FINAL REPORT

on the

Technical Assistance Study
(T.A.1480 SRI)

PHASE II

IRRIGATION MANAGEMENT AND CROP DIVERSIFICATION

VOLUME II
KIRINDI OYA PROJECT

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INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE
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in association with

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Department of Agriculture

Irrigation Management Division
Land Commissioner's Department

GOVERNMENT OF SRI LANKA

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Abbreviations and Acronyms

ac	=	acre
acft	=	acre feet
ADB	=	Asian Development Bank
AI	=	Agricultural Instructor
BAO	=	Block Agricultural Officer
BCC	=	Block Coordinating Committee
BCW	=	broad crested weir
BE	=	Block Engineer
BEA	=	Block Engineering Assistant
BIE	=	Block Imgation Engineer
BM	=	Block Manager
BOP	=	Blocking Out Plan
CC	=	Consultative Committee
CEMAGREF	=	Centre National du Machnisme Agricole dy Genie Rural des Eaux et des Forets (France)
cm	=	centimeters
CE	=	Civil Engineer
CO	=	Colonization Officer
CRE	=	Chief Resident Engineer
CGP	=	Crop Growth Period
cumecs	=	cubic metres per second
cusec	=	cubic feet per second
CRWS	=	Cumulative Relative Water Supply
DAS	=	Department of Agrarian Services
DC	=	Distributary Channel
DCO	=	Distributary Canal Organization
DOA	=	Department of Agriculture
DHL	=	Debarawewa Right Bank High Level
DRL	=	Debarawewa Right Bank Low Level
DPR	=	Delivery Performance Ratio
DRPM	=	Deputy Resident Project Manager
EC	=	Electrical Conductivity
EIS/OES	=	Ellegala Imgation System/Old Ellegala System
ET	=	Evapotranspiration
Eq.	=	Equation
FA	=	Field Assistant
FC	=	Field Canal
FI	=	Field Instructor
FMU	=	Flow Monitoring Unit
FO	=	Farmer Organization
FR	=	Farmer Representative
FSD	=	Full Supply Depth

FSL	=	Full Supply Level
ft	=	feet
GO	=	Gate Operator
GOSL	=	Government of Sri Lanka
GR	=	Gated Regulator
ha	=	hectares
ID	=	Imgation Department
IDO	=	Institutional Development Officer
IDU	=	Institutional Development Unit
IE	=	Irrigation Engineer
IFAD	=	International Fund for Agricultural Development
IIMI	=	International Irrigation Management Institute
IL	=	Irrigation Laborer
IMCD	=	Irrigation Management and Crop Diversification
IMD	=	Irrigation Management Division
IMIS	=	Irrigation Management Information System
IMPSA	=	Irrigation Management Policy Support Activity
INMAS	=	Integrated Management of Major Agricultural Schemes
IO	=	Institutional Organizer
IRMU	=	Imgation Research Management Unit
JCWM	=	Joint Committee on Water Management
kg	=	kilogram
km	=	kilometer
KOISP	=	Kirindi Oya Irrigation and Settlement Project
LB	=	Left Bank
LBMC	=	Left Bank Main Canal
LCD	=	Land Commissioner's Department
LHG	=	Low Humic Gley
LP	=	Land Preparation
LPP	=	Land Preparation Period
l/s	=	litres per second
m^3/sec	=	cubic meters per second
Maha	=	Rainy season (October to March)
MASL	=	Mahaweli Authority of Sri Lanka
mcm	=	million cubic meters
MEA	=	Mahaweli Economic Agency
MECA	=	Mahaweli Engineering Construction Agency
mm	=	millimeters
MMP	=	M. Mcdonald & Partner
MOL	=	Minimum Operating Level
MOU	=	Memorandum of Understanding
MP	=	Member of Parliament
MSL	=	Minimum Spill Level
na	=	not available

NGO	=	Nongovernmental Organization
NIS	=	New Irrigation System
O&M	=	Operation & Maintenance
OES/EIS	=	Old Ellegala System/Ellegala Irrigation System
OFC	=	Other Field Crop
PAR	=	Participatory Action Research
PCC	=	Project Coordinating Committee
PMC	=	Project Management Committee
RBE	=	Reddish Brown Earth
RB	=	Right Bank
RBMC	=	Right Bank Main Canal
RE	=	Resident Engineer
RID	=	Restoration of Irrigation and Drainage
RO	=	Research Officer
ROSES	=	Reservoir Operation Simulation (Extended) System
RPM	=	Resident Project Manager
RVDB	=	River Valley Development Board
RWS	=	Relative Water Supply
S&P	=	Seepage and Percolation
SAC	=	Study Advisory Committee
SCC	=	Study Coordinating Committee
SCOR	=	Shared Control of Natural Resources
SLFO	=	Sri Lanka Field Operations
SPCC	=	Subproject Coordinating Committee
SSC	=	Substudy Committee
TA	=	Technical Assistant
TC	=	Technical Committee
TLL	=	Tissawewa Left Bank Low Level
TO	=	Technical Officer
TOA	=	Turnout Attendants
TWL	=	Tank Water Level
UCC	=	Unit Coordinating Committee
UM	=	Unit Manager
WIIP	=	Walawe Irrigation Improvement Project
WMU	=	Water Management Unit
WS	=	Work Supervisor
WUG	=	Water User Group
Yala	=	Dry season (April to September)
YHL	=	Yodawewa High Level

CHAPTER 1

Introduction

1.1 BACKGROUND

The International Irrigation Management Institute (IIMI) was invited by the Asian Development Bank (ADB), the main funding agency for the Kirindi Oya Irrigation Settlement Project (KOISP), to assist with improvements in the system performance. by carrying out a diagnostic study. The Phase I Study results were published in 1990 (IIMI, 1990).

One of IIMI's major conclusion was that the irrigation water use efficiency of Kirindi Oya was low and there was a great potential for saving water if proper management policies were adopted. Major pints were that water use efficiency could be considerably improved through development and implementation of a seasonal allocation plan, effective use of rainfall and drainage water, improved operation of the main system and through improved tertiary system management. Also, there would be great improvement in water use efficiency if flexible scheduling were adopted, especially during land preparation period, to match more closely the water use pattern adopted by farmers.

In addition, the Kirindi Oya System as a whole is short of water; water supplies were initially overestimated by about 30 percent. In view of the scarce water resources and large area to be brought under irrigation, there was an urgent need to diversify crops to use the water resources more efficiently and to maximize farmers' production and income.

IIMI's Phase I report proposed a series of innovations in a) water management at both the main system and tertiary system levels, b) crop diversification and c) institutional strengthening. High level government officers selected a few important and implementable recommendations for field-testing by IIMI through participatory action research at Kirindi Oya with funds provided under Phase II study by the ADB. This Phase II study, originally designed for 27 months, was started in May 1991. A no-cost extension of 5 months was given up to February 1994 to monitor the internalization and implementation of innovations introduced into the project.

Three major areas were chosen for research under this phase: main system management, tertiary system management, and a pilot program in other field crops (OFCs). The following key activities were selected (IIMI, 1991a).

1) Improvement of main system management through development and implementation of seasonal crop and water allocation plans, through more efficient main canal operation, through water balance and operation studies of the Ellegala Irrigation System (EIS), and through improved maintenance management.

2) Improvement of tertiary system management through strengthening of farmer organizations, better tertiary maintenance management, improved seasonal planning, coordinated acquisition of agricultural inputs, and improved operations in field and distributary channels (DCs) during the land preparation and crop growth periods.

1.2 METHODOLOGY: PARTICIPATORY ACTION RESEARCH (PAR)

Participatory Action Research (PAR) in irrigation management is a mode of research in which the system management agencies, including farmers, become the implementers of the research program. The basic premise is that full involvement of the agencies and the farmers is an effective method for ensuring that their concerns are incorporated into innovations and that they understand, accept and transmit the research results. PAR can be an efficient mechanism for developing coordination among various agencies and the farming community for research-based problem-solving; also it results in cost-effective and sustainable internalization of research innovations.

In a PAR activity in irrigation management:

* Researchers together with agency personnel and, if appropriate, farmers, jointly plan innovations to be tested in the project.

* The planned interventions are made by the agency personnel and farmers.

* Much of the data needed to monitor and evaluate the innovation is gathered by the agency personnel and farmers.

* Researchers document the process and provide feedback to the implementers to allow for mid course corrections.

In PAR, the agency personnel and farmers are actors in the research process, not the subject of research. Besides being documenters, the researchers are catalysts who bring new ideas to the problems and who help train the others in application of those ideas. To make PAR work, all involved have to put a good deal of effort into planning, training, and coordinating field efforts; teamwork is of vital importance.

PAR yields three types of results:

1) Improvements in system performance that are implementable because they have ben carried out by regular working personnel.

2) Internalization of the innovations among the implementers, including understanding how and why they work.

3) Research reports to disseminate the results of the experiments to others who can made use of them.

The distinguishing characteristic of PAR is that the actors "on the spot" take part in research as well as in their everyday activities.

For the Phase II activities at Kirindi Oya, the basic strategy for getting the participation of the agency officers was the creation of committees to oversee each of the research components. Each committee was chaired by a officer and included personnel from the involved departments together with IIMI researchers drawn from an interdisciplinary team of four researchers stationed at Kirindi Oya to assist with the planning and implementation and to document the process and results.

The steps followed in implementing PAR in the Kirindi Oya were as follows:

1) Establishing coordinating and implementing committees.

2) Preparing an Inception Report with the participation of the agency officials and farmers.

3) Organizing planning workshops and preparing action plans for each of the key activities.

4) Training agency personnel and farmers.

5) Implementing the action plans.

6) Documenting the lessons learned.

7) Preparing reports and training modules for replication at other schemes.

This process was followed for the different components implemented at the Kirindi Oya project under the Phase II Study. Details of this process are described under each chapter in the text.

1.3 ORGANIZATIONAL SET-UP FOR PHASE II RESEARCH

The organogram used for planning and implementing Phase II research is shown in Figure 1.1. As stated earlier, the basic strategy adopted for getting the participation of the agency officers was the creation of subcommittees which planned, implemented and oversaw each of the

research components. Coordination at the project level was provided by the Study Coordinating Committee. Monitoring the implementation of the project and dissemination of research results at the national level were achieved through the Study Advisory Committee (SAC) and the Consultative Committee of IIMI-SLFO. In addition, a one-day national level workshop was organized by the newly set-up Irrigation Research Management Unit,(IRMU) of the Irrigation Department to discuss the methodology and results of Kirindi Oya Project and its adaptation to other projects in the island. About 80 middle level managers drawn from the department of Imgation Department (ID), Irrigation Management Division (IMD), Department of Agriculture (DOA), Department of Agrarian Services (DAS), Universities, Provincial Councils, Consultants and Nongovernmental Organizations (NGOs) participated in the workshop. The proceedings of the workshop will appear soon.

1.4 SUMMARY OF RESULTS AND LESSONS LEARNED

The following is a brief summary of each of the activities implemented under the Phase II study.

1.4.1 Seasonal Planning

As described in the Inception Report, development and implementation of a seasonal water allocation plan to effectively match supplies to demand was a basic need in Kirindi Oya System. No such plan existed in 1990.

Developing and establishing a seasonal allocation system is a political process, not just a technical process. The technical process included:

* assessing supply,
* planning seasonal demand,
* matching supply to meet the demand.

The case of developing a seasonal allocation plan in Kirindi Oya has warranted much more than merely technical interventions. The political process by which the decision making body, the allocation principles, and even the technical factors themselves became accepted was very important.

The political nature of this process demanded a strong technical basis for an effective allocation system which necessitated acquiring additional knowledge through necessary studies. In the case of Kirindi Oya, this included the water balance study of the Ellegala tanks as well as the reassessment of inflow to Lunugamvehera Reservoir. An interdisciplinary technical body - the Kirindi Oya Technical Committee (TC) including irrigation, agriculture, and institutional officers - took responsibility for providing technical advice for making the seasonal decisions.

Farmers' knowledge of the environmental and technical limits to seasonal allocations has become very important. Therefore, they were educated about the system as much as possible. More importantly, they were brought into the decision-making process as soon as possible and allowed to make their own decisions, with professional advice, so that they could learn from their mistakes. It took time for the farmers and other interested parties to learn the limits of their power and to get the agreements necessary to make an effective seasonal allocation system work. This time was allowed for in the case of Kirindi Oya.

Some of the major lessons learned through this process include:

* Acceptance by the Ellegala farmers that they did not have an absolute priority right to Kirindi Oya water. Over time, as they were defeated again and again, they learned that their rights would be protected only to a certain extent. The disaster in yala 1992 due to the drought probably hastened this acceptance.

* Acceptance by virtually all farmers of the Project Management Committee (PMC) as the legitimate and best body for making the seasonal allocation decisions. At times both Ellegala farmers and New Area farmers attempted to bypass the PMC.

* Acceptance of the planting of OFCs as a way to help conserve water in both Ellegala and the New Areas.

* An increase in knowledge and understanding of the water supply situation and of many technical aspects of the irrigation system among the farmers. There is a big difference between the lack of understanding shown by farmers in 1992 when some thought they could use the dead storage in Lunugamvehera as compared to the understanding demonstrated by a group of New Area farmers in 1993 to the carefully worked out water requirements and availability contained in the detailed alternative seasonal plan.

* Reduction of suspicion about the ID. Not only have most of the farmers come to trust data from the ID, but most have come to respect the advice of the Department officers. In part this respect is due to the Department officers' improved expertise due to their better knowledge of the system brought about by studies carried out under the Phase II activity. In part it is the result of the fact that the ID officers have not tried to take the decisions away from the PMC.

The process has been costly for many, including the Ellegala farmers who lost crops in yala 1992, the farmers who lost OFCs in maha 1992/93, the officers who have had to endure harassment and abuse, and the politicians whose reputations may have suffered. However, this process has been necessary to get general agreement on a seasonal allocation planning system. Overall the farmers, officers, and politicians have all learned a great deal and most have come to respect the others more.

The experience of maha 1993/94 Seems to imply that the seasonal allocation plan is well established and likely to endure, particularly if the problems identified by the Chief Resident Engineer can be solved. However, allocation of the excess water that will be available at the end of maha 1993/94 due to the heavy rains will pose a new and different challenge to this system. The evidence would imply that the PMC, if well supported by the agencies, particularly the ID, will be able to rise to this challenge.

1.4.2 Main System Operations Management

The main objective of undertaking this component of research is to improve main canal operations to provide reliable and predictable water supplies to tertiary systems and to effect saving in water use.

Improved main system operation management was introduced through a three-stage process consisting of:

* system diagnosis,
* introduction of the data collection program and communication network and
* introduction of the computerized Irrigation Management Information System (IMIS).

Simple concepts of system analysis were used in this study to identify the lack of real-time information for the Managers to formulate and implement appropriate control decisions. Also a communication network linking main canal operational centers (Unit bffices) with the Resident Engineer's Office was introduced. Through this two-way communication between the Gate Operators (GOs), Work Supervisors (WSs) and Resident Engineer (RE), it was possible to develop and implement a management information system which makes use of the transmitted data for real-time analysis. Effective communication also allowed careful monitoring and supervision of data collection and utilization, collection of accurate data and provision of feedoack to the relevant people engaged in operations.

Based upon the system diagnosis, a data collection and monitoring network was extensively discussed between the ID and IIMI and implemented starting maha 1991/92.

To accelerate the learning and integrating the additional work of data collection and transmission into their normal functions, IIMI and ID staff provided field staff with necessary training.

The IIMI-CEMAGREF team developed software named the Irrigation Management Information System - Right Bank Main Canal (RBMC), Kirindi Oya. This software helps the System Manager to make quick and appropriate decisions by facilitating computation and verification of discharges and easy storage and retrieval of data, including historical data. Provision has also

been made to help the Manager evaluate the performance of the system through a set of hydraulic and performance indicators.

Introduction of **IMIS,** together with the data collection and communication network, is a low-cost but satisfactory solution for obtaining information on current gate settings at each gated structure along the main canal and on water levels at each control point along the main canal and at the heads of offtake canals. This innovation is a great help to the Manager in managing the canal, since he is able to pinpoint trouble areas which require more attention, to make better decisions and hence to maintain reasonable equity in water distribution. Also, there is better control over field staff and ad hoc operations. Since there is daily monitoring program, field staff also have to improve their operations and to make accurate readings.

Introduction of IMIS and improved water management practices adopted under this component of research have effected about 20 percent water saving in the RBMC during maha 1992/93 when compared to maha 1990/91.

