PROGRESS REPORT 1

CROP-BASED IRRIGATION OPERATIONS IN NWFP

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pakistan

Crop yield / Irrigation Operations / water requirement
Performance evaluation

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PROGRESS REPORT NO. 1: RABI 91/92

ON THE

TECHNICAL ASSISTANCE STUDY

T.A. NO. 1481-PAK

CROP-BASED IRRIGATION OPERATIONS IN THE NWFP

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June 20, 1992

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PROGRESS REPORT NO. 1: RABI 91/92
CROP-BASED IRRIGATION OPERATION

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EXECUTIVE SUMMARY

The present report covers the period from October 24. 1991 to May 15, 1992 corresponding lo tlic first cropping season, i.e. Rabi 91/92, of the study undertaken by the International Irrigation Management Institute under the Technical Assistance Agreement No. 1481-Pak.

Activities conducted during this first reporting period have significantly advanced our understanding of existing conditions in the project areas, and have provided a first insight into the particular circumstances that govern the behavior of the actors, agencies and end-users --- who, eventually, would determine the success or failure on the efforts of moving the modernized systems in the Northwest Frontier Province towards a more flexible irrigation operations.

Preliminary results on the simulation of main canal operations at CRBC indicate that additional infrastructure may be required in order to manage the canal strictly on crop-based water requirements, and that the present management approach. although sound, will not suffice once tlic entire system becomes operational. Simulation activities will be expanded to the distributary level, in the forthcoming season, in order to set the pace for the development of water allocation alternatives tinder a setting of crop-based irrigation operations.

The perception that the areas presently served are enjoying an over abundant water supply is largely confirmed both through performance indicators such as the Delivery Performance Ratio and Relative Water Supply, and by close interactions with end-users. Cropping patterns were found to have deviated, significantly, from designed ones. Although. not necessarily an unexpected result, it has implications for the planning and management of future system operations, hy realizing that any attempt to control cropping patterns in a context of crop-based operations is likely to result in failure.

Field work conducted so far indicates that irrigation practices in the CRBC study area are scanty, still evolving, and largely unsystematic. They are neither based on any established *warabandi* system that is practiced in most other areas in Pakistan, nor on any scientific flexible system that takes account of crop water requirements

On a more positive note, a first analysis of yield data from crop cuts, in distributary 3 # of CRBC, has shown that the average yield of wheat for the 24 farmers surveyed is relatively high : 2.800 kg per ha. However, differences exist among watercourses, within watercourses and within farms. While it is rather early, and improper, to try to establish a causal relationship between increased water duties and higher yields, it is nevertheless encouraging to see the new areas at those levels of crop production.

Several system responsiveness options for water supply delivery are presented and. at least two : Demand-Refusal and Modified Demand-Refusal look promising. Forthcoming activities will explore these and new options as their requirements are monitored under Kharif season conditions.

Work carried out at LSC has been largely restricted to collection of secondary information through interviews with both government officials and farmers, The above notwithstanding, the intervention has been useful, leading to a preliminary understanding of the economics of the remodelling and of attempts made on other demand-based type of irrigation operations, like the so called "Merriam project". Furthermore, it is providing an insight into the role of agencies in the framework of design-management interactions.

In general, collaboration from the various government agencies related to tlie project was quire satisfactory. Documents, data and other types of information requested were readily provided. Constraints in project implementation, in the context of government agencies participation, came more from intrinsic problems faced by the agencies themselves. like shortages of staff and lack of funds.

Finally, the report sets the stage for forthcoming activities in the Kharif season with which a full cropping cycle of study activities will be completed, thus allowing innovating management interventions to be developed and introduced.

I. INTRODUCTION

1.1 Context of the Seasonal Report

This Seasonal Progress Report relates to the study undertaken by the International Irrigation Management Institute (IIMI), under the Technical Assistance Agreement No. 148I-Pak dated 25 July 1991 between IIMI, the Government of the Islamic Republic of Pakistan (GOP), the Government of the North West Frontier Province (GONWFP) *of* Pakistan, and the Asian Development Bank **(ADD).** The report is presented in terms of Sec. 8(II) of the Terms of Reference, Schedule I of the TA Agreement, which requires Seasonal Progress Reports to be issued within a month of each cropping season, indicating study activities, seasonal data analysis and interpretation.

With the signing of the TA agreement, IIMI started tlic inception activities of the study forthwith, and after their successful completion was able to capture the onset of the *1991*/92 Rabi season for essential data collection work. Pre-Rabi activities were reported in IIMI's Inception Report issued on 24 October 1991. The study activities undertaken from the beginning of the Rabi season are presented in this first Seasonal Report. **As** agreed in the Terms of Reference, the contents of this Seasonal Report have also been presented for discussion at the last Study Advisory Committee **(SAC)** meeting held in Peshawar on 23 April 1992.

1.2 Coveraae

As mentioned in the Inception Report of24 October 1991, the major effort in seasonal data collection focussed on the study site at the Chashma Right Bank Canal (CRBC) in D. I. Khan. The activities at the Lower Swat Canal (LSC) site were limited to a detailed study of the circumstances that led to the installation of outlet gates and the subsequent decision to remove them, plus an attempt of an economic analysis of the impact of the remodelling efforts. The study in its original tlcsign, basically, concentrates at present on the CRBC.

The Seasonal Report, therefore, covers study activities in the CRBC in greater detail, including data collection, some preliminary data analyses and related tentative findings, while it describes only the present status of the institutional study which was undertaken in the LSC as a case, focussing on design-management interactions. The Report also covers the rapid appraisal on the LSC which, as mentioned in the Inception Report, led to this decision to concentrate on the CRBC.

II. PROJECT SUPPORT-RELATED ACTIVITIES

2.1 Staffing

The staffing requirements for the project at the CRBC field site were consolidated during the reporting period. A total of two field research professionals (FRPs) and six field assistants (FAs) are now in place. Following standard IIMI working patterns, the staff is rotated among different field activities to ensure continuity of work in case of unexpected leaves.

The project also drew support from other local and international IIMI staff in order to complement permanent project staff activities. For example, for simulation of main canal operation a specialist from IIMI headquarters and a local counterpart were involved in the formulation and calibration of the model. Matters related to flow measurements were assisted by both local and international staff. They provided advice and expertise on selection of appropriate measurement locations and methods. Likewise, a Senior Irrigation Specialist from IIMI headquarters provided insight into options for system operation under different management scenarios. Finally, local staff helped in the planning and subsequent implementation of crop-cut yields for wheat and *warabandi*-related interviews.

In Annex-1 a list of IIMI personnel involved in project activities during this reporting period is provided.

2.2 Study Advisory Committee

The first meeting of the Study Advisory Committee was held in Peshawar on November 24. 1991. The Terms of Reference for the Committee were approved as proposed (see Inception Report, page 32). However, given the importance that the provincial government is attaching to the project it was decided to take the composition of the committee from the "director-level" positions, as it had been constituted, to a higher level. Thus, it was agreed by consensus that the new members would be as follows:

1. Additional Chief Secretary, P&D	- Chairman
2. Secretary Irrigation	- Member
3. Secretary Agriculture	- Member
4. General Manager (North), WAPDA	- Member
5. Project Leader, IIMI- Pakistan	- Secretary/Member
6. Director General IWASRI	- Observer

In this regard, it was also agreed that each department would arrange to have no more than two functional representatives to attend the SAC meetings to provide technical support as may be required.

Other important decisions taken (see full minutes in Annex-2), and subsequently implemented, were as follows:

* official letters would he sent to concerned officials at project sites asking for their full cooperation towards the implementation of activities.

* that activities would proceed at CRBC as first priority and that work at LSC could be taken **up** at a later stage.

* work will be done in the SI system, but english units, currently used in Pakistan, will also be utilized to facilitate understanding of local staff.

The second meeting of the Study Advisory Committee was held in Peshawar on April 23. 1991. The new configuration of the committee was enforced (see ahove).

While the full minutes **of** the meeting arc presented in Annex-2. the most important decisions taken **by** the SAC were the following:

* the Director General of IWASRI was elevated from his current SAC position as Observer to that of Member, in compliance with the PC-II document.

* the establishment of Project Coordination Committees (PCC) was approved by the SAC, as called for under the Technical Assistance (TA) agreement.

* the SAC approved the study tour as called for under the TA agrcenient. It was suggested by the committee that the study tour take place in the second semester of 1992. A visit to Spain with side-trip to Morocco has been identified as suitable to fulfill the study tour's objectives of putting project officials in contact with systems. in other countries, in which the concept **of** demand-type of irrigation is practiced. Four participants were nominated as follows:

  i) Executive Engineer (Remod). CRBC. PID, D.I.Khan
  ii) Executive Engineer. CRBC. WAPDA. D.I.Khan
  iii) Superintendent Engineer, PID, Mardan
  iv) Deputy Director. Agric Extension, D.I.Khan

* the government of the NWFP will take proper action so that the above decision are enforced in due course.

The Study Advisory Committees has become **a** very important tool in the process of project implementation; because of the high level of the officials constituting the Committee, the process of its convocation has been found somewhat cumbersome. This disadvantage has been fully offset. however, by the prompt enforcement of the decisions taken. **A** third **SAC** meeting is expected during the forthcoming cropping season.

2.3 Procurement of Equipment

Two double-cabin pick-ups that had been ordered since project inception were finally delivered in late February. They arc presently in service. Likewise, three more Honda 125cc motorcycles were purchased to match staff expansion. There are now a total of seven motorcycles stationed at D. 1. Khan.

All field equipment ordered, as reported earlier, has been now received and is currently in use. Some of this equipment has been temporarily transferred to the D.I.Khan meteorological station for their use (see next section).

New field equipment ordered includes 10 units of RBC flumes which have been made by a local shop after a prototype was developed by IIMI, in order to fit particular field conditions. These flumes will be utilized for water measurements at on-farm level. Also. a compensating polar planimeter was purchased locally to facilitate area-related calculations. Finally. special gauges, for measurement of distributary off-take gates' openings, were design to fit each site. and made locally .

The D. I. Khan staff office has been provided with a portable computer Toshiba 1100 and an Epson LQ 870 printer. Standard and specific software has been made available also. The computer equipment has enhanced data management at field level and expedites conventional calculations before data is finally sent to Lahore for further analysis.

2.4 D.I.Khan Meteorological Station

As part of routine project work. a visit was made to the D.I.Khan meteorological station in order to secure climatic data for crop water requirements calculations and other related activities. Instrumentation of the station was found very deficient to serve project purposes. Conspicuously missing was evaporation data that is central to our needs. Equipment for this purpose had been damaged many years back and never replaced.

The idea of upgrading the station through equipmcnt obtnined from the project was thus explored. Contacts in this regard were made with Pakistan Meteorological Department at both regional and national levels. As a result of this effort, the following pieces of equipment were provided, in early January, on loan basis until a more permanent decision in this regard is taken, to the D.I.Khan Meteorological Station :

* Class A evaporation pan complete with still-well, hook gauge and protective screen,
* Floating maximum/minimum thermometer, and
* Fence-type rain gauge

As part of the agreement, IIMI personnel assisted in the initial installation and handling of the equipment, designed suitable formats for data collection and trained the Met staff in the use of the instruments. It will also, on regular basis , supervise and monitor the data gathering process.

The met staff, on the other hand, will be responsible for providing security. appropriate maintenance and care for the equipment. They will give additional training, if needed, to new staff; and, of course, allow the project to readily obtain the data collected.

The Pakistan Meteorological Department, at its Lahore office, is currently engaged in a program to computerize meteorological data received from the various stations established throughout the country. This effort began in early 1992, and fortunate enough the data corresponding to D. I. Khan station has been selected as one of the first to undergo the computerization process.

In Annex # 3, Table AN#3-1, provides a summary of meteorological data for the D.I.Khan area covering various time period as per availability. The information includes Mean Daily Maximum anti Minimum Temperatures (1961-1990), Daily Sunshine Hours (1968-1990), Monthly Relative Humidity (1961-1990), Mean Daily Wind Speed (1961-1983). and Monthly Rainfall (1961-1990). The data are also presented graphically in the Annex (Fig AN#%-I.2 and A). including Monthly Potential Evapotranspiration derived from the previous information.

2.5 ADB Review Mission

A one-man review mission, Dr Chris Wensley, from the Bank, visited the project from January 15 to 21, 1992. The review included field visits to both CRBC and LSC irrigation systems, as well as meetings with government officials involved with the project.

Among provincial agencies contacted during the review were: Planning and Development, Agricultural Department (both On Farm Water Management and Agricultural Extension). and Irrigation Department. Among federal agencies WAPDA and IWASRI were contacted. Likewise, a visit was made to the Additional Secretary of the Ministry of Water and Power.

Field trips included a one-day visit to LSC with emphasis given to Distributaries # 8 and # 6 and the Sheikh Yousuf Minor. In CRBC, a two-day trip provided an extensive field visit to boih Stages I and II. The current field sites (Distributaries # 3 and 4) were visited in detail with a general inspection of the on-going work included.

A salient point of the review was the special importance that the Provincial Government is attaching to the project which was clearly stated by several of the officials met.

Dr Wensley expressed his pleasure with the accomplishments obtained so far, and urged the provincial government to continue their support for the project, specially in being able to expedite matters related to vehicles import permits and taxation; and allocation of suitable numbers of PID personnel to the CRBC project. At the same time, he briefed IIMI on the importance of getting fast results related to the operation of the CRBC, in the context of a demand-based type of system.

2.6 Interaction with GOP Agencies

Since the beginning of the seasonal study activities, the study team closely interacted with WAPDA, Irrigation and Agriculture staff in D. I. Khan. Several visits were undertaken by IIMI's senior staff to D. I. Khan, Mardan and Peshawar to meet GONWFP senior staff and discuss various aspects of study implementation,

A number of visits to Peshawar P&D officials resulted in obtaining a date for the first SAC: meeting and resolving the issue of proper representation of the various agencies at the SAC. The first SAC meeting was held on November 24, 1991, with Mr. A. J. Moghul, Secretary/P&D in the Chair, and with participation from senior representatives of Irrigation. Agriculture, and WAPDA. The study objectives and activities under way were explained, the decision to concentrate on the CRBC site was ratified. One other important decision was to upgrade the representation of the SAC, so that it would be chaired by the Additional Chief Secretary /NWFP, and the members would be the Secretaries themselves from Irrigation and Agriculture, and the GM/WAPDA. This gesture was seen as a very positive response from government authorities toward the study.

On 15/1/92, a meeting was held in Peshawar with Director On-Farm Water Management, Mr. Mohammad Yousaf Khattak, and his senior staff. A representative of Agriculture Extension (Mr. Mohammad Zulfiqar) also participated. Since Dr. Chris Wensley from ADB was also present. a very useful discussion took place to understand the perceptions the agency staff had on the concept of crop-based irrigation. The need was identified to hold a similar discussion session with the project-based staff along with their seniors.

Continuous interactions with D. I. Khan based officials helped in the collection of institutional data and in establishing a good rapport with them on a personal basis. However a discussion in February 1992, with WAPDA XEN Mr. Younas Awan and ID XEN Mr. Akhtar Parvez, revealed that the intended Project Coordination Committee (PCC) at the project level could not be properly constituted and productively used without specific. directions from senior level authorities in Peshawar. The reason was a feeling of skepticism that some of tlie project-based officials had regarding the success of a crop-based irrigation operations system.

To discuss this aspect at a higher level, several meetings were planned to be held in Peshawar, and its first meeting was arranged with Secretary Agriculture with participation of all senior Agriculture officials. The idea was to brief them about what the study intended to do, and what involvement of the agency staff was expected. The meeting was postponed twice (March 5, March 26) due to the Secretary's busy schedule, and later was subsumed in the second SAC meeting held on April 23 1992. The second SAC meeting was very productive. The PCC and its representation were officially approved, the four agency staff members for the proposed Study Tour were nominated, and the progress of the study were discussed by highest level of officials in the Province.

Meanwhile, GM/WAPDA (North), and Executive Engineers of WAPDA and ID (Remodelling), D. I. Khan, responded with their written comments to the study's Inception Report issued *in* October 1991.

On the LSC institutional study, the SE/Irrigation Circle Mardan, Mr. Raqib **Khan,** and WAPDA officials in both Peshawar and Martlan cooperated with IIMI staff in providing important planning documents relating to the design of Mardan SCARP. Several discussions were held with these officials. Structured interviews were conducted with ID staff in Mardan, and they also responded lo a questionnaire. These data will be analyzed shortly and used for a research report titled "Design-Management Interactions in the Lower Swat Canal Irrigation System".

The role of IWASRI in the study process was something that had riot been clearly identified. IWASRI was the sponsoring GOP agency inentioned in the PC II. Several meetings were held between IWASRI and IIMI representatives to discuss this issue and provide the information on study activities, Arrangements were also made for IWASRI to participate at some meetings in Peshawar with GONWFP officials, including the second **SAC** meeting at which it was decided to have the IWASRI representative as a full member of the SAC.

To fill the need of the aborted March briefing meeting in Peshawar with Agriculture officials, arrangements are being made to hold **a** seminar at D. I. Khan for all concerned agency staff during Kharif. This will hopefully start off the smooth functioning of the PCC.
IIMI's reports relating to this study so far, (PC II, Inception Report. Rapid Appraisal at LSC, and the Socio-Economic Survey of the CRBC study site) have been distributed to key agency staff concerned with the study.

III. PROJECT IMPLEMENTATION AND DISCUSSION OF FINDINGS

3.1 Lower Swat Canal Irrigation System

3.1.1 Rapid Appraisal of the LSC Command Area

3.1.1.1 Backsround to the Rapid Appraisal

The remodelling design of the LSC included two important changes to the original system: first, it was to increase the capacity of the physical canal distribution system to cope for increased cropping intensity, and second, it was to replace the old APMs at the distributary outlets with gates. making it possible for discharges to watercourses to be adjustable according to crop demand.

However, before completing the remodelling activities. the Irrigation Department urged the construction authority WAPDA, to stop installing the outlet gates except in the a selected Minor (Sheik Yusuf) which was *to* he used by IIMI for a pilot study. As this decision removes one important feature of the LSC that makes the system as a whole suitable for crop-based irrigation operations, IIMI decided to obtain some information regarding the perceptions of the farmers and the operating staff regarding the effects of reinodelling. before undertaking any pilot level experimentation in a selected portion of the system. Since this information was urgently required during the inception stage of the study, IIMI contracted EDC (Pvt.) Limited of Islamabad to carry out a rapid appraisal.

In the guidelines provided by IIMI to the contractor, the following concerns were highlighted:

i) The novel feature of regulatory gates at the moghas will he seen only in this rather academic pilot-study area.

ii) Only the farmers in this particular minor will be subjected to some kind of intervention and regulation.

iii) For these interventions, the operating agency is likely to be a passive observer, shifting an unexpected field responsibility to an external group (IIMI).

iv) Replication of any research results would be having only a very remote chance

Regarding these concerns, IIMI's guidelines particularly mentioned the following main aspects lo hc clarified through the rapid appraisal:

i) Perceptions on the Crop Based Irrigation Operations
ii) Perceptions on the LSC Project (role of the different actors - ID, **AD,** Farmers, WAPDA - before and during the project, future of the project...)

iii) How to improve the system ? (and willingness to improve

iv) The point of view of Agency staff and of the farmers.

