious problems of waterlogging and salinity. To relieve the lands of these problems significant research efforts are needed as all the agricultural inputs including water would show their effect only when the soil environment is free from pollution.

6. DRIP has selected the following four priority themes for research.

i) Drainage to counteract waterlogging and salinity in the irrigated areas

ii) Collaboration and active participation of the farmers in drainage projects

iii) Monitoring of already installed drainage projects for feed back and generation of scientific data for use in planning and implementation of future drainage projects

iv) Water management to minimize drainage requirement

7. Within these themes, DRIP carried over modest programmes of research, either independently or in collaboration with other organizations. Integration of water management with minimum drainage requirement has been the approach in drainage projects. At the same time agricultural activity is linked up with drainage provided to see the impact of drainage and improved water management practices on crop production and salinity. Experimentation on land reclamation and saline agriculture continued.

8. The programme covered the following specific projects/activities:

i) Monitoring Studies of Tile Drainage Pilot Project Khairpur

ii) Water and Salt Balance Studies of Pilot Tile Drainage Project Khairpur

iii) Monitoring Studies of Isolated Tile Drainage Projects Installed under Surface drainage and Watertable Control Project of ISM-R

iv) Skimming Well Modelling for Irrigation and Drainage of Agricultural Lands

v) Development of Tile Drainage Project in Phase-II Area of DRIP in East Khairpur Tile Drainage Pilot Project

vi) Alternative Project Development for Drainage of Agricultural Lands

vii) Qadirabad Drainage Research Project

viii) Salt Affected Soils and Their Reclamation Project

ix) Lysimetric Research in Water Management

x) Water Requirement of Major Crops under Field Conditions

xi) Collaborative Research in Water Management

3.1 Monitoring Studies of Tile Drainage Pilot Project Khairpur

9. The first significant research effort by the Institute is the launching of a Tile Drainage Pilot Project in WAPDA's largest East Khairpur Tile Drainage Pilot Project. The DRIP pilot area covers 2000 acres and is divided into two phases. Phase I comprised of 1200 acres and drain installation in this phase was completed in June 1985. Since then the project is being monitored to observe changes in parameters and evaluate the performance of the system. It may be mentioned that laterals are installed at 1.8 m and 1.5 m depth below the ground surface and spacing in different drainage blocks was kept 150 and 300 m so as to arrive at definite conclusion for suitability of spacing between drains.

10. Standard procedure for soil salinity monitoring and watertable observations was followed using grid system. The intensity of observation was approximately one site per 10 acres. Composite soil sampling was followed and watertable observations were recorded at equilibrium in each sampling plot including groundwater quality after harvest of each crop. The revised sampling depths are 0-25, 25-50, 50-75 and 75-100 cm, modified due to improvement in surface salinity. Sampling time was kept as start of each season because salinity especially affects germination.

11. Simultaneously monitoring of the drain discharge is required after the construction of a tile drainage system. For this purpose discharge measurement of the lateral drains and at the sump was

recorded daily to see the efficiency of the drains. The discharge of lateral drains was measured at the manholes at the junction of the laterals and collectors.

12. The project is being monitored to observe changes in the following parameters and evaluate performance of the system.

i) Drain discharge

ii) Depth to watertable

iii) Groundwater quality

iv) Soil salinity

v) Crop survey

3.1.1 Drain Discharge

13. Discharge measurements were taken regularly in all the blocks of the drainage system to evaluate the performance of the tiles installed in the Pilot area. Table 1 presents the rate of drain discharge from July 1992 to June 1993. It shows that composite system is working better than the long laterals. Block 2B, 2C, 3A and 3B, having long laterals, are working at lower than 40% of their design capacity. Even near the outlet of laterals, it would cause heavy reduction in drain discharge unless the drains are cleaned. Maintenance is another problem with long laterals since flushing pipe can not work efficiently for longer laterals.

Table 1

Average Monthly Discharge of Different Drainage Blocks (l/m)

Block	Design	July	Aug.	Sept.	Oct	Nov.	Dec.	Jan	Feb.	Mar.	Apr.	May	June
		1992						1993					
Trial	885	-	-	-	400	380	390	450	400	425	-	-	-
1	920	-	-	-	-	-	-	-	-	-	-	-	-
2-A	1354	550	560	570	680	670	690	600	520	480	250	360	305
2-B	920	-	-	-	-	-	-	-	-	-	-	-	-
2-C	922	-	-	-	-	-	-	-	-	-	-	-	-
3-A	868	-	-	-	-	-	-	-	-	-	60	67	64
3-B	799	280	290	300	-	-	-	-	-	-	178	222	230
4	1579	-	-	-	-	-	-	-	-	-	360	400	378

Remarks : The pumps were stopped from 05-08-1991 to 12-9-1991 and then from 01-12-1991 to 05-01-1992 onwards due to non payment of electricity bills by Tubewell SCARP Khairpur and also defects in the pumps.

3.1.2 Depth to Watertable

14. Monthly watertable measurements were recorded in all the drainage units as per layout plan and grid system prepared keeping in view the tile drainage systems of the Pilot area. In addition to this, watertable position was also recorded during soil salinity sampling in whole of the project area seasonally with the help of auger hole and watertable was recorded at each site in equilibrium condition. Per cent distribution of watertable observed during pre and post project periods in whole of the project is shown in Table 2.

Table 2

Preproject and Postproject analysis for Groundwater Depth (Per Cent Distribution)

Groundwater Depth (cm)	Preproject	Postproject						
	1982	1985	1986	1987	1988	1989	1990	1991	1992
0 - 50	52	33	12	0	0	0	0	0	0
50 - 100	39	42	73	53	24	18	35	32	33
100 - 200	09	25	15	47	76	82	65	68	67

15. A comparison between preproject and postproject levels of groundwater shows that drainage system lowered down watertable below 50 cm in whole of the project area. However, 33 percent of the project area has watertable within 50 to 100 cm depth and in 67 percent of the area the watertable depth is from 100 to 200 cm at the end of December 1992. It shows that there is significant control over watertable through out the project area. However, due to faults in the pumps during the year 1991, 1992 watertable has risen to 15 percent in 100-200 cm depth but decreased to 15 percent in 50-100 cm depth.

16. Watertable measurements were recorded in each drainage block on monthly basis keeping in view the layout plan of the drainage system. The findings coincide to those measured in grid system on seasonal basis as shown in Table 3.

Table 3

Preproject and Postproject Analysis of Groundwater Depth (Per Cent Distribution)

Groundwater Depth (cm)	Preproject	Postproject							
	1982	1985	1986	1987	1988	1989	1990	1991	1992
0 - 50	52	53	4	0	0	0	0	0	0
50 - 100	39	24	50	33	52	54	60	47	61
100 - 200	09	25	46	67	48	46	40	53	39

17. Fluctuation of groundwater table mainly depends on recharge to and discharge from water bearing strata. The recharge source in DRIP Pilot area is seepage from Sathio Wah irrigation canal running along one side of the project area in addition to field irrigation losses. Average monthly watertable from July 1992 to June 1993 is presented in Table 4.

Table 4

Average Monthly Watertable Depth in Different Drainage Blocks (cm)

Block	July	Aug.	Sept.	Oct	Nov.	Dec.	Jan	Feb.	Mar.	Apr.	May	June
	1992						1993					
Trial	78	-	80	93	-	87	143	140	138	125	130	141
1	105	-	110	95	98	100	170	174	155	145	165	168
2-A	110	-	122	85	87	86	185	180	175	170	178	183
2-B	78	-	82	72	75	73	95	80	85	92	90	93
2-C	75	-	73	65	70	68	94	91	85	87	80	78
3-A	115	-	130	100	102	103	140	138	125	120	128	115
3-B	110	-	120	95	96	97	138	140	125	130	128	121
4	112	-	125	101	102	103	135	130	120	125	128	122

Note: No data was collected during the month of August 1992 due to heavy rain fall.

18. During the monitoring period it was observed that watertable in the whole project area remained high during rice cultivation in the months of July-August because of heavy irrigation requirement of this crop. Unexpected monsoon rainfall, high temperatures resulting in excessive evapotranspiration rate and sometimes electrical and mechanical faults in the pumps raised groundwater table. However, in general groundwater table measurements recorded on monthly basis remained below 50 cm depth in whole of the pilot area through out the year.

3.1.3 Groundwater Quality

19. For groundwater quality samples were collected at the time of discharge measurements from lateral drains and collector at sump and from each grid point separately at the time of soil salinity sampling after the harvest of each crop. Samples were analysed in the field by portable EC meter or in DRIP laboratory at Tando Jam. A comparison of groundwater quality for postproject with preproject conditions is given Table 5.

Table 5

Preproject and Postproject Analysis for Groundwater Quality (Per Cent Distribution)

Salinity	EC mmhos/cm	Preproject	Postproject							
		1982	1985	1986	1987	1988	1989	1990	1991	1992
Usable	0 - 1.5	8	16	28	33	45	41	43	35	14
Marginal	1.5 - 3.0	39	40	23	38	32	31	30	22	38
Hazardous	Over 3.0	53	44	49	29	23	28	27	43	48

20. The results indicate that the quality of groundwater has significantly improved. The usable groundwater has increased from 8 to 43 per cent of the project area up to the year 1990 and then decreased to 14 per cent due to stoppage of pumps for longer period. The marginal groundwater has reduced from 39 to 30 per cent up to the year 1990 and then increased to 48 per cent up to the end of the year 1992 which is a good achievement within 6 years of operation of tile drainage system. This reflects that the flow of groundwater towards to the drains beyond rootzone.

3.1.4 Soil Salinity

21. Salinity refers to the presence of soluble salts in the soil in such a quantity that it has an adverse effect on crop growth. Usually salinity is a characteristic of arid and semi arid regions where temperature is high and rain fall is low and scanty to leach down the salts. Due to capillary action the saline groundwater comes to the surface of the soil, from where the moisture evaporates leaving behind the salts on the surface. Under such conditions, if there is no or less rainfall and sufficient irrigation water over and above the crop water requirement is not applied to leach down the salts, this process continues resulting in the development of saline soils.

22. Therefore, it was considered essential to monitor the salinity status of the Pilot area before and after the installation of tile drainage. After the preproject monitoring, postproject monitoring for soil salinity is carried out twice a year, once each after the harvest of Rabi and Kharif crop. Such a systematic approach enables

the study of salt movement to the underlying layers. Table 6 presents the results of soil salinity survey.

Table 6

Preproject and Postproject Maximum Soil Salinity (EC dS/m)

Depth (cm)	Preproject	Postproject						Depth	1991-92
	1982	1985	1986	1987	1988	1989	1990		
0 - 2	168	90	88	55	45	44	30	0-50	24
2 - 25	86	82	68	40	32	34	22	50-100	23
25 - 50	55	88	29	48	23	22	17	100-150	15
								150-200	

3.1.5 Crop Survey

23. The main purpose of the crop survey is to find how the farmers have reached in making best use of agricultural land after installation of drainage system. Pre and postproject status from Kharif 1985 to Kharif 1992 is presented in Table 7.

Table 7

Comparison of Preproject and Postproject Kharif Cropping (Per Cent Area)

Crop	Preproject	Postproject							
	1992	1985	1986	1987	1988	1989	1990	1991	1992
Cotton	23	28	8	52	30	30	23	25	23
Rice	15	8	49	Nil	2	7	3	9	6
Jantar	4	10	3	8	24	27	22	17	20
Date Palm	24	26	27	27	26	27	27	27	28
Jawar	12	10	3	6	10	3	13	13	12
Fallow	22	18	10	7	8	6	12	9	11

24. The results obtained are compared with preproject crop survey in order to find out benefits achieved after the installation of tile drainage in the project area. Comparison shows that the fallow land or uncultivated land has reduced from 22 to 11 percent. From the visible conditions of the crops and information collected from the farmers, it reveals that yield levels of crops have substantially increased after the operation of tile drainage system. The yield of wheat crop has increased from 8 to 25 maunds/acre, and cotton from 5 to 15 maunds/acre.