The methodology used in the RBMC was adopted in the Left Bank Main Canal (LBMC) to improve monitoring and feedback of information through a new data collection program. In applying the improved canal operation procedures, a number of constraints were faced. The efforts put in by the research team and the resources provided for introducing the changes needed were not sufficient to create a sense of commitment and interest on the part of implementing personnel. Since the Restoration of Irrigation and Drainage ('RID) works were in progress in Ellegala, the RE could not devote much time to understanding and implementing the IMIS. The main lesson learned from this replication of proven innovation is that any innovation introduced in an irrigation project may not be internalized. Even if it is internalized, it will not be successful unless the environment is conducive. Interest, commitment, and incentives to operating personnel play a major role in determining whether an innovation is successful or not.

1.4.3 Water Balance Study of Ellegala Irrigation System

Before April 1991, there were no reliable measurements of water releases to the EIS and nobody knew how to calculate the amount of water from Lunugamvehera Reservoir needed by EIS. Without knowing this requirement, it was extremely difficult to allocate water to the new areas of Kirindi Oya, especially during a dry year. Because of inadequate data, water releases from Lunugamvehera Reservoir to Ellegala were made on ad hoc basis. Often the new system was in dire need of water, while the tanks in Ellegala were spilling as they did in maha 1991/92.

The flow measurement and water balance program initiated under this study have provided limited but reliable flow data which include the determination of the amount of water originating from rainfall and drainage as well as that released from the Lunugamvehera Reservoir. In addition, it has also provided information on the water released from the different Ellegala tanks from maha 1991/92.

The data collection plans were jointly designed and implemented by IIMI researchers and ID officers. The generated information has been used to develop a new release pattern from Lunugamvehera Reservoir to satisfy the water requirement of EIS as well as to make seasonal cultivation plans for the old and new system based on the expected inflow into the Lunugamvehera Reservoir and agreed seasonal water allocation between the two systems.

The actual reduction in water use achieved todate is modest. However, because this study was carried out through participatory action research, the results have been well accepted by both the agency and the farming community. There has been virtually no difficulty in making planning and operational changes in response to the results. The ID officers, in particular, view the results as the product of their efforts and are proud to use them' to improve operations at Kirindi Oya. In many cases, when an outside agency like IIMI undertakes a study without the participation of the agency officers, the officers distrust the results and move very reluctantly in implementing operational changes. The officers themselves now have a powerful tool for learning more and for making further improvements on their own without IIMI's assistance.

This particular component of the study clearly illustrates two key points:

1) Improvements in water use efficiency can come about only when there is a good understanding of current operational procedures and of the basic hydrological relations within the system.

2) The use of participatory action research as a way to get the necessary information makes it easy to implement effective changes in response to the information and makes it likely that the changes will be sustained and/or improved upon in the future.

1.4.4 Maintenance Management

The main focus of the research was on financial and physical management of maintenance programs and not on technical aspects of maintenance. Research was directed to obtaining tangible results by conducting interventions in managerial aspects. In fact this proved the correct approach because some changes suggested in financial procedures and the methodology adopted for prioritizing maintenance components can be implemented without additional resources.

All activities under this component were carried out with the active participation of agency officials and farmers, This research component demonstrated that, by carrying out day-to-day work in a methodical manner, better results could be achieved.

The following are some of the salient conclusions and recommendations:

1) Administrative overhead of maintenance work for ID is high compared with the physical work; the administrative costs are covered by using the funds provided for physical work. It was found that the administrative cost of the Tissa Division

was not proportionate to the maintenance cost and needs to be corrected. When construction activities are diminishing in a project, administrative (overhead) costs should be adjusted to suit the workload. Under administrative cost, there are certain fixed costs like salaries, vehicle maintenance, electricity, telephone, etc., which are difficult to minimize.

To overcome this situation and to minimize fixed expenditures, the ID should reorganize its operation and maintenance division by bringing in more command area under each division in order to maximize the manpower utilization; such rearrangement would lead to reduced per acre maintenance overhead cost.

2) The preparation of work estimates on the basis of needs is well accepted by the agencies and farmers. The preparation of detailed work plans for maintenance well in advance provided for successful maintenance implementation during the closure season.

3) Identification, prioritization and decision-making walk-through surveys were found to be effective. Farmer participation increased as farmers felt their ideas and suggestions were being entertained. The environment strengthened relationships between users and operators. New formats designed in consultation with irrigation staff and used in identification, quantification and preparation of cost estimates were found to be effective, efficient and useful for needs-based maintenance. Procedural changes provided ample opportunity for high ranking Imgation Managers to participate and supervise maintenance planning work. Their involvement improved the quality of maintenance planning; lower ranking field staff were motivated and encouraged to perform better through appreciation of superiors and users.

It is recommended to internalize the concept of the diagnostic walk-through for the whole system to ascertain maintenance requirements and preparation of work plans; to implement the suggested maintenance procedure and methods used in each stage of the process within the framework of the ID and IMD and to make known at the beginning of the year, for each subsystem, the total maintenance allocation, allocation for main and tertiary systems, estimated value of work in tertiaries and shortfall in tertiary funding to be supplemented by Farmer Organizations (FOs).

4) A substantial difference exists in per acre allocations for maintenance between Mahaweli systems and ID systems. This difference has to be reduced.

It is recommended that every effort should be made to motivate and mobilize farmers through training and awareness for getting their contribution in bridging the resource gap. Norms and standards for different kinds of maintenance activities should be revised after analyzing the progress of each activity. The

existing maintenance laborers should be used and monitored to carry out maintenance in a planned manner with established norms.

1.4.5 Salinity Management in the Ellegala Irrigation System

Consequent to the construction of the Lunugamvehera Reservoir upstream of the old EIS in the KOISP, farmers in the old Ellegala began complaining that their paddy fields were being affected by soluble salts leached from the Kirindi Oya New Imgation System. They maintained these soluble salts collected in the four major tanks and were then transported to the paddy fields through the imgation canals.

Their complaints reached a peak during the maha season of 1992/93 when several isolated but visible patches of stunted young paddy plants could be readily observed in specific locations on lands situated in the flat alluvial plain of the old Ellegala. During this study, an attempt was made to provide an explanation as to why the salinity problem became so acute during this particular maha season and to propose preventive measures based on a monitoring system which needs to be set in place.

Starting January 1990, the DOA began a program to test, once every fortnight, the quality of water in the Lunugamvehera and in the five Ellegala tanks. The results of this analysis for the years 1990 to 1993 indicate that while Lunugamvehera has Class I dater, the quality of water in the Ellegala tanks fluctuated over a wide range during a season, depending on whether the tanks received considerable amounts of salt-enriched drainage water from the new areas and depending on the amount of good quality water received from the: Lunugamvehera via the Ellegala Anicut.

Ellegala has inadequate landscape drainage and now must cope with the added soluble salts coming from the drainage water of the new system. Ellegala presently acts as a sink for salts coming from both the upstream new areas and normal cyclic salts and other accretions.

Present indications are that a considerable amount of leaching of soluble salts is taking place from the new areas. This rate of leaching may decrease with the passage of time as happened in the adjacent Badagiriya System, provided drainage courses are kept ih good working condition to flush out salts.

The exceptional increase in salt concentration during maha 1992/93 was due to the absence of irrigation during the previous yala season, the lack of high quality water from the Lunugamvehera because of the decision to begin maha irrigation with rainfall and runoff water, and the flushing of salts by the heavy November rains.

Field inspections and interviews with farmers revealed that most of the salt affected areas were located in poorly drained grey alluvial soils. Stunted plants were mostly prevalent in locations where farmers had not applied basal phosphates irrespective of soil type.

The following are the proposed solutions to the salinity problems of Ellegala:

1) The quality of water used for irrigation during the critical crop growth period, namely seedling establishment and flowering, should be between Class II and Class I. Arrangements should therefore be made to release sufficient quantity of the Class I water from Lunugamvehera to the Ellegala tanks during these periods.

2) Although the main emphasis up to now was to restrict the quantity of water supplied to Ellegala, the events that occurred during maha 1992/93 suggest that water scheduling to Ellegala must take into consideration the quality as well as the quantity of water to overcome the incipient salinity problems.

3) Inexpensive water quality monitoring of the five reservoirs should be sustained with a view to releasing the required amount of Class I quality water from the Lunugamvehera reservoir to effect the necessary dilution.

4) One should take cognizance of the differences in the landscape hydrology and drainage density between the Weerawila irrigation system and that of the Tissa - Yoda wewa systems in regulating the quality of tank waters. The Weerawila irrigation system can tolerate waters of Class II quality, while the Tissa - Yoda wewa systems should be kept within the Class I quality.

5) Although farmers' perception that the construction of Lunugamvehera reservoir has contributed to the increased salinity problems of old Ellegala is correct, farmers should be advised that salinity can still become a problem even without receiving the drainage water from the NIS as happened in maha 1992/93.

6) There are two factors that are major contributors to the salinity problems of Ellegala. The **first** is the increased salinity contribution of tank water which can in the future be modified by proper monitoring of water quality and sufficient dilution from Lunugamvehera water. The **second** is the drainage congestion in the Tissa and Yoda wewa command areas and the poor drainage in micro-depressions and lower topographical locations which have poorly drained soils.

7) Early action should be taken to clear the drainage congestion and keep the drainage ways free from blockage and ensure that they are connected to the main arterial drains and eventually to the outfalls to the sea.

8) Farmers should be advised and trained concerning the provision and maintenance of the drainage facilities around their fields, and also in the use of adequate application of basal phosphate fertilizer in poorly drained soil locations.

9) It is extremely important that the fortnightly monitoring of water qualities of all reservoirs and the four outfalls (Basnawas) be continued over the next five years. This would help to keep track of the trends in salinity over this period and it would thus form the basis for the appropriate corrective actions.

10) Special note should be taken of the salinity levels of waters during extraordinarily dry years such as 1992, so that the necessary levels of dilution in the Ellegala tanks can be maintained.

1.4.6 Tertiary System Management

The Phase I study indicated that there was a great potential for improved water use efficiency if tertiary system management could be improved, particularly if the land preparation period could be shortened. The term "tertiary system" here refers to all portions of the system below the DC offtakes. Under the participatory management policy, the tertiary system is to be managed by the farmers organized in Distributary Canal Organizations (DCOs).

The activities proposed to achieve these objectives were:

a) institutional strengthening,

b) tertiary maintenance management,

c) seasonal planning and coordinated acquisition of agricultural inputs,

d) operations during land preparation and

e) operations during the crop growth period.

One of the expected outcomes of this component was a defined prbcedure for turning over tertiary system operations to the DCOs.

At the beginning of Phase II, it was presumed that this work should focus exclusively on the New Areas. However, during implementation of the Phase II study, the importance of the management of Ellegala for the Kirindi Oya System as a whole became much clearer. Hence, investigations into tertiary system management in Ellegala were added to this component.

It was expected that the field staff of the IMD and the ID would carry out most of the work with the farmers in selected pilot areas. IIMI was to be responsible for collecting data and monitoring progress. However, because of difficulties faced by the agency staff, IIMI field staff had to take a more active role.

Because of lack of water for irrigation, work in the New Areas could be carried out only during two seasons, maha 1991/92 and maha 1992/93. Work in Ellegala consisted solely of basic data collection and was carried out during maha 1992/93.

In the New Areas,

* Although there were small improvements in efficiency of water use, the interventions carried out were largely ineffective because of the weaknesses of the FOs. The necessary cooperation among the farmers could not be obtained. Most of the small improvements in water usage noticed can be attributed to changes in main system management.

* Although the weaknesses of the FOs have various causes, including lack of common experience among the settlers and lack of effectiveness of imgation officers, the basic cause is the farmers' fundamental economic problem caused by lack of adequate and predictable water supplies. Many farmers simply cannot make a living in the New Areas and thus choose to reside or work elsewhere. Many farmers are not willing to seriously invest in imgated agriculture and thus are not willing to participate in the FOs in communal water management activities.

* Despite the problems, it was possible to get some of the farmers to innovate. This suggests that, if water supplies can be made adequate and more predictable so that farmers are willing to invest more in irrigated agriculture, working with farmers will succeed in improving tertiary system management. The limits to improvement are likely to be limits created by the difficulties faced by the ID in managing water deliveries to the DCs.

In Ellegala,

* Because of extensive reuse of imgation water it does not appear that improvements in tertiary system management offer much scope for improvements in water use efficiency in Ellegala.

* Lack of structures and other complications make control of water flows very problematic in Ellegala. Although the FOs are reasonable effective, the physical and design problems appear to be beyond the capability of the FOs to solve on their own. Physical improvements, coupled as needed with improvements in the management capacity of the farmers and FOs, are likely to make improvements in the equity and effectiveness of water distribution.

Based on these findings, the following is recommended:

1) In the New Areas, the newly introduced improvements in seasonal planning are likely to make irrigated farming more attractive to the allottees. Efforts at strengthening the **FOs** should now be renewed. These efforts should include work with the FOs to improve their capabilities in tertiary system management in order to make water distribution more effective and to help prepare the FOs for turnover.

2) In Ellegala, a program should be developed to rectify some of the tertiary level design deficiencies (lack of farm turnouts and other structures, etc.) under some version of "essential structural improvements." This should be linked both to the regular maintenance program and to efforts to raise a large part of the **necessary** funds from the farmers themselves.

1.4.7 Diversification into Other Field Crops

In the Inception Report, the activity entitled "efficient **use** of scarce water to maximize production" **focussed** on pilot testing practices for crop diversification in Tract 3 of the Left Bank. The main objective was to test the possibility of cultivating **OFCs** during both maha and yala **seasons** under irrigated conditions.

The experience gained during maha 1991/92 brought two new approaches: 1) promoting non-paddy crops during both seasons on appropriate soils in the command area of all tracts **in** the NIS by making maximum use of seasonal rainfall (with or without supplementary irrigation), and 2) cultivation of non-paddy crops with both residual soil moisture and limited rainfall during the yala season in the Ellegala Imgation System. **A** study on growing limited **OFCs** using water from dug wells, initiated by farmers and encouraged by agency officials, was also undertaken. This study assessed incomes which could be obtained from **OFCs** using water from dug wells and to observe the behavior of the water table in dug wells. The study also examined the possibility of replicating the experience in other areas.

One major outcome of this study was for IIMI to assist the respective agencies evolve appropriate strategies for the adoption and testing of IIMI's institutional knowledge and past experience in irrigation management for crop diversification in the larger area of RB and LB Tracts in addition to obtaining lessons learned from the pilot project experimentation.

Some of the salient lessons learned are as follows:

1) To maximize the use of limited inflow to the Lunugamvehera Reservoir, seasonal rainfall was effectively used to raise OFCs. Because of the high variability in rainfall both during the season and between seasons, weekly probability values of past seasonal rainfall based on long term records were used in planning and implementing the **OFC** program in the pilot project area.

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2) **Based** on economic returns, crops other than paddy grown in Kirindi Oya System **can** be grouped into high profitability (high value) crops and low profitability (low value) crops. Chili and big onion come under high value crops while greengram, cow **pea,** vegetables, soyabean and groundnut come under low value crops.

Cultivation of low value crops like groundnut and greengram should commence with the onset of seasonal rains during the first and second weeks of October. Commencement of cultivation of low value crops after receiving 70 mm of cumulative rainfall is found to be appropriate. To avoid moisture stress during the crop growth period, irrigation issues should be made during the latter weeks of December or early January, depending on rainfall. Only two imgations were issued in November and December during maha 1991192. No irrigation was supplied in November and December during maha 1992/93.

3) For high value crops, at least 2 imgations are necessary during land preparation in early October to prepare proper quality **seed** beds and establish crops. Assured regular irrigation supply is necessary during crop growth period for better performance of high value crops to encourage increased fertilizer application and use of high yielding and short duration varieties. However, irrigation supply could be limited to three imgations in November and December since rainfall is high during this period. Further irrigations are **needed** after December up to March for crops like chili. It is found that a minimum of 10 waterings should be planned for chili, 2 during crop establishment, 3 during the rainfall period of November and December and *5* after December.

4) The present practice of raised-bed cultivation for chili and onions and row seeding for groundnut and greengram with graded terraces is found suitable.

5) Sharing 1 cusec flow by two farmers at a time is found to be appropriate and was adopted by farmers. However, allotting a fixed and uniform time for each one of the farmers under a turnout did not work due to soil type and geographical location of the plot in the turnout.

6) There is a high variation in the economic performance of OFCs within **seasons** and between seasons. In-seasonal variations are mainly due to variations in soil and drainage conditions while seasonal yield variation is mainly due to variations in weather conditions and occurrence of diseases. Also, poor crop management practices, inadequate land preparation methods, and low application of fertilizer, particularly for chili, resulted in low yield performance.

7) During maha season, chili and greengram performed well **on** well drained soils. Farmer incomes from chili and greengram cultivated on well drained soils gave a 50 percent higher return than when these crops were cultivated on imperfectly drained soils. Soybean performed better on imperfectly drained soils. OFCs

planted on poorly drained soils were completely destroyed by excess seepage, drainage water and rainfall.