The Rapid Appraisal was completed and reported on by the conti-actor towards the end of October 1991. The main findings that helped IIMI to decide on the study strategy were only briefly mentioned in the Inception Report. A further summary of Rapid Appraisal results is given below.

3.1.1.2 Perceations on Croa Based Irriqation Operations

As there had been no extension messages received regarding water management among all farmers in general, the survey team had to explain the concept of crop based irrigation. On this explanation, the farmers' perceptions ranged from utopias of complete freedom they might get as a result of shifting away from the known fixed *warabandi* system, to clear objection to bring any regulation closer to their fields as they would have to bribe additional operators. Most farmers expected the mogha gates to be operated by officials. Some farniers had apprehensions on the sincerity of the move, expecting the department to one day permanently install gates in all outlets. Those who had suffered from shortage of water showed some intcrcst. while all farmers wanted a more detailed explanation of the changes contemplated.

None of the line departments had contacted the farmers regarding any aspect of the remodelling or future plans. The survey learn particularly observed the minimal coordination among the three main line departments. None had specific responsibility to initiate any purposive action to use the remodelled system for its design objectives. The absence of the Irrigation Department during remodelling construction has removed the regulation of water, and the official *warabandi* system is no more fully operational.

3.1.1.3 Perceations on the LSC Proiect

The survey team found no single body willing to take unconditional responsibility for the project in its present form. Nor did they find any sort of coordination instance or consultative body. Each actor was seen to play his role sub-optimally. Construction was slowing down. operation of the system's remodelled portion was not very visible, and agricultural extension to make best use of the new technology and increased water supply was not effective. Farmers show their usual flexibility to respond to the changing situation as best as they can, using convenience as the most important criterion. The knowledge level among farmers about the physical changes taking place in the project can be summed up as: there is going to be more water soon, which will mean that we can grow more sugarcane and rice.

The future of the project, according to most agency staff, remains uncertain, given the preference of the irrigation department to go back to APMs. WAPDA is preoccupied with attempts to complete all construction work of the project, which is understandable in view of the pressure from the donors. Firm policy decisions regarding future plans are yet to he taken.

3.1.1.4 Improvements to the System

Farmers generally are oblivious of any adverse effects that may occur due to the changes introduced. They are willing to work with and help any improvements to be brought about, provided they are not subjected to additional financial stress.

The Irrigation Department is more in favor of the traditional water distribution system for the present. The major constraint seems to be their difficulties in obtaining additional staff for a more flexible system of water management. The involvement of farmers or their organizations in operating part of the system is not among their current considerations.

3.1.1.5 Recommendations

Installation of gates in an isolated pilot area without prior preparation either in terms of farmer awareness or operator training minimizes the replication of the project results. The level of involvement required from the agency staff to operate and protect the outlet gates could not be perceived. What was seen in the survey was some attitude of skepticism towards "crop-based" approach. Under these circumstances, clear short- and long-term benefits from an IIMI experimental operation are not foreseeable.

3.1.2 Evaluation of "Merriam's" Project

The evaluation of a pilot project called "Farmers Operated Variable Flow Arranged Schedule Irrigation System Pilot Project", designed by Prof. J.L. Merriam (California Polytechnic State University) and consiructed and supervised by the Irrigation Department, Mardan (named as the "pilot project") has been included in our work in **LSC.** The main reasons of this choice are some similarities between the pilot project and what IIMI confronts in CRBC and LSC : higher water duties and different approaches to manage the irrigation water.

The main components of the pilot project are :

* a level top canal, off-taking from distributary 8 by a gated outlet, assuring an automatic distribution of the water for the pilot project,

* a distribution box for the distribution of the water between a network of pipes.

* a network of buried pipes and valves, to distribute the water all over the selected project area of 25 hectares,

* two tools for a proper management of the irrigation system. a key to open and close the valves in order to start or stop the irrigation of a specific field, and a probe to check the depth at which irrigation water has penetrated.

The irrigation system is currently managed by a Common Irrigator paid by the Irrigation Department, to accommodate the demand of irrigation water from the different farmers of the pilot project area (the system has been designed for a maximum of three farmers irrigating at a time).

The pilot project package calls for the formation of a Water Users Association, the training of the farmers of the pilot project area and the installation **of** a demonstration farm, and the training of staff of the different line agencies, to ensure a good use and operation of this new irrigation system.

The main anticipated benefits of the pilot project are :

* the elimination of night irrigation
* the possibility for farmers to irrigate easily their fields and to match the supply oi water to the crop water requirements
* to save labor used in irrigation by increasing the size of the water stream
* low seepage losses for the new system
* low maintenance costs
* to increase the agricultural production

The evaluation undertaken was focused on the agricultural and water management side, in order to highlight the benefits, problems and constraints of this pilot project and did not include any analysis of the technical performances of the pilot project. Two questions guided our work on the pilot project:

i) does the pilot project meet its general objectives, in terms of water management at the farm level ?

ii) is the pilot project economically beneficial ?

Information was collected in January 1992 through interviews of Irrigation Department, Agriculture Department and On-Farm Water Management officials and farmers. Secondary data from the different agencies (mainly the lrrigation Department and the Agriculture Department) were collected as well.

After 2 years of operation, farmers recognize the benefits of the buried pipe system : more water, a higher flexibility, a reduced maintenance and low seepage losses. However, for the following reasons there is a difference between what was anticipated and how the system really works.

* there is irrigation at night for some of the farmers, especially during the Kharif season,

* there is no real management of the stream size by the farmers: they always supply water with the same stream size,

* farmers did not receive specific training. They do not use the probe to control their irrigation. Moreover, so far, no demonstration farm has been installed. Thus, there is serious doubts about the efficiency of water use in the pilot project.

A tentative economic analysis of the pilot project was carried out. The main economic indicators. the Net Present Value and the Benefit/Cost ratio, calculated at different discount rate are given in the box below . The Internal Economic Rate of Return of the project is equal to II.7%

Net Present Value and Benefit/Cost Ratio
at 3 discount rates (10%, 12% and 14%)

Discount rate	10%	12%	14%
Net Present Value (million rupees)	+ 0.22	-0.02	-0.21
Benefit/Cost ratio	1 17	0.98	0 R3

The analysis shows that the benefits from the increased agricultural production are not enough to justify the high costs of the project. Thus the project is not economically viable within its current operational environment.

During the interviews, an important but unexpected aspect came to light: the role of the Common Irrigator and his relationships with the farmers. The Common Irrigator favors some of the farmers of the area who thus gained a priority to irrigate, day or night. and can use the key to open and close the valves. By employing a Common Irrigator, a supplementary level in the management of the irrigation system has been added meaning, at the same time, that an additional problem has been introduced for some of the farmers of the area.

3.1.3 Impact of remodelling on the farming system and farming practices

Three objectives listed below have guided our work at farm level in the LSC irrigation system :

* to further check some of the findings of the Rapid Appraisal team,
* to evaluate the impacts of the remodelling of LSC, specially the higher water duties, on the farming system and irrigation practices in the area,
* to evaluate the (some) benefits of the remodelling and to compare them with the (some) costs of the remodelling.

It was fully understood at the planning stage of our work in LSC that the evaluation of the benefits of the remodelling could be a very difficult task, depending on the availability of the data that could be collect and the time to be allocated to this work.

Primary data were collected in January 1992 by interviewing farmers of distributary 3 and Sheikh Yusuf Minor. Totally, 65 farmers were interviewed, 20 in 4 watercourses of distributary 3 (2 watercourses at the head and two watercourses at the tail of the distributary) and 45 in 6 watercourses (located from the head to the tail) of Sheikh Yusuf Minor. Information was complemented by secondary data (cropping pattern and cropping intensity, irrigation water supply data)·and interviews of officials from the Irrigation Department,

The processing and the analysis of the primary and secondary data has been started. The first results of the analysis show that the impact of the remodelling is not similar for the two channels, Sheikh Yusuf Minor and distributary 3, because they are at two different stages of their development : remodelling works were still under progress in Sheikh Yusuf Minor at the time data were collected, thus having a negative impact on the canal water supply, especially for the tail watercourses of the minor ; distributary 3 had been remodelled two years ago and already was receiving a higher irrigation water supply.

For distributary 3, all the farmers report an increase in the cropping intensity and changes in their cropping pattern with a high increase in the area under sugarcane and orchards. and a decrease in the area under tobacco and maize. This increase has been accompanied by an increase in crop yiclcls but the use of the different inputs (mainly fertilizers and pesticides) did not change beiwccn "before" and "after" the remodelling.

Of first interest is the fact that the increases in the cropping intensity and in crop yields have been higher for the farmers of the tail watercourses than for the farmers of the head watercourses, leading to a sort of "equalization" of the performance, of the head vs tail, of the farming systems.

Those results are presented in the boxes below: Changes in cropping intensities at the tail were reflected by an increase of 23 percent; while the increases at the tail were higher, at 46 %. In the second box, the values at head and tail increased 72 and 71 for wheat and maize, respectively; while those at the tail were of the order of 120 and 103 percent for the same crops and order.

Position of the watercourse	Before	After	Change in %
Head Watercourse	168%	207%	+23%
Tail Watercourse	126%	183%	+46%

Impact of the remodelling and the higher water duties on wheat and maize yields (Distributary 3, LSC)

Changes in wheat and maize yields from "Before" to "After"		
Crops	Wheat	Maize
Head Watercourse	+72%	+71%
Tail Watercourse	+120%	+ 103%

Yields for the "before" and the "after" situations have been reported by farmers during interviews. The increase reported for a period of nearly **5** years is consistent with Agriculture Department data of the last **5** years.

In Sheikh Yusuf Minor, farmers complain about the remodelling : the temporary decrease in the water supply during last Kharif season has had a negative impact on their yields, especially for sugarcane. Moreover, the intensive drainage system in the area has lowered the water table diminishing possible contribution by capillary rise; thus. increasing the irrigation requirements of the crops. Cropping intensity here is much lower than in distributary 3 (on average, 150% in Sheikh Yusuf Minor against 200% in distributary *3)*. Farmers at the tail of the distributary are still operating their tubewells to increase their irrigation water supply.

Results of our analysis will have to be used very cautiously. Firstly, data have been collected through interviews and not by monitoring the system from the "before remodelling" situation to the "after remodelling" situation. Secondly, the LSC area has been the theater of more than one intervention, with an increase in the water duties, the remodelling of the canal system, the installation of the gates at the watercourse outlets, the implementation of an important drainage program ; thus. it is rather difficult to assess the level of the marginal impact of a specific component on the farming system and the agricultural production.

3.1.4 **Institutional Issues**

An institutional study was started in January 1992 to find out how and why this particular design approach was undertaken at the beginning, and what interactions took place between the designers and eventual operators of the remodelled system. This study involves the collection of information on early design documents, planning documents, feasibility and appraisal reports and subsequent World Bank Aide Memoirs. Several discussions and interviews have been held, but there are still some information gaps which need to he filled before being able to fully document the design-management processes. The work is under way, and is expected to be finalized for inclusion in the next Seasonal Report.

3.2 Chashma Riaht Bank Canal Irrigation System

3.2.1 Irrigation Systems Operations

3.2.1.1 Simulation of main canal operations

Because a key issue in the potential introduction of crop-based type of irrigation operations to Pakistan is the impact on the traditional way in which main canals are operated in the country, the need to simulate the effect of different operational modes was clearly identified earlier on.

A recurrent question, for example, has been whether the main canal can he operated at values much less than the traditionally accepted lower level of 75 percent of full supply discharge, and its effect on both the structural and sediment-related conditions of the canal.

The best way to asses the impact that flow fluctuations in the main canal can have on system performance is through a simulation model. IIMI has had a good deal of experience with just that type of tool. Under an on-going IIMI project entitled Decision Support Package, and of which the CBIO project is taking advantage of, computer models for simulation of main canal operations and maintenance decisions for distributary canals, are being applied and fitted to Pakistani conditions. A brief description of the Model used and its application for the conditions present in the CRBC follows.

The performance of a canal irrigation system is judged by the efficient. reliable and equitable water distribution that it can provide. These parameters are directly or indirectly related to technical (design), institutional (operation and maintenance) and social (users' conflict like water theft etc) aspects. The dynamic flow conditions of a system are generated, and to a large extent controlled, by these factors.

For a demand-based distribution system, efficient monitoring of the system depends upon:

i) correct assessment of the canal water supplies. based on reasonable estimates of the water requirements and the design and operational limitations of the water supply system,

ii) an appropriate operational scheduling for the variable flow conditions, and

iii) proper design and efficient control of the distributary structures (gate openings etc).

Fourth-generation mathematical flow models are the current computer tools utilized to simulate the complex operational and management scenarios and hydraulic status of the canal, with reference to the above mentioned considerations.

The hydrodynamic mathematical flow model uses a standard mathematical description of the gradually varied one-dimensional flow phenomena in open channels and solves it for the different boundary conditions. Saint Venant's equations are used to describe the energy and momentum variations in transient flow conditions.

The SIC (Simulation of Irrigation Canal), developed by CEMAGREF (France), is a software package which solves the Saint Venant's equations numerically using Preissman's finite difference scheme. It contains three basic operational units:[1]

Unit 1 is basically the data input component, used for a first description of the canal and to compute topography data files;

Unit 2 performs the steady flow computations using tlie files of unit one and the complete description of the offtakes, regulators, discharges, seepage, Manning coefficients eic, and

Unit 3 performs the unsteady flow computation using the initial steady state derived from unit 2. The equation used for the unsteady flow computation are the complete De Saint Venant's equations. This unit calculates the water surface levels and discharge in different reaches of the niain canal and the offtake discharges based upon main canal situation, gate openings and offtake downstream conditions.

Our work with the model on CRBC has resulted in a good approximation of the reality since reasonable information from the field has been made available. The brief discussion of the results below indicate that the model can he used as a management tool for the CRBC.

Until now the SIC Model has been successfully applied. in order to:

i) simulate the actual hydraulic and operational conditions of the CRBC; the model was used to simulate two sets of actual field discharge conditions, under slightly different scenarios. These discharges were 47 cumecs, and it is shown in Fig.III-1, representing the lowest flow required in the main canal as per crop water requirements, and 60 cumecs, representing an intermediate requirement. The results show good correlations between actual and predicted values. In the former case, the observed water surface levels were achieved through appropriate gate settings using indent seasonal discharges as a reference. In the latter case. actual gate openings were used for 5 distributaries with design discharges used in the remaining 3 offtakes. Measured values of roughness coefficients and seepage were utilized in all reaches. At this discharge, good delivery performance of the system is observed; and all the design discharges could he achieved.

ii) to simulate the canal's hydraulic and operational behavior at different supplies which allows to predict a set of gate openings, water surface levels (and slopes) in the main canal, and the discharge of the escape at the end of stage I. The results show that at 40 cumecs (Fig.III-2) not all the offtakes can carry the designed discharge, but they could take discharges very near to the indent of the low-demand months but with only

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[1] An in-depth discussion of the SIC model is found in: CEMAGREF. 1990. Simulation of Irrigation Canals, Theoretical Concepts. (Draft)

15 cumecs going beyond stage I. This would be hardly enough to cover the requirements of stage II, and much less those of stage III. In Table-I the design, indents and predicted discharges are given. In Fig.III-3, the water surface level at the end of stage I is maintained at the design level through gate operation: thus, water is stored in the lower reaches and its effect travels upstream quite a distance as exhibit by the change in water surface slope at different discharges,

iii) to test the design modifications (already planned by the canal operating agency, WAPDA) required to achieve certain water surface levels in the main canal at low flows. The Model was run for the 40 cumecs head sluice discharge, and the predicted water supply level (WSL) checked against the results of step ii) above. To have the appropriate WSL and offtake discharges a Cross Regulator is superimposed at 45 km from the barrage, as shown in Fig. III-4, and then tried again imposing the regulator at 57 km from the barrage. Results show that the former option provides a slightly better picture for water levels in the nearer [to the barrage] offtakes. In the latter case, the impact on the first offtake was found negligible.

Simulation activities will be expanded in the forthcoming season to the distributary level in order to develop alternative water allocations in the framework of crop-based irrigation operations. The first steps in this direction were taken during the canal closure period, when a profile and cross-section surveys were undertaken in both distributaries # 3 and 4. This topographic information is the basis for the application of the SIC model.

3.2.1.2 Development of Ratina Curves

An important task undertaken since project inception has been the development of rating curves for selected distributaries and watercourses. These are essential in the context of project performance evaluation and water management monitoring activities which are basic to the understanding of overall system behavior.

In the beginning, distributaries 1 to 4, and 8 watercourses of distributary # 3 were identified for this purpose. It was felt that an intensive flow monitoring and measurement program could provide results by the end of the Rabi 91/92 season. While considerable progress was made during the reporting period, towards fulfillment of this goal, our perception of the task at hand was somewhat underestimated.

A number of unforeseen constraints interfered with the full completion of the development of the rating curves. Among these:

* Constant flows throughout the season. There was very little variation in flows both in main canal and distributary levels which narrowed the readings range significantly.

* Presence of *Karries* near heads of distributaries. These created backwater effects that affected readings.

* Head gates spindles. These are covered which did not allow indirect readings of gate openings; this situation was further complicated by permanent high water depths in main canal which made it impossible to measure openings directly.

The above constraints were overcome through different approaches, like designing special gauges for reading of gate openings, by seeking the cooperation of both WAPDA and PID in varying flows in the canals to obtain a wider range of readings, and by correlating field and formula-based results. Some of these actions came late in the season thereby preventing the full accomplishment of the curves. In Figure 111-5. rating curves developed for Distributaries **# 3** and **4** are given. Likewise, curves were developed for specific watercourses outlets of distributary **# 3.**

Other measurement points have now been added to the previous mentioned; i.e. Head and tail of Girsal Minor, head of Kech Minor and four watercourses in Distributary **# 4.** We are currently in the process of developing rating curves for these new added points.

3.2.1.3 System Responsiveness Options

For the implementation of crop-based type of irrigation operations, it is necessary to identify a set of scenarios under which alternative management setups, at different levels and by different participants of the irrigation process, can be analyzed in order to gauge the responsiveness of the system under those conditions.

Each option can elicit a different perspective in terms of the infrastructure needed, the communication arrangements necessary or the degree of information required. Likewise. the actors (agencies and end-users) would need to play a more or less prominent role according to the choice being made.

With the above in mind, we set out to explore a range of possibilities on the nature that the delivery of the water supply could take. The concepts fall between the extreme "supply-based" as currently practiced in the country to the "demand-based" characterized by the prominent role played by the end-user and typical of highly developed countries, but unlikely to implement in Pakistan's social environment.

Two options: Demand-Refusal and Modified Demand-Refusal offer promising results. These two schemes which take root in the concept of crop-based irrigation offer a "middle of the road" strategy by assigning a certain degree of participation to the farmer which has been otherwise denied under the present system operation. In return the role of the agency is enhanced in the measure that a greater emphasis in training of the personnel would be needed.

In Table-2, a matrix of intervention levels are given for the responsiveness options.[2]

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[2] Material for the table has been extracted from H. Murray-Rust's field report on his visit to D.I.Khan.(Feb/1992).

3.2.2 Supply and Demand of Irrigation Water

A key issue of the study is the integration of the demand and
supply of the irrigation water in order to enhance productivity.
By closely monitoring the water supply at different levels of the system, and matching it with the water demand at those respective levels, we can determine the real impact of the upgraded water duties.