25. The table shows that the cropping intensities have also increased. During crop survey it was observed in some fields that the farmers have cultivated sugarcane crop, a high delta crop. Because of changes in soil and watertable conditions farmers are now trying to change the cropping pattern in order to cultivate more profitable crops in the project area.

26. The results of this small but significant effort of postproject monitoring studies show that there is a favourable change in crop condition, watertable depth, groundwater quality, and soil salinity, etc, as shown by 6 year operation of the project. It is expected that there would be more favourable changes in each of the above parameters if the system is maintained and properly operated. The results collected so far have greatly assisted in planning and implementation of new drainage projects. With a reasonable degree of success, tile drainage system can be considered most appropriate alternative against tubewells for the drainage of soils with bad drainability and poor groundwater quality.

27. It is felt that the data collection on the above parameters should be continued for few more years so that each and every aspect of tile drainage system is studied in detail and properly evaluated.

3.2 Water and Salt Balance Studies of Pilot Tile Drainage Project Khairpur

28. Technical Advisory Committee during second meeting recommended water and salt balance studies of the pilot area. Accordingly data collection on various parameters started from June, 1991 with following objectives:

i) To assess parameters, specially drainage coefficient assumed in the design of drainage system.

ii) To measure different parameters of the water balance for management of irrigation water in the Pilot area.

iii) To measure quantity of water and its salinity which enters the Pilot area and designate a particular drainage unit or pilot area as a whole for salt balance study. The salt balance study would indicate whether desalinization has occurred in the pilot area or salinization continues.

3.2.1 Water Balance Studies

29. The water balance in the pilot area is presented as follows:

GWS = S+ R-ET-GWF-D

Where,

GWS = Groundwater storage

S = Seepage from Sathio Wah irrigation canal

I = Total irrigation application and seepage from water courses excluding evaporation.

ET = Evapotranspiration

GWF = Groundwater flow (out going seepage) from the area

D = Drainage effluent pumped out from the sumps in the pilot area.

3.2.1.1 Watertable Observation

30. Data collection for evaluation of above parameters started from June, 1991. Watertable depths were recorded monthly from all the selected 61 observation points. Average monthly watertable depths of the various blocks are given in Table 8 for the year 1992.

Table 8

Average Monthly Watertable Depth (m)

Block No.	Year 1992											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Trial	1.00	1.01	1.00	1.04	1.01	0.99	1.01	-	0.96	1.13	0.94	0.76
One	1.19	1.16	1.17	1.11	1.04	1.05	1.06	-	1.05	1.21	1.18	0.74
2-A	0.84	0.80	0.79	0.85	0.82	0.85	0.87	-	1.02	1.39	1.10	0.97
2-B/ 2-C	0.68	0.68	0.70	0.79	0.71	0.70	0.80	-	0.73	1.01	0.89	0.62
3-A/ 3-B	0.68	0.68	0.70	0.69	0.71	0.70	0.80	-	0.73	1.14	0.87	0.68
4	1.06	1.12	1.09	1.05	1.09	1.09	1.07	-	1.08	1.10	1.04	0.84

3.2.1.2 Irrigation Application and Seepage from Water Course Excluding Evaporation

31. Phase I area of the pilot project is irrigated by six water courses. Design discharge data of water courses was collected from Irrigation Department. In addition actual discharge, length, width, water depth and water quality at head and tail of each water course were measured. Table 9 presents these data.

Table 9

Design, Actual Discharge and Electrical Conductivity of Water Course

Water Course No.	Design Disch: (cusecs)	Actual Disch: (cusecs)	Length of Water Courses (m)	Width of Water Courses (m)	Water Depth (m)	EC at Head (dS/m)	EC at Tail (dS/m)
27 R	1.08	3.20	3581	0.9	0.35	0.3	0.40
28 R	0.64	0.72	855	1.0	0.36	0.3	0.40
28 R	0.64	0.90	3178	0.9	0.40	0.3	0.41
30 R	0.81	2.13	1120	1.0	0.57	0.3	0.41
32 R	1.02	2.50	2930	0.94	0.65	0.3	0.40
33 R	0.82	3.20	1200	0.88	0.22	0.3	0.40

3.2.1.3 Seepage from Sathio Wah Irrigation Canal

32. Sathio Wah irrigation canal is the line source of seepage and Kotdiji Main drain is line sink in the pilot area. Accordingly to measure seepage towards pilot area and groundwater flow towards Kotdiji Main drain 21 piezometers were installed at seven locations along Sathio Wah irrigation canal and 21 piezometers at seven locations along Kotdiji Main drain. After installation, piezometers were checked regularly. The latest position is that 60 per cent piezometers are damaged. As such watertable was measured by auger hole method. Tables 10 & 11 give the average monthly watertable depth at seven locations each along Sathio Wah irrigation canal and Towards Kotdiji Main drain respectively.

Table 10

Average Monthly Water Table Depth at Seven Locations Along Sathio Wah Irrigation Canal (m)

Site No.	Piezo-meter No.	Year 1992											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1.	1	1.00	1.10	1.20	1.30	1.35	1.40	0.56	-	1.03	0.93	0.89	0.90
	2	1.15	1.25	1.35	1.48	1.55	1.61	0.58	-	0.91	1.13	1.11	1.06
	3	1.20	1.30	1.42	1.53	1.69	1.70	0.60	-	0.72	1.14	1.12	1.10
2.	4	0.60	0.70	0.80	0.90	0.80	0.70	0.40	-	0.80	0.67	0.58	0.60
	5	0.70	0.90	1.05	1.15	1.20	1.25	1.50	-	1.00	1.01	1.02	0.91
	6	0.65	0.85	1.00	1.08	1.10	1.15	0.08	-	1.10	1.04	1.01	0.98
3.	7	0.95	1.00	0.90	1.00	1.05	1.10	1.10	-	1.56	0.89	0.91	0.99
	8	1.00	1.10	1.10	1.15	1.20	1.25	1.29	-	1.39	1.10	1.06	1.03
	9	1.05	1.15	1.20	1.55	1.30	1.35	1.25	-	1.35	1.19	1.07	1.06
4.	10	1.20	1.30	1.40	1.54	1.50	1.48	0.95	-	1.48	1.06	1.00	1.10
	11	1.25	1.35	1.45	1.50	1.65	1.70	1.00	-	1.38	1.01	1.17	1.18
	12	1.15	1.25	1.35	1.40	1.60	1.65	1.20	-	1.56	1.34	1.23	1.21
5.	13	0.69	0.70	0.75	0.80	0.70	0.60	0.35	-	0.66	0.50	0.48	0.48
	14	-	-	-	-	-	-	-	-	Ponding	do	do	do
	15	-	-	-	-	-	-	-	-	0.47	do	do	do
6.	16	0.70	0.85	0.90	0.95	1.00	0.98	1.00	-	0.65	0.79	0.81	0.79
	17	0.90	1.00	1.05	1.10	1.29	1.15	1.05	-	0.75	1.03	1.11	0.91
	18	1.00	1.10	1.15	1.20	1.15	1.10	1.45	-	0.98	0.91	0.93	0.91
7.	19	1.15	1.25	1.25	1.30	1.25	1.18	1.10	-	1.65	1.06	0.99	1.00
	20	1.20	1.35	1.40	1.48	1.52	1.42	1.50	-	Irri	1.39	1.27	1.19
	21	1.10	1.20	1.30	1.35	1.40	1.30	1.48	-	1.61	1.25	1.08	0.99

Note: All Piezometers are damaged by the local people, therefore, data was collected by auguring.

Table 11

Average Monthly Watertable Depth at Seven Sites Towards Kotdiji Main Drain (m)

Site No.	Piezo-meter No.	Year 1992 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	22	1.00	1.19	1.15	1.25	1.20	1.25	1.15	-	0.81	1.12	1.32	0.98
	23	1.10	1.20	1.25	1.25	1.30	1.35	1.20	-	0.67	1.10	1.20	1.00
	24	0.95	1.05	1.10	1.20	1.15	1.20	1.10	-	0.54	1.08	1.18	0.91
2	25	1.10	1.20	1.30	1.45	1.50	1.60	1.70	-	1.37	1.34	1.48	1.23
	26	1.20	1.35	1.45	1.40	1.45	1.50	1.60	-	1.40	1.29	1.34	1.17
	27	1.35	1.45	1.44	1.50	1.55	1.60	1.70	-	1.29	1.20	1.23	1.03
3	28	1.30	1.49	1.45	1.55	1.50	1.55	1.40	-	1.91	1.38	1.31	1.16
	29	1.05	1.05	1.15	1.20	1.15	1.20	1.05	-	1.60	1.30	1.19	1.07
	30	1.05	1.15	1.25	1.35	1.45	1.60	1.55	-	1.42	1.08	1.17	1.03
4	31	0.95	1.19	1.15	1.20	1.25	1.35	1.48	-	1.55	1.12	1.18	1.10
	32	1.19	1.29	1.25	1.35	1.40	1.55	1.60	-	1.41	1.07	1.16	1.07
	33	0.70	0.80	0.90	1.00	0.90	1.00	1.45	-	1.33	1.07	1.16	1.03
5	34	1.25	1.40	1.45	1.50	1.55	1.65	1.45	-	0.95	1.16	1.13	1.03
	35	0.75	0.90	1.00	1.05	1.10	1.15	1.10	-	0.98	1.08	1.10	0.99
	36	0.75	0.80	0.90	1.00	1.08	1.10	1.13	-	1.13	1.10	1.11	1.01
6	37	0.80	0.00	1.10	1.15	1.20	1.35	1.40	-	1.80	1.18	1.19	1.03
	38	1.20	1.35	1.45	1.40	1.60	1.70	0.90	-	1.67	1.18	1.17	1.00
	39	1.05	1.20	1.35	1.40	1.50	1.60	1.65	-	1.66	1.17	1.13	1.01
7	40	0.70	0.85	0.95	0.90	0.95	0.60	1.05	-	2.30	1.13	1.07	1.05
	41	0.60	0.60	0.65	0.60	0.65	0.60	6.90	-	1.08	1.00	0.97	1.01
	42	0.50	0.55	0.60	0.55	0.60	0.58	0.45	-	Rain Water	1.02	0.98	0.99

Note:- All piezometers are damaged, therefore data was collected by Auger holes.

3.2.1.4 Crop Survey

33. The distribution of each crop and cropping intensity in Phase-I area of the project for Kharif 1992 is presented in Table 12.

Table 12

Crop Distribution Kharif 1992

Crop	Area	Cropping Intensity (Per Cent)
Cotton	272	23
Rice	71	6
Jantar	237	20
Date Palm Orchard	331	28
Sorghum	141	12
Fallow	130	11
Total	1182	100

3.2.1.5 Seepage Towards Kotdiji Main Drain

34. For evaluation of seepage towards Kotdiji Main drain watertable depths in each piezometer installed at seven sites along drain were observed. Drainage effluent discharge was measured at all sumps for a calculation of pumpage from pilot area. Average monthly discharges are presented in Table 13 and drainage effluent pumpage in various months in block 2A is presented in Table 14.

Table 13

Average Monthly Discharge of Different Drainage Units (l/m)

Block No.	Year 1992 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Trial	-	-	-	-	-	-	-	-	-	-	-	-
1 (one)	-	-	-	-	-	-	-	-	-	-	-	-
2-A	600	560	550	580	660	670	550	560	570	400	380	390
2-B	268	250	261	145	170	225	-	-	-	-	-	-
2-C	-	-	-	-	-	-	-	-	-	-	-	-
3-A	-	-	-	-	-	-	-	-	-	-	-	-
3-B	-	-	-	-	-	-	280	290	00	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-

Table 14

Drainage Effluent Pumpage from Block 2-A

Month	Year 1992 Pumping (Days)	Pumping Time (Minutes)	Discharge (l/m)	Pumpage (Cum)
January	23	11040	600	6623
February	20	9600	560	5375
March	21	10080	550	5543
April	19	9120	580	5289
May	21	10080	660	6652
June	22	10560	670	7074
July	19	9120	550	5015
August	13	6240	650	4655
September	17	8160	570	40650

3.2.2 Salt Balance Studies

35. For salt balance studies data collection started from the month of June 1991. It included measurement of water quality at head and tail of each water course, quality of drainage effluent at each sump, water quality of lateral line and groundwater quality. Table 9 gives the water quality of each water course at head and tail. Table 15 presents the groundwater quality at selected points.