8) Among the crops tested, chili gave the highest average gross value added and average farmer income. All other crops tested gave an average income similar to that of paddy. In the case of chili, the input cost in terms of labor, fertilizer and chemicals ranges between 2 to 3 times those for other OFCs. Capital required for greengram and groundnut was comparable with that for paddy.

9) Extending the maha cultivation into the yala season is a new innovation introduced by the Tract 3 farmers. Most of these innavations took place in the middle reaches of FCs where groundwater is available closer to the surface. Crops were established with rain received during March and/or with one or two waterings received for maha crop. These crops effectively utilized the rainfall received during March and April for crop growth. Water from dug wells was used only to water vegetables like onions and beans. Although the area cultivated is small under this innovation, it demonstrates the potential for farmers to earn additional income by extending maha cultivation into yala.

10) In the Ellegala System, the study demonstrated that OFCs can be grown in brown alluvial soils utilizing residual moisture left over from maha season coupled with April and May yala rains. The crops grown are: greengram, cow pea, groundnut and vegetables. In order to get better yields and be free from pest attacks and diseases, cultivation, especially that of greengram, should start early, preferably in April.

11) The on-farm distribution system in EIS needs better flow controls. In many turnouts, irrigation is from field to field and a number of fields utilize water from drainage canals for raising paddy. Under these conditions, raising high profitable crops such as chili, onion, etc., is risky and farmers are not willing to venture raising these crops.

12) Cultivation of OFCs in the newly developed area is possible using dug wells. However, yala cultivation can be carried out only in those places where groundwater is available in sufficient quantity for considerable length of time such as riverine alluvial deposits, valley axes and areas adjoining main irrigation canals. Since the groundwater table improves during maha, especially in areas adjoining to main canals, farmers in the newly developed area who do not cultivate paddy could cultivate OFCs using dug wells.

13) In the **NIS**, during a wet maha, farmers prefer to grow paddy with very little area going for **OFCs.** On the other hand, in a dry maha, farmers make use of rainfall and supplementary irrigation to grow **OFCs.** This is a positive development. In maha 1992/93, 560 ha were planted with **OFCs.** This area can be increased to about 1,000 ha.

14) During yala, the **NIS** farmers are reluctant to cultivate rainfed **OFCs** due to high variability in irrigation supply. The seasonal allocation planning procedure, now well integrated into the main system management component, ensures a rational allocation of the available seasonal supply to the NIS. With this assured canal supply in conjunction with rainfall and dug well supplies, it would be possible to increase the **OFC** cultivation from the 250 ha now being cultivated to about 1000 ha. This area could be further improved by bringing more lands, especially from Tracts 1 and 2 of RB and LB, under semi-permanent crops such as banana which need few irrigations between June and August.

15) The results of diversification of crops in Kirindi Oya show that even with poor yields, farmers can earn a profitable income from **OFCs,** if they can avoid problems such as late cultivation and the stray cattle menace and if they can acquire sufficient knowledge about how to cultivate **OFCs** on irrigated lands. The two major economic constraints observed in this system were fluctuations in output price and yield variation within and between seasons.

1.4.8 Concluding Remarks

The major achievements of this study can be listed as follows:

* Developing and implementing a seasonal allocation plan which was accepted by the farming community and agency officials including politicians.
* Institutional strengthening by making the **PMC** the nodal agency for making all irrigation related decisions.
* Introducing the IMIS and improving main system operation management of **RBMC** through a better communication network and monitoring.
* Evolving appropriate strategies for the adoption of institutional knowledge and past experience in irrigation management for crop diversification in the RB and LB Tracts including EIS.
* Effecting water saving and minimizing salinity problems in the EIS tanks through skilful operations of the system.

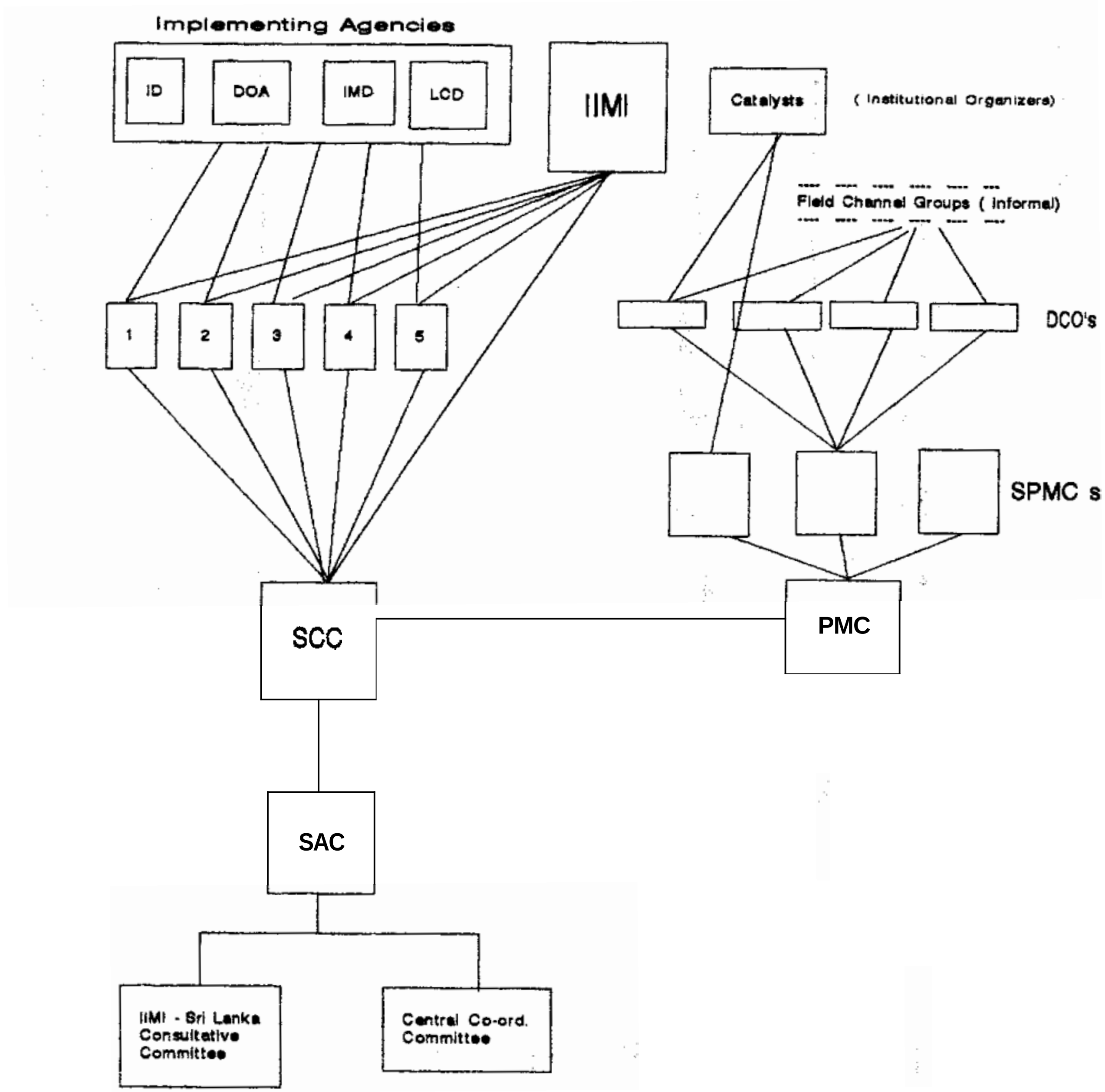
These achievements have led ***to:***

* Increasing the intensity of irrigation in the Kirindi Oya System **(Figure 1.2.).** Although the increase has been modest due to droughts, like yala 1992, there is a trend starting from 1989 maha.

* Improving the water use efficiency both in the old EIS and the NIS (Figures **1.3** and **1.4).**

* Evolving a process and a framework for improving and sustaining irrigation system performance **(Figure 1.5).**

Figure 1.1. ORGANIZATIONAL STRUCTURE FOR PARTICIPATORY ACTION RESEARCH IMPLEMENTATION IN Kirindi Oya Irrigation and Settlement Project



Area Cultivated in KOISP

Maha 1987/88 to Yala 1993

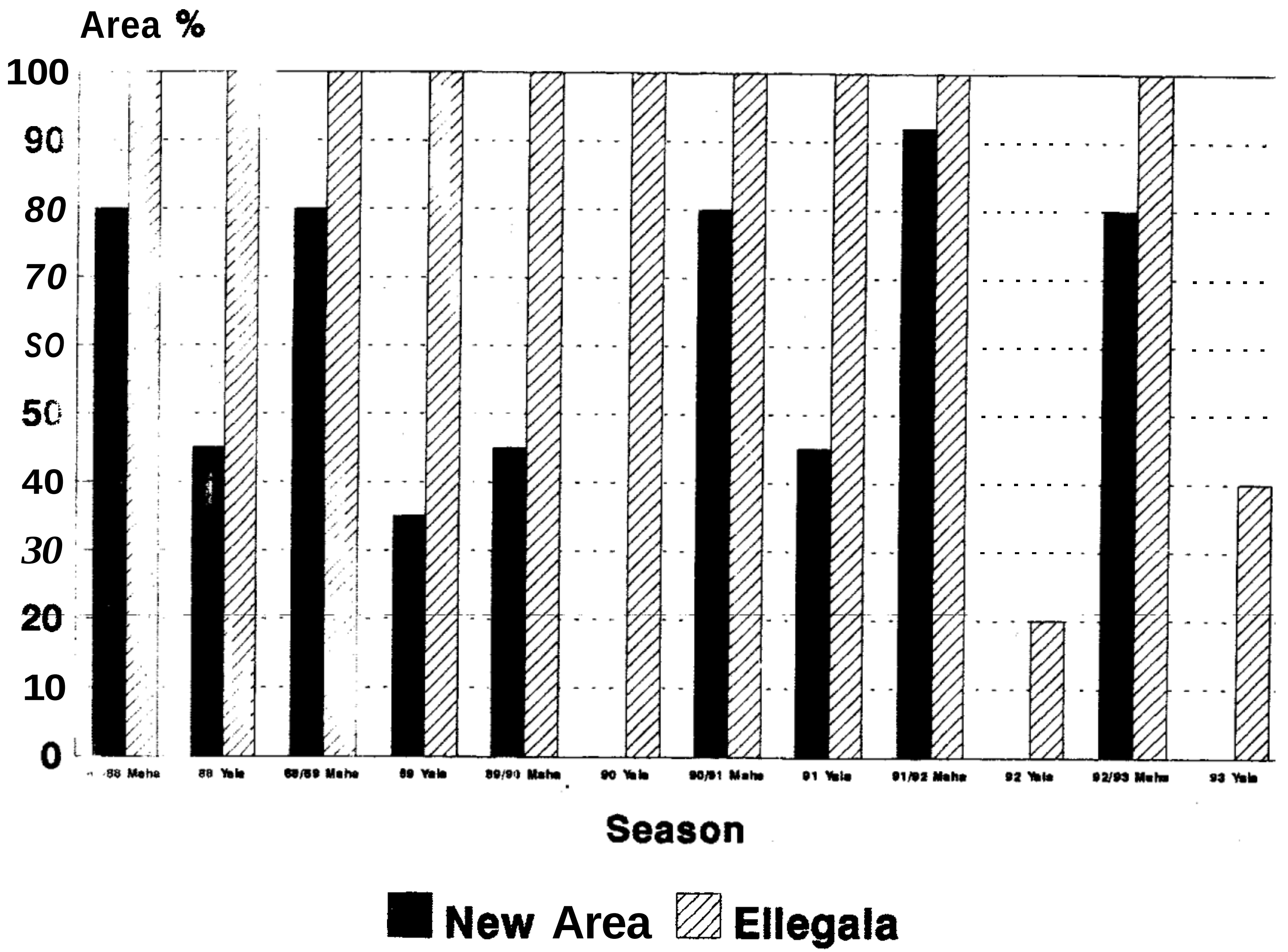


Figure 1.2

Crop - Paddy

Water Duty for Paddy in Ellegala System
(Irrigation & Rainfall Contribution)
Maha 1987/88 to Maha 1992/93

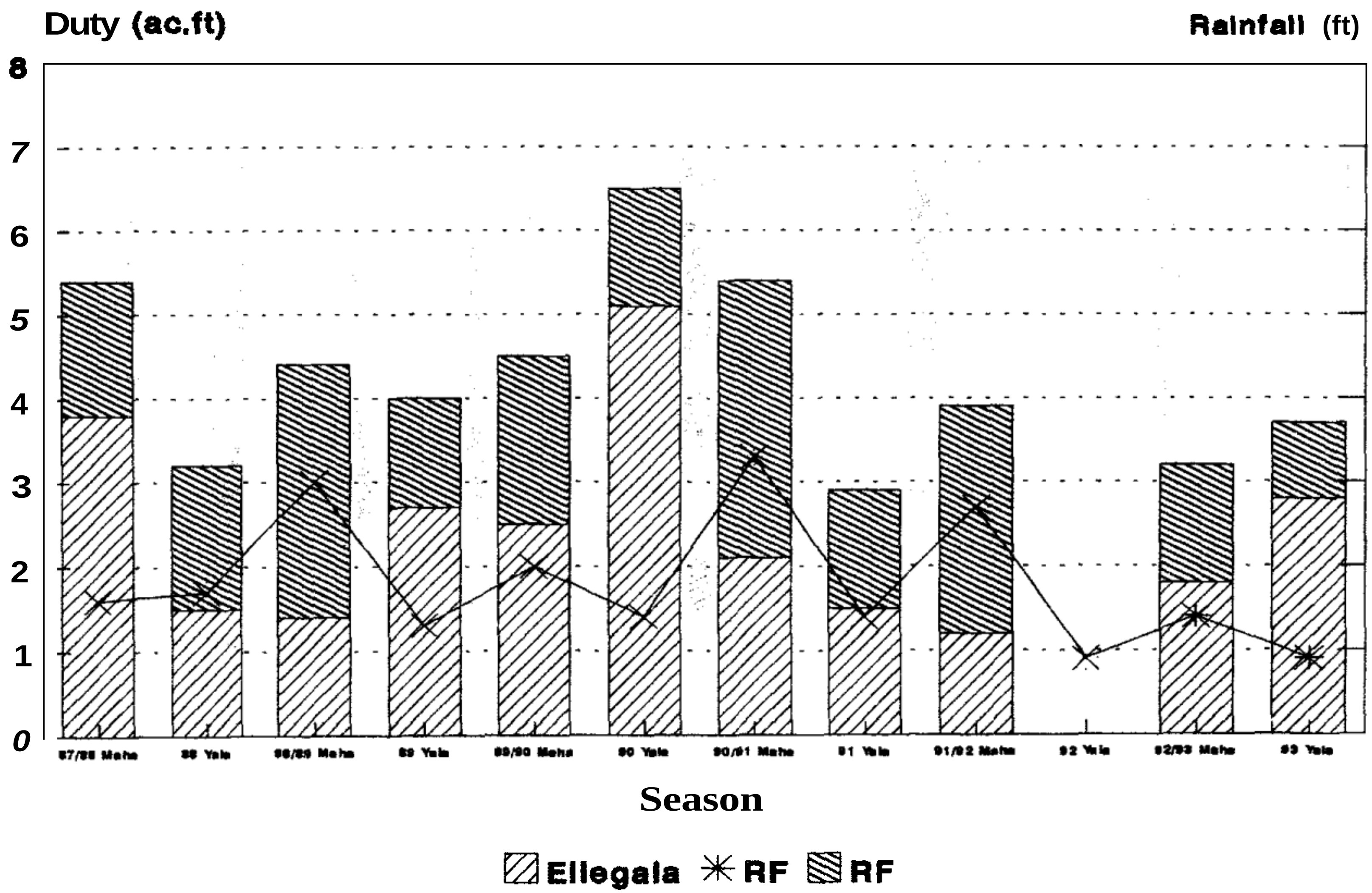


Figure 1.3

Water Duty for Paddy in KOISP New Area
(Irrigation & Rainfall Contribution)
Maha 1987/88 to Maha 1992/93