Below, in this section, several parameters on both side of the equation are discussed and related to the potential of crop-based operations:

3.2.2.1 Delivery Performance Ratios (DPR)

A useful indicator being utilized in our work at the CRDC is the Delivery Performance Ratio (DPR) which shows the relationship, in decimals, between the actual and the design discharge. The DPR can be utilized at different levels of the system as a measure of the equity of water distribution. Deviation from unity indicate over or under delivery, as the case may be,

In Figure III-6, the monthly DPR values, for Rabi 91/92 are shown for selected watercourses of distributary # 3.

Analysis of results showed that both the standard deviation and coefficient of variation for discharge values were extremely small, indicating little flow variability within outlets. The DPR values, however, in 5 out of 8 outlets indicate an excess delivery throughout the cropping season, with values as high as 1.87. The distributary is then delivering much more water than required according to the design. More so if we keep in mind that the design values correspond to peak water requirements under the crop-based approach.

The above notwithstanding, it can be readily observed in the figure that inequity of water distribution still exists, with a declining trend from head to tail of the distributary. The difference in DPR values, between say the first (570-R) and last (15382-R) outlet, is relatively large. For those outlets whose DPR values fall below one, the shortages can be associated with either the position of the outlets with respect to drop structures (provided with stop logs that are normally utilized to enhance the water head), or with problems of the present condition of the outlets like leakages or breakage.

A final, but interesting piece of information contained in Table 1 refers lo the "count" in days; this refers to the number of days that the outlets were "open" during the period. It should be noted that in October 91 only its second half was monitored coinciding with the starling of the season; likewise. only 17 days were monitored in January 92 as a result of the starting of the closure period that lasted until the **29** of February [therefore the absence of data for this latter month, also]. This suggests that farmers are often closing the watercourse thereby refusing the water allocation. In fact, the farmers seem to be moving already towards a demand-type of irrigation and trying to fit the supply into their perceived crop water requirements. Further analysis of this finding will be provided in a forthcoming section below.

3.2.2.2 Water losses in watercourses

A first attempt was made, during the reporting period, to assess the losses in watercourses of distributary number 3 and **4.** Discharge measurements were taken at different points in three watercourses of distributary number 3 and two watercourses in number **4,** by utilizing current meter in lined portions and RBC flumes in the unlined ones. Normally, readings were taken at the beginning and ending of lining, and head, middle and tail reaches of the watercourses.

During the measurements, it was observed that the conveyance losses are a combination of those accruing from pure seepage in the canal, and various others stemming from more managerial-related losses like canal overtopping, leakages through poorly maintained banks, leaks at other division points and, even, illegally open field outlets (*nakkas*). In at least two cases, canal overtopping at the tail-end of the watercourse was due to insufficient capacity of the canal to carry the full discharge. In this case, farmers had chosen to split the flow among two or more farmers. a sensible management intervention that nevertheless confounds the traditional concept of *warabandi* and that creates difficulties in the process of monitoring farmers' water management activities at field level.

Preliminary results indicate that pure seepage losses from unlined stretches are in the range of 5 to 10 l/s per 1000 m^2. This loss will remain independently of actions taken to remove all other managerial type of losses. Losses in lined canals were found to he smaller ranging from 0 l/s per 1000 m^2 in well maintained watercourses with no signs of breakage in the lining, to 8 l/s per 1000 m^2 in those with less appropriate maintenance conditions and where leaks from *nakkas* were pi-esent.

In a joint study of Colorado State University and Mona Reclamation Experimental project[3] involving 220 measurements on 18 watercourses in the Punjab, an average seepage loss of 2.3 l/s per 100 meter of watercourse length was reported (with large variability around this average). Assuming an average wetted perimeter of 1.7 meters for a typical watercourse. the value amounts to 13.5 l/s per 1000 m^2. The loss rate obtained for CRBC watercourses seems, therefore, quite reasonable since lower values than in the Punjab would be expected due to the higher clay content of it's soils.

While the measurements results are indicative of the losses conditions present in the system, they are not enough to provide detailed seepage losses for individual watercourses. However, it is possible to obtain an average for pure seepage losses value for a typical CRBC watercourse by using real field data, **as** follows:

* **CCA** = 110 ha
* Design Q = 60 l/s
* Actual Q = 75 l/s
* DPR = 1.25
* average w/c length = 2000 m
* average lining = 500 m

[3] WAPDA. 1981. Measurement of watercourses losses by ponding method and study of factors which affect watercourses losses. CSU-Mona Reclamation Experimental Project. Bhalwal. Pakistan. Publication 110.

* length where seepage occurs = 1500 in
* typical wetted perimeter = 1.7 m
* wetted area = 2550 m^2
* average seepage loss rate = 7.5 l/s/1000 m^2
* total seepage loss = 19 l/s

The 19 l/s value above is a 25 percent loss of the actual discharge at the head, which provides a watercourse conveyance efficiency of 75 percent taking into consideration pure seepage ONLY. When this value is applied to the total **CCA,** this gives a seepage loss of **1.5 mm/day**, if the watercourse is running day and night.

Total conveyance losses of up to 75 percent weie recorded during the measurements (only 18 l/s, out of 72 l/s, reaching the tail). This figure, however has to be interpreted very carefully because it **is** extremely difficult to separate real losses from those where the farmers chose to divert water to other fields in order to avoid overtopping (as reported above) or simply hecause he did not need all the water being allocated during his turn. An extensive patrolling of the watercourse would be needed during the measurements period to ascertain the true nature of the conveyance losses, this was not done during this reporting period but will be in the agenda in future interventions regarding losses in watercourses.

3.2.2.3 Relative Water Supply

Another useful indicator to try to understand the performance of an irrigation system is the Relative Water Supply **(RWS).** It is a simple but powerful tool because it is indicative of the "behavior" of the users in response to the amount of water available (or expected to be availnblc) at specific location of the system in relation the perceived needs.

The parameter is defined as the relationship between the amount supplied (both irrigation and rainfall) and the amount needed (crop demand plus seepage and other losses). Mathematically,

$$RWS = \frac{\text{Irrigation} + \text{Rainfall (effec.)}}{\text{ETc} + \text{Seepage} + \text{Other losses}}$$

During the reporting period, each one of the variables intervening in the **RWS** were monitored down to the on-farm level, for selected watercourses of distributary **3** #. In Table-3 the crop water requirements of the Rabi season [4] are presented; and in Table-4, the information needed to obtain RWS values, on a 10-day period basis, is presented for a selected watercourse. i.e. 11920-L of Distributary # 3. In Figure 111-7, the RWS values are presented against the ideal crop needs.

4 Crop walcr requirement calculations **have** been **done** following guidelines set by the Food and Agriculture Organization through their computer program CROPWAT.

The graph shows a favorable RWS until the start of the canal maintenance-related closure period in mid-January when the crop undergoes a severe stress condition. The closure, however. coincides with the lowest crop demand needs (see Annex # 3, ETo graph for D.I.Khan). Nevertheless, such low values of RWS for the extended two month period are bound to have a negative impact on the yields of crops.

Preliminary observations with respect to RWS values give support as to the contention that excessive water is being allocated to the farmers of Stage I of CRBC. The RWS values, greater than unity, of the early season are certainly indicative of generous allocation, as compared to Punjab systems were RWS is normally below unity. But, the very low values in the latter part of the season once again underline the dry environment under which farmers are growing their crops, in the absence of irrigation water.

Two important water management issues that have impact on the performance of *the* system, can be discerned from the RWS information: i) the lengthy closure period has a negative impact on the crop. Although a 30 days period was envisioned it finally lasted **45** days due to structure repairs in Distributary # **4,** and ii) conveyance losses are very high. Wastage, like overtopping or leakages, account for the lion share of the loss. While the first one falls under the purview of the government agency (or agencies), the latter falls more under the responsibility of the end-user. In both cases, however, an effort towards improvement would translate into high benefit to the output of the system.

3.2.2.4 Open and Closure of Outlets

Very early in the system monitoring process, **it** was observed that farmers readily opened or closed the outlets although this was a deviation of the traditional *warabandi* set-up. It was decided, therefore, to document this activity as it could provide a clue as to farmers response to perceived crop water requirements, and in addition serve as venue for the rationalization of a water distribution scheme that could be tailored to farmers needs.

An example of the outlet open-close seasonal record **for** watercourse 11920-L is shown in Table-5. It is rather surprising to see that of 173 days monitored during the season, the outlet was open only 56 percent of the time; the percentage closed was **42,** with the remaining period of 2 percent accounting for partially open conditions of the outlet. It should be kept in mind, however, that the "closed" period includes **42** days of forced canal closure which increases the actual "open" time to 75 percent of the season, a less disturbing but nevertheless interesting information.

In Figure III-8, the crop water requirements for the average cropping pattern of Distributary *# 3* during the Rabi 91/92 season, is superimposed on the observations on open-days outlets in watercourse 11920-L.

Under idealized farmer's response , one could expect a matching trend of open days and crop water needs. This is not entirely obvious from the graph, although some rational behavior seems apparent. For example, it was documented in the field that farmers were over-irrigating their plots in the month of December in preparation for the announced January-1st canal closure. However. closure was delayed until the 17th and farmers tried again in those last days to "fill" their plots. The behavior at the peak of the requirement is also consistent in the graph, but the large number of open days at the beginning of the season is less easy to explain. The comparison exercise as described above should again be view with care since the data does not provide an accurate account of the number of hours within open days that the outlets were actually running, that is whether there was or not night irrigation.

3.2.2.5 Cropping Pattern and its Impact

During the design stages of the system a cropping pattern was developed (stemming from field observations in nearby irrigated areas, crop economic conditions in the province. plus farmers interviews to asses crop preferences). in order to have a base for calculations of various canals capacities according to this projected crop water needs. Nobody. howevei-. can expect that changes in time, in this idealized cropping pattern, will not take place.

This could certainly be the case for the CRBC; once the increased water duties became available to farmers, a shift towards niore water demanding crops, representing higher economic returns like rice, was to be expected.

Because of the potential impact on water demand that major shifts in the cropping pattern could have in the short-term operating conditions of the system. this issue was also identified as an important one to monitor in the early stages of IIMI's intervention.

The results of the cropping pattern and intensities for selected watercourses of distributary # 3 during the first cropping season that has been evaluated (Rabi), are conipared with the design conditions in Table-6.

While the cropping intensities remained fairly close to the 90 percent of the design, ranging from 90.6 to 97.5 percent; the cropping pattern showed major deviations particularly with respect to wheat and gram. These differences are highlighted in Fig.III-9 where significant increases in the area planted under these two crops is apparent from comparison with design figures.

It is interesting to note that while farmers increased wheat intensities by as much as 20 percent (as compared to design values), they seem to have compensated the overall crop water requirements by similar increases in the area under gram, a crop not norinally irrigated in Pakistan. 'Thus, farmers are projecting some understanding of the limitations of a demand-based system, a fact not readily recognized by the irrigation agency. It is precisely this supposedly lack of understanding of the farmers, on water management related issues, that leads the government agencies to proclaim that this new type of irrigation operations has little chance of being implemented in Pakistan.

3.2.2.6 Field vs "transect" cropping patterns

In the NWFP the fields are more often than not of highly irregular shapes, unlike the traditional grid system that is observed in Punjab's farmers fields. This creates a serious problem when pursuing accurate information on cropping patterns since it requires a very detailed field by field inspection. To this, it should be added that farmers will reshape fields season by season which could render obsolete quite quickly the detailed field surveys.

To tackle this particular problem, in was decided to undertake a combination of field and desk study, by comparing actual cropping patterns obtained from a very detailed field survey with the results obtained from running "transects" at different widths on the crop survey map produced,

We chose watercourse 11920-Lof Distributary # 3, and after developing a highly precise *chakbandi* map of the watercourse we ran transects at 100, 200 and 400 m intervals. The results of that exercise can be seen in Table-7. Very much as expected, it was found that the closer the transects the more accuracy possible in reflecting actual field conditions.

However, it was surprising to observe the very small difference between the 100 and 200 m results, if we were prepared to allow a somewhat higher deviation from actual values (in this case 98 and 97 % of the cropping pattern in the transect results falls within 15 % of actual field values. as oppose to only 88 and 71 % if our target is to be within 10 % of the actual figures). The 400 m trnnsects, on the other hand, gives very inaccurate results as only about half of the area is predicted within 10 % of real field values. In all cases, those crops with small areas are missed by the transects. For example, none of the transects reflected the presence of sugar cane which constitutes only 0.15 % of the cropping intensity of the watercourse.

The transect approach is important if we consider the significant amount of time spent by our staff in trying to asses the existing cropping pattern; if this exercise *is* going to be needed regularly as part of crop-based activities, it is highly unlikely that the irrigation or the agricultural department would have the necessary manpower to do so on a seasonal basis. In fact, the season was over and we could still not obtain the cropping pattern to be utilized by the PID for purposes of revenue collection. This third option of cropping pattern was also to be utilized in the transect comparisons; once it becomes available it will be included in this analysis.

The transect approach offers a quick alternative and provides an indication of the deviation that might beexpected from actual field conditions. If the field disposition for this watercourse is lo vary greatly during the Kharif season, then the work done during Rabi will prove fruitless and we will have to consider the transect technique very seriously. It would be impossible for our field teams to spend so much time in pursuing cropping pattern information, but given its importance in the context of crop-based irrigation an alternative to extensive field survey will surely prove useful.

3.2.3 Irrigation Facilities

The simulation exercise on the operation of the main canal, as described above, has begun to provide some indication of the possibilities of additional structures that would be required at this level.

If rotation at main canal level were to be established, then the present number of cross regulators in Stage I would be clearly insufficient. It may be recalled that in order to secure design flows into the link feeder canals under low crop demand conditions (for example, **40** cumecs), an additional regulator at around km 45 from the barrage would be necessary (see Fig III-4). The precise location of the structure would depend on the allocation scheme finally adopted.

Further work in this regard will be carried out in the coming months. In addition, similar consideration would be needed to determine the particular conditions present in Stages II and III, although this kind of work falls beyond present project targets and capabilities.

At distributary level, preliminary results are indicating that the ungated pipe outlets are being opened and closed by farmers through either the clogging of pipes with various materials. or closing of the control box on the downstream size (the box is, in fact, part of the watercourse lining program under OFWM scheme). This advances the idea of gated outlets, provided that steps are taken to insure that farmers are properly trained in the management of the structures. (See section 3.2.2.4, above, for more discussion on the watercourse closure record).

Given present farmer behavior, it could be argued that a simple "double-gated" pipe outlet could prove useful. The first gate on the upstream side would be under the control of the PID and managed according to crop water requirements. The second gate, on the downstream size would be under the control of the farmer who would manage according to his perceived needs. This latter gate would be the equivalent of the one already in place in the control box. The farmers would have the opportunity of refusing the water and avoid potential damage to crops from unwanted excess water, something that has been observed in the area already. Tight control over the PID-managed gate would be required with severe sanctions imposed, for tampering (a measure which is hardly practiced in today's setup). While the farmers would not be in a position to augment the flows being provided by the PID, they would, at least, be in a position to cut their unwanted supply without putting in danger the integrity of the outlet. Also, their action would serve as a signal to the agency as to water needs at distributary level (refer to section 3.2.1.3 and Table-2, above).

In a survey carried out, by IIMI staff, during the closure period, a large percentage of the pipe outlets were found broken in Distributary # **3** (30 percent) and *#* **4** *(33* percent). Since this pipes are considered temporary, their replacement should be carefully evaluated. **A** more sturdy type of structure appears to be needed judging by the conditions of the existing one which are not yet five years old and present a sad state of disrepair. Similar situation was found in both distributaries for other structures like drops, those at the tails, etc.

In the coming periods further assessment of structure facilities needs will be undertaken; for example the need for scape structures at, both, the distributaries and watercourses levels.

3.2.4 Irrigation Institutions

As indicated in the Inception Report, the study objectives include the identification of the institutional context of the project, and the development of adequate collaborative relationships with both the operating agencies and the farmers. These two inter-related activities were both initiated during the season under review, and the work progressed slowly but steadily.

Efforts to establish collaborative relationships which will be essential for field-testing of the finally identified research recommendations were briefly discussed in Section 2.6 above. Data being collected on the irrigation organizations and their rules will be used to analyze the institutional context and will be reported in a separate paper along with the next Seasonal Report.

Study Team's interactions with the farmers were initiated during the Rabi season through selected sample farmers in two distributary canal commands (Disty. # 3 and 4) and Girsal Minor. A total of 72 farmers, 24 in each, were contacted. This part of the work has turned out to be very productive. Very useful information has been collected through this process. Some constraints experienced in both these efforts will be mentioned later in the section.

Some results arising from farmer interviews pertaining to existing irrigation practices are summarized below.

* Water distribution on both the Distributaries (3 & 4) is in a state of **flux,** both because of changes being effected to the physical infrastructure and the lack of experience among the farmers. As new areas have been brought under irrigation, keeping in line with the normal practice, only the pipe outlets have been provided, which would later be converted to *pucca* outlets after the farm lay out (*chakbandi*) is fairly stabilized. Some of these outlets are still being relocated to improve the command of the area. Another instance is the construction of Jabbar Wala minor on Disty # 4 to better serve the area with the smaller outlet *chaks,* transferring the irrigation of some areas from Disty # 3 to Disty # 4. Several farmers are dissatisfied with the present sources of the irrigation water and therefore further changes in the *chakbandi* are likely to take place in the near future

* An official *pucca wurubundi* has been drawn up by the Irrigation Department only for one outlet in both Disty Nos. 3 and 4, outlet No. 19248/L of Disty # 4. For other outlets, the farmers had called upon the local *patwaris* to assist in the drawing up their unofficial *wurubundi,* and this process is under way. Of the 8 selected watercourses, 4 each on the Disty # 3 & 4, some sort of *wurubundi* has been drawn up only in 5, where as in the remaining 3 watercourses some ad hoc arrangements are agreed upon by the farmers for sharing the irrigation supplies. The decisions seem to be taken by influential farmers. Only two written down *wurubundi* schedules could be traced; for study purposes, IIMI staff prepared the schedules on the basis of information (extent land and irrigation times) obtained from the farmers.

* In all cases it is found that the duration of the *wuruhundi* rotation is 7 days with no apparent allowance for conveyance or the *nikal*.

* Interviews with the tail-end farmers have reported shortage of water as compared to the farmers near the head of the watercourse.

* Farmers have reported that there is an excess of water during Rabi so that they are not concerned about adhering to the *warabandi*; changes from the agreed *wuruhundi* frequently take place by mutual agreement. At times the farmers close off the outlets when there is no demand. During Kharif when there is greater demand, the farmers tend to strictly follow the agreed *wurubundi*.

* No farmer reported any dispute in the operation of the present system. Apparently the chairmen of the Water Users Association (which was formed during the watercourse lining program) who is usually a big landowner, or any other big landowner, is the person who intervenes in the event of a dispute. This was confirmed by the officials of the Irrigation Department, when they stated that there is no *pucca wuruhundi* for these except on one watercourse, and that, because of the big land lords, no formal request jointly have been made by the affected farmers for the Irrigation Department to step in and lay down the official *wuruhundi*.

* The mode of agriculture in the area by the smaller farmers is primitive. They hardly use any modern techniques of farming and think that agriculture production depends on nature rather than human efforts. General crops sown in the area are rice and wheat.