Table 15

Average Electrical Conductivity of Groundwater at Selected Grid Points (dS/m)

Block No.	Jan.	Feb.	Mar.	April	May	June	July.	Aug.	Sep.	Oct.	Nov.	Dec.
Trial	2.2	2.3	2.5	3.0	3.1	3.2	2.5	-	2.3	2.5	2.6	2.6
One	5.8	6.6	6.2	6.6	7.0	7.1	6.7	-	5.7	5.8	5.9	5.7
2-A	3.8	3.5	3.2	2.9	3.3	3.2	2.8	-	2.7	2.8	2.9	3.2
2-B	3.8	3.5	3.2	2.9	3.3	3.2	2.8	-	2.7	2.8	7.7	7.8
2-B/2-C	7.0	7.6	7.7	7.8	7.6	7.6	7.8	-	6.8	7.8	7.7	7.8
2-C	4.4	4.5	3.8	4.1	3.6	3.3	3.4	-	2.9	3.8	4.3	4.5
3-A	4.3	4.1	4.0	4.5	4.1	4.2	4.0	-	3.8	4.1	4.3	4.0
2-B	4.2	3.8	4.0	4.5	4.1	4.0	4.3	-	3.7	3.8	3.7	3.9
4	4.1	4.0	4.2	3.9	3.8	3.7	3.8	-	3.6	3.6	3.5	3.5

36. At present data on salt and water balance studies is not being collected regularly because of non availability of electricity due to non payment of bills by SCARP authorities. There is regular stoppage of pumps. Therefore, work on the above studies is not being carried out properly from 5-8-1991 to date. Regular data collection on

water and salt balance studies would be started and properly computed when pumps become in working conditions.

3.3 Surface Drainage and Watertable Control Project

3.3.1 Monitoring Activities

37. Six isolated tile drainage projects have been completed in this project. The monitoring activities continued to evaluate how far the field drainage system has remained successful in controlling the rising watertables and reclaiming the saline soils of the affected areas.

38. The monitoring activities in Sarwan Farm Karachi, Sugarcane Breeding Farm Sujawal and, Lashari Farm Khipro could not be performed due to law & order constraints in these areas. The monitoring results of other projects are summarized as below;

3.3.1.1 Tile Drainage Unit At Atomic Energy Agriculture Research Center Farm Tando Jam

39. The average drainage discharge (Q) and groundwater quality analysis of the drainage effluent of tile drainage unit at Atomic Energy Agriculture Research Centre (AEARC) Farm, Tando Jam are presented in Table 16.

Table 16

Average Drainage Discharge Q, Drainage Co-efficient q and Water Quality Analysis of AEARC Unit

Month		Q (l/m)	q (mm/day)	EC (dS/m)	pH
July	1992	156	5.05	4.49	7.6
Aug.	1992	-	-	-	-
Sep.	1992	598	19.35	6.01	7.5
Oct..	1992	-	-	-	-
Nov.	1992	309	9.93	6.25	7.6
Dec.	1992	263	8.45	5.31	7.6
Jan.	1993	398	12.79	7.23	7.6
Feb.	1993	324	10.41	5.13	7.5
March	1993	207	6.65	6.5	7.5
April	1993	135	4.36	5.25	7.6
May	1993	100	3.23	4.28	7.6
June	1993	97	3.13	4.43	7.6

40. The project area was uniformly and heavily recharged from heavy rainfall that occurred through the 2nd week of July 1992. Therefore, discharge could not be measured during August 1992 because of some repair problems in pumping machinery etc. A high drainage co-efficient was observed in the following month of September.

41. The crop survey report for the Kharif 1992 and Rabi 1992-93 of AEARC farm, Tando Jam is presented in Table 17.

Table 17

Crop Survey Of AEARC Farm

Kharif 1992 Crop	Area under Cultivation (Acres)	Total Input (Rs.)	Total Output (Rs.)
Physiology plantation	1.73	2722	-
Cotton	3.00	5074	1522
Fodder	1.3	910	200
Paddy	1.09	2085	350
Kalar Grass	0.83	650	-
Jantar	0.56	500	1000
Fallow	2.49	-	-
Total	11.00	11046	3072
Rabi (1992-93)			
Wheat	4.50	6165	8125
Physiology Plantation	1.73	605	-
Kalar Grass	0.83	650	-
Sugarcane	0.21	1567	-
Fallow	4.42	-	-
Total	11.00	8987.0	8125.0

42. The low yield obtained from the crops of kharif 1992 is because most of the plants became damaged in heavy rain water.

43. The soil analysis results as obtained after taking soil samples from the selected plots in the project area are presented in Table 18.

Table 18

Pre & Post Project Soil Analysis Data of AEARC Farm Tando Jam

Depth	1988		1989		1990		1991		1992		1993	
	EC_e*	pH	EC_e	pH	EC_e	pH	EC_e	pH	EC_e	pH	EC_e	pH
0-15	19.7	7.8	6.6	7.9	3.7	7.3	2.7	7.5	5.6	7.8	5.4	7.7
15-30	19.9	7.7	7.1	7.9	2.8	7.2	3.8	7.6	5.3	7.8	5.1	7.6
30-60	16.5	7.8	4.8	7.8	2.5	7.2	2.3	7.2	3.6	7.3	3.3	7.2
60-90	14.1	7.9	4.4	7.7	2.6	7.5	2.5	7.6	4.7	7.8	4.4	7.7
90-120	9.3	7.7	-	-	3.0	7.6	2.7	7.2	4.4	7.6	4.2	7.5

EC_e^* = The unit of EC is (dS/m)

3.3.1.2 Tile Drainage Unit At Bughio Farm Mirpur Khas

44. The results of the monitoring work performed at this drainage unit are presented in two tables. Table 19 presents the results of hydrologic monitoring and Table 20 gives details of crops grown and their out puts. The soil samples were collected for soil salinity analysis from various depths of soil profile and sent to laboratory for analysis. However, the analysis results have not been received so far.

Table 19

Average Drainage Discharge Q, Drainage Coefficient q, and Water Quality Analysis of Bughio Farm Unit

Month	Q (l/m)	q (mm/day)	EC (dS/m)	pH
July 1992	-	-	-	-
Aug. 1992	411	3.65	4.83	7.6
Sep. 1992	480	4,26	4.16	7.6
Oct.. 1992	397	3.43	5.25	7.5
Nov. 1992	400	3.55	4.5	7.6
Dec. 1992	-	-	-	-
Jan. 1993	-	-	-	-
Feb. 1993	-	-	-	-
March 1993	-	-	-	-
April 1993	238	2.12	6.5	7.5
May 1993	287	2.55	4.2	7.51
June 1993	300	2.67	-	-

Table 20

Crop Survey Of Bughio Farm

Kharif 1992 Crop	Area under Cultivation (Acres)	Total Input (Rs.)	Total Output (Rs.)
Sugarcane	8	10000	----
Jantar	8	8000	15250
Banana	3.76	10009	----
Physiology plantation	7.3	2722	----
Fallow	12.94	----	----
Total	40.00	30731	15250
Rabi (1992-93)			
Sugarcane	12.82	19460	134533
Cauliflower (Inter Crop in S.C)	1.68	2792	3379
Onion (Inter Crop in S.C)	1.96	3911	13712
Wheat	6.71	9617	19627
Physiology Plantation	7.30	----	-----
Toorio	0.31	654	992
Berseem	2.71	6429	21849
Fallow	10.15	3023	-----
Total	40.00	45886	194092

3.3.1.3 Tile Drainage Unit AT Nawazabad Farm Hyderabad

45. The monitoring results of Nawazabad Farm are presented in Table 21 & 22. Table 21 gives the results of hydrologic monitoring and Table 22 presents the seasonal crop survey and the benefits accrued from crop yields.

Table 21

Average Drainage Discharge Q, Drainage Co-efficient q and Water Quality Analysis of Nawazabad Farm Unit

Month	Q (l/m)	q (mm/day)	EC (dS/m)	pH
July 1992	-	-	-	-
Aug. 1992	-	-	-	-
Sep. 1992	-	-	-	-
Oct.. 1992	277	1.00	5.50	7.5
Nov. 1992	657	2.36	7.5	7.6
Dec. 1992	-	-	-	-
Jan. 1993	275	0.99	7.45	7.5
Feb. 1993	119	0.43	3.83	7.6
March 1993	102	0.37	5.75	7.4
April 1993	134	0.48	6.5	7.6
May 1993	700	2.52	9.12	7.5
June 1993	530	1.90	8.8	7.9

Table 22

Crop Survey of Nawazabad Farm

Kharif 1992 Crop	Area under Cultivation (Acres)	Total Input (Rs.)	Total Output (Rs.)
Mango Garden	60	95777	52523
Cotton as Inter Crop in Mango Garden	44	31900	68640
Guava Garden	5.0	1945	-
Coconut Garden	2.0	1145	-
Physical Plantation	3.55	1197	-
Cotton	3.0	4854	10200
Fallow	26.45	7913	-
Total	100	144731	131363

Rabi 1992-93

Mango Garden	60.00	18960	-
Wheat (Inter Crop in M.G.)	30.00	17850	41925
Guava Gaeden	5.00	2180	-
Wheat Inter Crop in G.G)	5.00	8675	8612
Wheat	4.44	5732	9408
Physiology	3.55	774	-
Plantation			
Fallow	27.01	2863	-
Total	100.00	57034	59945

3.3.2 Completion Report

46. Completion report of the Surface Drainage and Watertable Control Project is under preparation. A draft of the report has been sent to IIMI, Lahore. Technical papers are also produced. These are mentioned in DRIP publication section later.

3.4 Skimming Well Modelling for Irrigation and Drainage of Agricultural Lands

3.4.1 Survey and Investigations

47. The primary and detailed survey of following sites were performed in order to explore the soil lithology, groundwater position & quality and to work out the feasibility of skimming wells in those sites.

i) Samar Zar Farm Gadap Road, Karachi.

ii) Sand Farm and Sayed Mazhar Ali Shah Farm Bhit Shah.

iii) Feroz Din Shah Farm near Matiari.

iv) Rind Farm at Jatoi near Sanghar.

v) Peer Amjid Hussain Shah Farm near Hyderabad.

48. The test bores were made upto the depths of 90 - 110 feet and soil stratification noted. Soil and water samples were collected and got analysed from laboratory. The feasibility of skimming wells was worked out on the basis of technical information.

3.4.2 Tube Well & Piezometers Installation

49. A skimming well physical model was installed at Noor Khan Farm near Gumbut District Khairpur. After completion 14 piezometers were installed at this farm in order to note the fall in watertable by operating tube well. Ten piezometers were installed at Panhawar Farm District Shikarpur so that time to time monitoring trials might be carried out. A pump house was also constructed at Jagir Farm for the security of pumping machinery and facilitating the monitoring activities.

3.4.3 Monitoring Activities

50. The skimming well installed at Junaid Farm Shikarpur was visited for monitoring purposes. During that visit the pump was got operated and its discharge measured. The time-draw data was collected for a 4-hour continuous operation of the tube well. The area under the domain of skimming well physical model was under heavy irrigation to rice crop grown there. Therefore distance draw-down informations could not be noted and monitoring trial was quit till the area is free from heavy irrigations. However, the water samples ware taken from each piezometer and from tube well discharge after each hour of

pump operation so that the changes in water salinity might be noted with the pump operation.

51. The pump of Noor Khan Farm was operated for about two days and pumping test data was collected to estimate the aquifer parameters.

52. The usual monitoring of skimming well at DRIP Campus Tando Jam continued as and when the pump was got operated for supplemental irrigation purposes. In addition to that the seasonal fluctuations in watertable were also noted through piezometers installed at DRIP Campus in the domain of skimming well.

3.4.4 Computer Modelling

53. The modelling activity of DRIP Campus skimming well computer remained in progress. The model has already been calibrated for steady state conditions. During this year the calibration runs for non-steady-state conditions were taken and considerable progress was achieved. However, some technical difficulties were faced during the model calibration for solute transport.