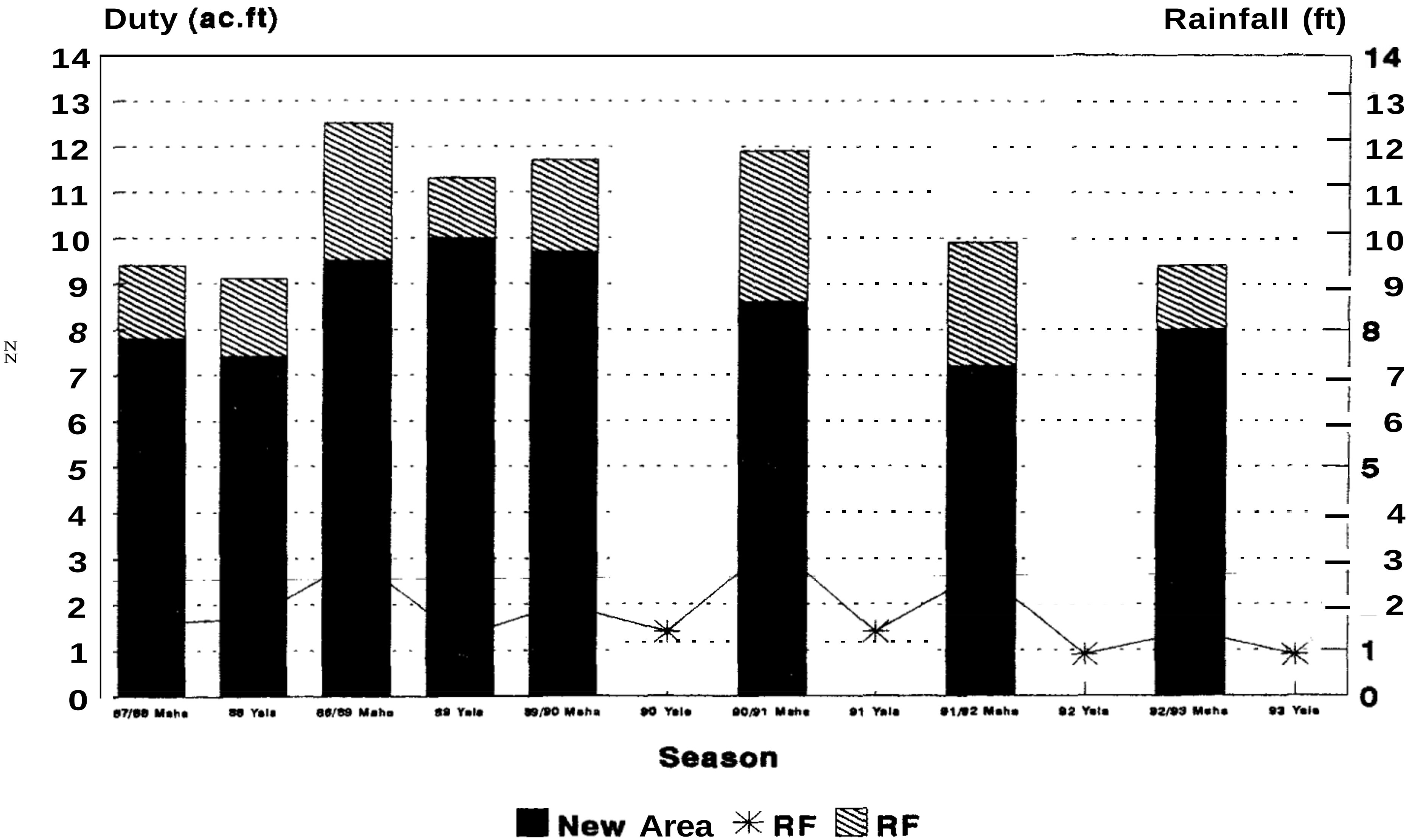


Figure 1.4

A FRAMEWORK FOR IMPROVING AND SUSTAINING IRRIGATION SYSTEM PERFORMANCE

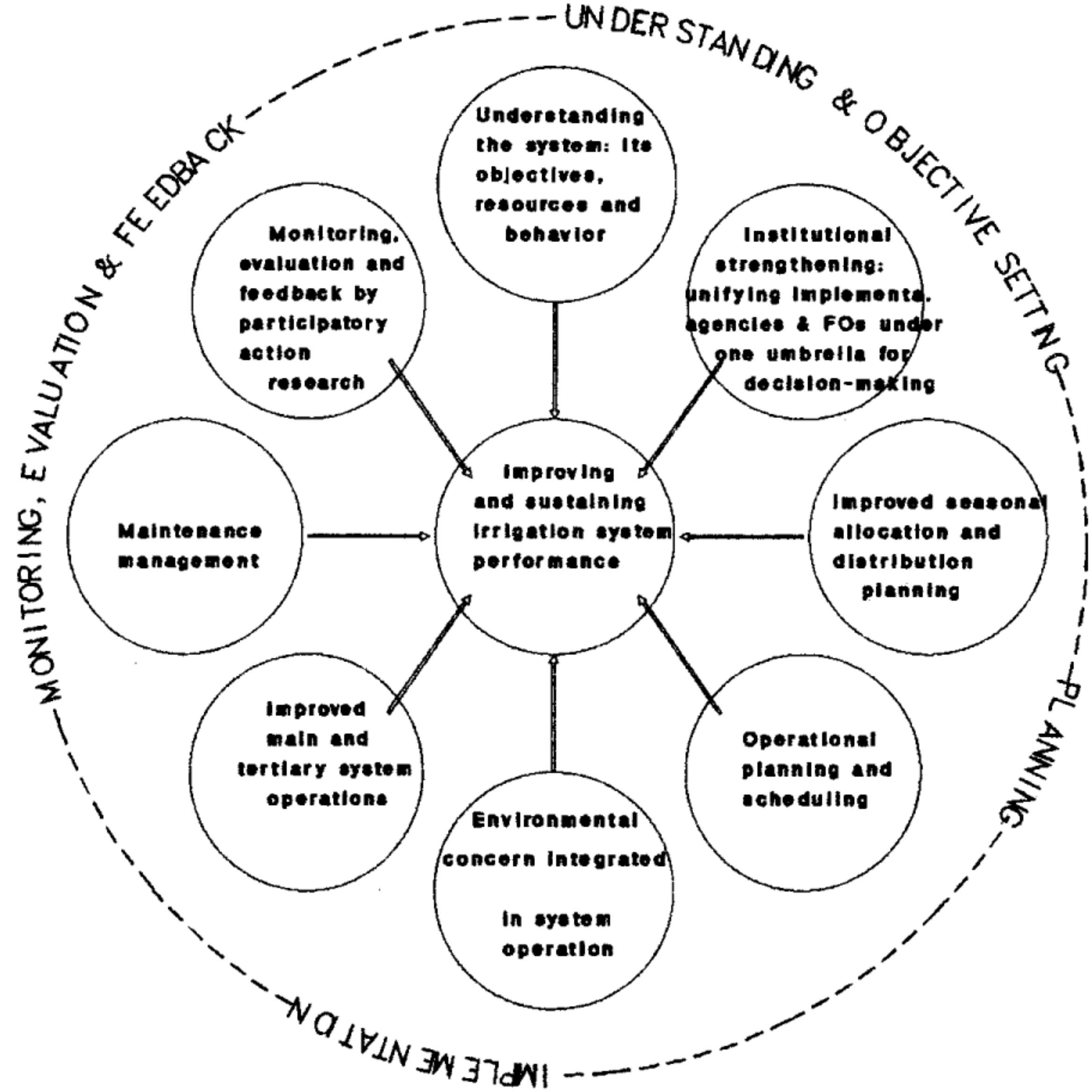


Figure 1.5

CHAPTER 2

Seasonal Planning

2.1 OBJECTIVES

At the beginning of Phase II of the Irrigation Management and Crop Diversification (IMCD) activity in 1991, it was well known that water availability at Kirindi Oya was significantly less than originally estimated and even less than estimated at the time of formulation of Phase II. As described in the Inception Report, development and implementation of a seasonal water allocation plan to effectively match supplies to demand was a basic need. No such plan existed in 1990.

The Inception Report outlined several steps to be taken, including:

* assessing quality,
* establishing water rights and priorities,
* planning seasonal demand,
* implementing the allocation plan (with the help of computer simulation) and
* resolving various institutional issues.

Over the life of the project, the efforts of agencies, IIMI and others have produced a seasonal allocation planning system that seems to answer the needs, although it is still too soon to be sure. This planning system was, however, not developed solely as a technical exercise. As will be shown, resolution of the institutional issues came about largely through political processes beyond the control of the agencies and IIMI.

2.2 IMPROVING THE TECHNICAL BACKGROUND

The Inception Report identified three key technical issues:

* assessing supply,
* planning seasonal demand and
* implementing the allocation plan.

The last item refers to operational planning and is discussed in Chapter 3 under Improvement of Main Canal Operations. This discussion covers only the first two items.

2.2.1 Improved Supply Assessment

At the beginning of Phase II in 1991, the estimates of water availability were known to be faulty. Work on reappraising inflow data began early in the IIMI Phase II project with the collection of 35 years of Kirindi Oya monthly discharge records from the Irrigation Department (ID). A detailed analysis of these. records was carried out. As part pf the analysis, outlying values were replaced by recently observed values. The analysis was carried out for 70, 75 and 80 percent exceedance probabilities. The results of the analysis are given in **Table 2.1.**

Table 2.1. Probable inflows at Lunugamvehera.

Month	Inflow (acft)				
	50%	70%	75%	80%	90%
September	5467	2916	2349	1944	1188
October	14985	10206	7557		4050
November	46778	34344	33210	26568	19494
December	32400	23166	20436	17010	9747
January	21060	14094	11259	9234	6129
February	13851	7695	7695	3105	3105
Subtotal	134541	92321			
March	19116	10530			
April	40500	32235			
May	23652	16200			
June	7371	5427			
July	5265	4050			
August	4374	2997	2810	2511	1053
Subtotal	100278	71439	64580	53946	32211
Total	234819	163860	146321	120366	75924

Using this data the cumulative values shown in **Table 2.2** were calculated.

Table 2.2. Monthly Cumulative Inflows at Lunugamvehera.

Month	Inflow (acft)				
	50%	70%	75%	80%	90%
September	5467	2916	2349	1944	1188
October	20452	13122	9906	7776	5238
Mid November	43841	30294	26511	21060	14985
November	67230	47466	43116	34344	24732
December	99630	70632	63552	51354	34479
January	120690	84726	74811	60588	40608
February	134541	92421	81801	66420	43713
March	19116	10530	8691	7614	4779
April	59616	42765	41601	35802	23490
May	83268	58965	54399	45198	28026
June	90639	64392	58773	49086	30429
July	95904	68442	61770	51435	31158
August	100278	71439	64580	53946	32211

The results were analyzed and evaluated by a TC that included officers from the ID, the Irrigation Management Division (IMD), the Department of Agriculture (DOA) and IIMI. Two key conclusions were drawn from this analysis:

1) Using the 70, 75 and 80 percent exceedance figures, estimates were made for wet, normal and dry maha seasons and wet, normal and dry yala seasons as shown in **Table 2.3.**

Exceedance probability	Nature of season	Range of inflow (acft)	
		Mahaseason	Yala season
80%	Dry	66000 - 70000	50000 - 55000
75%	Normal	80000 - 85000	60000 - 65000
70%	Wet	90000 - 95000	70000 - 75000

2) It was concluded that sufficient inflow into the Lunugamvehera would normally be received so that imgation issues could be made from 15 November for maha and from 15 April for yala even assuming that the reservoir starts from sill level (150 feet above minimum spill level [MSL]) for maha.

When these results were presented to the Study Coordinating Committee **(SCC)** and other local officers, they suggested that the definition of six types of seasons (three for maha and three for yala) was **too** complicated and did not fit the observed inflow pattern. They suggested that inflow during yala has little variability while maha inflow has two distinct categories. As a result, inflow into the Lunugamvehera can be divided into three classes: **a)** dry maha inflow of about **60,000** acre feet (acft), b) wet maha inflow of 80,000 acft or more and c) normal yala inflow of **40,000** acft.

After the events of maha **1991/92** and maha **1992/93** (see Sections **2.4.2** and **2.4.4**), the TC suggested that at the beginning of each maha season it assume that the season would be dry. By the end of December, it would be possible to tell from the storage in the Lunugamvehera whether inflow has been high enough to classify the season as a wet maha. If it is a wet maha, water could be allocated for a late maha crop, sometimes called **a "meda"** crop, in portions of the New Areas not previously authorized for paddy cultivation.

2.2.2 Technical **Aspects** of Determining Seasonal Demand

Seasonal demand can be calculated only when the principles and priotities for allocating water have been established. This subject is discussed in detail below. There were three key technical aspects to calculating seasonal demand that needed to be clarified:

* Crops **to** be cultivated and the amount of water to be allocated to each class.

* Zoning the New Areas since the expected inflow figures indicated that it would not be possible to plan on irrigating paddy in the whole of the New Areas in most years.

* The amount of water required for the Ellegala given that in some seasons the Ellegala tanks receive a large amount of drainage water from the New Areas.

After trying several different ways of classifying crops, the TC defined three types of crops for the New Areas: paddy, irrigated other field crops (OFCs) and rainfed OFCs. The difference between irrigated and rainfed **OFCs** is that irrigated **OFCs** are allocated six waterings while rainfed **OFCs** are allocated only two. Bananas were considered a separate class because of the long growth period but they have since been dropped, because banana$ are not being cultivated to any significant extent. For the New Areas it was decided that during maha paddy should be allocated six to seven feet of water, imgated **OFCs** three feet and rainfed OFCs 1.2 feet.

Zoning the New Areas is a way of simplifying the identification of areas to which water can be allocated. After careful consideration, the TC defined three zones each covering approximately 4,000 hectares:

* Zone 1: Tracts 1 and 2 of the Right Bank
* Zone 2: Tracts 1 and 2 of the Left Bank
* Zone 3: Tracts 5, 6 and 7 of the Right Bank

Using these zones, demand for water in the New Areas could be calculated using the figures shown above. Also, because there are only three zones it would be easier to get agreement on a decision about which areas should get water.

Prior to Phase II, the Irrigation Engineer (IE) for Ellegala assumed 56,000 acft as the Ellegala's requirement for paddy in the absence of drainage during both maha and yala. If relevant portions of the New Areas were to be irrigated, he assumed that 30 percent of the water issued to the New Areas came as drainage to the Ellegala tanks. These figures greatly overestimated the Ellegala's demand.

To obtain more accurate figures, IIMI collaborated with the ID on a Water Balance Study of the Ellegala tanks (Chapter 3).

Based on the findings of the study and experience gained since 1986, it is now estimated that

* during a wet maha, 15,000 acft of water is needed for 100 percent paddy in the Ellegala,
* during a dry maha, 25,000 acft of water is needed for 100 percent paddy in the Ellegala and
* during a normal yala, 30,000 acft is needed for a cropping pattern which includes 50 percent of the area in paddy, 25 percent in OFCs and 25 percent fallow.

Combined with demand figures for the allocation to the New Areas, these figures allow calculation of the total demand.

2.3 RESOLVING THE INSTITUTIONAL ISSUES

The Inception Report identified two key institutional issues:

* establishing water rights and priorities and
* resolving various institutional issues.

The latter refers to determining the roles and responsibilities of the various parties in making key decisions.

2.3.1 Establishing Water Rights and Priorities

Rights to receiving imgation water are a key concern in defining an allocation system. In Sri Lanka, all surface water legally belongs to the Government and there is no legally recognized system of individual or group water rights. The practice is to assign water rights each season. The Irrigation Ordinance defines mechanisms for seasonal allocations but adds that all decisions are subject to review and change by the Government. The final authority is the Minister in charge of irrigation. In 1991, this was the Minister of Lands, Irrigation and Mahaweli Development. Currently it is the Minister of Forestry, Imgation and Mahaweli Development.

There are certain widely accepted principles for water distribution that govern the seasonal assignment of water rights to individuals:

* One principle for water distribution is that water is distributed to all farmers in proportion to landholdings within the authorized area. This rule is modified for different crops; paddy farmers receive more water than farmers growing OFCs.

* Equity is an important principle. Sri Lankan farmers and system managers have devised various ways of sharing water in water short seasons.

* A third principle is that a standing crop has priority oven a yet to be planted crop. Thus if one group of farmers gets water to start a crop they may be able to deny water rights to another group who were planning to use the water later.

In some localities, local principles are also accepted. One of the more common of these is that during short water seasons some areas within a system are authorized to receive water while others are not. Presumably this type of rule has arisen from repeated allocation decisions which have come to color the expectations of farmers and officers, thus giving them legitimacy. For Kirindi Oya, two local principles were recognized prior to 1991:

* Ellegala farmers consistently claimed prior rights to all Kirindi Oya water on the grounds that they were using it first. They publicly claimed that they had enjoyed 200 percent paddy cropping intensity prior to the construction of the Lunugamvehera. Records and private conversations have clearly indicated that the actual average cropping intensity was not more than 150 percent. Until 1991, this claim was tacitly respected by officers managing the system. The Ellegala farmers hoped that the claim would come to be generally accepted. Since then they have threatened to go to courts to have this priority legally established.

* Since 1986, whenever water was available for the New Areas, system managers assigned it to different subareas in a crude rotation system intended to assure long-term equity.