The present situation of the Watercourse No. **14810-R** of the distributary No. **3** is illustrative of some of the general observations made above, but also provides a special story. Three big landlords have chalked out its *wuruhundi* plan one year after the construction of the canal. The farmers belong to three separately identifiable groups among whom the water distribution plan was made in the first instance. In the second stage, the water allotted to each group was distributed further among their members by their mutual agreement. The water distribution thus effected does seem to be equitable; some landowners got more than their actual right while others got less than their due share. **As** a result proper *wurubandi* is not prevailing in the area and water distribution seems to dependent on power and influence. According to information collected in the field, this pattern is as shown in Table-8, and its glaring inequity can be seen in Figure III-10.

Data collected during Rabi from the watercourse study will be further consolidated during this Kharif season, and will be reported in a separate discussion paper along with the next Seasonal Report.

Summarizing, field work conducted so far indicates that irrigation practices in the CRBC study area are scanty, still evolving, and largely unsystematic. They are neither based on any established *warabandi* system that is practiced in most other areas in Pakistan, nor on any scientific flexible system that takes account of crop water requirements.

Two causal factors for this situation are discernible. One is the fact that the command area is still developing, and water distribution pattern within the watercourse command is not stabilized yet. In this regard, the involvement of agency staff has been minimal. The other is the dominant role played by the large landowners. The interviews with farmers suggest that the big landlords have been instrumental in determining tlie water sharing arrangements where they exist, and that they are also responsible for interfering with the water turns of the nominal *warabandi.*

Even the *warabandi* as it is known to exist in the study area is not strictly adhered to during the Rabi season as there is apparently more water available than necessary for the developed parts of the command area. However, during Kharif season when demand is likely to be greater, the water distribution may be effected with greater care and consciousness. This aspect will be studied further during the Kharif season.

3.2.5 Economics of Crop-based Operations

The main objectives of the economic component of the CBIO project as stated in the PC-II of the project is to evaluate the benefits of crop-based irrigation operations and identify costs and opportunities for implementation on a wider scale. To fulfill this objective, it is necessary to establish a benchmark that would allow future comparison. Thus a socio-economic survey was undertaken in CRBC area at the beginning of the Rabi season. To complement the information collected through the survey, the monitoring of the farming and irrigation practices, input use and output of a selected number of sample farmers in distributary 3 of CRBC was included in the regular field work of the field team in D.I.Khan.

During the planning stage of our work in CRBC, some activities on Girsal Minor (old Paharpur canal system) were organized. It was decided to include the comparison between two situations of Girsal Minor, "before" the remodelling and the introduction of the higher water duties and "after" with higher water duties, in the economic component of the project, to evaluate tlie impact of higher water duties on the farming system and the agricultural production.

3.2.5.1 Baseline Socio-economic survey

The overall objective of the baseline survey was to obtain an understanding of the present socio-economic conditions of the farmers and of their farming and irrigation practices. The survey was undertaken by the same firm IIMI contracted for the Rapid Appraisal in LSC, EDC (Pvt.) Limited, a private consulting firm based in Islamabad.

Guidelines provided by IIMI to EDC for the preparation of the questionnaire focused on the need to identify :

* key social and economic variables which influence production practices,
* relationship between socio-economic variables and irrigation practices,

* problems associated with irrigation management, and how farmers cope with them,

* other possibilities for project intervention

The questionnaire was pre-tested and finalized in collaboration with IIMI staff

A total of 193 farmers from 8 watercourses of distributary 3 and 125 farmers from 8 watercourses of distributary 4 were interviewed by the EDC team during November-December 1991. Watercourses were selected from the head to the tail of the distributaries (2 watercourses in each quartile), where other IIMI regular field activities are taking place. The analysis of the data collected was undertaken by EDC staff during the first 2 months of 1992. The report outline and a first draft were discussed between EDC and IIMI team members before finalizing the report. At this stage, EDC was specifically asked to include a comparison between distributary 3 and distributary 4 as well, to see whether distributary 4 could be used as a control.

The final report was submitted to IIMI at the end of March 1992 and distributed to the different key agency staff concerned with the study.

An important output of the work done by EDC was the comparison between some important socio-economic characteristics of distributary 3 and distributary 4 (control). The analysis of the data highlighted that the main differences between the two distributaries are in the demographic variables and the availability and use of water. No significant difference was found lor land ownership or land use, livestock resources, expenditure and credit. Additional work on the water use, irrigation practices and the market for water in the two distributaries was suggested in their final report.

Another IIMI requirement was to compare the watercourses of different quartiles for the two distributaries. However, the EDC report states : "a considerable effort was made to understand inter-quartile differences in land use, cropping pattern, cropping intensities and yields. It is not possible to conclude, however, whether or not there are systematic changes in the agricultural production, as one progresses from the head to the tail reaches of a distributary."

The main findings and conclusions of the report regarding the socio-economic characteristics of the farms and their water management practices are summarized below.

i) Socio-economic variables

* Farmers of distributary 3 belong to two villages, with 51% of them being from the same clan. For distributary 4, the ethnic composition and settlement is niore diverse.

* The average farm area is around 12.5 hectares, Land holdings and distribution of farmers by farm size are similar in both distributaries.

* Sources and amount of income are similar for the two distributaries, except for income from wage labor which is higher on distributary 4. However, consumption patterns are similar for both distributaries.

* Differences in farm expenditure are found only for animal feed and repair and maintenance of equipments, which are higher in distributary **4** where farmers are more livestock oriented and use more farm machinery,

Agricultural Resources, Practices and Services

Land use is similar on the two distributaries with rice-wheat as the main cropping pattern. Gram, which normally is not provided with irrigation, counts for 20% of the cropped area during the Rabi season. Distributary **3,** however, shows a more diversified cropping pattern, with a greater emphasis on maize, sugarcane and grain cultivation than distributary 4. This higher diversification is also reflected in the farming practices which are more intensive for maize, sugarcane and gram in distributary 3 than in distributary **4.**

* One third of the sample farmers have a cropping intensity lower than 100%, while 20% reported a cropping intensity ranging from 150 to 200%. On average, the cropping intensity is respectively 126% and 119% for distributaries 3 and **4.**

Reported crop yields are not significantly different between the two distributaries, except for sugarcane. No clear relationship was generally found between farm characteristics and crop yield.

Even if the requirements of credit are similar for the farmers of the two distributaries, their sources differ, distributary *3* having a more diversified institution-oriented pattern for sources of credit than distributary 4.

On-Farm Water Management

All of the farmers have experienced irrigated agriculture before the commissioning of CRBC. They mainly irrigate by wild flooding, have performed land levelling and stay on their farm during their irrigation time.

* Some farmers claim that they do not have enough water, especially farmers from the first and the last quartile in distributary 3 and from the third quartile in distributary 4. A higher level of water theft and a stronger impression that water is rationed by *warabandi* in distributary **3** gives as well the impression that water scarcity is higher for this distributary.

By purchasing water and exchanging turns, farmers have increased the flexibility of the irrigation system, The purchase of water is more common at the tail of the watercourses than at the head, whereas exchanges occur more at the head than at the tail (this is significant only for distributary **3).** Large farmers purchase more water than small farmers in both distributaries. Purchase and sale of water is significantly related to the tenurial status of the farmers : owner-cum-tenant farmers buy water more frequently than other types of farmers.

3.2.5.2 Monitorina of farmers practices

A total of **24** farmers from **4** selected watercourses of distributary 3 (570-L, **6468-L,** 10150-R and **14810-R)** have been monitored regularly during Rabi **91/92.** Five wheat fields were selected in each farm for which farming activities and inputs used were recorded carefully. Data related to the location of the farm within the watercourse, its cropping pattern, its socio-economic characteristics and constraints, and the characteristics of each field were collected as well to complement the information of the regular data collection work.

At the end of the Rabi season, yield data have been collected. Two different methods were used to collect wheat yields :

i) crop cuts have been made for the sample fields. In each field, **3** samples were selected randomly. For these samples, plants were cut, spike length were measured, tillers per square meter and grains per panicle were counted, and grains were weighted.

ii) farmers have been interviewed as well. Most of the time, it was not possible to obtain the yield for each sample field but only an average yield for the whole area operated in the watercourse.

The main objective of collecting wheat yields in two ways is to compare two methods of data collection and select the most appropriate one for the coming seasons, according to the time spent, the complexity of the method, the willingness of farmers to cooperate and the quality of the data obtained.

The entry of the different data by the field staff in some specific proforma has been finalized. **A** first analysis of yield data from crop cuts has shown that the average yield for the **24** farmers **is** quite high **: 2,800 kg** per ha. However differences exist among watercourses, within watercourses and within farms. WC **6468-L** has the highest average yield (3,200 kg/ha). WC 10150-R has the lowest wheat yield **(2,400** kg/ha) and the highest variability among farmers as well, see Figure III-11.

A quick comparison between wheat yields and DPR shows that WC 10150-R has the lowest average DPR as well. For the other watercourses, however, the relation between average wheat yield and average DPR is not clear. **A** more in-depth analysis of the data will be necessary to relate yields and quantity of canal water supplied, in order to estimate the efficiency of the irrigation water use in terms of yield per unit of water.

The collection of farm level data will be enhanced during Kharif **1992.** Rice, sugarcane and fodder fields of **48** farmers in **8** watercourses of distributary 3 and **24** farmers in **4** watercourses of distributary **4** will be monitored regularly for input/output data.

As stated above the objective of this regular monitoring is to estimate figures for the economic return per unit of water, per unit of land and per farm, and to study their evolution from one season (or one year) to the other. **A** second objective of the Rabi **91/92** work was to accustom field staff to the collection of farm and field level data, since only two staff out of the 8 stationed in D.I.Khan had previous experience in this specific activity.

3.2.5.3 Girsal minor

Some of the expected changes in Girsal Minor area due to an increase in the irrigation water duties are:

* an increase in the cropped area and the cropping intensity
* a change in the cropping pattern, with a shift from crops with low water requirements to crops with high water requirements,
* an increase in the yields
* a change in the use of farm inputs other than water

The relative importance of these changes will vary according to the main constraints faced by the farmers.

No comprehensive set of data has been collected to assess the impact of the remodelling and the higher water duties on different aspects of the farming system. Thus, primary data and secondary data were collected for this component of the study. Data collected through farmers' interviews during Rabi 91/92 were complemented by Irrigation Department and Agriculture Department data. Farmers' interviews focused on the management of irrigation water at a farm and watercourse level, the changes in the agricultural production, the farming practices and the different constraints of the farming system. In total, 32 farmers (24 interviews based on a questionnaire and 8 informal interviews focusing more on the changes in the farming system related to the changes in the irrigation water supply) from 4 watercourses from Girsal Minor were interviewed. Specific field observations on the watercourse itself (length of the watercourse, lined or non-lined, number of farm gates, etc) were collected at the same time than farmers were interviewed.

Data have been processed and analysis is close to completion. A further step is however still needed, i.e. to correlate the changes in area cropped, cropping pattern and yields to changes in the irrigation water supply (see 3.2.2).

The analysis done so far shows that the main impact of the remodelling and the higher water duties in Girsal Minor has been a shift from a Rabi oriented farming system towards a more Kharif oriented farming system, The remodelling had first a negative impact on the area under each crop and the cropping intensity (see Figure III-12), because of the disruption in the canal water supply due to the works on the irrigation system. Afterwards, with the increase of the water supply, the area under most of the crops, except for wheat, has increased. As expected, sugarcane and rice have been the main beneficiaries of the changes in water duties (see Figure 111-13). More surprising is the relatively high percentage of the area still under gram, essentially due to its position in the crop sequence just after rice.

3.3 Summary of Season Interventions

The **box** in the next page provides a bird's eye view of the various activities conducted in both LSC and **CRBC** during this reporting period. **As** can **be** seen, the interventions in the former were more interview oriented, while in the latter both interviews and more "hands-on" type of work was accomplished. The difference in approach was the result of the decision taken, in the early stages of project implementation, of concentrating efforts in **CRBC** while the on-going construction works in the intended study area was finalized; this is still the situation.

The "study" column of the **box** refers to those broad issues identified, during the project formulation stage, as central to the formulation of **a** strategy leading towards the introduction of crop-based irrigation operations in the country. The "components" column, on the other hand, refers to areas or disciplines that need to be addressed in order to analyze the issues.

The box also serves as **a** guide to the nature of activities that will be forthcoming in the next cropping season, Kharif **92.** For the most part, the interventions carried out during Rabi 91/92 in **CRBC** will **be** continued as changes in the behavior of the system are expected with the seasonal change.

SUMMARY OF RABI SEASON INTERVENTIONS

Loc	Study	Component	Field Activity	MainSyst	Dty	W/C Farm
LSC	**Irrigation institutions**	Role of agencies **Design/Management Interactions**	**Officials' Interviews**	XXX	XXX	-
	Economics of CBIO	**Farming system**	**Farmers' Interviews**	-	-	XXX
		Pilot **project**	Officials' + Farmers' Interviews	-	-	XXX
	Irrigation System Operation	Water management	Farmers' Interviews	-	XXX	XXX
CRBC	Irrigation System Operation	Simulation	Canal Monitoring	XXX	XXX	-
		Water management	Interviews *warabandi*	-	XXX	XXX
	Supply & Demand of Irrigation Water	Water supply	Flow measure-ments	-	XXX	XXX
		Water losses		-	-	XXX
		Crop Requirements	maps, crop **survey**	-	-	XXX
	Irrigation Institutions	**Role of agencies**	**Officials' Interviews**	XXX	XXX	XXX
		Role of **fanners**	Farmers' **Interviews**	-	XXX	XXX
	Economics of CBIO	**Farming practices**	Practices **Monitored**	-	-	XXX
		Agri. Input/Output	Farmers' **Interviews**			XXX
	Others	**Social environment**	**survey (EDC)**	-		XXX
		Meteorology	rain/evap.	XXX		-

IV. PROJECT CONSTRAINTS

4.1 LSC Study Activities

This part of the project is an institutional study that involves close collaboration with agency personnel, consultants and the farmers. It also requires the collection of many documents containing design stage and project monitoring data, including drawings and plans. The study team confronted many difficulties and obstacles in this regard. Some documents were not traceable; some were probably available, but not easily retrievable. Numerous visits and meetings were undertaken, just to collect one important document. However, with the assistance of some understanding agency staff, most of the information could be collected, but the intended package is not complete.

Considering the need to expedite this study component. particularly in view of the on-going planning work for the Upper Swat Canal Rehabilitation Project, the study team started analyzing the collected inforniation towards the end of this reporting period; hence, results will be reported in next season's progress report.
No further work is being contemplated at the LSC system: the issue of gated or un-gated outlets continues to be unresolved. Hence, uncertainty remains as to the type of intervention that our project could undertake. While construction work in the originally targeted Sheikh Yusuf Minor has finally been completed, it is not at all clear, which -- the new or existing -- outlets will be finally put into operation; and whether gates would be installed or not. The early decision taken of concentrating efforts in the CRBC system appears to be fully vindicated.

4.2 CRBC Activities

In general, and as mentioned elsewhere in the report. collaboration from the various government agencies related to the project was quite satisfactory. Documenis, data and other types of information requested were readily provided.

Constraints in project implementation, in the context of governnient agencies participation, came more from intrinsic problems faced by *the* agencies themselves. For example. IPHED has an acute staffing deficit and therefore it is difficult for the department to assign anyone on a more regular basis to interact with IIMI field staff. This was obvious during the time that IPHED was assisting with flow variations for development of calibration curves. The IPHED staff was present during the first day and then had to leave to engage in other pressing activities.

Likewise, **WAPDA** personnel have interacted occasionally with project personnel hut have little time to engage in specific activities required by the study **like** the calibration ***of*** structures or regular monitoring of water surface levels in the main canal.

The constraints faced by the Agricultural Extension Department are of a slightly different nature as they refer to the question of whether they are to be involved at all in irrigated agriculture. There is no tradition in this government agency to train personnel that can address irrigation specific issues, and therefore their interaction with the project has been understandably limited.

On the end-users side. data collection through farmer interviews suffered the usual problem of lack of enthusiasm or lack of awareness. Also it depended heavily on the farmer's memories regarding the water distribution history, use of water, inputs and output data.

There was considerable difficulties in contacting the respondents as they were not readily available in the area after sowing, and being new to irrigation some of them were not keen to spend much time in the fields. Despite repeated visits, the study team could not meet some of the respondents. Consequently, occasionally information pertaining to such farmers had to be ohtained from their neighbors and particularly from those who demonstrated sufficient knowledge of the farm area in general.

A final, but serious constraint experienced by the project, at this point. refers to the imbalance against needs for funds for local travel and national salaries and what is available in the budget. The wide range of issues that are being addressed has resulted in far higher travel and assistance from Lahore-based staff. This was not foreseen during the project development stage and has resulted in undue strain in its implementation. A review in budget levels has been requested from the ADB.