3.5 Development of Tile Drainage Project in Phase-II Area of DRIP in East Khairpur Tile Drainage Pilot Project

3.5.1 Monitoring Of Tile Drainage Unit at Jagir Farm

54. The drainage system installed is working properly and post project monitoring is being performed by DRIP Monitoring Unit established at Khairpur. Data collection on soil salinity sampling, watertable measurements and crop survey was completed. Further data

collection was stopped due to non installation of pump at sump. Therefore, it was decided that data collection on different parameters will be started after installation of pumps. Meanwhile manholes were cleaned so that chocking or any other problem might be identified before installation of pump.

3.5.2 Monitoring of Tile Drainage Unit at Nabi Shah Farm

55. Watertable measurements were taken weekly. However, in the last quarter no discharge measurements were taken due to non-functioning of pump and lack of proper disposal system. Table 23 gives watertable measurements in the unit area.

Table 23

Watertable Position at Nabi Shah Farm Tile Drainage Unit

Maximum (m)	Minimum (m)	Average (m)
1.72	1.30	1.59

3.5.3 Construction of Tile Drainage Unit at Soomra Farm

56. The construction of drainage unit at Soomra Farm, Jacobabad is complete. The tile drainage has been introduced over a total area of 150 acres. The total length of lateral lines is about 5250 meters and collector line is 800 meters. The two kinds of filter materials, comprising of coconut fiber and gravel, have been used around the perforated pvc laterals. On the basis of hydraulic conductivity value

of 1.36 m/day the laterals have been laid about 125 m apart. A total number of 11 manholes and 2 sumps have been constructed in this project. The project has been partly funded by Pakistan Science Foundation. It also have been decided that two students working for Master Degree in Mehran Engineering University will present their thesis based on the data collected from the monitoring of this Farm. The monitoring work will soon be started under the supervision of Deputy Director Monitoring DRIP Khairpur.

3.6 Qadirabad Drainage Research Pilot Project

57. The prime objective of this project is to install a comprehensive type of drainage system that includes the tile drains, disposal drains and tubewells in the area. Moreover, it is aimed that the further activities will be tailored in this field keeping in view the research findings of this project. The work was partly left pending because of heavy torrential rains at the beginning of this year. The investigations were restarted on the field drainage parameters when the rainy season was over.

58. For this purpose the blocks 6A and 6B were selected. The design parameters of these blocks were revised. The new values of these design parameters are:

i) The hydraulic conductivity, K = 0.75 m/d

ii) The drainage co-efficient, q = 3.00 mm/d

iii) The drain spacing, S = 80 m

59. The design maps for field parameters were redrawn to rectify any confusion to field engineer. The previous contractor failed to

show any appreciable progress in construction of drainage system therefore his contract was cancelled. It has been decided that the construction work at Qadirabad project will be performed by DRIP construction unit itself. Therefore, the material requirements for blocks 6A and 6B have been worked out and supply orders placed for the pvc lateral and collector pipes. The material required for the manholes, sump constructions, and pumping units for disposal of groundwater will be arranged from nearest local markets. The DRIP pipe laying machines are in transition stage for shifting from Jacobabad project to Qadirabad tile drainage Research Project. The planning for construction work schedule is in progress.

60. Meanwhile the survey team continued the survey work of agriculture practices being performed in the project area. These informations will set up the base line for evaluating the benefits of drainage system when it operates.

3.7 Alternative Project Development for Drainage of Irrigated Lands

61. Under this project a tile drainage unit at Essani Farm, Jacobabad district has been constructed and put into operation. Monitoring of this unit has been going on since the completion of the project. For watertable measurements 30 piezometers are installed. Watertable in the project area is not controlled satisfactorily because of high seepage rate from two irrigation minors passing around the project area, and due to lateral groundwater flow from the adjoining rice fields. Table 24 gives the watertable position as observed in the last quarter (April-June 1993). Discharge measurement

could not be taken due to stoppage of pump. The pump was stopped due to canal closure to provide residual moisture to orchard trees and sugarcane crop.

Table 24

Maximum, Minimum and Average Watertable in Essani Farm Project Area

Maximum (m)	Minimum (m)	Average (m)
2.90	0.96	2.20

3.8 Salt Affected Soils and Their Reclamation Project

62. Under this project the Institute mainly carried out the studies on reclamation through different reclamative measures and use of saline drainage effluent. These studies are briefly reported here:

i) **Reclamation of Saline-Sodic Soils by Gypsum under Tile Drainage System Being Conducted at Atomic Energy Agriculture Research Farm Tando Jam**

63. Three years of study are complete and data on three berseem and three rice crops were recorded and a technical paper was published in DRIP Journal. After completion of this experiment in order to see the desalinization process the wheat-cotton rotation was tested. The objective is to see whether the soils become desalinized once these are reclaimed by Gypsum under tile drainage system or not. Wheat crop (Sursabaz-variety) was sown in Rabi 1992-93 and cotton (NIAB-78) has been sown during Kharif 1993 for economic evaluation of tile drainage system on the same experimental area. Wheat was harvested from this

experimental plot and average yield of 3000 Kg per hectare was recorded in all the treatments. Soil samples were collected and analysed in the S&W analysis laboratory. It is revealed from the results that desalinization has not occurred so far. After preparation of land, cotton is sown under this experiment as Kharif 1993 crop.

ii) Performance of Sorghum, Maize and Sudan Grass for Dry Matter Production in Calcareous Saline-Sodic Soils

64. This experiment was started at Atomic Energy Agricultural Experimental Farm Tando Jam under Tile Drainage System. Under this experiment data on three crops of Sorghum, Maize and Sudan grass was collected, whereas fourth crop has been sown in May 1993 and data collection is in progress. The pre and post harvest data of third crop regarding soil and forage was tabulated during the period under report. Table 25 reports this data.

Table 25

Soil Analysis and Average Yield of Crops

Soil Parameter after 3rd crop upto the depth of 90 cm.	T1 Sorghum		T2 Sudan Grass		T3 Maize		T4 Control	
	1.	2.	1.	2.	1.	2.	1.	2.
ECe (dSm-1)	6.56	5.54	8.10	7.16	6.35	5.38	9.69	9.49
pH	8.29	8.00	8.30	8.42	8.59	7.55	7.62	7.80
SAR	12.82	12.44	8.79	9.90	10.57	9.44	15.77	15.98
ESP	14.64	13.66	10.46	10.94	13.15	12.45	17.77	18.06
Average yield Tons/ha	126		83		102			

1= Pre sowing and 2 = After sowing

65. It is observed that sorghum performed well among three forage crops under study as regards increase in yields and reduction in soil salinity.

iii) **Effect of Different Irrigation Levels on Soil Salinity**

66. This experiment is being conducted at DRIP Campus, Tando Jam. The main objective of study is to see whether the salts are deposited in the soil profile or not by application of 100% consumptive use, 125% consumptive use and 75% consumptive use of crops. The soil and yield data from three cotton and three wheat crops have been obtained, statistical analysis of data is completed and literature is sorted out for report writing. From results it is observed that 75% CU has less influence on increase in soil salinity but there is no any significant difference among the treatments.

iv) **Comparative Effect of Organic, Inorganic and Biological Materials on the Reclamation of Saline-Sodic Soil under Tile Drainage Area**

67. This experiment was conducted at Bughio Farm near Mirpurkhas under Tile Drainage Area. Data on two berseem and two rice crops was completed under this experiment. Salient features of the study are as under:

i) Nature of Soil :

a) Soil texture: Silt loam

b) Bulk density: 1.42 gcm^{-3}

c) Infiltration rate: 0.85 m day^{-1}

d) Kind of Soil: Saline- Sodic

e) ECe : 13.3 dSm^{-1}

f) pH : 8.8

g) SAR : 33.0

h) ESP : 33.6

ii) Treatments

T1 = 100% G.R of soil upto 30 cm depth

T2 = 50% G.R of soil upto 30 cm depth

T3 = Kallar grass

T4 = Press mud at 20 tons/acre

T5 = Press mud at 10 tons/acre

T6 = Press mud at 20 tons/acre + 50% G.R

T7 = Press mud at 10 tons/acre + 50% G.R

T8 = Control

iii) Period of Study : Kharif 1989 to Rabi 1990-91

68. Table 26 gives the yield of rice and berseem. Table 27 gives the effect of treatments on soil.

Table 26

Average Yield of Rice and Berseem (Tons/h)

Crop	T1	T2	T3	T4	T5	T6	T7	T8	
Rice 1989	0.22	0.10	-	-	-	-	-	0.05	NS, LSD at 5% 0.35
Berseem 1989-90	5.23	2.09	-	-	-	-	-	3.04	NS, LSD at 5% 1.08
Rice 1990	a 2.92	a 3.04	-	a 2.83	ab 2.08	ab 2.11	ab 1.97	ab 2.00	NS, LSD at 5% 2.37
Berseem 1990-91	a 28.98	a 41.42	-	ab 20.14	ab 18.29	ab 17.03	ab 16.14	ab 16.79	NS, LSD at 5% 17.69

Table 27

Effect of Various Treatments on Soil Properties (0-90 cm depth)

Treatments		T1	T2	T3	T4	T5	T6	T7	T8
ECe	Initial	13.13	13.13	13.13	13.13	13.13	13.13	13.13	13.13
	Final	3.78	2.87	5.02	4.70	4.21	4.24	5.59	4.35
	% Reduction	71.02	81.01	61.07	64.02	67.09	67.07	57.04	66.08
pH	Initial	8.78	8.78	8.78	8.78	8.78	8.78	8.78	8.78
	Final	7.79	7.31	7.81	7.42	7.88	7.85	7.87	7.90
	% Reduction	11.27	16.74	11.04	15.05	10.02	10.59	10.03	10.00
SAR	Initial	34.35	34.35	34.35	34.35	34.35	34.35	34.35	34.35
	Final	16.64	12.39	14.69	16.31	15.53	12.79	17.28	18.10
	% Reduction	51.05	63.09	57.02	52.05	54.07	62.07	49.07	47.03
ESP	Initial	32.91	32.91	32.91	32.91	32.91	32.91	32.91	32.91
	Final	18.01	14.11	18.68	18.24	17.60	14.64	19.00	19.78
	% Reduction	45.02	57.01	43.02	44.05	46.05	55.05	42.02	39.09

69. From the research findings, it can be concluded that applying 50% of the gypsum requirement for sodic/saline sodic soils is effective in reducing sodicity and increasing crop yields. However, press mud and kallar grass could also be used in reclaiming the soil over time and could be economically used as reclaimants in sodic soils. The technical report has been written and a technical paper also produced and presented in the ISM-R symposium held at Lahore in April 1993.

v) Reclamative Effect of Recommended Irrigation Practices on Saline Soil (Medium texture)

70. This research study was started at Nawazabad Farm tile drainage area near Mirpurkhas. The purpose of this study is to determine the effect of cotton and wheat on saline soil under tile drainage condition. Due to prevailing law and order situation this study was stopped for a year and thereafter is restarted from rabi 1992-93 with sowing and data collection of wheat crop. The yield obtained from different treatments in plot size of 30'x40' is as: T1 R1 = 65 Kgs, T1 R2 = 45 Kgs, T1 R3 = 80 Kgs, T1 R4 = 62 Kgs, T2 R1 = 60 Kgs, T2 R2 = 70 Kgs, T2 R3 = 65 Kgs, T2 R4 = 08 Kgs, T3 R1 = 55 Kgs, T3 R2 = 65 Kgs, T3 R3 = 15 Kgs and T3 R4 = 75 Kgs.

Where T1 = Recommended irrigation delta for cotton and wheat,

T2 = T1 + leaching fraction to bring down original soil salinity 8.00 dS/m upto a depth of 90 cm,

T3 = T1 + leaching fraction to bring down the original soil salinity to 4.00 dS/m upto a depth of 90 cm.

71. Soil salinity status was also observed at the end of wheat crop and there is positive effect of each treatment. The study would be continued for two more years, therefore it is too early to draw any conclusions at this stage.

vi) **Use of Saline Groundwater Effluent for Crop Cultivation**

72. The experiment is in progress in Block 2A at Khairpur. The objectives of the experiment are:

i) To see the effect of saline groundwater on crop cultivation

ii) To see the effect on crop yields in normal soil by using marginal and hazardous water in order to exploit groundwater resources for crop cultivation.