To help adapt the generally accepted principles to the specific needs of Kirindi Oya, in 1991 the Special Task Force created to look into the Phase I recommendations appointed a Subcommittee, which included high level officers from the ID, the Land Commissioner's Department (LCD), the IMD and IIMI. The Subcommittee made its recommendations in January 1992. Members of the Subcommittee discussed this proposal with Farmer Representatives (FRs) on 27 May 1992. The farmers asked for the opportunity to discuss it among themselves. A second meeting of 20 FRs was held on 6 June 1992 at which the FRs presented their own set of proposals aimed at making it possible to cultivate the whole of Kirindi Oya every season.

At that time, the local TC referred to in Section 2.2.1 was created to develop these two sets of recommendations into a workable plan. On the basis of the improved data on water availability, the TC prepared a set of proposals. A slightly modified version of this proposal was used as the basis for the initially approved allocation for the 1992/93 maha season. Events during that season (Section 2.4.4) led to reconsideration of the allocation strategy by the TC. The revised strategy was discussed with FRs in July 1993 and with one adjustment has been accepted as the basis for allocation planning (Section 2.4.6).

The revised strategy included the following provisions:

1) The New Area (except Tract 3 of the LB) is divided into three zones of about 4,000 acres each as mentioned earlier. At the beginning of the maha season, it is assumed that the season will be dry. Therefore, two out of three zones are authorized water for paddy and the third for rainfed OFCs. The area authorized for OFCs rotates among the three zones. If at the end of December the season is judged to be a wet maha, the other field crop zone will get water for a late maha paddy crop following harvest. If it is a dry maha, then the zone would get water for irrigated OFCs during the following yala. Zones authorized for paddy during maha will normally not get water during yala.

2) The Ellegala is allocated water for 100 percent paddy during maha. During yala, the Ellegala is allocated water for at least 50 percent paddy plus some portion in OFCs.

3) Badagiriya is allocated up to 5,000 acft of water during maha if there is a shortage but receives nothing during yala.

4) Tract 3 of the LB is allocated water for irrigated OFCs during both maha and yala.

Maha water issues begin by supplying the Ellegala by 1 November each year. If there is adequate water in the reservoir, both the Ellegala and one of the New Area paddy zones are started simultaneously. After three weeks (by 21 November) water is supplied to the second paddy zone.

One of the key points is that, because the third zone might be authorized water for a late maha paddy crop if there is enough water, some of the yala inflow might be used for such a crop. Thus not all of the yala inflow is reserved for the Ellegala. Table 2.4 shows the percentage allocation for the major subareas in Kirindi Oya under this strategy.

Table **2.4.** Percentage allocation of water to major subareas.

Type of season	Percentage allocation		
	New Area	Ellegala	Badagiriya
Dry Maha	**55%**	**40%**	**5%**
Wet Maha	75%	20%	5%
Yala	20%	80%	-

2.3.2 Defining Decision-Making Roles and Responsibilities

The key concern was defining which body is responsible for making seasonal allocations and other aspects of the seasonal plans.

The Irrigation Ordinance of 1968 specifies that seasonal planning is carried out jointly by farmers and officers at "Kanna" (seasonal) meetings called by the Government Agent. In fact, Kanna meetings in large irrigation systems have not worked effectively for seasonal allocations because the size of the systems and number of farmers involved make decisions impossible. Commonly, decisions were made by agency officers and disseminated to farmers via Kanna meetings.

Under the participatory imgation system management policy, the seasonal planning role of the Kanna meeting is to be taken over by the Project Management Committee (PMC). However, this did not happen in Kirindi Oya although the Integrated Management of Major Agricultural Schemes (INMAS) program was introduced in 1986. At that time, two Project Managers (PMs) appointed - one for the Ellegala and one for the New Areas - and separate PMCs were created. Creation of the PMs, however, did not make major changes in the seasonal allocation planning system because the two separate Committees were not in a position to decide water allocations between the Ellegala and the New Areas.

Therefore prior to 1991, seasonal decisions were generally made by the Government Agent as advised by ID officers. When discussion among officers was required, it usually took place at the Kirindi Oya PCC, a body whose main responsibility was to oversee construction and settlement efforts.

In its Phase I Final Report, IIMI recommended that the two PMCs should be expanded to three and that a superior Water Management Committee (WMC) should be created for seasonal allocations. Instead, the State Secretary of Irrigation recommended combining the two existing PMCs into one and creating Subproject Committees (SPCs) to support them. Therefore, in September 1990, one of the PMs was transferred and the two PMC combined into one.

Although most officers accepted the unified PMC as the legitimate seasonal planning body from the very beginning, there have been disputes among farmers over this assignment. The roles of the Government departments have been and continue to be providing technical advice and support to the PMC.

2.4 ESTABLISHING THE SEASONAL ALLOCATION PLANNING SYSTEM

In light of the water shortage in Kirindi Oya and the conflicting demands from groups of farmers, actually putting an effective seasonal allocation planning system into place took a great deal more than the technical efforts described so far. The real key has been to get general acceptance by the farmers of the various principles and practices described above. This acceptance can come only when all interested parties accept one way as the best compromise possible. Achieving this acceptance requires discussion and negotiation among the various parties including learning what the practical limits of demands are. This discussion and negotiation together with generated conflict make up the political process of coming to a general agreement.

In Kirindi Oya, these processes have taken place over several seasons; for this reason, the processes will be. described as a history beginning with establishing the unified PMC in September 1990, the first innovation introduced as a result of the IIMI project.

2.4.1 Maha 1990/91 and Yala 1991: No Change

The first meeting of the unified PMC was held on 25 September 1990 in time to make seasonal allocation decisions for maha 1990/91.

No FRs from the Ellegala were present at the first meeting. The Ellegala farmers suspected that the PMC would try to curtail the virtual absolute priority rights to water that they had enjoyed since 1986. It had become apparent to the farmers that there was sentiment among officers for a "fairer" allocation of water, that is an allocation that gave more water to New Area farmers even at the cost of reducing water supplies to the Ellegala.

For this reason, they demanded assurances that their rights would be recognized before they would participate in the new Committee. No such assurances were given but after the first meeting, Ellegala FRs began attending as "observers." They gradually chose to take part and within a few months their "observer" status was forgotten.

For maha 1990/91 and yala 1991, although seasonal plans were discussed at the PMC, no changes from preintervention seasonal allocation patterns were observed. During both seasons, the Ellegala received authorization for 100 percent paddy. During maha 1990/91, 10,600 acres of the New Areas were authorized water for paddy and 1,500 acres in Tracts 6 and 7 of the RB were authorized water for OFCs. During yala 1991, a small amount of water was authorized for OFCs in Tract 3 of the LB.

2.4.2 Maha 1991192: Disputes and Late Maha Crops

In July 1991, the PMC adopted an initial seasonal plan that came under severe criticism from many quarters:

1) Because it authorized water releases to the New Areas at the same time as releases to the Ellegala, Ellegala farmers objected on the grounds that saline drainage water from the New Areas would affect their seedlings.

2) Badagiriya farmers complained that they should get second priority for water after Ellegala.

3) Farmers in Tracts 6 and 7 of the RB, speaking through officers, got the Central Coordinating Committee to authorize water for paddy to their tracts several weeks earlier than had been decided by the PMC.

After these complaints were dealt with, the final plan authorized paddy cultivation in the Ellegala, Tracts 1 and 2 of the RB and Tract 1 of the LB beginning in September. Water for paddy was authorized for Tracts 6 and 7 of the RB beginning mid October. OFCs were authorized for Tract 3 of the LB after 75 mm of rain. In addition, three issues of water were authorized for OFCs in Tracts 2 and 5 of the RB. Supplementary water would be issued to Badagiriya only when water became available presumably by 1 November. The PMC also decided that in the future it would issue water to Ellegala prior to the New Areas until the DOA could fully investigate the salinity problem.

All of the authorized areas were under cultivation by the end of November when, because November inflows were good, the ID recommended that paddy be authorized for Tracts 2 and 5 of the RB, the sole areas not under cultivation. The PMC decided to issue water to these tracts on 30 November. Cultivation in Tract 2 of the RB began in December but cultivation in Tract 5 of the RB was delayed until January because of a drop in rainfall in December.

As it turned out, maha 1991/92 cultivation was very successful in all areas. A key innovation during the season was changing the plan in response to conditions. Prior to this season, once allocation decisions were ratified by Kanna meetings, they were followed unmodified through the season. Without the PMC, there had been no means by which plans could be changed.

2.4.3 Yala 1992: Disaster in the Ellegala

The Ellegala farmers' suspicions about the intentions of the officers and New Area farmers appeared to be confirmed by the PMC decision to authorize late paddy cultivation for maha 1991/92. In a January 1992 meeting of the PMC, a FR from Ellegala stated that "some farmers in the RB have said that they will try their best to get water for a late maha crop and deprive the Ellegala farmers of their yala crop." Thus right from the beginning of the January discussion of the yala 1992 seasonal plans, the Ellegala FRs consistently demanded authorization of paddy for the whole of the Ellegala largely to maintain their claim to priority water rights.

Because the Weerawila tank was spilling from drainage water from Tract 2 of the RB, water issues for paddy under the Weerawila were authorized from 1 March 1992. Authorization for other areas was taken up at the March PMC meeting. At that meeting, paddy cultivation under the Pannegamuwa tank was discussed and some said approved. Decisions for the other subareas were delayed because of lack of rain. One issue at the meeting was the amount of water actually available. The figures quoted officially by the ID included only water about the minimum operating level (MOL) for the Lunugamvehera, that is 156 feet above MSL. However, one IE and several farmers insisted that the 12,000 acft of water between the MOL and sill level (150 feet above MSL) should be included. This argument recurred several times in later discussions.

Rains began in mid April 1992 and issues to the Pannegamuwa began soon after. However, the PMC delayed further authorizations on several occasions because the rains were light. Finally, however, a special PMC meeting held on 1 May, approved water issues for paddy for all of Ellegala, against the advice of the ID officers. Because of their concern, the Department officers organized meetings of farmers in the areas where cultivation had not already begun. At these meetings, the officers explained the risks. At these meetings at least some of the FRs claimed that, instead of 7,000 acft of water in the Lunugamvehera as reported by officers, there was really 33,000 acft. This figure apparently included both the water between MOL and sill level and the dead storage. Although some farmers said later that they were at first persuaded at these meetings that the risks were too high, their own representatives pushed them to cultivate to maintain their claim to priority rights to the water.

Rains were unusually light during yala 1992. Even by the end of March the lack of rain had become a major topic of discussion all over Sri Lanka. As the season progressed, it became apparent that the worst predictions for the season would be fulfilled. Rains were lighter than usual and failed totally in mid June. Water issues were stopped on 2 July on the orders of the Deputy Director of Irrigation to protect domestic water supplies to the New Areas. On that date, the water level in the Lunugamvehera was two feet below MOL. Protests through the

State Minister for Irrigation resulted in the release of an additional 3,000 acft of water, but water issues ended finally on 23 July.

The result was total crop failure in all parts of Ellegala except Weerawila and Pannegamuwa. Weerawila farmers, because they started much earlier and because they had their own supply of water suffered only minor losses. Pannegamuwa farmers suffered losses but some farmers achieved reasonably good crops. In the other areas, use of wells and other last-ditch efforts were tried but were not sufficient to save the crops. About three-fourths of the Ellegala yala 1992 crop was lost to drought.

This disaster in 1992 yala taught important lessons to the Ellegala farmers, including:

1) At the beginning of the yala 1992 season, the Ellegala farmers' distrusted the data on water availability provided by the ID. The distrust was caused in part by the failure of the ID to explain the workings of the reservoir and especially the significance of the MOL. Attempts to get more water during the season taught the farmers a great deal about reservoir operations; by the end of the season, most Ellegala farmers, and many other farmers as well, understood the significance of the **MOL** for seasonal allocations.

2) During yala, the Ellegala farmers learned that it was not wise to disregard the ID warnings as counselled by some of the their leaders., One result of the yala disaster was a massive change of leadership in Ellegala, farmer organizations.

These lessons became important in later seasons.

2.4.4 Maha 1992/93: Conflict and Political Intervention

By July 1992, the TC had prepared recommendations for an allocation strategy based on the Subcommittee's recommendations, farmer suggestions and a new analysis of water availability. Based on these recommendations, the PMC tentatively authorized paddy cultivation in all of the Ellegala and Tracts 2 and 5 of the RB and other field crop cultivation in Tracts 1, 6 and 7 of the RB and in Tracts 1, 2 and 3 of the LB. Water issues were to begin only after water in all of the tanks had risen above MOL.

Opposition to this plan grew rapidly, particularly in Tracts 1 and 2 of the LB and Tract 1 of the RB. In these tracts, during August, an "independent" farmers' organization was formed with the support of a Divisional Secretary to work against the plan. At the September PMC meeting, the FR from Tract 1 of the LB complained that local officials answerable to the Divisional Secretary were removing barbed wire and fence posts from the area to prevent farmers from cultivating OFCs instead of paddy.

Rains came late and the water level in the Lunugamvehera rose more slowly than expected. The new rules meant that all cultivation had to be delayed. Because of lack of water, decisions were postponed twice until a PMC meeting on 19 November. Heavy rains arrived in mid November. The 19 November PMC confirmed a) the allocation of water for paddy in the Ellegala and Tracts 2 and 5 of the RB, b) allocation of water for OFCs in Tracts 1, 6 and 7 of the RB and Tracts 1, 2 and 3 of the LB, and c) allocation of 5,000 acft to Badagiriya for paddy.

In response, the independent farmer organization held a meeting on 20 November to mobilize support for getting water for paddy in these three LB Tracts. With the support of this group, a local politician appealed personally to the Minister for Lands, Irrigation and Mahaweli Development. On the Minister's orders, a special PMC meeting was convened on 22 November but made no change in the allocation. That evening a meeting was held among many of the same officers, an Member of Parliament (MP) from the district and the leaders of the independent farmer organization. It appeared that the farmers believed that the ID was understating the available water by the 12,000 acft between MOL and sill level. At the meeting, the MP asked the farmers to nominate three people to meet the Minister.

During the first week in December, the delegation of farmers met with the Minister. Also present were the Minister of Agriculture, several State Ministers, the Director of Irrigation, the Director of the IMD and the Deputy Director of Irrigation. Although the Director of the IMD claimed that 50 percent of the area had been planted with OFCs which would be damaged by water issues for paddy, the farmers argued that only 5 percent of the area had been planted. They also claimed that some farmers had already completed plowing using only rainfall. They agreed to get other farmers to complete all plowing with rains only. The Minister then agreed to issue water for paddy to Tract 1 of the RB and Tracts 1 and 2 of the LB subject to several conditions, the most important of which was that all plowing would be completed before 20 December using only rain.

Very little plowing had been carried out by 20 December, in part because rainfall was less than expected during the period. The ID was faced with a serious difficulty in delivering water to only those few fields where farmers had completed plowing. When ID employees tried to deliver only to the plowed fields, they were harassed and threatened by farmers. Water delivery to the Ellegala was blocked by farmers to get more for the LB tracts - the cables to control the gates for the Ellegala feeder canal were cut - and some farmers operated gates and regulators to divert water to their fields instead of to the intended destinations.

Following another meeting called by the MP, at which one FR was physically assaulted for opposing water issues for paddy, some FRs and the Deputy Director of Irrigation met the Minister who was in the area for other reasons on 25 December. On the advice of the Deputy Director, the Minister ordered that water issues for paddy were authorized for all parts of the three tracts from 27 December.

One consequence of this decision was the loss of at least 650 acres of OFCs. In many cases these crops were simply plowed under; in other cases, farmers hurried to get some small part

of the crop before plowing them under. Many of the farmers have claimed compensation from the Government. Ultimately the maha paddy crops in Kirindi Oya all turned out well. However, the maha season extended into May and required the use of Inflow from yala rainfall. In turn this affected the yala 1993 cultivation in the Ellegala.

The dramatic events of the season taught important lessons to officers, politicians and many farmers, including:

1) Many New Area farmers learned that they can successfully demand more rights to water.

2) Some New Area farmers learned that working outside the PMC causes conflicts among themselves. One result has been a disbanding of the "independent farmer organization" but emergence of many of the leaders of the independent organization as leaders of the officially recognized farmer organizations.

3) Ellegala farmers learned that they could not trust the administrators and political authorities to protect their claimed priority rights to water. One result was that the Ellegala farmers threatened to go to court to establish their rights legally. After discussing the matter with lawyers, they dropped the issue and have chosen to work through the PMC.

4) The interventions by political authorities generated a great deal of criticism. Grounds included loss of OFCs, loss of part of the yala 1993 paddy crops in the Ellegala, harassment faced by ID employees, damage to irrigation structures and interference in the establishment of a technically sound seasonal allocation strategy.

These lessons have been important in publicly establishing the limits of power to influence events.