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TABLE - 2

SYSTEM RESPONSIVENESS OPTIONS

CONCEPT	MAIN CHARACTERISTIC OF OPTION	DECREE OF INTERVENTION REQUIRED BY ACTORS			DEGREE OF REQUIREMENT OF			POSSIBILITY OF IMPLEMENTATION AT CRBC UNDER PRESENT CIRCUMSTANCES
		WAPDA	IPHED	END-USERS	INFRA-STRUCTURE	COMMUNI-CATION	INFORMA-TION	
SUPPLY-BASED	Does not address the issue of crop-based irrigation. Typifies Pakistan's current management of major irrigation schemes. Not productive	Low	Low	Low	Low	Low	Low	Current System
PURE DEMAND	Farmers determine their own schedule to obtain water as needed. Management can not deny supply, fully "bottom-up".	High	High	High	High	High	High	None
PURE CROP-BASED	Uses actual cropping patterns to determine crop requirements and fix deliveries on short period basis. "top-down" management.	Medium	High	Medium	High	Medium	Medium	Low
MODIFIED CROP BASED	Targets patterns and requirements to develop target deliveries. Tight control on cropping patterns needed. "top-down" management.	Medium	Medium	Low	Medium	Low	High	Medium
DEMAND REFUSAL	Targets deliveries at watercourse Levels. Mixed management, farmers option to control outlets.	Low	High	High	Medium	High	Low	Promising
MODIFIED DEMAND REFUSAL	Target deliveries at watercourse levels. "bottom-up" management. Full control of outlets by farmers.	Low	Medium	Lou	Medium	Low	LOU	Promising

TABLE -3

CROPWATER REQUIREMENTS (**RABI** CROP D I KHAN)

Month	Crop **Intensity** Period	**Gram** 21.6% ETc mm/period	**Wheat** **55.70%** ETc mm/period	Sugarcane 4.61% ETc mm/period	**Oil Seeds** 0.65% ETc mm/period	R-Fodder *1.82%* ETc mm/period	**Total** *90.38%* ETc mm/period
Oct	1			214.4		173.6	388
	2	373.7		185.8		193.9	753
	3	362.9		162.3	6.2	219.7	751
Nov	1	328.3	512.4	136.0	6.0	208.8	1192
	2	326.2	423.3	107.9	5.6	165.0	1028
	3	356.4	518.0	92.2	6.9	144.7	1118
Dec	1	358.6	668.4	74.2	8.1	122.8	1232
	2	328.3	757.5	59.5	8.8	103.2	1257
	3	356.4	919.1	60.4	10.6	111.8	1458
Jan	1	391.0	1008.2	62.7	11.8	122.0	1596
	2	408.2	1052.7	61.3	12.3	121.5	1662
	3	468.7	1208.7	65.9	14.1	146.2	1904
Feb	1	527.0	1359.1	69.2	15.9	165.0	2136
	2	587.5	1515.0	71.0	17.0	183.8	2374
	3	678.2	1749.0	75.6	16.9	211.9	2732
Mar	1	719.3	1988.5	84.4	14.7	240.9	3048
	2	686.9	2027.5	103.3	1.2	269.8	3089
	3	652.3	1893.8	129.5		313.6	2989
Apr	1	58.3	1637.6	159.0		356.6	2212
	2		1253.3	190.9		351.9	1796
	3			223.1			223

TABLE - 4

RELATIVE WATER SUPPLY (RWS)

CRBC Disty # 3 Watercourse # 11920-L Rabi 1991-92

CCA = 81.8 HA CI = 90.6%

Item	OCT			NOV			DEC			JAN			FEB			MAR			APR		
Period = 10 days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Water flown days	5	9	11	8	9	4	6	8	11	1	5	0	0	0	1	10	10	4	0	3	7
Flow mm/period	40.2	68.3	82.0	61.6	58.3	27.7	42.0	52.0	75.3	6.8	32.0	0.0	0.0	0.0	1.0	81.0	80.0	24.8	0.0	15.2	46.0
Effective Rainfall mm/period	2.4	1.3	1.0	0.8	0.6	1.3	2.0	2.8	2.7	2.7	2.7	3.4	4.1	4.8	6.3	7.8	9.3	8.1	7.0	5.8	5.4
Area Cultivated ha	6.97	19	28.4	39.8	51.2	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	72	72	72	72	67.4	38.6	5.37
ETc mm/period	3.9	7.5	7.5	11.9	10.3	11.2	12.3	12.6	14.6	16.0	16.6	19.0	21.4	23.7	27.3	30.5	30.9	29.9	22.1	18.0	2.2
Conveyance Losses (40%) mm/period	16.1	27.3	32.8	24.7	23.3	11.1	16.8	20.8	30.1	2.7	12.8	0.0	0.0	0.0	0.4	32.4	32.0	9.9	0.0	6.1	18.4
Percolation losses (1.5 mm/day) mm/period	7.5	13.5	16.5	12.0	13.5	6.0	9.0	12.0	16.5	1.5	7.5	0.0	0.0	0.0	1.5	15.0	15.0	6.0	0.0	4.5	10.5
RWS	1.6	1.4	1.5	1.3	1.3	1.0	1.2	1.2	1.3	0.5	0.9	0.2	0.2	0.2	0.3	1.1	1.1	0.7	0.3	0.7	1.7

TABLE - **5**

SEASONAL OPENICLOSE RECORD

WATERCOURSE 11920-L DISTY # **3;** RABI 91/92

	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL	SEASON TOTAL
# DAYS OPEN	26	16	22	6	1	19	7	97
PERIOD 1	8	5	6	0	0	9	0	28
PERIOD 2	8	8	7	6	0	8	1	38
PERIOD 3	10	3	9	0	1	2	6	31
# DAYS CLOSED	1	8	4	19	23	3	14	72
PERIOD 1	1	2	3	7	8	0	5	26
PERIOD **2**	0	1	1	3	9	0	6	20
PERIOD 3	0	5	0	9	6	3	3	26
# DAYS P/C	0	0	0	0	0	2	2	4
PERIOD 1	0	0	0	0	0	0	0	0
PERIOD 2	0	0	0	0	0	0	2	2
PERIOD 3	0	0	0	0	0	2	0	2
TOTAL DAYS MONITORED	27	24	26	25	24	24	23	173
% OPEN	96	67	85	24	4	79	30	56
% CLOSED	4	33	15	76	96	13	61	42
% PIC	0	0	0	0	0	8	**9**	**2**
TOTAL	100	100	100	100	100	100	100	100

TABLE - 6

CROPPING INTENSITIES FOR SELECTED WATERCOURSES
CHASHMA RIGHT BANK CANAL IRRIGATION SYSTEM
DISTRIBUTARY # **3;** RABI SEASON 1991192

	DESIGN	570L	690R	6468R	6468L	10150R	11920L	14810R	15382R	DISTY AVERAGE
GCA (HA)		82.66	168.83	89.88	115.04	59.19	82.42	82.41	110.93	791.36
BARREN (HA)		11.98	13.68	1.82	4.18	5.85	0.62	1.44	0.00	39.58
CCA (HA)										
CROPS	CROPPING INTENSITIES (% OF CCA)									
WHEAT	45.00	61.70	66.30	58.44	34.66	57.20	54.50	64.80	49.40	55.70
GRAM/PULSES	5.00	10.30	11.70	25.34	33.26	22.20	25.16	19.10	26.90	21.60
SUGARCANE	15.00	11.30	4.80	5.15	0.10	8.90	0.15	0.80	8.20	4.61
FODDER	10.00	4.00	7.00	8.24	17.84	0.90	11.27	2.40	5.80	7.82
OILSEEDS	5.00	1.20	1.50	-	0.85	1.40	-	-	-	0.65
GARDENS	5.00	-	-	-	-	-	-	-	-	0.00
MISC (VEGE)	5.00	-	0.60	0.30	0.61	-	0.08	0.70	3.10	0.79
CI	90.00	88.50	91.90	97.47	87.32	90.60	91.16	87.80	93.40	91.17
FALLOW	10.00	11.50	8.10	2.53	12.68	9.40	8.84	12.20	6.60	8.83
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE - 7

COMPARISON OF CROPPING PATTERNS (IN %)
BY DIRECT FIELD SURVEY AND A "TRANSECT" APPROACH

WATERCOURSE # 11920L; DISTRIBUTARY # *3;* CRBC

CROP	FIELD SURVEY	TRANSECT WIDTHS (M)		
		100	200	400
WHEAT	54.50	57.17	53.32	52.44
GRAM	25.16	23.40	26.66	29.88
FORRAGE	11.27	9.91	10.35	8.94
SUGARCANE	0.15	0.00	0.00	0.00
OTHERS	0.08	1.20	1.56	3.25
FALLOW	8.84	8.35	8.11	5.49
% AREA BY TRANSECT THAT FALLS WITHIN:				
10 % FIELD SURVEY RESULTS		88	71	52
15 % FIELD SURVEY RESULTS		98	97	52

FARMER GROUP	NO. OF FARMERS	AREA IN KANALS	AREA IN HECTARES	WATER TURN (HOURS)	AVAILABILITY OF WATER PER HECTARE (HOURS)
1	3	350	17.71	31	1.75
2	8	480	24.28	45	1.85
3	9	921	46.59	92	1.97
OVERALL	20	1751	88.58	168	1.90

FARMER SUB-GROUP	NO. OF FARMERS	AREA IN KANALS	AREA IN HECTARES	WATER TURN (HOURS)	AVAILABILITY OF WATER PER HECTARE (HOURS)
1	1	150	1.59	21	2.77
2	2	200	10.12	10	0.99
OVERALL	3	350	17.71	31	1.75

BROTHERHOOD WARABANDI FOR OUTLET NO. 14810/R - GROUP 2

FARMER SUB-GROUP	NO. OF FARMERS	AREA IN KANALS	AREA IN HECTARES	WATER TURN (HOURS)	(HOURS)
3	3	108	5.46	10	1.83
4	3	72	3.64	9	2.47
5	1	150	7.59	14	1.85
6	1	150	7.59	12	1.85
OVERALL	8	480	24.28	45	1.85

BROTHERHOOD WARABANDI FOR OUTLET NO. 14810/R - GROUP 3

FARMER SUB-GROUP	NO. OF FARMERS	AREA IN KANALS	AREA IN HECTARES	WATER TURN (HOURS)	AVAILABILITY OF WATER PER HECTARE (HOURS)
7	4	625	31.62	92	2.91
8	1	100	5.06	0	0.00
9	1	24	1.21	0	0.00
10	1	100	5.06	0	0.00
11	1	36	1.82	0	0.00
12	1	36	1.82	0	0.00
OVERALL	9	921	46.59	92	1.97

Figure III-1

CRBC Water Surface Levels

Observed & predicted at 47 cumecs

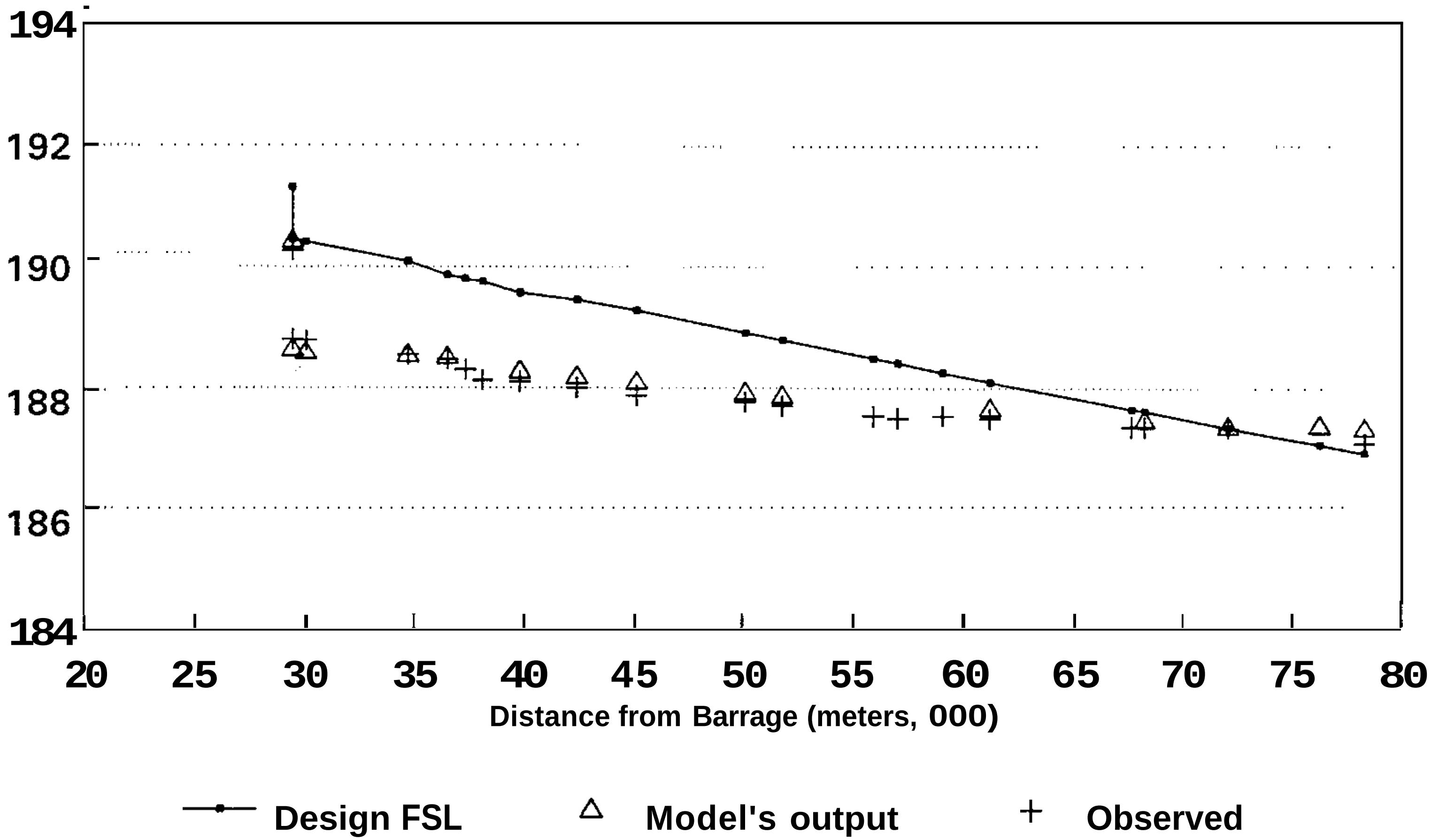


Figure -2

Chasma Right B l (

Bed, Water Surface & Structure Elev.