73. The treatments replicated thrice are:

T1: Canal water

T2: Drainage effluent

T3: 1:1 Drainage effluent + canal water

T4: Alternate drainage effluent and canal water

74. The soil is medium texture or moderately fine texture, slightly saline (Ece 4-8 dS/m) or non saline (ECe less than 4 dS/m) porous, and permeable. Drainage effluent having an EC of 4000 micromhos/cm was used for crop cultivation. The experiment was started from Kharif 1993 and would end in Rabi 1994-95. Cotton and wheat are the test crops. The EC of canal water used was 300 to 400 micromhos per cm.

75. First cotton crop sown in Kharif 1992 was totally damaged due to heavy rain fall in the area, therefore no yield was obtained.

Wheat as Rabi 1992-93 was cultivated and yield obtained was recorded. At present cotton as a Kharif 1993 crop has been sown and the growth of crop is normal and results are being recorded according to schedule.

vii) **Effect of Saline Groundwater on Salt Affected Soils**

76. The experiment is in progress in Block 2-C at Khairpur. The objectives of the experiment are:

i) To see the effect on saline soil by using marginal/hazardous groundwater effluent.

ii) To see the effect on yields of crops and if the results achieved are positive, then use of saline groundwater could be exploited and more saline lands could be brought under cultivation.

77. The treatments replicated thrice are:

T1: Recommended irrigation (Saline groundwater EC 3-4 mmhos/cm) with soil salinity (ECe 20-30 dS/m).

T2: T1 + leaching fraction to bring down original soil salinity to 8 dS/m upto 100 cm depth.

T3: Recommended irrigation with mixing ratio of 25% saline groundwater + 75% canal irrigation water + leaching fraction to bring down original soil salinity to 8 dS/m upto 100 cm depth.

T4: Recommended irrigation with mixing ratio of 50% saline groundwater + 50% canal irrigation water + leaching fraction to bring down original soil salinity to 8 dS/m upto 100 cm depth.

78. The soil is medium textured and saline (ECe 20-30 dS/m). The salinity of groundwater effluent is 3-4 mmhos/cm while that of canal

water ranges 0.3 to 0.4 mmhos/cm. The test crops are berseem in Rabi and Dhancha in Rabi and rice in Kharif for the third year.

79. Two years' cropping has been completed as Dhancha in Kharif and Barseem in Rabi. The results are encouraging with Dhancha and Barseem crop. In third year wheat as Rabi 1992-93 crop was sown. As this was the first cereal crop, therefore due to surface salinity crop growth was poor and yield was negligible. The last Dhancha crop in Kharif 1993 is cultivated. Crop growth is normal. The experiment would be completed after the harvesting of Dhancha crop in Kharif 1993.

3.9. Lysimeter Studies in Sindh

80. A research study titled " Determination of Reference Evapotranspiration (ETr) under different watertable depths" is in progress in lysimeters at DRIP Campus. There are 12 lysimeters (3 m x 3 m x 5 m). Half of these lysimeters are filled with Sultanpur soil series while the other half are filled with Miani soil series. Three watertable depths replicated twice in each soil are kept. The watertable depths kept are, i) 1.5 m, ii) 2.25 m and iii) 3.0 m. Alfalfa is sown as reference crop in all the lysimeters which is being clipped at a recommended height in between 30 to 50 cm regularly. Weekly irrigation of 75 mm depth is being applied as surface irrigation (canal water) so that the crop may not be short of water, whereas watertable depths are maintained by supplying water to each lysimeter from marriotte bottles daily. Drainage water coming from each lysimeter is measured daily and recorded. Thus reference evapotranspiration (actual crop Etr) is calculated as under:

ETr(mm) = (Irr+Ir+R)-Dr

whereas, ETr = Reference Evapotranspiration in mm, Irr = Surface irrigation (mm), Ir= Subsurface irrigation (water consumed in maintaining the watertable depths in mm), R = rainfall in mm(if any) and Dr= drainage water in mm.

81. The results achieved under the report period are presented in Table 28.

Table 28

Monthly ETr and Average Daily ETr

Watertable Depth(m)	Dec. 1992	Jan. 1993	Feb. 1993	March 1993	April 1993	May 1993	June 1993
			Monthly ETr (mm)				
1.50	89.9	34.1	61.6	130.2	186.0	241.8	474.0
2.25	74.4	24.8	58.8	117.8	177.0	241.8	438.0
3.00	68.2	19.5	56.0	108.5	174.0	198.4	375.0
			Avg. Daily ETr(mm)				
1.50	2.9	1.1	2.2	4.2	6.2	7.8	15.8
2.25	2.4	0.8	2.1	3.8	5.9	7.8	14.6
3.00	2.2	0.6	2.0	3.5	5.8	6.4	12.5

82. For comparison of ETr, potential evapotranspiration (ETp) has been calculated also using modified Penman equation and crop coefficient (Kc) values are estimated as:

$$Kc = \frac{ETr}{ETp}$$

83. Table 29 presents the ETp

Table 29

Monthly ETp and Average Daily ETp

Dec. 1992	Jan. 1993	Feb. 1993	March 1993	April 1993	May 1993	June 1993
			Monthly ETp (mm)			
86.8	77.5	75.6	164.3	198.0	285.2	309.0
			Avg. Daily ETp(mm)			
2.8	2.5	2.7	5.3	6.6	9.2	10.3

84. As ETr or actual crop consumptive use (cu) is different for each watertable depth, therefore Kc values are also different for each watertable depth as given in Table 30.

Table 30

Kc Values at Different Watertable Depths

Watertable Depth(m)	Dec. 1992	Jan. 1993	Feb. 1993	March 1993	April 1993	May 1993	June 1993
1.50 m	1.03	0.44	0.81	0.79	0.93	0.84	1.53
2.25 m	0.85	0.32	0.77	0.71	0.89	0.84	1.41
3.00 m	0.78	0.25	0.74	0.66	0.87	0.69	1.21

3.10. Water Requirement of Major Crops under Field Conditions

85. Over and under irrigations to crops not only decrease the yields but also create the problems of waterlogging and salinity. The main objectives of this research are to determine optimum quantity or irrigation water for optimum yields of major crops. In this way an appreciable quantity of irrigation water could be saved which can be used either for reclaiming salt affected lands or to bring new agricultural lands under cultivation, thereby increasing the agricultural production of the country.

86. Keeping in view the above objectives, the following research studies are being carried out at DRIP Campus, Tando Jam. These studies will be completed by the end of October 1993.

i) Determination of Consumptive Use of New Cotton and Wheat Varieties and Soil Salinity Assessment at Different Irrigation Levels

87. Cotton in Kharif and wheat in Rabi are being studied for consumptive use of water. Two years under cotton have been completed and third year i.e. 1993 crop is in progress. Under the report period, cotton (TH3/83 variety) obtained from Agriculture Research Institute, Tando Jam was sown in May 1992 and cotton picking was completed in October 1992 in two pickings.

88. The main objectives of this study are, i) to determine water requirement of TH3/83 variety of cotton and wheat (S-230 variety) and to assess the salinity status of the soil under different irrigation levels. Thus three treatments each with four replications are kept in this study for both the crops. The treatments are as under:

T1 = 0.75 cu

T2 = 1.00 cu
T3 = 1.25 cu

89. The size of each plot is 16 m x22 m. Thus there are 4x3=12 plots. For the assessment of soil salinity five soil samples are taken from each field plot before sowing and after harvest of each cotton and wheat crop. The soil samples are drawn at depths 0-15 cm, 15-30 cm, 30-60 cm, 60-90 cm, and 90-120 cm. These samples are analysed for ECe and pH values in DRIP laboratory. The irrigations are applied on the basis of daily ETp which is calculated from climactical parameters using modified Penman equation and by multiplying it with Kc values of the relevant days. However, the water requirement or cu is calculated on the basis of root development of the plant, as because of increasing height of plant and its root, cu is also increased. All the cultural practices such as seedbed preparation, sowing method, fertilization, interculturing etc are followed as per recommendations of Agriculture Research Institute (ARI), Tando Jam. The irrigation water is applied through cut throat flume which is installed in water channel. The yields are estimated on whole plot basis. The results of cotton 1992 crop and wheat 1992-93 crop are presented in Table 31. Table 32 presents the soil salinity assessment.

Table 31

Water Requirement of Cotton and Wheat under Field Conditions

Treatments	Yield (tons/ha)	Water Used (mm)	W.U.E Kg/mm/ha
	a. Cotton 1992		
T1 (0.75 cu)	1.97	440.05	4.47
T2 (1.00 cu)	2.14	542.21	3.95
T3 (1.25 cu)	2.16	644.37	3.35

b. Wheat 1992-93

T1 (0.75 cu)	3.67	492	7.46
T2 (1.00 cu)	3.58	516	6.93
T3 (1.25 cu)	4.09	557	7.34

W.U.E = Water Use Efficiency.

Table 32

Soil Salinity Assessment

Treatments	Wheat 1990-91		Cotton 1991		Wheat 1991-92		Cotton 1992	
	ECe	pH	ECe	pH	ECe	pH	ECe	pH
T1	3.9	7.6	2.6	7.6	3.6	7.9	2.8	7.8
T2	2.9	7.8	2.5	7.7	2.2	7.8	2.5	7.7
T3	2.7	7.6	2.9	7.7	3.0	7.8	2.1	7.6

EC_e= Electrical conductivity of soil saturated paste extract in dS/m at 25°C. Values are average of 4 replications.

90. Tables 31 & 32 reveal that T1 is dominant over T2 and T3, and salinity of the soil remains almost unchanged in all the treatments. However, statistical analysis of data would conclude the results finally.

ii) **Testing of Irrigation Scheduling of Cotton and Wheat**

91. After conducting the research in lysimeters and under field conditions on cotton and wheat crops, keeping in view the rotational delivery system of irrigation water (warabndi) being practised in the country, DRIP has formulated irrigation schedulings of cotton and wheat for lower Sindh. Therefore, these irrigation schedulings of cotton and wheat are being tested at DRIP Campus so that after the verification and confirmation of results these could be recommended to the farming community. In this way the farmers would be able to avoid

over and under irrigation to cotton and wheat crops for obtaining optimum yields and to prevent waterlogging and salinity problems of their lands.

92. The irrigation schedulings of cotton and wheat are presented below:

a) **Irrigation Scheduling of Cotton**

Soaking dose =100 mm

Six subsequent irrigations each 75 mm depth after soaking dose that is:

1st irrigation = after 4 weeks

2nd irrigation = after 7 weeks

3rd irrigation = after 10 weeks

4th irrigation = after 13 weeks

5th irrigation = after 15 weeks

6th irrigation = after 18 weeks

Total water = 75 x 6 + 100 = 550 mm

b) **Irrigation Scheduling of Wheat**

Soaking dose =75 mm

Five subsequent irrigations each 75 mm depth after soaking dose that is:

1st irrigation = after 21 days

2nd irrigation = after 42 days

3rd irrigation = after 77 days

4th irrigation = after 105 days

5th irrigation = after 130 days

Total water = 75 x 5 + 75 = 450 mm

93. The said irrigation schedulings of cotton and wheat are under test since Rabi 1990-91 wheat crop at DRIP Campus for a period of three years. It is pointed out that three years under wheat crop have been completed, whereas two years under cotton are completed and third cotton crop is in progress.

94. The irrigation water is applied through cut throat flume which is installed in water channel and all the cultural practices such as seedbed preparation, sowing, fertilization, interculturing, pesticide applications etc are being followed as per recommendations of ARI, Tando Jam. It is pointed out that due to heavy rains received in July-August 1992, all irrigations were not applied. However, the effective rainfall was taken into account. It is further stated that low yield of cotton in 1992 attributed to extra ordinary rains received during flowering stage of cotton. The yields are estimated on whole plot basis which are further calculated as tons/ha.