2.4.5 Yala 1993: Other Field Crops in the Ellegala

Because of the events of maha 1992/93, the TC felt it necessary to consider a yala seasonal plan, based on the proposals accepted by the PMC in July 1992, well ahead of time. In January 1993, the TC carried out an analysis of probable water supplies and requirements which showed that there would not be enough water for 100 percent paddy in Ellegala let alone in the New Areas. The Committee then sketched out a series of steps to develop an accepted plan. These steps included a number of meetings with FRs and farmers at various levels to inform them of the water shortage so they could make an informed allocation decision.

The Ellegala FRs were anxious not to repeat the disaster of yala 1992 and thus cooperated with the TC to develop a plan that would fit the available water. The biggest problem was a disagreement among the Ellegala FRs over whether they would respond to the water shortage

by giving priority to one or two tanks as had been done before the construction of the Lunugamvehera or whether they would share the water among all of the subareas. At the urging of the TC, the PMC agreed to share the water among all of the subareas in proportion to the command areas. The PMC also agreed to maximize the area cultivated by planning for diversified crops including paddy, OFCs and fallow.

The final decisions about which areas would have paddy, which OFCs and which would be fallow were made at Kanna meetings held in the first week of May 1993. At these meetings, disagreements among farmers were evident but only Weerawila farmers demanded the right to plant paddy in the whole area; all others accepted the necessity of restricting the planting of paddy on the advice of the ID. The Kanna meeting decisions are shown in **Table 2.5.**

Table 2.5. Kanna meeting decisions.

System	Extent to be cultivated		Date of first water issue	Final date for planting/sowing	Last water issue
	Paddy	OFCs			
Pannegamuwa	200	350	6.5.1993	31.5.1993	31.8.1993
Weerawila	750	1550	7.5.1993	2.6.1993	2.9.1993
Debara wewa	350	750	4.5.1993	30.5.1993	30.8.1993
Tissa wewa	1000	2000	7.5.1993	31.5.1993	31.8.1993
Yoda wewa	1050	2150	10.5.1993	5.6.1993	5.9.1993
Gamunupura	125	275	9.5.1993	3.5.1993	3.9.1993

The outcome of the season was that the area under paddy exceeded the planned area by 10 percent but only 65 percent of the area planned for OFCs was actually planted. The paddy crops turned out well but the OFCs did not. A major reason was that the long delay in making the seasonal decision meant late.planting which led to pest and disease problems. By the end of the season the water level in Lunugamvehera Reservoir was three feet below MOL.

A survey of 110 Ellegala farmers carried out by IIMI showed that 40 percent believed that the seasonal decisions were made jointly by the FRs and ID officers. Twenty percent of the respondents did not know how the decisions were made while 19 percent felt the decisions were made by FRs and officers after consulting farmers. The rest of the answers were scattered. None felt that a decision was made at the Kanna meetings. However, half said that they learned of the seasonal decisions at the Kanna meetings. The remainder learned of the decisions from a variety of sources. Despite this, 85 percent of the farmers said that they would agree with the type of decision reached for yala 1993 in a water short season.

The results of the decision-making process in yala 1993 contrast vividly with the results in yala 1992. Not only was the decision very different - in fact it was the first time there has ever been agreement on such widespread planting of OFCs - but also the process itself was less confrontational and problematic. In large part this was a result of lessons learned in 1992. It is significant that the Weerawila farmers were most opposed to the plan. The Weerawila farmers had experienced crop failure in yala 1992 as had the Ellegala farmers.

2.4.6 Maha 1993/94: Resistance *to* Political Intervention

The events of maha 1992/93 in Kirindi Oya - including the claim for damages to OFCs - generated a great deal of concern both locally and at the level of the central Government. One result was the appointment of two MPs to investigate four issues, one of which was the seasonal allocation of water. Two other MPs from Hambantota District also got involved. At public meetings with FRs and local officers, the MPs were convinced of the necessity of a water allocation plan. Also, at one meeting, the FRs asked the MPs not to interfere but to leave the seasonal decisions to the PMC.

Partly as a response from this concern at political levels and after the experience of maha 1992/93, the TC felt a need to revise the overall principles for seasonal planning. The revised set of principles (Section 2.2.2), incorporating the concept of the late maha crop and some other changes from the 1992 proposal, was presented for discussion to FRs at a special meeting on 8 July 1993. At this meeting, the FRs proposed some changes to the plan:

1) Instead of the proposed 60 percent of yala inflow allocated to the Ellegala, 80 percent should be allocated to ensure that 70 percent of the Ellegala could be planted with paddy.

2) Farmers in the New Area zone assigned OFCs should be allowed to grow kekulan (rainfed) paddy with supplementary irrigation as needed.

3) The amount of water allocated to Badagiriya should be 3,000 acft or less.

4) New Area farmers should cultivate bananas and OFCs op RBE soils. To promote OFCs the cattle problem and the non-residence of New Area farmers should be addressed.

5) The Ellegala system should be adequately rehabilitate4 to use water efficiently and solve the salinity problem.

6) The Government should supplement inflow to Lunugamvehera by diverting water from another source.

7) The Government should redistribute land in Ellegala farmed under tenancy arrangements since landlords oppose cultivation of OFCs.

After this meeting, the proposed seasonal plan was discussed by meetings of various groups of farmers, including a meeting held by the Divisional Secretary. A group of New Area farmers, including the President of the Right Bank SPCs and some of the leaders of the now disbanded "independent" farmer organization, met to develop an alternative plan.

In fact they developed two such plans:

* Under the first plan, during maha, Ellegala would have 100 percent paddy; Tracts 1 and 2 of the LB and RB Tracts 1 and 2 would get paddy; and RB Tracts **5,** 6, and 7 would get paddy but would have to begin land preparation solely with rain. Water would be saved by closing the canals two days a week; some of this water would be given to LB Tract 3 for OFCs and some to Badagiriya. During yala, Ellegala would get water for 50 percent paddy and the rest of the available water would be distributed to other areas on a rotation. Every farmer in the New Areas would be expected to cultivate at least five acre of his land with permanent or semi-permanent crops to Save water from yala 1994.

* Under the alternate plan, no water would be issued for yala cultivation anywhere and all water would be used for maha paddy cultivation throughout the whole system. The farmers worked out a detailed calculation of water requirements to show that this would be feasible under some water saving assumptions.

These plans were written up in a report that also claimed that the TC was ignoring the necessity of finding an additional water source for the system. The report was signed by the President of the Right Bank SPC.

The seasonal plan was first discussed by the PMC at its meeting on 22 July 1993. At this meeting, the fact that a group of farmers was developing an alternative plan was made known. No decisions were made but the necessity of making the decision at the September meeting at the latest was stressed.

The seasonal allocation was not discussed at the August PMC meeting. At the meeting on September 17, an amended version of the TC plan was presented by the Chief Resident Engineer (CRE) of the ID. The sole amendment was an increase of Ellegala's share of the yala input from 60 percent to **80** percent. Based on allocations during past maha seasons, for maha 1993/94 the top priority for paddy in the New Areas would go to RB Tracts **5,** 6, and 7; second priority to RB Tracts 1 and 2; and third priority to LB Tracts 1 and 2. By this time, the local MPs had made a request to issue water for paddy to LB Tract 3 but the CRE pointed out that the decision to restrict LB Tract 3 to OFCs had been made by the Ministry and could not be changed by the PMC.

At the meeting, the New Area FRs proposed the alternative plans described above but were opposed by Ellegala and Badagiriya FRs. Because of these differences, the PMC did not decide on a seasonal plan except to allocate 5,000 acft to Badagiriya.

At the request of **FRs,** the PM held hamlet level meetings to discuss the seasonal plans. However, several of these were not attended by the ID officers. Without ID officers to refute the technical arguments of proponents of the alternative plans, it was difficult or impossible to convince farmers that the alternative plans were very risky and that the TC plan was the best.

Another PMC meeting was held on **23** September to make the seasonal allocation decision. At this meeting, the alternative plans were dropped and the **TC** proposal was adopted. There was considerable discussion about the starting dates for water issues. Table *2.6* shows the results of the discussions.

Table *2.6*. Allocation plan for Maha 1993/94.

System	Date of first issue
Ellegala System	**25.10.93**
RB Tracts 5, 6 and **7**	20.11.93
LB Tract **3** (OFCs)	**20.10.93**
Badagiriya	**5.11.93**

The decision about issues for paddy in LB Tracts 1 and **2** was postponed until January as specified in the plan. In the meantime farmers in those tracts could plant **OFCs** with the rain in the expectation that, if needed, they would receive some water issues later.

At this meeting, the FRs from the LB tracts warned the **PMC** that some farmers were trying to get water for paddy through political intervention. The CRE promised to inform the Ministry and higher level officers about the plan. However, following this meeting, some of the LB farmers, through other politicians, contacted the Minister of Agricultural Research and Development who requested the Director of Irrigation to issue water for paddy cultivation to the LB tracts. In response he asked for a special PMC meeting to be held on *25* November to discuss this possibility.

At the meeting, an early issue of water to these tracts for paddy was opposed by the ID officers as well as by several **FRs** on the grounds that they should stick to the plan. The FR from LB Tract **2** also said that an early issue of water would damage the OFCs planted in his tract. The LB Tract **1** FR claimed that very few people in his tract had cultivated OFCs and that they would sign papers agreeing not to claim compensation for any damages caused. The PMC decided to send a letter to the Director of Irrigation opposing the early issue of water and noting

that the water situation should be reviewed in January. In addition, the letter stated that the decision should be left to the PMC and to the FRs from the legal farmer organizations. No water was issued for paddy.

Rains were heavy and by the date of the next PMC meeting on 24 December, there was already 30,000 acft more water in Lunugamvehera than would be needed for the whole of Kirindi Oya. At the meeting, the CRE explained that several persons, including a prominent local politician from LB Tract 1, had requested water issues for paddy in all three LB tracts. The local politician had encouraged some farmers in LB Tract 1 to plow their land with the rains to strengthen their claim to water issues for paddy. Although water for paddy was requested for LB Tract 3, the sentiments expressed were for delaying water issues for paddy in LB Tracts 1 and 2 until the harvesting of the OFCs. However, the meeting did determine that for maha 1994/95 LB Tracts 1 and 2 would have first priority, RB Tracts 1 and 2 would have second priority, and RB Tracts 5, 6, and 7 would have third priority. This was a change from the expected rotation.

On 3 January 1994, the local politician, later joined by two monks and 8 others, went on a hunger strike on the Lunugamvehera bund. He demanded that LB Tracts 1 and 2 be given the same priority rights enjoyed by Ellegala, that water for paddy be issued immediately to the LB tracts, and that the farmer organizations be reorganized to change the leaders. Although the hunger strike was supported by some of the farmers, most felt it was useless since they would get water for paddy anyway after the OFCs were harvested. The PMC had assured water issues on 15 February. The fast ended on 5 January after a visit from an MP who promised water issues by 15 January.

The next PMC meeting was held on 5 January and was attended by two MPs, one from Hambantota and one from Moneragala. Although the MPs asked that the date of water issue to LB Tracts 1 and 2 be moved forward, this action was opposed by the FRs, particularly those from LB Tract 2, to prevent damage to OFCs. At this meeting, DOA officers promised to visit the field and recommend the earliest possible date for water issues that would not damage the OFCs. One of the MPs also requested issues for paddy for LB Tract 3 but again the CRE said that the decision had to be taken by the Ministry.

A special PMC meeting was held on 10 January to discuss the issue again. This was attended by another MP from Hambantota who asked for immediate issues of water for paddy to all three LB tracts; the PMC did not agree.

Another PMC meeting was held on 13 January which was attended by the local politician who requested water issues to LB Tract 1 on 20 January. This request was opposed by the FRs from LB Tract 2 and was turned down. This meeting, however, revealed that 140 acres in LB Tract 1 had been planted with OFCs, considerably more than had been admitted earlier.

A Kanna meeting for LB Tracts 1 and 2 was held on 24 January. At the meeting, LB Tract 2 farmers unanimously asked for issues for paddy beginning in mid February while FRs from LB

Tract 1 asked for issues immediately. The President of the Left Bank SPC spoke in favor of issuing water on 10 February. Some of the farmers, mostly supporters of the local politician, physically assaulted the SPC President and it took police to disperse the crowd. The meeting ended without a decision. Members of the SPC publicly protested this assault while one of the MPs intervened with the police to protect the assaulters.

A PMC meeting on *25* January proposed 10 February as a suitable day for commencing water issues although many farmers wanted to delay issues further. A special PMC meeting was held on 10 February at which it was decided to issue water from *25* February on the recommendation of the Left **Bank** SPC. This was the day on which issues finally started.

Another PMC meeting was held on 22 February at which the CRE pointed out that the problems that came up during this maha season arose largely from the fact that large parts of LB Tract 1 and portions of LB Tract 3 are not suitable for OFCs thus motivating the strong resistance of the farmers in those areas. He indicated that the TC would turn its attention to resolving this problems.

This maha season was particularly important since it showed that

1) Many of the politicians supported the PMC and the solutions arrived at with the help of the TC.

2) Most of the FRs supported the PMC and its decisions.

3) The politicians who demanded early issues of water could not drum up much support because the farmers knew that the water wbuld be issued for paddy in February as **specified** in the plan. This made the politicians look as if they were merely trying to show their power and were not Solving a problem for their constituents.

All in all, these experiences have probably strengthened the acceptance both of the plan as the best way to handle seasonal allocations and of the PMC as the best body to make the necessary decisions.

2.5 LESSONS LEARNED

This history clearly shows that establishment of an effective seasonal allocation system in Kirindi Oya has required much more than merely technical interventions. The political processes by which the decision-making body, the allocation principles, and even the technical factors themselves became accepted was very important.

Next >>

Major changes that have occurred through this process include:

* Acceptance by the Ellegala farmers that they did not have an absolute priority right to Kirindi Oya water. Over time, as they were defeated again and again, they learned that their rights would be protected only to a certain extent. The disaster in yala 1992 probably hastened this acceptance.

* Acceptance by virtually all farmers of the **PMC** as the legitimate and best body for making the seasonal allocation decisions. At times both Ellegala farmers and New Area farmers attempted to bypass the PMC.

* Acceptance of the planting of OFCs as a way to help conserve water in both Ellegala and the New Areas.

* An increase in knowledge and understanding of the water supply situation and of many technical aspects of the irrigation system among the farmers. There was a big difference between the lack of understanding shown by farmers in 1992 when some thought they could use the dead storage in Lunugamvehera as compared to the understanding demonstrated by a group of New Area farmers in 1993 to the carefully worked out water requirements and availability contained in the detailed alternative seasonal plan.

* Reduction of suspicion about the ID. Not only have most of the farmers come to trust data from the ID, but most have come to respect the advice of the Department officers. In part this respect is due to the Department officers' improved expertise due to their better knowledge of the system brought about by studies carried out under the Phase II activity. In part it is the result of the fact that the ID officers have not tried to take the decisions away from the PMC.

The process has been costly for many, including the Ellegala farmers who lost crops in yala 1992, the farmers who lost OFC crops in maha 1992/93, the officers who have had to endure harassment and abuse, and the politicians whose reputations may have suffered, However, this process has been necessary to get general agreement on a seasonal allocation planning system. Overall the farmers, officers, and politicians have all learned a great deal and most have come to respect the others more.

The experience of maha 1993/94 seems to imply that the seasonal allocation plan is well established and likely to endure, particularly if the problems identified by the **CRE** can be solved. However, allocation of the excess water that will be available at the end of maha 1993/94 due to the heavy rains will pose a new and different challenge to this system. The evidence would imply that the **PMC,** if well supported by the agencies, particularly the ID, will be able to rise to this challenge as well.

2.6 RECOMMENDATIONS

Developing and establishing a seasonal allocation system is a political process, not just a technical process. The political nature of this process must be understood and planned for. Therefore, we recommend the following:

1) A strong technical base is required for an effective seasonal allocation system; the necessary studies must be carried out to provide the needed knowledge. In the case of Kirindi Oya, this included the water balance study of the Ellegala tanks as well as the reassessment of inflow to Lunugamvehera Reservoir. In addition, an interdisciplinary technical body like the Kirindi Oya TC, including irrigation, agriculture, and institutional officers, should take responsibility for providing technical advice for making the seasonal decisions.

2) It takes time for farmers and other interested parties to learn the limits of their power and to get the agreements necessary to make an effective seasonal allocation system work. This time should be planned for.

3) Farmers' knowledge of the environmental and technical limits to seasonal allocations is very important. Therefore, they should be educated about the system as much as possible. More importantly, they should be brought into the decision-making process as soon as possible and allowed to make their own decisions, with professional advice, so that they can learn from their mistakes.

4) To avoid uninformed interventions by politicians or government officials, relevant politicians and government officials should be kept informed of the plans and decisions as they develop.