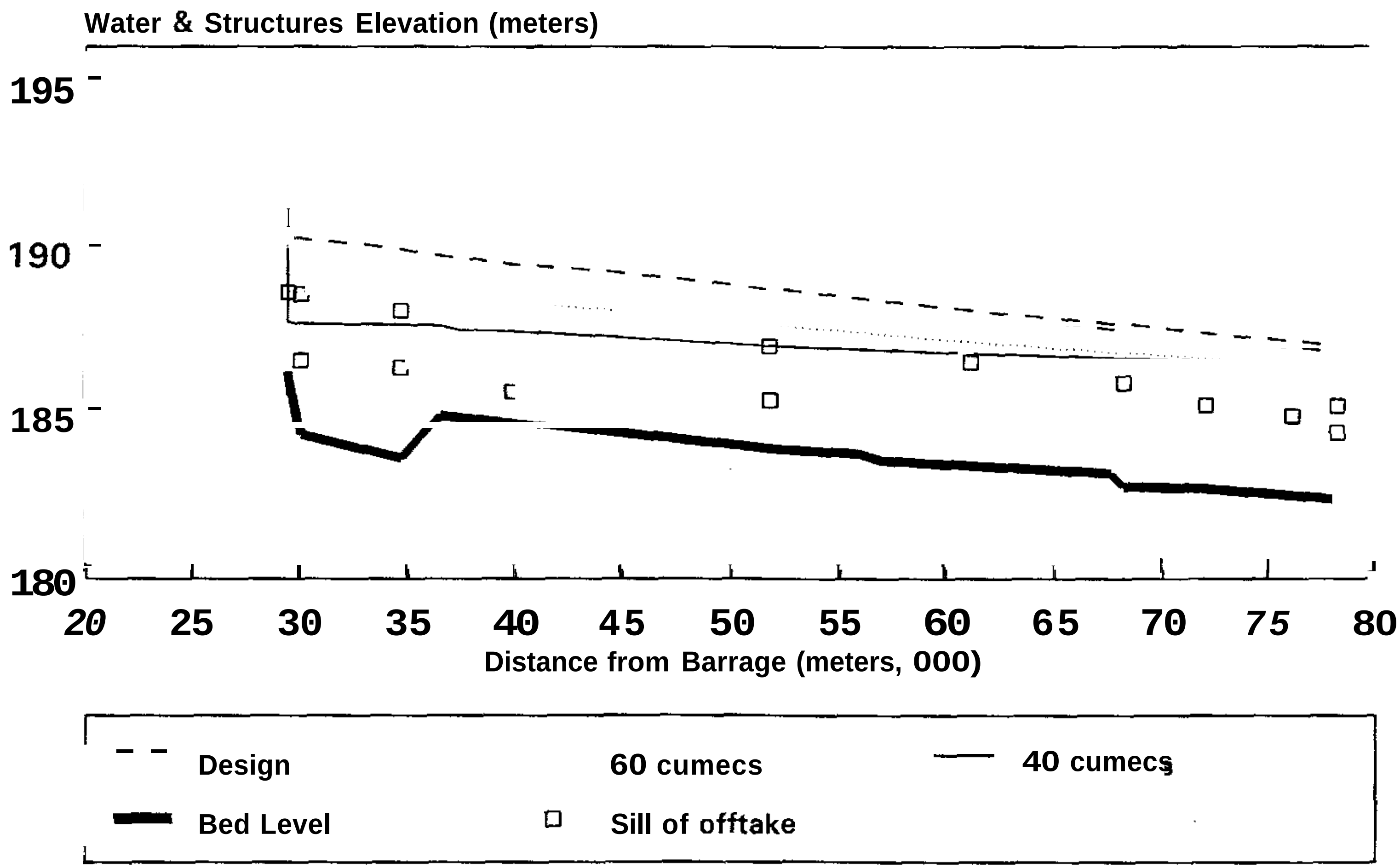


Figure 111-3

Chashma Right Bank Canal

Water Surface Slopes at different Q

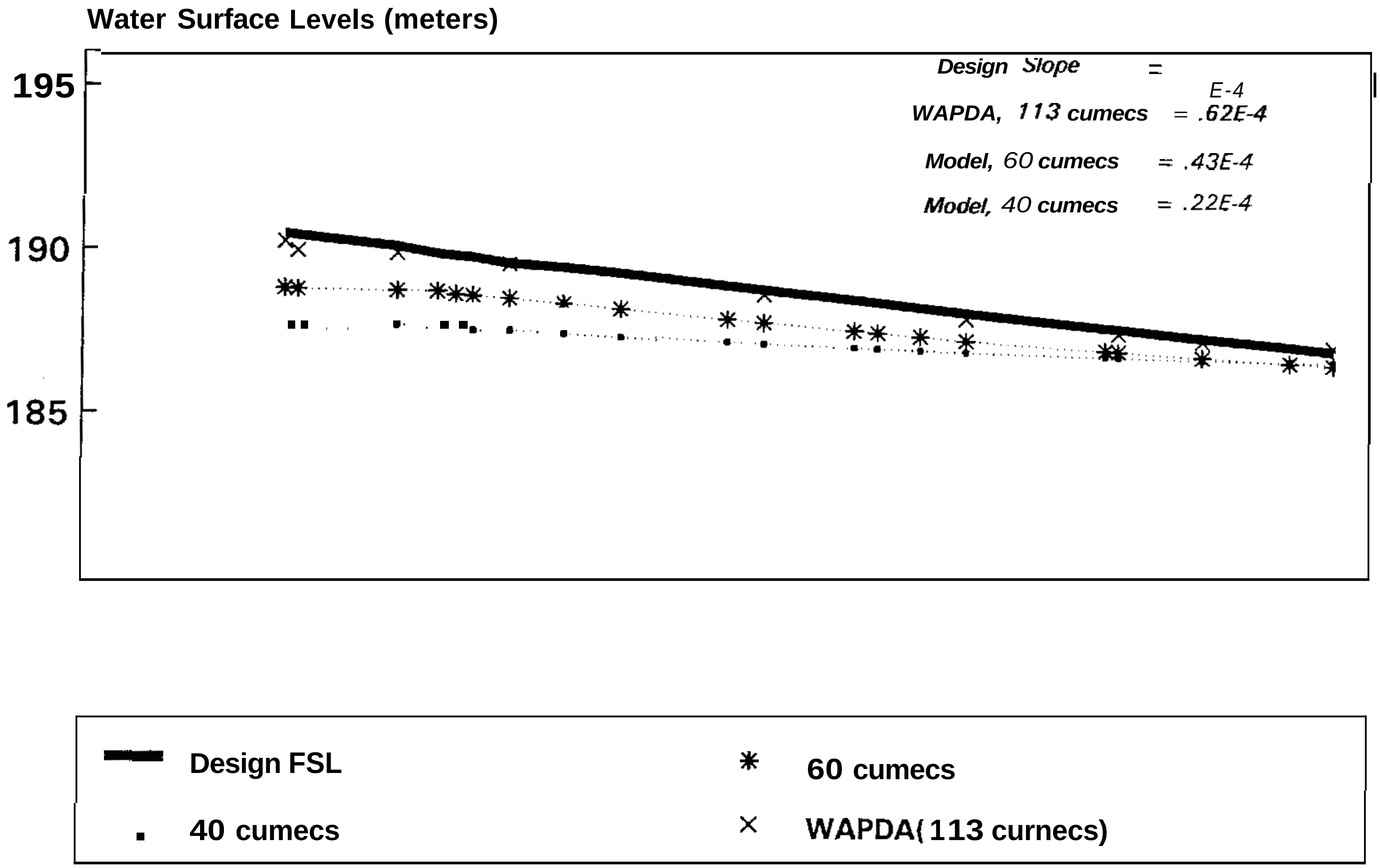
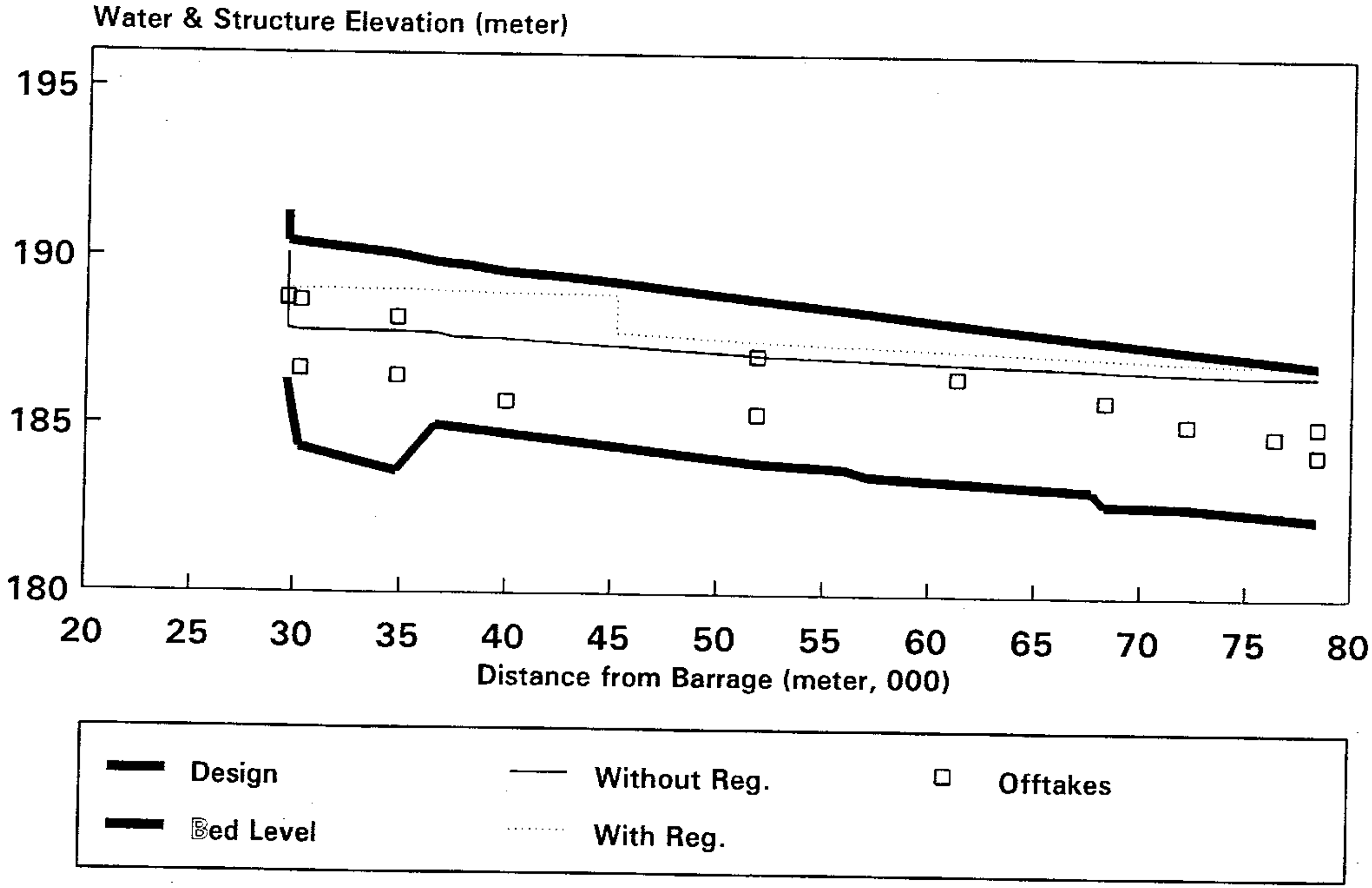
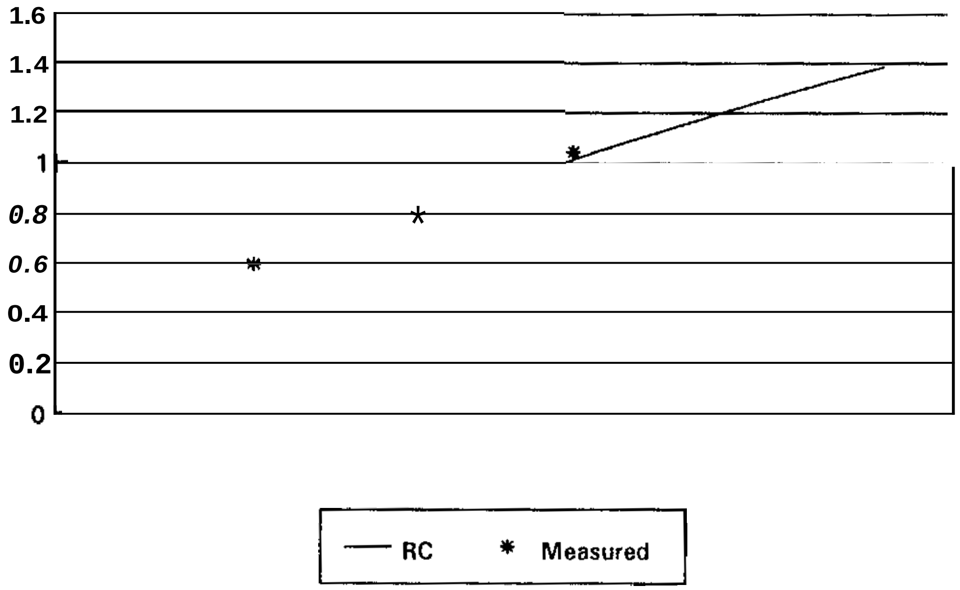


Figure III-4

CRBC - Q = 40 Cumecs

Cross Regulator is imposed at 45 km.





Discharge Measurement at disty # 4 CRBC

Discharge against Gate Opening

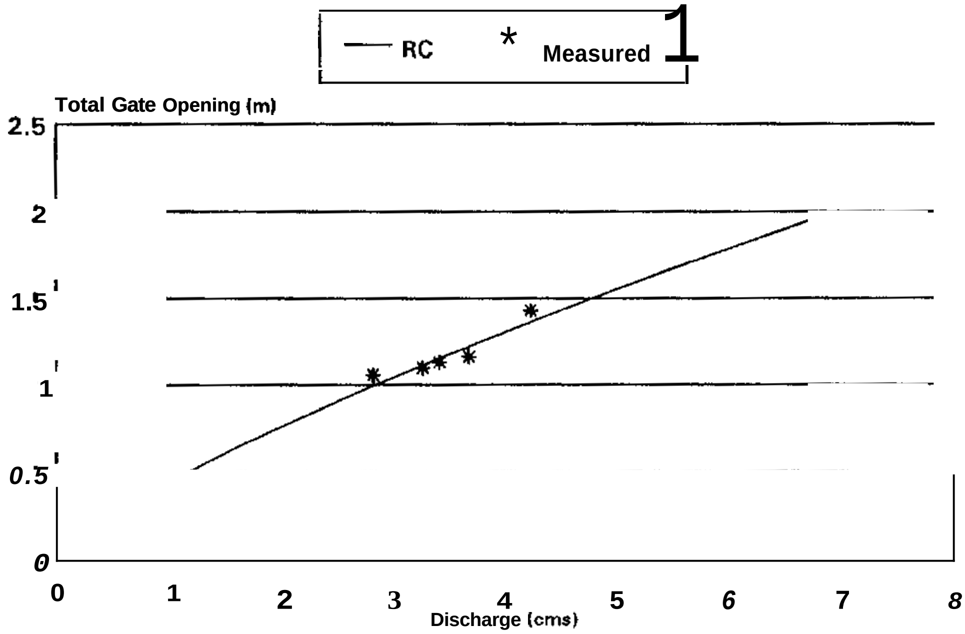
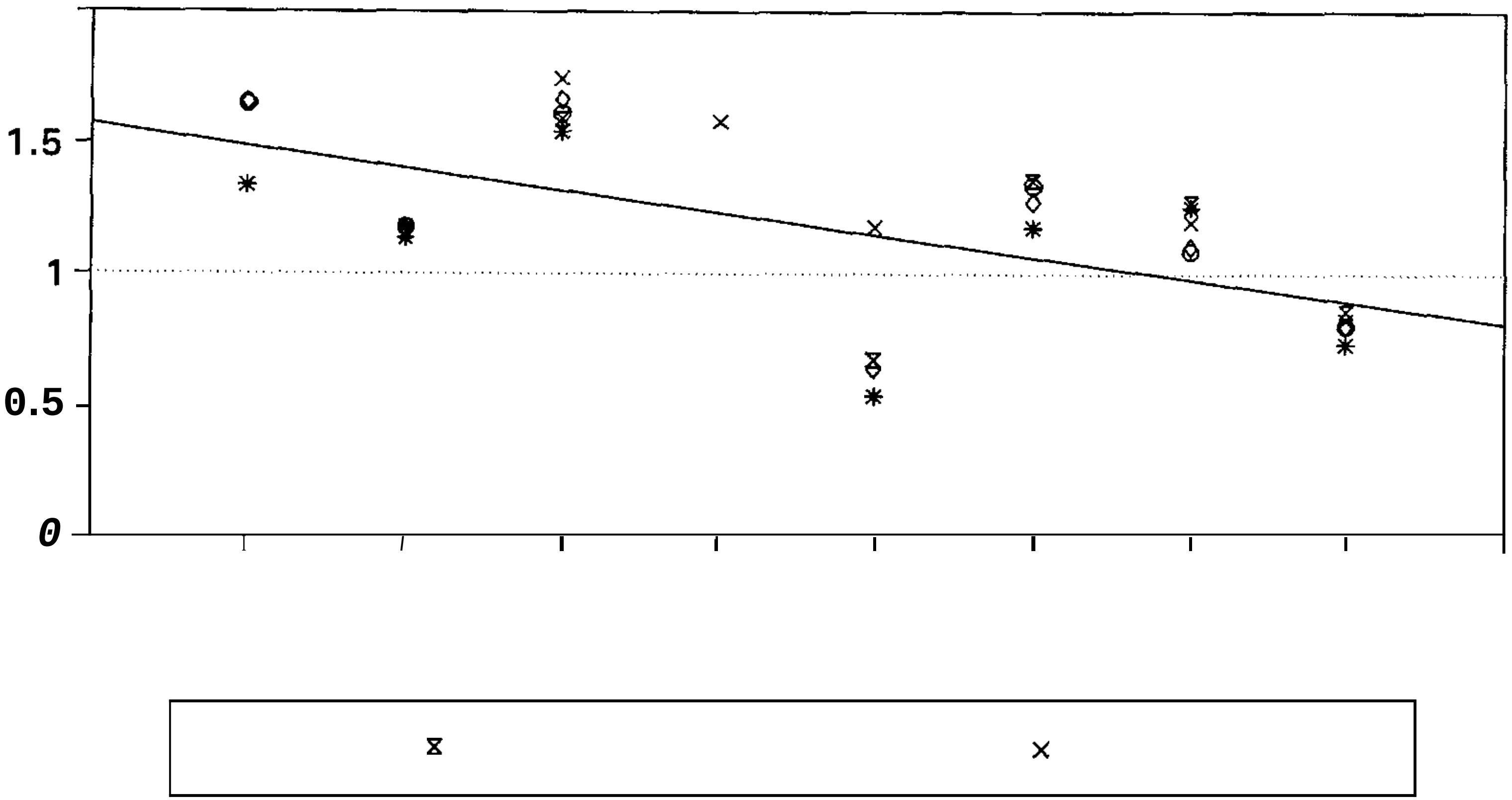


Figure 11-6

Delivery Performance Ratio

Watercourses of Disty #3 CRBC

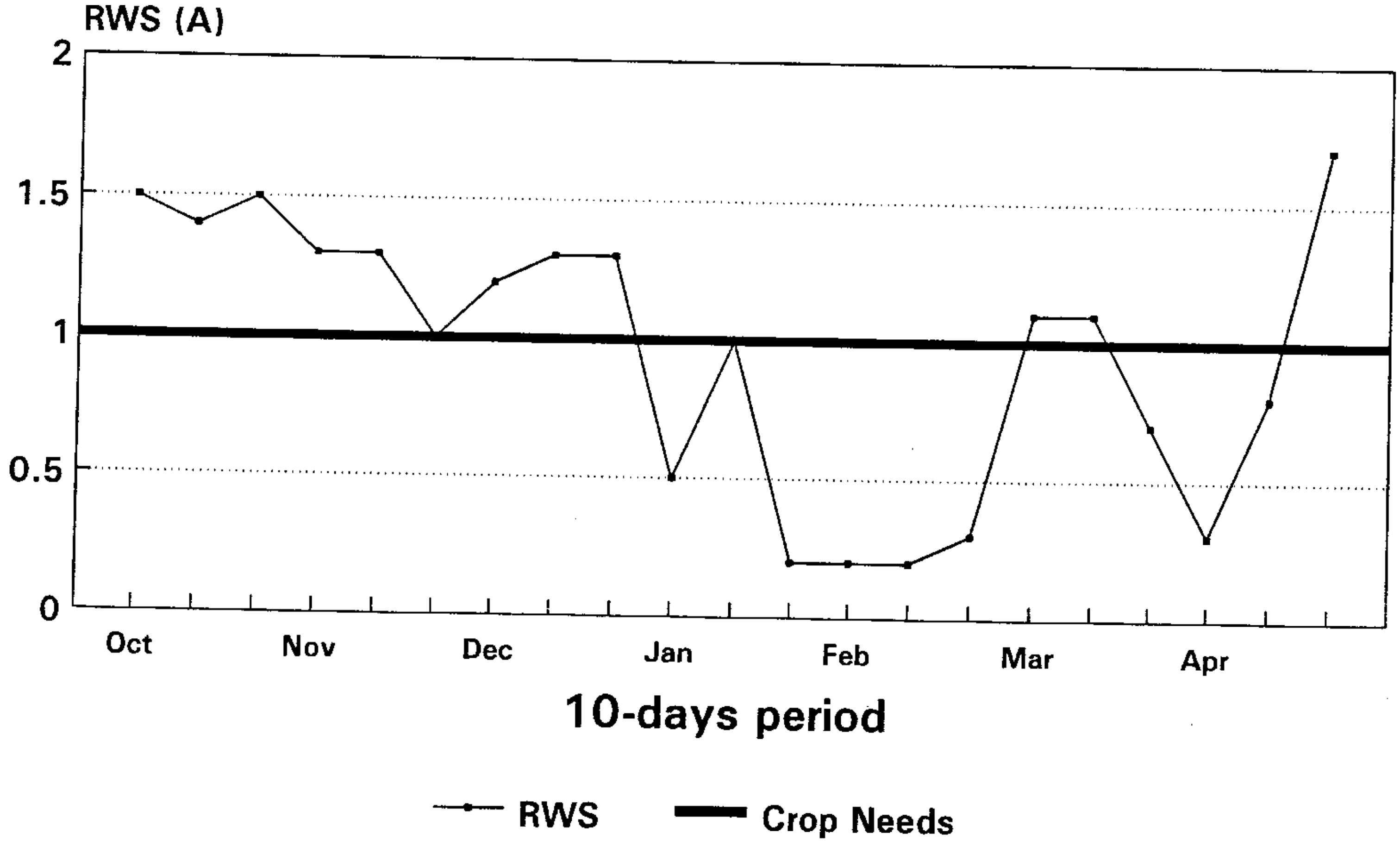


Note: Data for closure period Jan 16 to Feb 29, 1992 is not included.

Figure III-7

Relative Water Supply (Actual)