95. Under this study, eight field plots each 20 m x 23.5 m are kept for each cotton and wheat crop. To compare the results, four field plots are under scheduling and four plots under farmers' conditions (control). The results of cotton 1992 and wheat 1992-93 crops are reported in Table 33.

Table 33

Testing of Irrigation Scheduling of Cotton and Wheat

Treatments	Yield (tons/ha)	Water Used (mm)	W.U.E Kg/mm/ha
	a. Cotton 1992		
T1 = Scheduling	458.6	0.99	2.15
T2 = Farmers' Condition	608.6	1.00	1.64
	b. Wheat 1992-93		
T1 = Scheduling	450	3.36	7.46
T2 = Farmers' Condition	600	3.34	5.56

W.U.E = Water Use Efficiency.

96. Although the yields of cotton and wheat are almost the same in both the treatments but water consumption is more in T2 as compared with T1. Hence the water use efficiency is more in T1 as compared with T2. However, to come to a logical conclusion, statistical analysis of the data is necessary which is in hand.

iii) Effect of Alternate Skipping from Traditional Supply Irrigation System on the Yield of Cotton and Wheat

97. The main objectives of this study are to see the effect of skipping irrigation application on crop yields of cotton and wheat against traditional irrigation supply system being practised by the farmers, and saving of irrigation water. As the irrigation scheduling of cotton and wheat are different, therefore different treatments are kept in both the crops. This study was started in Rabi 1990-91 crop for a period of three years. Three wheat and two cotton crops are

completed under this study and third and final cotton crop is in progress which is sown in May 1993.

98. Under this study cotton (NIAB-78 variety) and wheat (Soghat variety) have been sown. All the cultural practices such as seedbed preparation, sowing, fertilization, interculturing and plant protection measures are followed as per recommendations of ARI, Tando Jam, whereas after calculations irrigation water is applied through cut throat flume which is installed in water channel for the purpose. There are 8 treatments in cotton and 7 treatments in wheat each with three replications. Thus there are 24 plots in cotton and 21 plots in wheat. The size of each plot is 19 m x 16 m. Randomized Block Design of layout is followed. The treatments of cotton and wheat crops are as under:

a) **Cotton Treatments**

T1 = All the 6 irrigations each 75 mm depths after 4,7,10, 13,15,and 18 weeks after soaking of dose 100 mm depth.

T2 = All irrigations according to farmers' condition.

T3 = Subsequent irrigation after 7,10,13,15, and 18 weeks after soaking dose.

T4 = Subsequent irrigation after 4,10,13,15, and 18 weeks after soaking dose.

T5 = Subsequent irrigation after 4,07,13,15, and 18 weeks after soaking dose.

T6 = Subsequent irrigation after 4,07,10,15, and 18 weeks after soaking dose.

T7 = Subsequent irrigation after 4,07,10,13, and 18 weeks after soaking dose.

T8 = Subsequent irrigation after 4,07,10,13, and 15 weeks after soaking dose.

b) **Wheat Treatments**

T1 = All five irrigations each 75 mm deep after 21,42,77,105 and 130 days after soaking dose of 75 mm.

T2 = All irrigations according to farmers' condition.

T3 = Subsequent irrigation(75 mm) after 42,77,105 and 130 days after soaking dose.

T4 = Subsequent irrigation (75 mm) after 21,77,105 and 130 days after soaking dose.

T5 = Subsequent irrigation (75 mm) after 21,42,105 and 130 days after soaking dose.

T6 = Subsequent irrigation (75 mm) after 21,42,77 and 130 days after soaking dose.

T7 = Subsequent irrigation (75 mm) after 21,42, 77, and 105 days after soaking dose.

99. The yields are estimated on whole plot basis under each treatment of cotton and wheat. The results of cotton 1992 and wheat 1992-93 crops are presented in Table 34.

Table 34

Water Used, Yield and Water Use Efficiency in Cotton and Wheat under Alternate Skipping

Treatments	Water Used (mm)	Yield (tons/ha)	W.U.E Kg/mm/ha
	a. Cotton 1992		
T1	458.6	1.18	2.57
T2	608.6	1.17	1.92
T3	383.6	1.21	3.15
T4	383.6	1.23	3.21
T5	383.6	0.78	2.03
T6	383.6	0.96	2.50
T7	383.6	1.07	2.78
T8	383.6	1.05	2.73

b. Wheat 1992-93

T1	450	3.50	7.77
T2	600	3.94	6.56
T3	375	3.50	9.33
T4	375	3.61	9.62
T5	375	3.00	8.00
T6	375	3.50	9.33
T7	375	3.34	8.90

W.U.E = Water Use Efficiency.

100. Table 34 reveals that in cotton higher water use efficiency was obtained in T4 and T3 followed by T7,T8, T1, T6, T5 and T2, whereas in wheat T3 and T6 dominate over other treatments. However, to come to a logical and scientific conclusion, statistical analysis of the data is necessary which is in hand. It is pointed out that cotton yield in all the treatments is low due to extra ordinary rains received in July-August 1992 during the flowering stage of cotton crop.

iv) Effect of Different Irrigation Methods on the Yield of Cotton

101. This study was started in May 1991 for a period of three years with the objectives, i) saving of irrigation water under different irrigation methods and, ii) to see the effect of these methods on the yield of cotton in relation to water consumption. Under this study two cotton crops have been completed and third and last cotton crop (sown in May, 1993)is in progress. The following six treatments each with four replications are kept in this study:

T1 = Ridges and furrows (irrigation to every furrow (with 0.75 cu)

T2 = Broad ridges and furrows (with 1.0 cu)

T3 = Ridges and furrows (with 1.0 cu)

T4 = Broad ridges and furrows (with 0.75 cu)

T5= Basin irrigation (with 1.0 cu), and

T6 = Basin irrigation (with traditional irrigation)

102. The plot size is 12 m x 11 m. For 6 treatments each with 4 replications, thus there are 24 plots. All the cultural practices such as sowing, fertilization, interculturing, pesticide applications etc. are being followed as per recommendations of ARI Tando Jam. The quantity of irrigation water to be applied in each treatment is calculated on the basis of ETp multiplied by Kc values of the relevant period and is applied through cut throat flume which is installed in the water channel for the purpose. Rehamani variety of cotton is sown in all the three years. The yield under each treatment is estimated on whole plot basis. The results of this study during the period of report that is cotton 1992 crop are presented in Table 35.

Table 35

Yield of Cotton under Different Methods of Irrigation

Treatments	Water Used (mm)	Yield (tons/ha)	W.U.E Kg/mm/ha
T1	601.6	0.82	1.36
T2	750.6	0.72	0.94
T3	758.6	1.57	2.06
T4	601.6	0.78	1.29
T5	458.6	1.43	3.11
T6	533.6	1.55	2.90

W.U.E = Water Use Efficiency

103. The above results reveal that water use efficiency dominates in T5 followed by T6, T3, T1,T4 and T2. However, final conclusions will be drawn after statistical analysis of the data and completion of cotton 1993 crop. It is pointed out that above mentioned yield of cotton in all the treatments is low because of heavy rains received in July-August 1992 during flowering stage of cotton.

3.11 Collaborative Research in Water Management

104. DRIP conducts collaborative research with other organizations in the field of water management. The collaboration with Pakistan Science Foundation and Sindh Forest Department are worth mentioning.

3.11.1 Collaboration with Pakistan Science Foundation

105. A research project " Developing Management Model for Optimum Use of Water Resources Under System Constraints" sponsored by Pakistan Science Foundation, is being implemented by DRIP. Under this project research is being carried out on trickle and sprinkler irrigation systems at DRIP Campus. A third component i.e construction of RCC Pipe water carrier for irrigation purpose has already been completed at DRIP Campus. The main objectives of research on trickle and sprinkler irrigation systems are to see the performance of these systems which are prepared by using local material, their feasibility in irrigated areas of Sindh, yield response and water saving. Another project entitled "On Farm Drainage to Minimize Environmental Impacts of Saline Drainage Effluent" is being implemented near Jacobabad for research on tile drainage, injection well and evaporation ponds. MS

students rom Mehran University of Engineering and Technology would be involved in research program.

3.11.1.1 Trickle Irrigation System

106. This system of irrigation is instaled on 0.75 acre of land at DRIP Campus. The component specifications are as under:

i)	Main	: PVC Pipe 5.0 cm, I.D.
ii)	Submain	: G.I. Pipe 3.75 cm I.D
iii)	Laterals	: Rubber Pipe 1.25 cm I.D.
iv)	Trickler (made from alkathine tube)	: 1.0 mm I.D.
v)	Water meters	: 3.75 cm I.D.
vi)	Gate valves	: 3.75 cm and 1.25 cm I.D.
vii)	Nipple	: G.I. 1.25 I.D.

107. The system is connected to an overhead water tank from where water delivers to the tricklers with a pressure of 2.3 pounds/inch^2. Under this system of irrigation Rabi and Kharif vegetables are studied for yield response and water saving as compared to furrow irrigation system. Clear canal water is used for irrigation. The system is working satisfactorily. The results of Rabi vegetables (1992-93) grown under trickle and furrow irrigation system are given in the Table 36.

Table 36

Water Saving of Different Vegetables Grown on Trickle Irrigation Over Furrow Irrigation

Name of Vegetable	Method of irrig.	yield (tons/ha)	Water Used (m^3)	W.U.E (kg/mm/ha)	Water Saving (%)
Tomato	T	13.4	15.97	0.83	27.0
-do-	F	9.09	58.32	0.15	-
Carrot	T	11.37	64.56	0.17	64.0
-do-	F	7.78	100.76	0.07	-
Spinach	T	4.98	39.92	0.12	62.4
-do-	F	4.57	63.92	0.07	-
Radish	T	21.00	28.29	0.74	41.0
-do-	F	9.72	69.00	0.14	-
Turnip	T	36.95	61.78	0.59	63.3
-d-	F	11.89	97.57	0.12	-
Onion	T	16.03	11.89	1.34	34.4
-do-	F	13.30	34.60	0.38	-
Cauli-flower	T	17.96	12.81	1.40	28.20
-do-	F	15.00	45.43	0.33	-

T = Trickle
F = Furrow
W.U.E = Water Use Efficiency

108. It is clear from Table 36 that high water use efficiency is obtained in trickle method as compared with furrow method and an appreciable amount of irrigation water is saved which ranged from 27.4 to 64.0% in different vegetables under trickle irrigation over furrow method. For further study Kharif vegetables i.e okra, guwar, long gourd, bitter gourd, ridge gourd and chillies are sown in April 1993 which are in progress.

109. It is pointed out that Pak-Swiss Training Centre (PCSIR Laboratories) Karachi is fabricating two special kinds of tricklers for DRIP on payment basis which would be used in this system of irrigation after testing their performance.

3.11.1.2 Sprinkler Irrigation System

110. This system of irrigation is also installed at DRIP Campus on about one acre of land. All the components used in this system are procured from local market. This sprinkler irrigation system is fixed type which is designed and installed by DRIP engineers and scientists. The design parameters of this system of irrigation are as under:

Main	: G.I. Pipe 7.5 cm, I.D.
Laterals	: G.I. Pipe 5.0 cm, I.D.
Risers	: G.I. Pipe 2.5 cm, I.D. (120 cm high from G.S)
Number of Sprinkler heads	: 15
Nozzle size	: 6.35 mm I.D.
Number of laterals:	: 3
Spacing	: 13.5 m x 13.5 m
Operating pressure	: 1.4 Kg/cm^2 (20 Psi)
Discharge rate	: 75 gpm
Uniformity coefficient	: 80-85 %

111. The system is connected directly to a tube well which operates at a pressure of 20 psi. Under this system of irrigation two major crops i.e cotton in Kharif and wheat in Rabi are being tried. Water and yield response under sprinkler system is compared with conventional irrigation method.

112. The system is working satisfactorily. Uptill now, one cotton crop (1992 crop) and one wheat crop (1992-93) are completed. The

cotton 1992 crop was deteriorated badly due to extra ordinary rains received during flowering stage of cotton in July-August 1992. The results of wheat 1992-93 crop are presented in Table 37.