CHAPTER 3

Main System Management

3.1 INTRODUCTION

Recent analysis of water available in the Kirindi Oya Irrigation and Settlement Project (KOISP) System by the Irrigation Department (Dharmasena 1988) and IIMI (1990) indicate that there is about 30 percent less water available than was estimated at the time the System was designed. Structurally, the Kirindi Oya is thus a water-short system.

Phase I of IIMI's research indicated that considerable water saving could be effected if improved operation, maintenance and management inputs were made at main and tertiary system levels. Research findings also emphasized the need to focus on the effective use of rainfall and drainage water and adopt planning of water scheduling and effective monitoring and feedback mechanisms.

Subsequent to IIMI's submission of the recommendations coming out of the Phase I Study, organizational and procedural changes in planning, operations and water allocation and distribution practices were introduced to improve water use efficiency in the System.

The Phase II Study, building on the changes and practices which had been initiated following the recommendations made at the conclusion of Phase I, further improved system performance through the systematic introduction of organizational and managerial innovations. It also assisted in the internalization of these changes and practices within the Imgation Department (ID).

3.1.1 Objectives

The Phase II Study dealt with three research objectives at main canal level. This section details one of these objectives: improvement of main canal operations. The action research undertaken included the testing of options for regulating flow and controlling water with the view to achieving water delivery schedules which were technically and managerially feasible to implement and could achieve overall water allocation objectives at system level while accommodating the desires of water user groups.

It is important to recognize that the usefulness of innovations is primarily dependent on the institutional capacities of the different groups involved in implementation. There is little point in recommending innovations beyond the financial capabilities and managerial capacities of either farmer organizations or Government agencies. This aspect was given due consideration when improved operation of the main canal and management procedures were designed and implemented. Effective main canal operations necessitate a clear plan which defines water delivery targets, a good system of monitoring and feedback to ensure that targets are met, an

evaluation process which determines whether targets are indeed apptopriate and a set of response mechanisms to allow for contingencies.

Each of these components were investigated and researched to ensure that water deliveries were reliable and predictable and that scarce water resources were used efficiently to maximize productivity and equity.

3.1.2 Scheduling of Irrigation in Kirindi Oya

During the early years of the project, water issue schedules were prepared manually. This took an unduly long time as water schedules for 10,000 acres had to be prepared every season. Later, a computer program was prepared by Mr. Jayasundara, the then Chief Irrigation Engineer (CIE), using "Lotus 1-2-3" for rotational water issue scheduling. A seven-day rotation was suggested at field *canal* level during crop growth and continuous irrigation during land preparation.

The package consisted of three programs. The first calculated weekly crop-water requirements using data on evapotranspiration, rainfall, seepage and percolation, the progress of land preparation and the starting date of cultivation. The program automatically calculated weekly crop-water requirements and retrieved the second program where scheduling was done, when the starting date of cultivation was entered into the computer.

The second program automatically calculated rotational water issue schedules for field canals, distributary canals and branch canals at tract level when tract numbers were entered. Canal data (acreage, soil type, efficiencies) were stored in separate files for easy updating. This program used data in the data files and results from the first program. The third program combined all the available information to obtain water issues at main sluice level. Macro programming was used to make the program user friendly.

The program is, however, currently not being used. Irrigation Schedules are based on the experience of previous years and lessons learned rather than on theoretical computations; however, these computations provide a basis to gauge how far schedules deviate from computed values.

3.1.3 Right Bank Main Canal Operation

The Physical System

The Right Bank Main Canal (RBMC) was originally designed to irrigate 5,000 ha of new land, adjacent to and above the existing Ellegala System. Under Phases I and II of the Project, 3,650

ha comprising Tracts[1] 1, 2, 5, 6 and 7 were completed. Tracts 3 and 4 were supposed to be completed under Phase II but could not be developed due to water-shortage in the Lunugamvehera Reservoir.

An earthen canal, the RBMC is 35 km long with a design bed slope of 35 cm/km and an active storage capacity of 18 mcm, taking off from the Lunugamvehera Reservoir at the same place as the Left Bank Main Canal (LBMC). The RBMC was designed to carry a discharge of 13 cumecs at its head but has not exceeded seven cumecs under present operating conditions. Forty-three distributary and field canals offtake from the RBMC. The offtakes are gated and are of the under-shot type. Control of water in the RBMC is ensured by 19 gated cross-regulators and sets of manually operated under-shot gates ranging in number from five at the head reach to two at the tail reach and a pair of lateral side walls.

3.1.4 Operational Context

The operation and maintenance (O&M) of the water distribution system is the responsibility of the ID of Sri Lanka. The RBMC is managed by a Resident Engineer (RE) with one JE, four Technical Assistants (TAs), four Work Supervisors (WSs) and 16 Turnout Attendants/Gate Operators (TOAs/GOs) to assist. Project level water management activities are coordinated by a Senior Irrigation Engineer (SIE). Irrigation activities at tract level are the responsibility of WSs. They are assisted by teams of four to six TOAs.

3.1.5 Main System Operation Management

Improved main system operation management was introduced[2] through a three-stage process consisting of:

* system diagnosis,
* introduction of the data collection program and communication network and
* introduction of the computerized Irrigation Management Information System (IMIS).

System Diagnosis

Simple concepts of system analysis were used to understand the system and its functional requirements and to identify areas needing improvement. The analysis, done during Phase I of

[1] The whole command area is divided into subdivisions called Tracts, each covering an area ranging between 500 and 1000 ha.

[2] This work was undertaken by IIMI under a Project introduced and funded by the French Government in cooperation with the Asian Development Bank. It is an on-going Project.

the study, indicated that the lack of proper data collection and inadequate communication facilities were major contributors to substandard performance. The lack of real-time information made it virtually impossible for management to formulate and implement appropriate control decisions. Although most structures at the main canal level were adequately equipped with measuring structures and the educational level of field level operational staff enabled them to read and record gauge heights, a good communication network linking main canal operational centers with the RE's office was conspicuous by its absence.

Introduction of Data Collection Program and **Communication Network**

The process of designing and implementing a data collection and monitoring network was extensively discussed during five formal meetings held between the ID and IIMI staff in June/July 1991. During these discussions, it was agreed that the ID would install ceramic gauges on both the upstream and the downstream sides of each structure of the canal. It was also agreed that the IIMI-French Project would take responsibility for designing and providing data collection forms, four wooden boards for displaying data in Unit Offices (tract level field offices) and one white board for displaying the whole set of daily data in the RE's office. Gate keepers were given wrist watches to enable them to record the time of every operation performed along the canal.

It was also decided that the French Project operated by IIMI would cover the cost of sending data daily from field offices to the **RE's** office. To facilitate computation of daily discharge at all offtakes, a lap-top computer was donated to the **RB** Office. This computer contributed significantly to the overall efficiency of the program.

The collecting of data and the monitoring of operations improved during maha 1991/92. Flow measurements were made twice daily at all offtakes from the main canal by irrigation laborers engaged in gate operations under the supervision of WSs. A booklet containing two forms, one to record daily water levels and the other to record operations carried out during the day, was provided to GOs to record observations. (Samples of forms used during the study are given in **Annexure 3.1.1**).

Data collected during the day was transmitted to the WSs' offices that same day. On receipt of the data, WSs in each Tract prepared the 'daily gate settings' form and updated the display boards. This made information available to farmers seeking clarification. "Gate settings" forms were personally conveyed by WSs to the **RE's** office around noon each day. In the RE's office, the data received was entered into the computer by a draftsman and discharge to each offtake along the main canal calculated. The daily discharge to distributary canals and to field canals was displayed on the white board kept at the **RE's** office. When inconsistencies in discharge figures were detected, the RE would ascertain the reason from the WS concerned and then instruct him on how to rectify the situation. Basic activities performed during the data collection program are summarized in Table **3.1.1**.

Table 3.1.1. Data collection program activities.

No.	Type of activity	Person	Place	Frequency	Source of data	Form used	Type of processing	Output	Destination of Output
1	Collection of gate readings	d	Field	Daily * Twice a day. 8.00 am/16.00 pm. * Every adjustment of gates.	-	Form (i) and (ii) of booklet for field staff	No processing	Time and settings/ levels of: * Offtake Spindle Heights * Up/Down stream water levels of Offtakes. * Spindle Heights of GRs. * Up/Down stream water levels of GRs	WS's office
2	Preparation of display board	WS	WS's office	Daily	Form (i)	Display board at WS's office	Display down stream water levels	Evaluation of water levels over 7 days	Display Board at WS's office
3	Preparation of gate settings tables	WS	WS's office	Daily	Form (i) or display board data	Gate settings Table	Copying the GR gate settings and offtakes data from Form (i) or display board	Time and settings of GR gates and Up/Down water levels	W's office
4	Sending data from WS's office to RE's office	WS	WS's office	Daily After 12.00 hrs	Gate settings table		One WS will be responsible for collecting gate setting tables from two head end Tracts. Similarly, data from the tail-end Tracts will be collected by one WS	Time and settings of GR gates and Up/Down water levels. Time and discharges to every offtakes's	RE's office
n	Preparation of RB display board	Draftman or any person assigned for this.	RE's office	Daily 13.00 hrs.	Gate settings table	RB display board	Computing the Flow data and water levels of different reaches from Gate Setting Tables	Evaluation of daily discharges to offtakes over 7 days. Feedback to WS's (Messenger) 1. Computed discharges 2. Action plan if necessary to control flow	Display Board at RE's office field
6	Filing of data to seasonal file. Storage in database	Draftman/TA	RE's office	Daily	Gate settings table	File database	filing and entering of data	Hardcopy + Database	RE's office

During the first week following the implementation of this procedure, problems were encountered in measuring and noting water levels and in filling in the appropriate forms. However, field staff quickly picked up the technique of measuring and recording and soon integrated these new tasks into their normal duties.

To accelerate the learning and integration process, IIMI and ID staff provided field staff with some training. Training was also provided to staff in the RE's office in the use of the lap-top computer. Data received in the office were stored and processed using LOTUS spreadsheets prepared by ID engineers.

Introduction of the Computerized Irrigation Management Information System

The computer used for operations developed memory problems during maha 1991/92. To overcome this, a set of program modules was developed using dBase III. This eventually led to the development of a management information system. The software which was developed has been named the Irrigation Management Information System - Right Bank Main Canal (IMIS-RBMC), Kirindi Oya.

In developing the program, emphasis was given to helping the system manager make quick and appropriate decisions by facilitating computation and verification of discharges and easily store and retrieve data, including historical data. Provision was also made to help the manager evaluate the performance of the system through a set of hydraulic and performance indicators.

Typically, irrigation managers collect data, store them in registers and do a limited number of discharge computations manually. Often these data are voluminous and not very efficiently handled. As a result, key information is not readily available in a usable form and is overlooked. It is clear that if information cannot be retrieved and analyzed quickly to arrive at a decision, even important information may not be of much use. It is in this context that the IMIS helps the manager.

The IMIS program consists of two types of files: database files and program modules. The user interface consists of two main options and a generic option to install the program. The main options relate to message entering and management options. The current configuration of the IMIS-RBMC message entering version helps input the following: sluice issues, daily water level measurements, daily gate operations, current metering data, structure survey data, canal bed survey data, schedule of water issues and rainfall data.

Management activities consist of specific tasks whose purpose is to display water distribution patterns along the canal for a given day; to compute hydraulic indicators such as volume issued, number of operations, level of submergence and level of fluctuation for any structure during any period of time and to compute performance indicators such as adequacy, efficiency and reliability. The generic option module is mainly to help installation of the program in irrigation schemes.

Two requirements are considered essential to install the IMIS. First, an accurate survey has to be done to collect all the physical data required for the data base. Second, proper training is needed. An intensive survey of the RB was carried out by TOAs and WS. The data collected was rechecked by the RE in order to ensure accuracy. A draftsman was selected and trained to use the IMIS. The training was conducted jointly by IIMI and the RE. The data collection program initiated during the maha 1991/92 season is being continued and has provided more data.

3.1.6 Utilization of the Irrigation Management Information System

The IMIS program has been effectively used by the RE in decision-making.

Before the introduction of the IMIS, the RE had neither a reliable database nor a data processing system to aid him in making the best operational decisions. Therefore, he was dependent on complaints from farmers and gate adjustments were made as and when found necessary. Irrigators and field level officers made quite a number of gate adjustments during the day to maintain appropriate water levels at gated regulators to provide the required discharges to branch canals and distributary canals.

With the introduction of the IMIS, the processing of data has become very convenient. The IMIS computes raw data and provides satisfactory and accurate output within a short time. Presently, it is possible to enter and compute daily flow data within 10 minutes.

While daily data is being entered, the IMIS retrieves data on previous water levels and gate openings, thus facilitating the task of the operator. During data entry, it is possible to check the validity of the data being entered in relation to previous data. Some types of data - for example, spindle heights which should not be more than 1.5 meters - are automatically verified during data entry.

Table 3.1.2 is an output of IMIS of water distribution pattern along the RBMC at a specific time on a particular day. It affords the RE a global view of water use in the different tracts and allows him to compare water use with total discharge at the head of the sluice in the reservoir.

The IMIS also supports the analysis of daily data in a broader sense and presents the results as hydraulic and performance indicators. Some of the indicators computed during the maha 1991/92 season and the maha 1992/93 season are presented in **Table** 3.1.3. Indicators such as the water delivery indicator are useful in helping to evaluate system performance whenever required.

It is also possible to prepare seasonal summary reports using IMIS. In addition, a large amount of information can be derived from the analysis of water issues made during the season in terms of spatial distribution among tracts and secondaries and temporal distribution during land preparation or rainy periods.

Table 3.1.2. Water distribution along the Right Bank Main Canal.

Discharges measured **at offtakes will be retrieved**

Specify a date: **01/01/93**
Specify a time: 12.00

Discharges (cusecs) and Tail Conditions (cm)

->D2	2.7	91	**->F34**	0.4	51	->F48	2.5	53	**HEAD**		**269.8**
->D3A	38.1	135	->D4	3.4	130	->F49	0.6	58			
->D3B	0.0	65	->D5	6.4	90	**->D9**	5.1	107	TRACT 1		
->D4	21.1	98	**->D6**	14.8	118	->F54A	1.1	57			
->D5	20.2	118	->D7	5.9	92	->F54	**0.9**	***66***	TRACT 2		
->F55	1.0	52	-F68	0.0	65	->F55	0.5	**51**			240.2
->F56	0.3	55	->D8	**4.0**	88	->D11	11.5	130	TRACT 5	76.0	
->F57	1.3	53	->D9	**4.8**	96	**->D12**	3.2	73			
->F58	0.9	51	->D18	1.6	32	->D13	13.6	**130**			
->D1	8.3	84	->D1	1.3	55						
->D2	22.3	154	->D1A	0.7	67				BALANCE		29.6

Table 3.1.3. Hydraulic indicators computed using the Irrigation Management Information System during the Maha 1991192 season and the Maha 1992/93 season for the Kirindi Oya Right Bank Main Canal.

Season	Tract	Consumption (m)	Total number of Gate Operations	Average submergence	Water Level Fluctuation (m)
Maha 1991/92	1	1.70	1428	0.67	0.13
	2	2.33	1593	0.73	0.08
	5	1.79	785	0.70	0.08
	617	1.82	642	0.69	0.15
	DAM	2.35	105		
Maha 1992/93	1	2.66	834	0.40	0.05
	2	2.38	1661	0.63	0.09
	5	2.05	1186	0.60	0.09
	6/7				
	DAM	2.52	85		-

This type of information *can* stimulate the manager to reconsider is procedures and improve them. **Typical** examples of tractwise water issues and tractwise weekly pattern of water issues **are** presented in **Figures 3.1.1 and 3.1.2.**

The rainfall pattern indicated in **Figure 3.1.1** is based on a single rain gauge station and as such suffers certain limitations in view of the scattered rainfall often experienced in the Kirindi Oya command area. To overcome this deficiency, there is a definite need *to* increase the rainfall measuring network within the command area to enable better response to rainfall contribution.

However, a few observations can be made on the tractwise weekly pattern of water issues:

* As water issues to Tract 1 began before the seasonal rains, weekly issues were nearly double normal issues during the initial period of land soaking and other land preparation activities.

* The pattern of water issues to different tracts also displays interesting features. **For** example, recorded water issues to Tract 2 do **not** reflect a *good* response to rainfall and do not clearly account for changes in crop water requirements during the later stages of cultivation. The relatively long period of seven weeks devoted to land preparation in this tract was due to delays experienced by farmers in getting loans to start the season. Most of the water issued during the first and second weeks was not fully utilized, leading to significant wastage.

3.1.7 Communication Network

The interaction and communication network shown in **Figure 3.1.D** was adopted in operating the RBMC.