Watercourse 11920-L Disty # 3

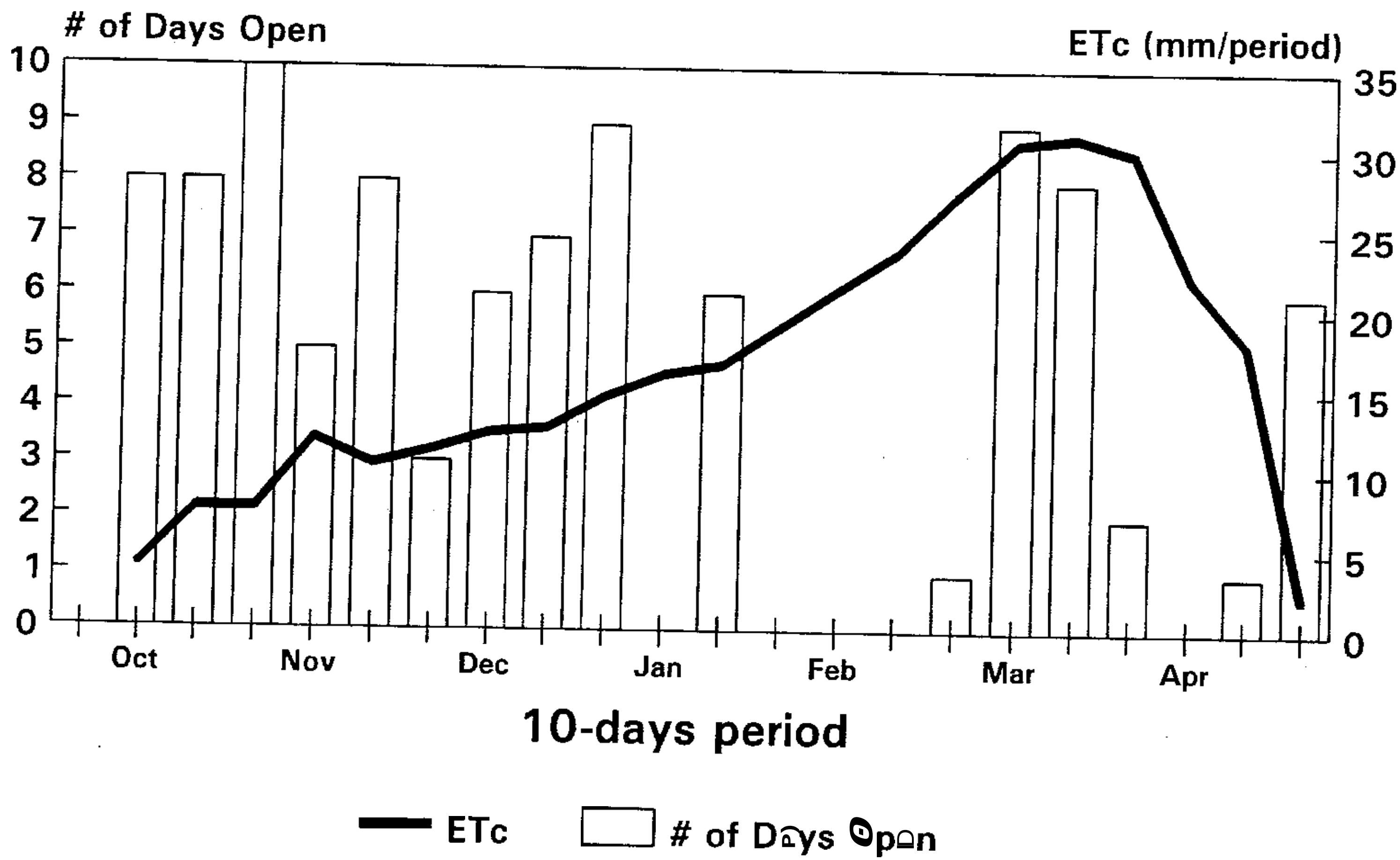


Rabi Season 1991-92

Figure III-8

ETc and Outlet Open Days

Watercourse 11920-L Disty # 3

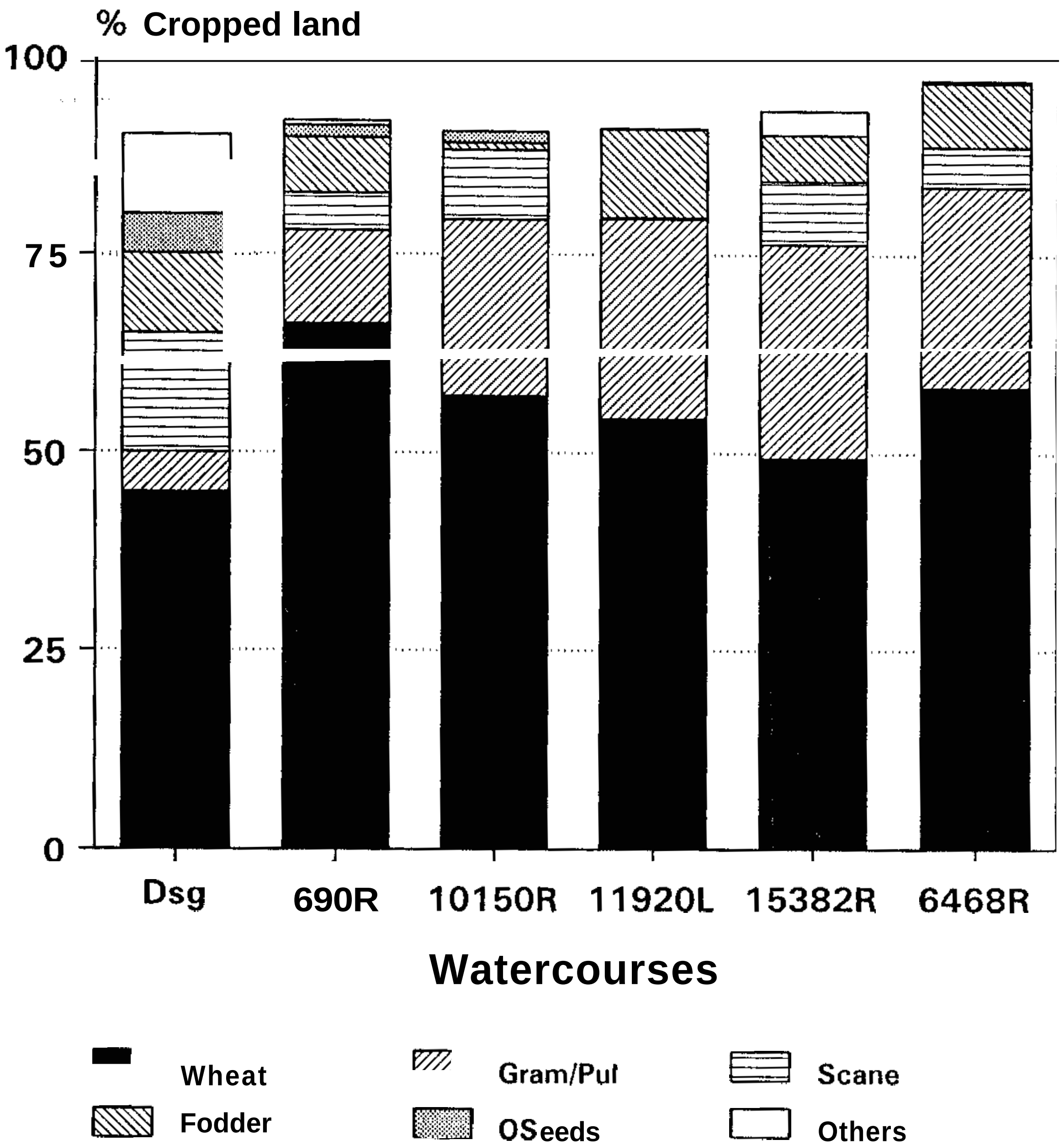


Rabi Season 1991-92

Figure III-9

Cropping pattern and intensity

Design vs selected watercourses. CRBC



Rabi 91/92

Figure III-10

WATER DISTRIBUTION ON OUTLET NO. 14810/R

DURATION OF WATER AVAILABILITY

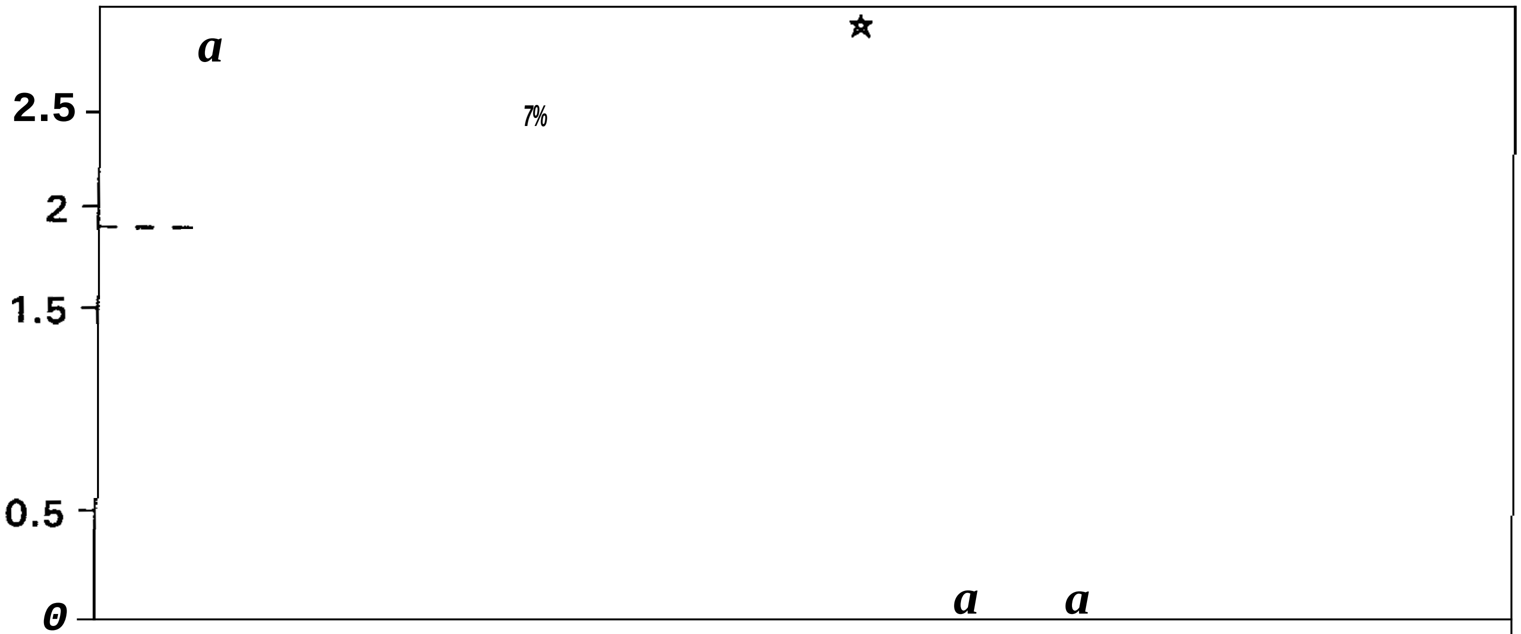


Figure III-11

AVERAGE WHEAT YIELD (crop cut)

4 sample watercourses, disty 3

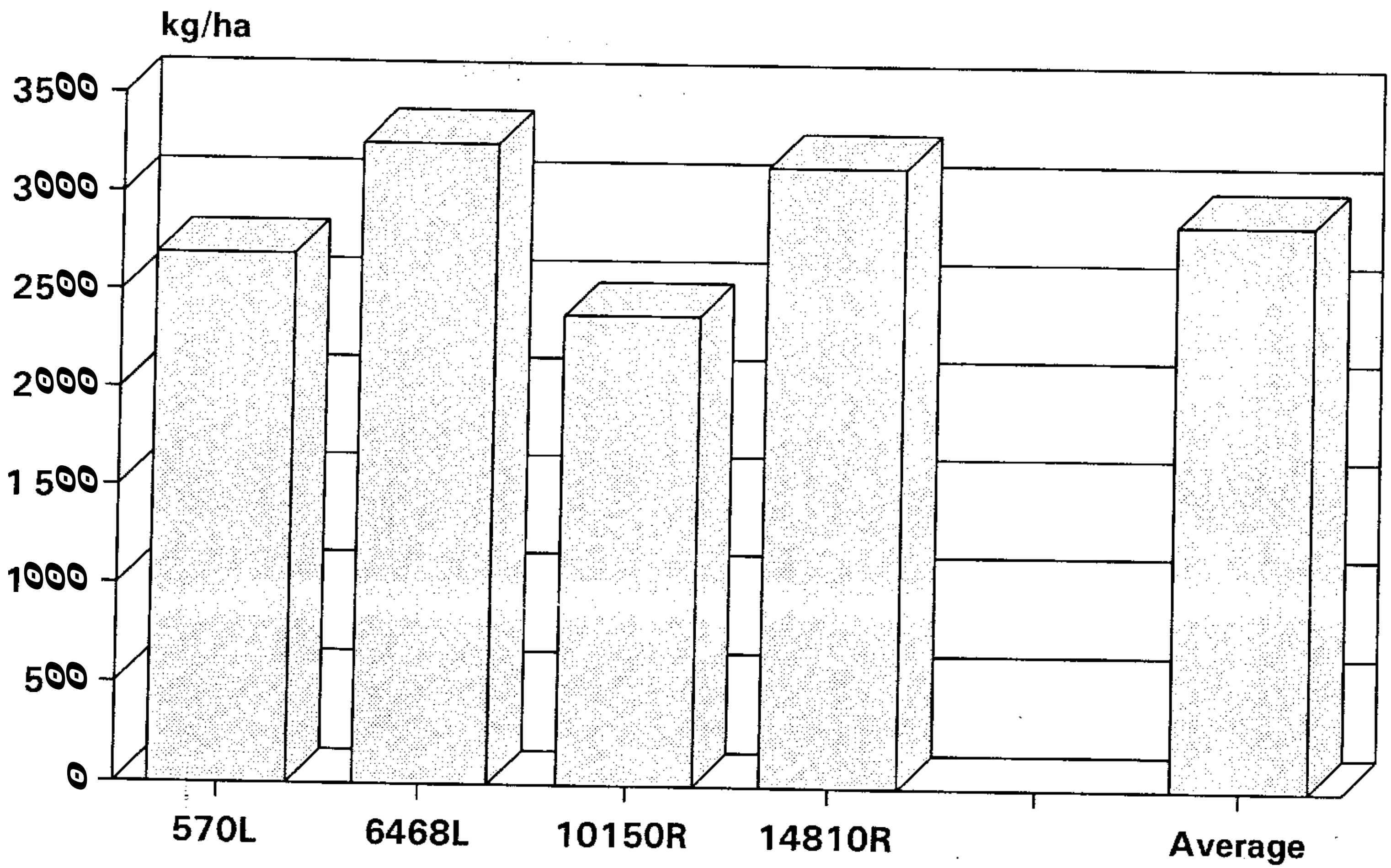


Figure 111-12

YEARLY CROPPING INTENSITY

Girsal Minor

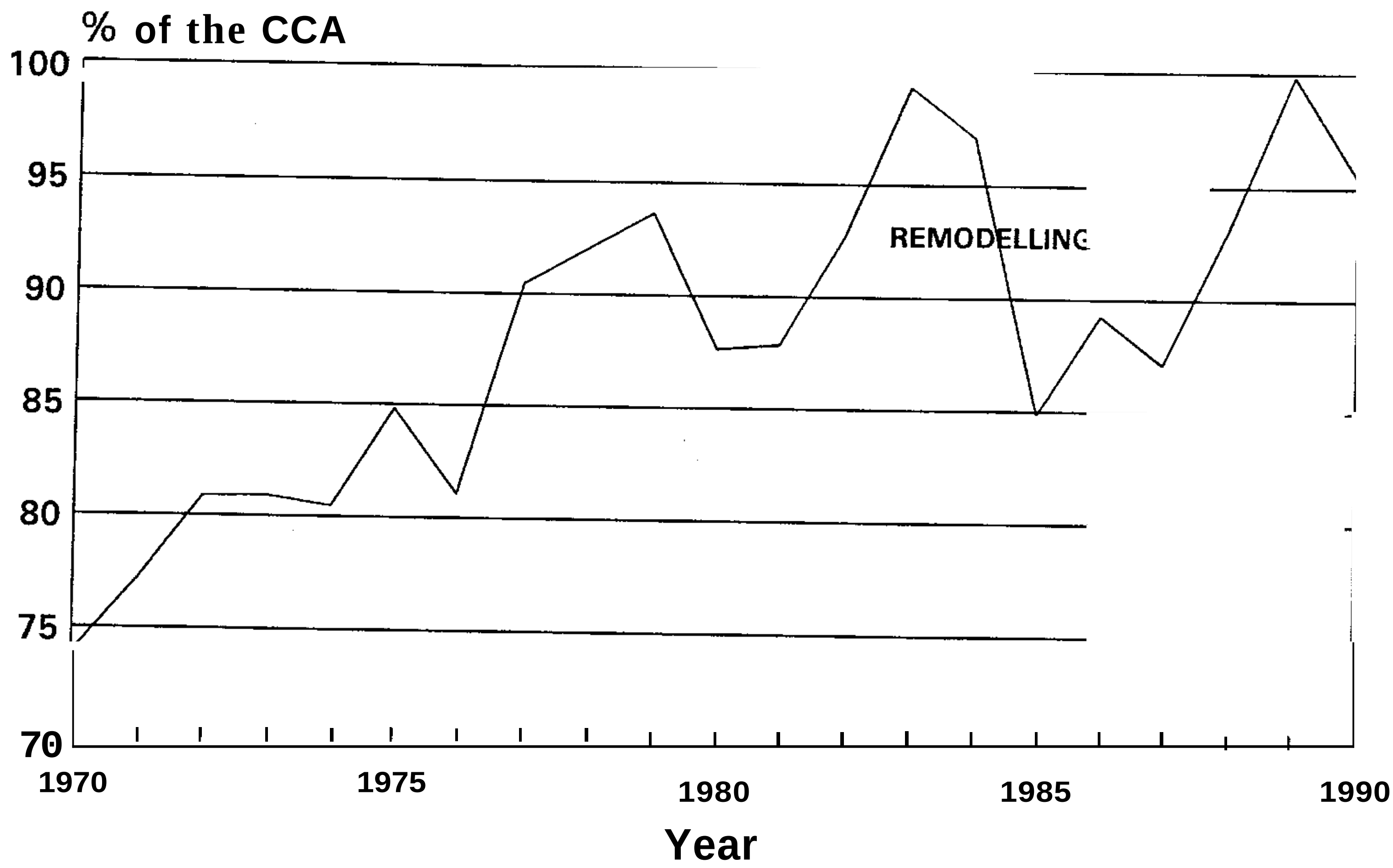
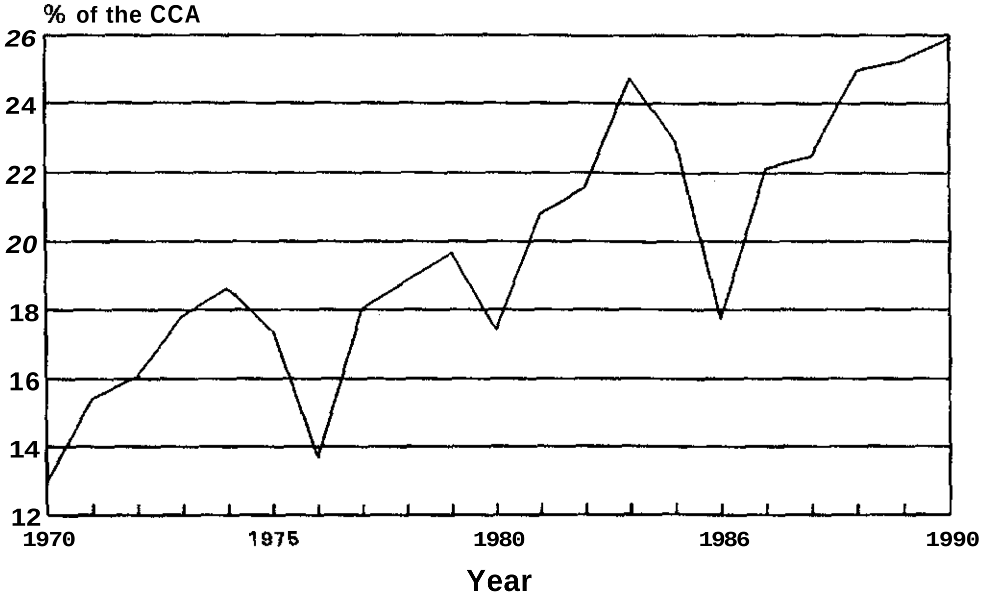
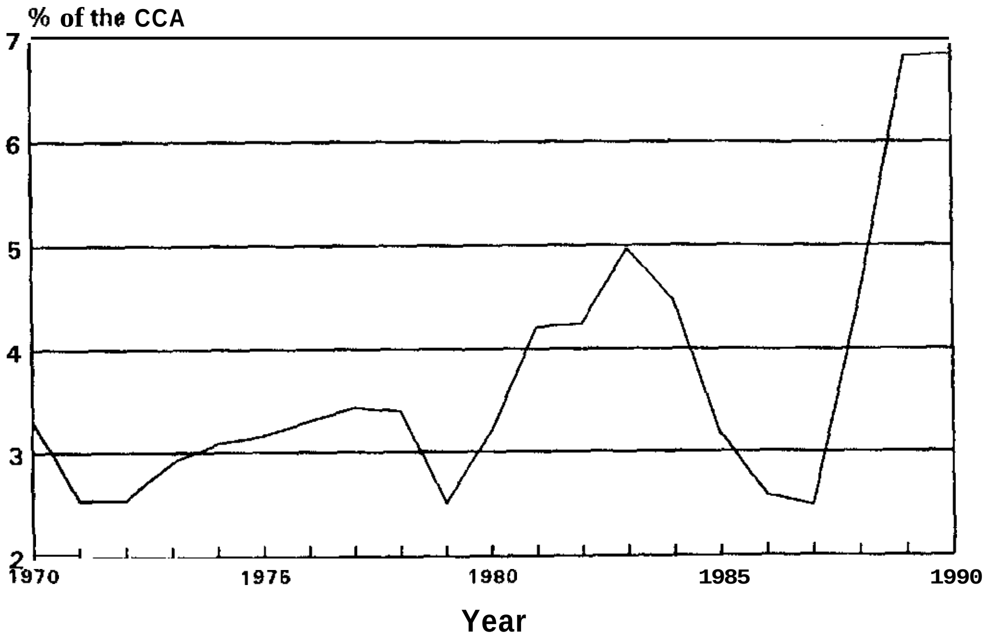


Figure 111-13

AREA UNDER PADDY CROP
Girsal Minor



AREA UNDER SUGARCANE
Girsal Minor



ANNEXES

IIMI PERSONNEL INVOLVEMENT

A. International Staff

1. Carlos Garces, Irrigation Engineer and Project Team Leader
2. Tissa Bandaragoda, Senior Management Specialist
3. Pierre Strosser, Agricultural Economist
4. Marcel Kupper, Agricultural Engineer
5. Erik Van Waijjen, Agricultural Engineer
6. Jacques Rey, Modelling Specialist (IIMI-HQ)
7. Hammond Murray-Rust, Senior Irrigation Specialist (IIMI-HQ)

B. National staff (fielded at D.I.Khan; full time with project)

8. Hakim Khan, Field Research Professional
9. Irfan H. Siddiqui, Field Research Professional
10. M. Rafiq Khan, Senior Field Assistant
11. Mahmood Ahmad, Field Assistant
12. Talha Awam, Field Assistant
13. Habibullah Baloch, Field Assistant
14. Abdul Maroof, Field Assistant
15. Sharif Ahmad, Field Assistant
16. Mohammad Iqbal, Driver

(based in Lahore; occasional support)

17. Rana M. Afaq, Irrigation Engineer
18. Zhaigham Habib, Systems Analyst
19. Saeed Ur Rahman, Agricultural Economist

CROP-BASED IRRIGATION OPERATION IN THE NWFP
STUDY ADVISORY COMMITTEE
MINUTES OF FIRST MEETING
HELD ON NOVEMBER 24,1991

The meeting was held in Peshawar at the P & D conference room from 10.00 to 12.00 a.m.