Table 37

Water Saving of Wheat in Sprinkler Irrigation System Over Conventional System

Irrig. Method	Water Used (mm)	yield (tons/ha)	W.U.E (kg/mm/ha)	Water Saving (%)
Sprinkler	330	2.90	8.8	45
Conventional	600	3.34	5.5	-

113. The results reveal that per hectare yield of wheat is more under conventional irrigation method as compared to sprinkler method, but the quantity of water consumed is also more in conventional method. However, irrigation efficiency in sprinkler dominates over conventional method as less water has been consumed in sprinkler method as compared to conventional method of irrigation. Hence 45% water saving is achieved in sprinkler irrigation system over conventional method. However, final conclusions can not be drawn from one crop season and without scientific analysis of the data. For further research cotton crop is sown in May 1993 under sprinkler irrigation system, which is in progress.

3.11.2 Collaboration With Forest Department of Sindh

114. DRIP is also conducting research in collaboration with Forest Department of Sindh (Silviculture Research Division). In this

regard DRIP is helping Forest Department in execution of a research project titled, "Use of Effluent Water Of LBOD for Afforestation in Uncommanded Forest Area Adjoining Thar Desert" The project is located near Ali Bandar, district Badin along L.B.O.D. adjoining Thar desert. In this regard field investigations were completed in May 1992. For better comparison and correlation, additional data on watertable depths was also collected in January 1993. After the analysis of soil and groundwater samples for various chemical parameters, compilation and tabulation of data, preparation of maps, graphs and figures, a comprehensive report, titled "Effect of Saline Drainage Effluent on Soil and Afforestation", was published in May 1993 as DRIP Publication No. 36. Five copies of this report were sent to Chief Conservator of Forests, Sindh.

4. PREPARATION OF NEW RESEARCH AND DEVELOPMENT PROJECTS

115. The Institute prepared a new project "On-Farm Drainage and Water Management to Minimize Environmental Impacts on Saline Drainage Effluent". The project seeks to provide horizontal drainage to sick lands of Sindh through research and demonstration in an area where land owners are willing to share 30% capital cost and full responsibility of operational and maintenance cost. The project was submitted to Pakistan Science Foundation for co-sponsoring. The Foundation has agreed to fund the project partly. On the release of funds the project works have since been started. The project works are tied to the already approved project "Development of Tile Drainage

Project in Phase II Area of DRIP in East Khairpur Tile Drainage Pilot Project".

5. SOIL AND WATER ANALYSIS LABORATORY

116. During this year, 2227 soil and 4410 water samples were received from various studies of the Institute. These samples pertained to East Khairpur Tile Drainage Pilot Project, Lysimeter Studies in Sindh, Trickle and Sprinkler Irrigation System, Water Management Studies, Skimming Well, Salt Affected Soils, Irrigation Systems Management Research, Alternative Drainage Project and Qadirabad Drainage Research Project. These samples were analysed for physical and chemical parameters. The results were checked, compiled, interpreted and communicated to the concerned quarters for further study.

117. The details of samples received, analysed and determinations made are given in Table 38.

Table 38

Details of Samples Received and Determinations Made

Kind of Samples			Determination Made
Soil	Water	Gravel	
1404	-	-	Electrical Conductivity pH, CO_3, HCO_3, Cl, SO_4, Ca+Mg, Na, SAR and ESP.
360	-	-	Electrical Conductivity and pH values.
146	-	-	Soil texture.
80	-	-	Soil particle size analysis, and graph plotting.
-	-	01	Particle size analysis.

76	-	-	Fertility status viz: Nitrogen, Phosphorus, Potassium and Organic matter.
-	192	-	Electrical Conductivity, pH, CO_3, HCO_3, Cl, SO_4, Ca+Mg, Na, SAR and RSC.
-	4218	-	Electrical Conductivity and pH values.

118. Besides, local progressive farmers approached DRIP for advisory services. They have been facing the problems of soil salinity and waterlogging. It is good to say that the Institute undertakes this service without any charge. About 10 agricultural farms were surveyed, investigated and physically observed by the laboratory staff. Soil and water samples were collected and analysed in the laboratory. Complete diagnostic reports along with appropriate remedies for reclaiming their deteriorated lands were communicated to the farmers to eradicate the problems by adopting scientific methods. They, being progressive farmers, tried their level best to follow the proper procedures, used chemical amendments according to advice to solve the problems and achieved positive results.

6. DOCUMENTATION AND DISSEMINATION

119. DRIP Newsletter, a monthly bulletin, was printed and issued regularly. It contains news about DRIP affairs, short summaries of technical articles, short technical articles in drainage and reclamation of waterlogged and saline soils, and water management. The newsletter is circulated widely and distribution is both national and international.

120. Work continued on composition and printing of Bibliography on land and Water Development, No. 4 (1986-90). The Bibliography has since been published. It contains 1215 references mainly drawn from journals received in DRIP library. The copies of the Bibliography were distributed to the national organizations engaged in research and development. Work on next Bibliography, that is No. 5, (1991-1993) has been started. The first two years data has been scanned and fed into computer.

121. Printing and publication of "Journal of Drainage and Reclamation" remained in progress. Technical papers for Vol. 4, Nos. 1&2, 1992 were collected, processed, peer reviewed and composed for printing. The camera ready copy was submitted to Pakistan Printing Corporation Press for printing. The printed copies have since been received from the press. The distribution is both national and international.

122. Work also remained in progress for printing and publication of "Journal of Drainage and Reclamation" Vol. 5, No. 1, 1993. In all, 8 papers have been received for this issue. These papers are either in review process by the experts, or in improvement by the authors. After review and improvement by experts and authors respectively, meeting of the editorial board will be called. In case these papers are not ready in time, we may combine both the issues of the Journal for the year 1993.

123. Brochure No.4, on research and development activities of DRIP was printed by PASTIC and published by DRIP. Copies of this

brochure have been widely distributed. It contains information on scope and functions of DRIP, research activities, facilities developed current research, training of manpower and research information.

7. IMPORTANT MEETINGS AND VISITS

7.1. High Power Delegation

124. A high power delegation comprising M/s S. M. Miranda, Senior Irrigation Specialist, IIMI Lahore and Jalil U. Ahmad, Project Officer USAID Islamabad along with Dr. Bashir A. Chandio, Chairman, Pakistan Council of Research in Water Resources Islamabad visited DRIP collaborated tile drainage units on 29-7-1992. The delegation visited the tile drainage units at Jagir Farm, Nabi Shah Farm, and Essani Farm, Garhi Yaseen, District Shikarpur. They also visited the proposed drainage and saline water use research project at Soomra Farm, Jacobabad.

125. The Director General DRIP explained the delegation about salient features of the collaborated tile drainage units with the help of charts, maps and photographs including preproject and postproject conditions of watertable depth, soil salinity, groundwater quality, changes in cropping pattern and cost-benefit ratio. He informed that at Essani farm rice has been totally replaced by other crops, like sugarcane, vegetables, and oil seeds.

126. The delegation appreciated the launching of collaborated tile drainage units by DRIP. They were satisfied with their operation and the role played in reclaiming waterlogged soils.

7.2 ISM-R Team Visit

127. Mr. S.M. Miranda, Senior Irrigation Specialist from IIMI-Pakistan and Engr. Jalil U. Ahmed, Project Officer, ISM-R, (USAID) visited DRIP Campus and discussed progress of ISM-R projects with Mr. Moula Bux Mirbahar, Director General, in his office on September 9, 1992. They discussed various fields of collaboration in drainage and reclamation, and irrigation water management where IIMI-Pakistan and DRIP could share the technical expertise. For acquinting themselves about on-going research in land drainage, reclamation, water management and infrastructure developed for research, they had a round of on-campus water management research, lysimeter station, laboratory, library, computer section, and tile drainage unit at Bughio farm.

7.3 Fourth Meeting of Board of Governors

128. The fourth meeting of Board of Governors of DRIP took place on September 3, 1992. Dr. Bashir A. Chandio, President Board of Governors, presided over the meeting. Mr. Moula Bux Mirbahar Director General DRIP and Secretary of the Board, explained briefly the research efforts of DRIP to find effective solutions to the problems of waterlogging and salinity in the country. He amply deliberated upon the progress achieved on development projects including i) monitoring studies on drainage ii) alternative drainage methods iii) groundwater exploitation and computer modelling iv) salt affected soils and, v) tile drainage. He also informed the members about collaborative research projects with Pakistan Science Foundation, Sindh Forest Department and International Waterlogging and Salinity Research

Institute (IWASRI). He informed that by initiating collaborative projects with the farmers on cost sharing basis the problems of waterlogging and salinity could largely be controlled. In collaborative projects farmers shared upto 60 percent of capital cost and full operational cost. The involvement of farmers had been highly encouraging.

129. The Board appreciated the research and development efforts put in by DRIP to evolve appropriate solutions to the menaces of waterlogging and salinity. The Board approved the budget estimates for the year 1992-93. It also decided some administrative matters.

7.4 Technical Advisory Committee Meets

130. Drainage and Reclamation Institute of Pakistan (DRIP) conducted its third meeting of Technical Advisory Committee on November 4, 1992 at DRIP Campus Tando Jam. Mr. Moula Bux Mirbahar, Director General DRIP and Chairman of the Committee, presided over the meeting.

131. The meeting aimed to discuss and approve DRIP research program and exchange experiences about research on problems of irrigated agriculture with special attention to the planning of research projects/studies. The committee approved various items of research including monitoring studies on tile drainage, water management studies in lysimeters as well as in field, research plan of Surface Drainage and Watertable Control Project of ISM-R, land reclamation research, collaborative research plan for on-farm drainage

and water management, research plan on skimming well modelling for irrigation and drainage, and research plan of tile drainage. The committee suggested some modifications in the studies/projects.

7.5 Interaction and Coordination Amongst the Science and Technology Establishments

132. A number of institutions are established under umbrella of federal Ministry of Science and Technology to conduct and promote scientific research and evolve technologies for the progress and prosperity of the nation. These institutions could be reckoned as modest ones and they have tried to cultivate Science Culture amongst the masses. To create an inter-institutional awareness and to maintain a better coordination and linkages, under directive of the Secretary Ministry of Science and Technology the heads of various Scientific Organizations, based at Karachi and Hyderabad, visited DRIP Campus on November 28, 1992. The visitors included: i) Mr. S.H. Niaz Rizvi, Director General, National Institute of Oceanography, Karachi ii) Dr. S.S.H. Rizvi, Director General, Pakistan Council for Scientific & Industrial Research, Karachi iii) Dr. Attaullah Mahar, Chairman, Council of Works & Housing Research, Karachi iv) Dr. S.S.A. Rizvi, Director General, Pak Swiss Training Centre Karachi v) Dr. S. Shahid Hussain, Director, Leather Research Institute, Karachi vi) Dr. J.N. Usmani, Director, Scientific Information Centre, Pakistan Council for Scientific and Industrial Research, Karachi vii) Dr. Nisar Ahmed, Director, Fuel Research Centre, Karachi viii) Mr. Muzammiluddin, Principal Economist, Directorate of Industrial Liaison, Karachi ix) Dr. S. Wajahat Ali, Director, Solar Energy Research Centre, Hyderabad.

133. Soon after their arrival and formal reception, Mr. Moula Bux Mirbahar, Director General DRIP, gave a comprehensive presentation on DRIP research and development activities. He especially highlighted the problems of waterlogging and salinity, their impact on agricultural production, and remedial measures by the Government of Pakistan to control these problems. He informed that DRIP had switched over to research on tile drainage to reclaim the affected lands for areas where tubewell drainage was not feasible because of saline groundwater and poor aquifer. He concluded that collaborative drainage with farmers could go a long way in reclaiming the lands.

134. The visitors took a round of DRIP library, computer section, laboratory, on-campus water management research, both in field and lysimeters, tile drainage unit at Atomic Energy Farm. They particularly showed interest in innovative irrigation techniques (trickle + sprinkler irrigation), skimming well and tile drainage. It was the general opinion of the visitors that DRIP was doing a useful research and the facilities developed could be shared amongst the science and technology institutions. Some offered their technologies and materials for testing at DRIP fields before their release to the general public.