Attendance was as follows:

1. Mr. A.J. Moghul, Secretary, P&D Dept., at the chair.
2. Mr. Hashmalullah, Director, WSIP Cell.
3. Mr. Fazal-e-Rabbi, Assistant Director (Water Management), Agriculture Department, Mardan.
4. Mr. Muhammad Akram, Assistant Director Design, Irrigation Department, NWFP.
5. Mr. A. Qayum Khan, Chief (W&P) P&D Department, NWFP.
6. Mr. Muhamniad Zaman Khan, Chief Engineer (WAPDA) Mardan.
7. Mr. Adnan Bashir Khan, Chief Agriculture, P&D, NWFP.
8. Dr. Abdul Waheed, Chief Planning Officer, Agriculture Department, NWFP.
9. Mr. Tissa Bandaragoda, SMS, IIMI-Pakistan.
10. Dr. Carlos Garces, Irrigation Engineer, IIMI-Pakistan.

The proposed agenda was approved without modifications. As the first point in the agenda was the introduction, by the Chairman, of the Committee members, a discussion was held to determine what should in fact be the composition of the SAC.

After a lively discussion, it was decided that given the importance of the project the SAC should be taken at **a** higher level than previously anticipated and it was agreed by consensus that the Study Advisory Committee should be composed as follows:

1.	Additional Chief Secretary, P&D, NWFP	-	Chairman
2.	Secretary Irrigation, NWFP		Member
3.	Secretary Agriculture, NWFP		Member
4.	General Manager (North), WAPDA		Member
5.	Project Leader, IIMI-Pakistan	-	Secy./Member
6.	Director General, IWASRI (originator of PC-II)		Observer

It was also decided that each Department may arrange to have no more than two functional representatives to attend the meeting. Among these officials **it** was mentioned, for example:

1. Chief Engineer Irrigation, Peshawar

2. Chief Engineers WAPDA (D.I. Khan and Mardan)
3. Chief Planning Officer, Agriculture Dept., NWFP.
4. Chief (Water & Power) P&D, NWFP.
5. Chief (Agriculture) P&D, NWFP.
6. Director Planning, WSIP Cell, NWFP

As the second point in the agenda, the Terms of Reference for the SAC were discussed and approved with the modifications to the composition of the SAC already mentioned above.

For the third and fourth points of the agenda, blended into one because of time constraints, IIMI's Team Leader and Management Specialist made a detailed presentation of the project and the initial workplan. There was a very good interaction between presenters and participants and it was agreed that the issues and activities presented are of great importance to the irrigated agriculture sector of NWFP.

A general discussion ensued after the IIMI presentation in order to determine the best way in which the SAC can assist with project implementation activities. The following decisions were taken:

a) Official letters will be sent by respective Departmental Heads to concerned officials at each project site asking for their full cooperation towards implementation activities.

b) That the project can and should work in the international (metric) units but that it should also keep the english units currently used in Pakistan to facilitate understanding of the local staff.

c) That activities proceed at CRBC as first priority and that work at LSC may be taken up at a later stage.

d) That work at LSC at this stage be initiated as proposed in the changed workplan presented to the SAC meeting.

e) That Mr. Hashmatullah Awan, the representative of WSIP Cell will coordinate (a) above and also will act as the contact person for IIMI to facilitate IIMI's collaboration with NWFP officials.

The meeting was adjourned at 12.30 p.m. and some of the participants attended the lunch **by** IIMI as planned in the agenda. No date was fixed for the next meeting but it was felt that maybe more than two meetings per year will be necessary.

CROP-BASED IRRIGATION OPERATIONS IN THE NWFP
STUDY ADVISORY COMMITTEE
MINUTES OF SECOND MEETING
PESHAWAR - APRIL 23, 1992

The meeting was held in Peshawar at the P & D conference room from 11.30 am to 12.30 pm on April 23, 1992.

Attendance was as follows:

1. Mr. Khalid Aziz, Addl. Chief Secretary, P&D; in the chair
2. Mr. Khalid Mansoor, Secretary Agriculture
3. Mr. Jan Sardar Gul, General Manager (North), WAPDA
4. Mr. Amir Haider, Chief Engineer (Dev) Irrigation Department, in representation of Secretary Irrigation
5. Mr. Inam Ullah Khan, Additional Secretary, P&D
6. Mr. F.A. Zuberi, Director General, IWASRI
7. Dr. M. Mehboob Alam, Senior Engineer, IWASRI
8. Mr. Hashmatullah Awan, Chief (W&P), P&D
9. Mr. Abdul Waheed, Chief Planning Officer, Agri. Dept.
10. Dr. Carlos Garces, IIMI-Pakistan, as Secretary SAC

The Chairman requested Dr. Carlos Garces to state the objectives of the meeting and to provide a brief background on the crop-based irrigation operations in the NWFP project. After this was done, the Chair asked the Secretary to proceed with the individual points in the agenda. The foregone discussion and decisions taken on each are summarized below:

1. INTRODUCTION OF NEW SAC MEMBERS

The Chair asked the Secretary to read the new configuration of the SAC. After this was done, Mr. Zuberi requested that IWASRI be upgraded from its present status as Observer to that of Member. He stated, rightly so, that the PC II document calls for his institution to have a senior position in the Committee. Upon consultation with other members, and after no objections had been raised, Mr. Khalid Aziz approved Mr. Zuberi's request.

2. APPROVAL OF AGENDA FOR 2ND SAC MEETING

The agenda was read out by the Secretary and approved without modifications

3. APPROVAL OF MINUTES OF THE IST SAC MEETING

Dr. Carlos Garces explained that since a new SAC had been formed it was thought proper to bring forward the minutes of the first meeting to the new members. Mr Khalid Aziz considered that these minutes had already been approved by the SAC and that no further action was necessary in this regard.

4. DISCUSSION AND APPROVALS OF PROJECT COORDINATION COMMITTEES (PCC)

The Chair requested the Secretary to provide the background on this item. Dr. Carlos Garces then proceeded to read the note prepared beforehand for the meeting. Dr. Garces stated that although frequent contact between IIMI personnel and government officials takes place within the framework of project activities, it was felt by the officials that the PCC should be officially established in order for them to be able to participate fully in these activities.

Mr. Khalid Aziz felt that the officials were correct in their appreciations and that it was indeed necessary to formalize the PCCs. Thus, the establishment of the PCCs was approved. The Chair indicated that once the minutes of this meeting are approved by the NWFP government, they will proceed to create the PCCs.

5. DISCUSSION AND APPROVAL OF PARTICIPANTS TO STUDY TOUR

The Chair, once again, requested Dr. Garces to provide the background of this particular point. Dr. Garces called the attention of the members to the Guidelines for Study Tour that was distributed beforchand. He explained that the project calls **for** a study tour under which **4** Pakistani officials involved with the project would be able to see irrigation systems in other countries in which the concept of a demand-type of irrigation is practiced. Dr. Garces explained that a 2-week tour to Spain with side-trip to Morocco in the 2nd half of June was being organized. A list of 7 potential positions, closely linked to project activities, were proposed. These slots are as follows:

1. Executive Engineer (Remod),PID, CRBC (New area),D.I.Khan
2. Executive Engineer, PID, CRBC (Paharpur System, D.I. Khan
3. Superintendent Engineer, PID, Mardan
4. Executive Engineer, WAPDA, CRBC, D.I. Khan
5. Director Water Management, Agriculture Dept., Peshawar
6. Deputy Director, Agriculture Extension, D.I. Khan
7. Director WSIP Cell, P & D, Peshawar

After consultation of the Chairman with other members of the **SAC,** the following four participants were selected.

1. Executive Engineer (Remod),PID, CRBC (New area),D.I.Khan
2. Executive Engineer, WAPDA, CRBC, D.I. Khan
3. Deputy Director, Agricultural Extension, D.I. Khan
4. Superintendent Engineer, PID, Mardan

The Chairman, however, advised that given previous commitments of the government, it was unlikely that the study tour could take place in June as proposed. He requested Dr. Garces to explore the possibilities of re-scheduling this exercise for the second semester. Dr. Garces is to inform what may be the new window of opportunity to conduct the study tour, and make necessary arrangements. The Chair indicated that those officials selected will be informed accordingly.

6. PRESENTATION OF PRELIMINARY FINDINGS RABI 1991/1992 SEASON AND WORKPLAN FOR KHARIF 92

Dr. Carlos Garces, in his capacity as IIMI Project Leader for the crop-based project made a 40 minutes presentation on preliminary findings corresponding to the on-going Rabi 91-92. With the help of "overheads" Dr. Garces showed the work done so far towards calibration and verification of the Simulation Irrigation Canal (SIC) Model that is being used to simulate main canal operation. He expressed that initial findings show that the model is very appropriate to tackle the problems at hand. Dr. Garces also presented initial findings of the socio-economic survey conducted in the study area, the cropping pattern and intensities in Distributary No. 3 of CRBC Stage I; the impact of CRBC on the Paharpur Irrigation system and the general layout of the research underway.

A short discussion was generated principally on canal modelling and cropping patterns. The members of SAC pointed out to the importance of this project for the future irrigation development of the province.

In general, the members of the SAC were pleased with present and forthcoming activities and urged IIMI to provide appropriate solutions to pending questions related to canal operation.

Since there were no further issues at hand, Mr. Khalid Aziz declared the meeting terminated. He urged the Secretary to provide the minutes as soon as possible in order to proceed with the implementation of the decisions taken.

Annex-3

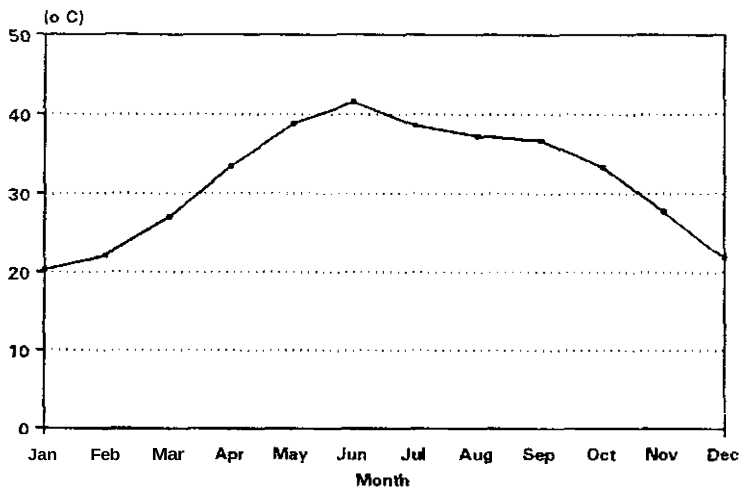
Table AN # 3-1

Climatic Data for D.I.Khan (Period 1961-1990)

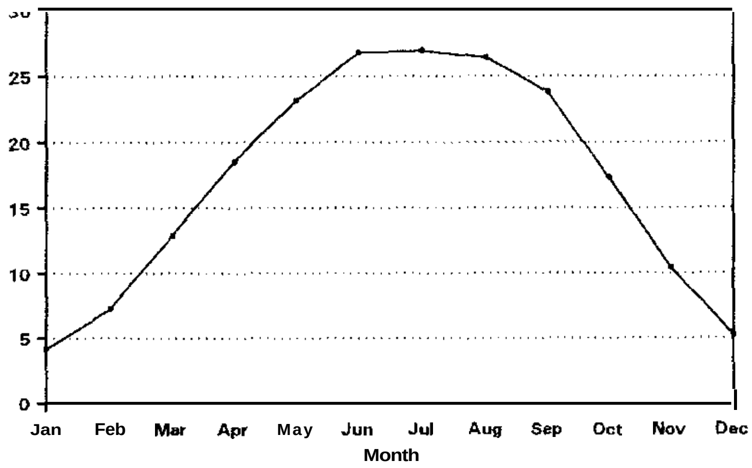
Altitude 174 m Latitude 31.8 N

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean daily Max. Temp. (o C)	20.3	22.1	27.0	33.5	38.7	41.5	38.5	37.3	36.7	33.4	27.7	21.8
Mean daily Min. Temp. (o C)	4.2	7.3	12.9	18.5	23.1	26.8	26.9	26.4	23.8	17.3	10.5	5.3
RH Mean (%)	59	55	56	46	37	42	60	65	58	52	58	62
Windspeed (km/day)	93	109	122	136	154	156	172	152	117	87	66	70
Mean daily Sunshine Hours	7.19	7.40	7.71	8.84	9.41	8.15	8.06	8.44	9.12	9.13	8.45	7.25
Rainfall (mm)	10.0	18.1	34.8	21.7	17.2	14.4	60.8	57.5	17.6	4.8	2.1	10.4

Mean Daily Maximum Temperature
(Average 1961-1990)



Mean Daily Minimum Temperature
(Average 1961-1990)



Actual Daily Sunshine Hours
(Average 1968-1990)

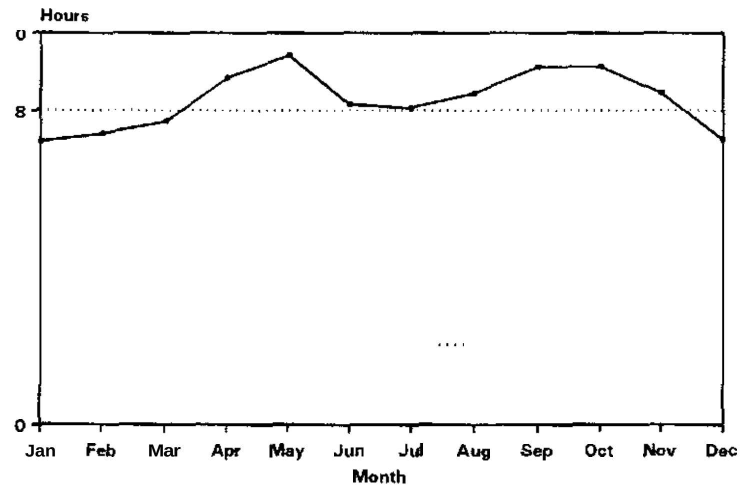
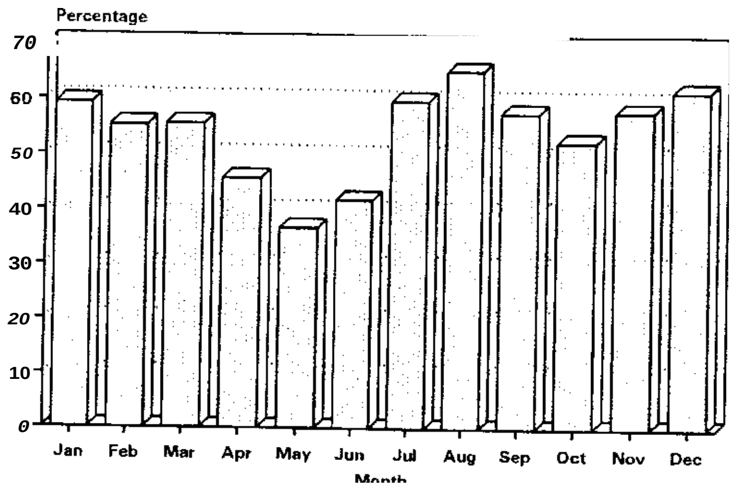


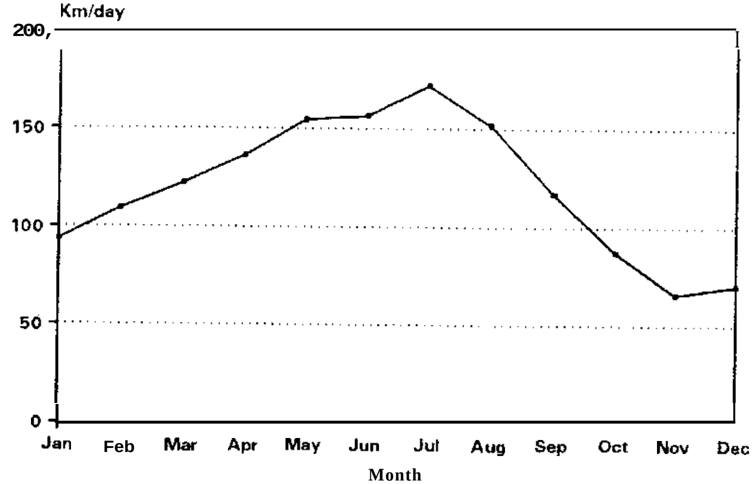
Figure AN # 3-1

Max. Temp., Min. Temp.
and Daily Sunshine Hours
For D I Khan area.

Monthly Relative Humidity
[Average 1961-1990)



Mean Daily Wind Speed
[Average 1961-1983}



Monthly Rainfall
[Average 1961-1990}

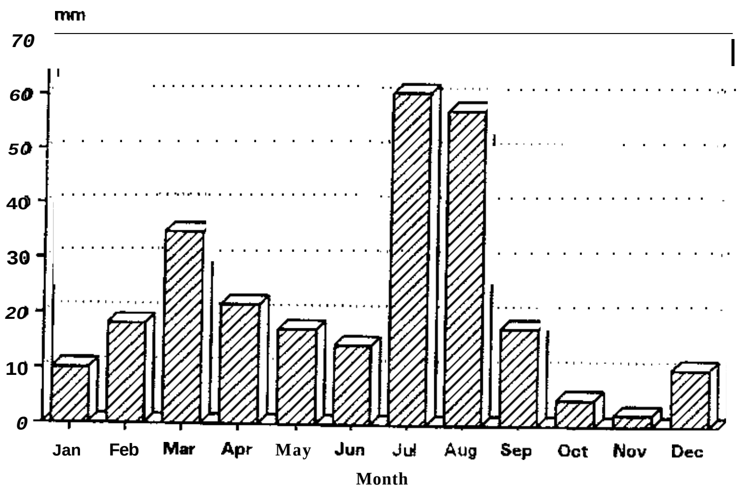


Figure AN # 3-2

Relative Humidity, Windspeed and Monthly Rainfall For D I Khan area.

Figure AN # 3-3

Monthly ETo for D.I. Khan Area