7.6. Chinese Delegation Visits Tile Drainage Unit, Jacobabad

135. Engineer Illahi Bux Soomro Federal Minister for Science and Technology visited Tile Drainage Unit Jacobabad with a Chinese Team led by Mr. Wang Wentong, General Manager, Jiangsu International Agricultural Services Corporation, Wanjing, on 28.1.1993. Mr. Moula

Bux Mirbahar Director General DRIP received Honourable Minister for Science and Technology and delegation. The Director General briefed them about research activities of DRIP with particular emphasis on the role of tile drainage to control waterlogging and salinity. The delegation appreciated work of DRIP and discussed various aspects of rice cultivation and possible improvements to raise per acre production.

7.7 Study Tour of Civil Engineering Students

136. A team of final year civil engineering students from Mehran University of Engineering & Technology, Jamshoro, visited DRIP Campus to acquaint themselves with research activities of DRIP, on January 24, 1993. Mr. S.M. Yaseen Director Lysimeters and Water Management received the visitors. He took the students to the various facilities of Institute and experimental fields and briefed about water management research, both in field and lysimeters, with particular reference to wheat, cotton, sugarcane and alfalfa. Innovative irrigation techniques including trickle irrigation and sprinkler irrigation were also explained.

137. Later he took the delegation to the Atomic Energy Farm, Tando Jam where DRIP has installed a tile drainage unit to control waterlogging and salinity. The students showed keen interest in the tile drainage technology and they raised various questions which were attended to by Director Lysimeters.

7.8. Project Technical Advisor UNDP

138. Mr. Michael Patto, Project Technical Advisor (UNDP) and Dr. M. Ramzan Chaudhry, Director, from IWASRI, Lahore visited DRIP Campus on 23-02-1993. Mr. Latif A. Soomro, Chairman, Soil Science Department S.A.U. Tando Jam led the delegation. They exchanged views on reclamation of salt affected and waterlogged soils and the efforts being made by DRIP in this respect with M/s Rashid Ahmad, M. Haroon Chang and Mohammad Khan Marri, Director and Deputy Directors respectively. Mr. Patto explored the areas where IWASRI could collaborate. The delegation had a round of on-campus water management research, lysimeter station, soil and water analysis laboratory, computer section, library and seminar hall. He was much impressed of DRIP research activities and appreciated the work of Institute. He desired to bring a UNDP delegation to the Institute for detailed discussions on collaborative research programmes.

7.9 Cabinet Committee Reviews the Research and Development Activities of DRIP

139. The Government of Pakistan constituted a Cabinet Committee under the Chairmanship of Minister for Science and Technology to coordinate the activities and evaluate the performance of Research and Development institutions in the country. For water sector, the cabinet committee selected the following experts to review and evaluate the research and development activities:

i) Dr. Bashir A. Chandio (Convenor)
Chairman (PCRWR),
Islamabad

ii) Dr. N.M. Awan (Member)
Director (CEWR), Lahore

iii) Dr. Haji Mahmood (Member)
Director Institute of
Irrigation & Drainage Engg.
MUET, Jamshoro

iv) Dr. Arshad Aziz (Co-opted Member)
Professor, Civil Engineering
Department, NWFP Engineering
University, Peshawar

v) Mr. Abdul Hafiz Qaiser (Co-opted Member)
Chief Water, Planning and
Development Division,
Islamabad

140. The experts visited DRIP Campus on 29-3-1993. They hold discussions with Mr. Moula Bux Mirbahar the Director General DRIP and evaluated the research and development information provided on Pakistan Council of Science and Technology questionnaire. A set of DRIP publications was presented to each member for favour of review and evaluation.

7.10. Fifth Meeting of Board of Governors

141. The fifth meeting of Board of Governors of Drainage and Reclamation Institute of Pakistan (DRIP) took place on May 30, 1993 at DRIP Campus Tando Jam. Dr. Bashir A. Chandio, President Board of Governors, presided over the meeting. Mr. Moula Bux Mirbahar, Director General DRIP and Secretary of the Board presented various agenda items for discussion and decision of the Board. The agenda spread over items including expenditure incurred, annual budget for 1993-94, service rules of DRIP, qualifications and experience requirements of various posts, medical rules, and few others. The Board deliberated extensively upon these items and approved some and modified others. The Board approved the qualifications and experience requirements of the various posts in DRIP. For medical rules, the Board decided to adopt medical rules of Pakistan Medical Research Council.

142. The Board also discussed the progress of DRIP in reclamation of waterlogged and saline soils. The significant opinion emerging from the discussions was that DRIP should further strengthen its collaborative research and offer consultancy services.

7.11 World Bank Mission Visit

143. A World Bank Team led by Mr. J. Wambio visited Bughio Farm Tile Drainage Unit on 14.06.1993. The visit was conducted by Mr. Abdus Sattar Choudhry, General Manager Water (South) WAPDA. Chief Engineer, Irrigation Development and On-Farm Water Management authorities, Government of Sindh accomopanied the mission. Mr. Moula Bux Mirbahar,

Director General DRIP, and Mr. S.M. Yaseen, Director joined the delegation at Hyderabad and escorted them to the Bughio Farm. Mr. Mohammad Haroon Chang, Director (Administration) received the delegation at site.

144. The Director General briefed the delegation about research activities of DRIP with particular emphasis on the role of the tile drainage for control of waterlogging and salinity with the help of maps and charts. He elaborated upon interceptor drain model for seepage control and reclamation experiment on saline-sodic soils by organic, in organic and biological reclaiments under tile drainage unit. The delegation appreciated the work done by DRIP, particularly its concept of collaboration with farmers. The delegation discussed various aspects of changes in cropping pattern, improvement in crop yields and rise in per acre production.

8. STAFF OF THE INSTITUTE

145. The Institute is adequately staffed to carry out its research and development activities. Out of 34 staff in position in BPS-16 and above, 30 are professional and 4 are managerial. Table 40 gives the staff position section wise.

Table 40

Professional/Management Staff of DRIP (From BPS-16 and Above)

S. No.	Name	Qualification	Designation	Remarks
1.	Moula Bux Mirbahar	M.E (Hydraulics)	Director General	
	Headquarter Services and Drainage Engineering			
2.	Mohammad Khan Marri	M.E.(Agri.)	Deputy Director	On deputation to NGO from 30.3.1993
3.	Mazharuddin Shaikh	M.Sc.(Agri.)	Deputy Director	
4.	Abdul Munaf Sipraw	M.E.(Civil)	Asstt. Director	Looks after Headquarter Services & Drainage Engineering
5.	Abdul Samad Chandio	B.E.(Agri.)	Asstt. Director	
6.	Abdul Salam Arain	B.E.(Agri.)	Asstt. Director	
7.	Ghulam Mustufa Moroojo	B.E (Civil)	Asstt. Director	
8.	Asmatullah Khuwaja	B.E. (Civil)	Asstt. Director	
9.	Zamir A. Soomro	B.E.(Agri.)	Asstt. Director	
10.	Amir Ahmad Lashari	M.Sc.(Agri.)	Research Officer	
11.	Mohammad Naeem	M.Sc.(Agri.)	Research Officer	
12.	Mohammad Ismail Jakhro	B.E.(Civil)	Asstt. Scientific Officer	
13.	Tahir Saleem	M.Sc.(Agri.)	Asstt. Scientific Officer	

14.	Abdul Majeed Raees	B.E.(Agri.)	Asstt. Research Officer	
15.	Zakir Hussain Jogi	B.E.(Agri.)	Asstt. Scientific Officer	
16.	Zafarullah Memon	B.E.(Agri.)	Asstt. Scientific Officer	
17.	Roshan Ali Mangi	D.A.E.	Asstt. Scientific Officer	
Lysimeters and Water Management				
18.	Syed Mohammad Yaseen	M.Sc.(Agri.)	Director	
19.	Allah Wasayo Malnas	M.Sc.(Agri.) Engg.	Deputy Director	
20.	Qadir Ali Sipio	M.Sc.(Agri.)	Assistant Director	
21.	Mohammad Ishtiaq Rao	B.E.(Agri.)	Assistant Director	
22.	Azizullah Mahar	B.E.(Agri.)	Assistant Director	
23.	Rajab Ali Samo	B.E.(Agri.)	Asstt. Scientific Officer	
Soil and Water Analysis Laboratory				
24.	Mohammad Haroon Chang	M.Sc.(Agri.)	Deputy Director	Current charge of Director Administration
25.	Abdul Qayum Soomro	B.Sc.(Chem.)	Research Officer	
26.	Zubbair Ahmad Memon	B.E.(Civil)	Asstt. Research Officer	(On Contract)
Administration, Accounts and Transport				
27.	Noor Mohammad Qazi	M.A.	Assistant Director	
28.	Janib Khan Baloch	B.Com.	Asstt. Accounts Officer	
29.	Noor Mohammad Arain	M.Sc.(Agri.)	Administrative Officer	
30.	Allah Bachayo Barich	B.E. (Mech.)	Technical Officer	

Documentation & Dissemination

31.	Rashid Ahmad	M.Sc. Hons. (Agri.)	Director
32.	Mohammad Ilyas Khan	M.A. Lib. Sc.	Librarian
33.	Ali Sher Shaikh	M.Sc.Geology	Asstt. Scientific Officer
34.	Tariq Iqbal Soomro	M.Sc. Geology	Asstt. Scientific Officer

9. TRAINING

146. Mr. Asmatullah Khawaja Assistant Director received training in operation research for managers at NIPA, Karachi from 6-2-1993 to 18-2-1993. Mr. Janib Khan Baloch Assistant Accounts Officer received training in financial management at NIPA, Karachi from 12-9-1992 to 8-10-1992. M/s Mohammad Ilyas Khan Librarian and Noor Mohammad Arain Assistant Scientific Officer participated in 7th Course in Communication Skills, held from April 10 to April 15, 1993 at NIPA, Karachi. Mr. Qadir Ali Sipio, Assistant Director participated in National Training Workshop on " Protected Area Management from June 12-22, 1993, organized by Department of Agri. Education, Extension and Short Courses, Faculty of Agri Social Science, Sindh Agriculture University Tando Jam.

10. DRIP PUBLICATIONS

147. The Institute prepared the following technical papers/reports/brochures during the 1992-93.

11.1 Technical Papers

S.No.	Title	Authors	Remarks
i)	Soil Polution by Water-logging and Salinity Its Extent and Impact on Pakistan Agriculture	S.M. Yaseen and M. Ishtiaque Rao	Prepared for Presentation at International Symposium on Environmental Assesment and Management of Irrigation and Drainage Projects for sustained Agricultural Growth schedulled to be held at Lahore in 1993.
ii)	Comparative Effect of Organic Inorganic and Biological Reclamation of Saline-Sodic Soils Under Tile Drainage System	M.H. Chang Moula Bux Mirbahar & M.K. Marri	Presented at Irrigation Systems Management Research Symposium, held at Lahore from 11-4-93 to 13-4-1993
iii)	Collaborative Tile Drainage System-Key to Solve Waterlogging and Salinity Problems	Moula Bux Mirbahar M.K. Marri and M.H. Chang	-do-
iv)	Effect of Drain Positions and Boundary Condition on Seepage Interception Using Galerkin Finite Element Model	B.A. Chandio A.S. Chandio A.M. Shaikh	-do-
v)	Information Needs and Services Required in Water and Environment.	Rashid Ahmad and M. Ilyas Khan	Presented at National Workshop on Library Management and Services, Resource Sharing, and Information Net Working, held from May 25-27 1993 at Islamabad

11.2 Technical Reports

	Effect of Saline Drainage Effluent on Soil and Afforestation, DRIP Publication No.36	S.M. Yaseen and A.Q. Soomro	Presented to Silviculture Research Division, Forest Department of Sindh

11.3 Brochures

Research and Development Activities, Drainage and Reclamation Institute of Pakistan, Brochure 4, DRIP Publication No.33.	-	-

11.4 Bibliographies

Land and Water Development Bibliography (1986-90) No.4, DRIP Publication No.35.	Rashid Ahmad M. I. Khan and Ali Sher Shaikh	-

11.5 Journal

Journal of Drainage and Reclamation (Bi-annual)	-	-

11.6 Newsletter

DRIP Newsletter (Monthly)	-	-