Farmers are expected to communicate their problems to field canal GOs who are either Farmer Representatives (FRs) or their nominees. Presently, field canal GOs communicate with the WSs by providing them with daily discharges. GOs then make necessary adjustments to gates on the instruction of WSs. Most operational decisions at the distributary level are made by WSs and the IE. When the Distributary Canal Organizations (DCOs) become stronger, this decision-making and water distribution function will be taken over by them and GOs will then communicate water problems to the DCO Chairman or his representative.

The two-way communication with regard to levels III and IV in **Figure 3.1.3** has become effective for the following reasons:

* developing and implementing a simple computer pragram making the transmitted information useful,
* careful monitoring and supervising of data collection and utilization,
* collecting accurate data and providing feedback to the relevant people engaged in operations,
* lightening the workload and giving incentive paymedts and
* providing incentive payment and housing in the field for WSs to enable frequent interaction with irrigators.

3.1.8 Operation of the Right Bank Main Canal During the Maha 1992/93 Season

The Lunugamvehera had not received sufficient inflow to commence cultivation in its command area by the first week of November 1992. Previously, the reservoir had been emptied to its dead storage level by farmers in the Ellegala Irrigation System **(EIS)** who had started a late yala cultivation without adequate water being available in the reservoir and at a time when further inflow was highly improbable.

In addition, rainfall in September and October 1992 was less than anticipated. The Project Management Committee (PMC) had to postpone making a decision regarding water issues to the various subsystems even though it was ready with a well planned agricultural program. The Committee met several times in November and finally made a decision on 19 November 1992.

According to the **19** November decision, water issues were to be made to Tracts **2** and **5** of the RB from **22** November. The Committee also decided to issue water to the **EIS** from **20** November and to provide supplementary irrigation to Badagiriya provided farmers in these systems commenced cultivation after the Ellegala tanks reached minimum operating levels (MOLs). Water issue to Badagiriya was restricted to a maximum of 5,000 acft for the whole year.

Farmers in Tract 1 of the RB and Tracts 1 and **2** of the LB were supposed to raise rainfed other field crops while the others were to wait until adequate inflow was received in the Lunugamvehera before demanding water for paddy. But when water was issued to the Ellegala and Tracts **2** and **5** of the RB, farmers in Tract 1 of the RB and Tracts 1 and 2 of the Left Bank (LB) also requested that they be issued water. The Committee refused this request and tried its best to implement the agricultural program as envisaged in the seasonal plan. However, when water levels increased in the Reservoir, farmers appealed to political authority and were successful in getting water released for paddy cultivation.

This created a rift between the Agency and the farmer community in these three tracts. The RE who had been the main spokesman at farmer level meetings organized to explain the proposed cultivation program became the target of criticism. The critics have since been identified with the independent farmer organizations. When water issues were attempted on **20** December as per the political decision taken at Ministry level to **those** fields in which two plowings had already been completed with **rain,** the farmers in these areas got violent and took operations into their own hands. From **27** December, water issues were made to all fields in the three tracts and the ID could not do much to regulate water, especially in Tract 1 of the RB.

Two incidents which took place during this period need special mention. In one incident, some fanner leaders complained to the Ministry that the RE had purposely released more water to the **RBMC** to reduce the water level in the Reservoir with the intention of causing crop failure in the three tracts which had obtained water for paddy cultivation against the decision of the **PMC.** In the other incident, one FR made a complaint to the Officer-in-Charge of the Lunugamvehera Police Station against the RE of wilfully releasing more water to the RBMC and thus wasting water.

The following are the comments made by the FRs involved in these incidents:

> "I came to know that the ID had said at the PMC meeting held in **January 1993** that water in the Lunugamvehera Reservoir was sufficient only for 65 days for the tracts where maha cultivation had started late. The Committee had decided to make farmers aware of this situation by holding the meeting. A meeting was also held on **23** January **1992.** However, the Irrigation Management Division (IMD) officers did not attend the meeting.

"The RE explained at this meeting that there was a shortage of **17,000** acft for the 3 tracts where maha cultivation had started late. Farmers proposed that the RBMC be kept closed for two days but the ID pointed out the impracticability of this proposal and suggested instead distributary canal rotations by keeping distributary canals closed for two days. However, though the ID promised to implement this within three days, they did not do ***so.*** Instead discharges in the RBMC were increased to ***250*** cusecs and on some occasion to **275** cusecs.

"I complained to the Provincial Secretary, Lunugamvehera. He had a meeting with the officers and decided to implement the rotations. Even though the rotations were implemented in the upper tracts, discharges to the RBMC from the Lunugamvehera remained the same. Therefore, I complained to our MP who informed the Ministry."

The Director of Imgation appointed a Senior Deputy Director to look into this complaint. ID officers discussed the issue with a Committee which included project level officials and the concerned FRs.

The following are the findings as recorded in the Director's report dated 10 February, **1992:**

* Two-hundred and twenty cusecs are being issued to the RBMC at the moment, about 40 cusecs of this to Badagiriya while the remainder is being issued to farmers in Tracts 1, **2** and 5. Committee members checked the relevant documents and were satisfied with their accuracy. As observed today, there is no wastage from Tracts 1, **2** and 5 **of** the RB.

  The RE is instructed to make every effort to keep discharges from the RB at 230 cusecs.

* Two-hundred and twenty cusecs are being issued from the LB sluice: **100** cusecs of this to the EIS and the remainder to Tracts 1 and 2. It is observed that there is a water scarcity in Tract **2,** DCs 9 and 10. Therefore, instructions were given to reduce discharges to the **EIS** to 80 cusecs in order to meet the requirements of farmers in Tract 2. However, it is decided not to increase discharges to the LB sluice.

* It is also recommended that FRs be made aware of the water issue plan for the whole system **as** frequently **as** possible.

The FRs who had complained, though he signed this letter, did not agree with the contents of the letter and believed that water was being wasted. He constantlp referred to the superior water management during the time of the former RE and argued that water duty was less during that period.

Toward the end of February, water issues to the RBMC were increased to **250** cusecs. The FRs again reported to the Project Manager of the IMD. When the Project Manager did not respond positively, he telephoned the RE and scolded him. Thereafter, he made a complaint at the Lunugamvehera Police Station and the RE had to explain his position regarding water issue to the Officer-in-Charge of the Police Station. This FR believes that discharges were reduced only after this incident.

As participants and observers of the process of decision-making and implementation of the seasonal plan for the *maha* **1991/93** season, it is necessary at this juncture to make some comment on these two incidents. The following is noteworthy:

* Data collected under the IMIS indicate that during the period the FR accused the ID of issuing more water to the RBMC, water issues were being made to Badagiriya as agreed upon at the PMC meetings. It takes a long time to issue 5,000 acft to Badagiriya while making issues to Tracts 1, **2** and **5** of the RB.

* Interviews with farmers revealed that certain interested parties within the ID had given them incorrect information.

* FRs who had prompted farmers to demand water for paddy cultivation felt they would face serious consequences if the crop failed. Therefore, they made vigorous attempts to prepare the ground to put the blame on the ID.

  Many operational problems were encountered during the season including:

  * interference by RB Tract 1 farmers at the distributary canal offtakes and cross regulators. On many occasions, the RBMC was under unsteady flow conditions causing much higher fluctuations in the tail end. This made water scarcity more acute in tail end areas. The RE had to increase discharges to the main canal to more than **230** cusecs to meet demands from farmers within a short time.

  * the RBMC had to be kept open almost throughout the season due to dry weather.

  * GOs reported that the number of operations in the RBMC increased as a lot of adjustments had to be made to bring the canal to steady flow conditions when farmer actions made the canal unsteady.

The total extent of Tracts 1, **2** and **5** in the RBMC was cultivated during the *maha* **1992/93** season. The area cultivated during the season was about 80 percent of the total area developed for cultivation under the RBMC. Irrigation issues were made in two staggers, the first stagger to Tracts **2** and **5** commenced on **22** November and the second to Tract 1 about five weeks later.

3.1.9 Water Consumption during the Season

Total water released to the different subsystems under the RBMC and area irrigated during the season is given in **Table 3.1.4.**

Tract	Water Released (mcm)	Area Irrigated (ha)	Duty m/ha
1	**20.438**	**753**	**2.71**
2	**20.988**	**902**	**2.32**
3	**21.863**	**1015**	**2.15**
Total	**69.526**		

Note: a) Water issued from the RB sluice **(22** November **'92 - 20 April '93)** = **68.742** mcm

b) Difference = **-0.784** mcm[3]

As against the total water issue computed as = **69.526** mcm

According to these values, total duty for the season is about **2.52** meters, slightly higher than the duty for the previous maha season.

The main reasons for this variation were:

* Water issues to Tract 1 started because of political reasons and officers were not in total agreement with the decision as water available in the reservoir was not sufficient to meet the requirements of all the farmers. Farmers in Tract 1 misinterpreted this and by organizing themselves took control of water issues. Therefore, during the first week, all offtakes were regulated by farmers and during this period no TOA was allowed to do his work. Though this situation was brought under control within a few weeks, farmers got more water throughout the season.

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[3] Errors due to additional inflow from rainfall and surface drainage.

* Since farmers in Tract 1 lowered cross regulators in the main canal during the night to increase offtake discharge, farmers in other tracts had considerable difficulty obtaining their fair share of water. Many times, flow conditions in the main canal were unsteady and water levels in some reaches were causing lower discharge to secondary canals.

  As a result, water issues in the tertiary canals were affected. Management had to increase sluice issues to fill some reaches in a short time.

* Total water used by the Tract 1 was 2.7 meters, compared to the previous maha value of 1.7 meters.

* The season was comparatively dry with total rain experienced during the season at 300 mm as shown in Table 3.1.5.

Table 3.1.5. Rainfall **contribution** during the Maha 1992/93 season.

Month	Rainfall (mm)
After 22 November	95
December	99
January	31
February	0
March	71
Upto 20 April	2
Total	298

Because of dry weather, the sluice was kept open throughout the season. Although there were problems in managing water during the season, in general it was a successful season where total water use was concerned. A comparison of water consumption for maha 1990/91 and maha 1991/92 seasons with maha 1992/93 is shown in Table 3.1.6.

Table **3.1.6.** Comparison of the Maha 1992/93 season with previous Maha seasons.

crop	1990/91	1991/92	1992193
	Rice 3.5 months	Rice 3.5 mouths	Rice 3.5 months
Average duration of land preparation	6 weeks	6 weeks	6 weeks
Area cultivated	2530 ha	2980 ha	2518 ha
Targeted duty	2.44 m	2.44 m	2.44 m
Rainfall	1.01 m	0.70 m	0.30 m
Achievements: Actual duty (ex-sluice) Ex-sluice+rainfall	 2.53 m 3.54 m	 2.35 m 3.05 m	 2.52 m 2.82 m

3.1.10 Results and Achievements

A lengthy discussion was held with FRs, farmers and officers to evaluate the impact of the activities undertaken under the IMIS program. A comparison was made between the situation as it existed prior to the implementation of the program and subsequent to its introduction.

The situation prior to the implementation of the IMIS activities:

* Though the ID had developed formats to collect data on daily discharges to the distributary canals, there was no systematic data collection program in the RB system prior to the introduction of the IMIS. On several previous occasions, attempts were made to collect data but these attempts failed for various reasons including inter-organizational rivalry, lack of monetary incentives, lack of understanding by field staff of the usefulness of data and the ID's interest in construction activities.

Even when data were collected, they were forwarded to the RB office once a week not once a day. There was no supervision of data collection and the data collected by TOAs were usually unreliable. If and when data were received by the RE, he merely forwarded them to the SIE. The SIE did not process the data or use them in decision-making. There was no feedback from him or the RE.

* Since discharges made to distributary canals were not known to the RE or the IE, they had to send field officers to the field whenever there were complaints from farmers. On such occasions, the solution readily available to officers was to increase discharge in the distributary canal.

* Due to the absence of a monitoring and feedback mechanism, system operators lacked necessary information on what was happening at the main system level. They did not know why discharges to a certain distributary canal were above or below target or why water levels at cross regulators had gone down. Therefore, the solution to water problems at the main system level was frequent gate adjustments at cross regulators and distributary canal offtakes.

* TOAs and WSs cannot be blamed for not collecting data because they knew that data collected by them was not going to be put to any beneficial use.

The situation subsequent to the implementation of the IMIS activities:

* Data on daily discharges to distributary canals are being collected by TOAts under the supervision of WS. Data thus collected are being forwarded to the RE by the WSs who are paid an incentive by the French Project of IIMI.

* On receipt of the data, the RE enters them into the computer for conversion into discharges. Feedback on discharges is provided to WSs. If there are deviations from the target, instructions are given to make the necessary gate adjustments with appropriate feedback to FRs. Data is thus being used for making decisions on operations.

* There are notice boards in the RE's office as well as in the WS's offices for displaying discharges made to distributary canals in a particular tract or tracts for a period of one week. Both the RE and the IE can thus get a feel for the discharges made to the distributary canals. Though the notice boards in the WS offices display spindle heights or water heights at distributary canal offtakes and cross regulators and not the discharges in cusecs, the WSs and the farmers can get an idea of discharges to distributary canals.

* Irrigators and WSs are serious about collecting accurate data because they perceive that inaccurate data would give a distorted picture of the system. They feel the computer is capable of detecting mistakes made in data collection.

* WSs are motivated to collect accurate data through irrigators for two reasons:

  i) they are paid an incentive of Rs 1,500/- per month by IIMI and

  ii) they are aware that their superiors are interested in the data collected.

* According to the views and ideas expressed by interviewees, the data collection and communication program introduced under the IMIS has had an impact on the daily operation of the RB system. For example, irrigation officials have detected an overuse of water in some distributary canals.

* The "volume charts" which have been introduced in the RE's office enabled him to look at the system holistically as these charts indicate sluice level cumulative volumes and water issues to each and every tract.

* Both the **RE** and the IE have accepted the usefulness of the data collection program and are very interested in implementing various activities under the IMIS.

3.1.11 Impact of Main System Management Research on System Performance

A two-day workshop on the impact of the participatory action research at Kirindi Oya was held on 11 and 12 December 1993 at the Peacock Beach Hotel, Hambantota. During the meeting, the RE of the RBMC discussed Main System Management and its impact on system performance. His comments on major problems, the involvement of IIMI and Centre National du Machnisme Agricole du Genie Rural des Eaux et des Forets, France (CEMAGREF), major activities under the research program, benefits accruing from the research work, problems in implementation and his recommendations are as follows.

Major Problems in Main System Management

Assuming the manager knows the physical system properly, the following are the major problems in the management of a main canal system:

i) Difficulty in obtaining information on current gate settings at each gated structure along the main canal.

ii) Difficulty in obtaining information on water levels at each control point along the main canal and at the heads of offtake canals.

iii) Difficulty in sending operational instructions to operators on time.

iv) Difficulty in assessing variation in water levels due to numerous gate operations.

v) Difficulty of proposing new gate settings for each structure on time to maintain main canal water levels at satisfactory levels with a minimum number of operations.

Problems i, ii and iii can be solved by proper data collection, transmission and feedback. Problem iv can be overcome by using a properly calibrated simulation model and the last problem can be overcome by improving the same model to simulate different operational scenarios within the time frame available to the manager.

Even without solving problems iv and v, management may be remarkably improved by achieving possible solutions to problems i, ii and iii.

The present situation may be improved by improving the mobility of operators and by introducing an electronic communication network between the manager and operational staff. But this may be very costly. A simple method of collecting data and hand delivering them to the manager on the same day will give him a better chance of getting a holistic view of the canal and trying out engineering solutions which may be better than the ad hoc operations of the isolated operator.

Involvement of IIMI and CEMAGREF

IIMI and CEMAGREF have been involved in Main Canal Management research since 1990 through the introduction of a simulation model. Field testing of this model has proved difficult for the following reasons:

i) Difficulty of collecting necessary data to run the model.

ii) Time and effort needed to enter the data into the model.

iii) Non-availability of long-term database management facilities within the simulation.

iv) Non-availability of a capable project computer.

IIMI and CEMAGREF, with the cooperation of the ID, have designed a data collection and transmission network. This was implemented during the 1991/92 maha season. IIMI provided computer facilities at the RB office. The first trial of the data management program was done with Lotus spreadsheets. Later, IIMI and CEMAGREF developed the IMIS data management software, which has enabled the manager to enter and process data into discharges effortlessly, see past performance and also run the simulation model by creating necessary input files.

The development of the software SIC[4] and IMIS was done by the IIMI and CEMAGREF Research Team. The designing and implementation of the data collection network was done jointly by IIMI and the ID. IIMI provided facilities such as the necessary tools and equipment, training for personnel, formulation of data collection forms, provision of incentives for data transmission, provision of continuous coordination and motivation of field staff. The program was implemented by the ID as part of their job. This approach has proved effective and ensures the program will continue in the future with little effort.

Major Activities Under the Research Pmgram

i) A topographical survey was done of the RBMC from the sluice to the last offtake and data on all physical hydraulic parameters of all structures including gate sizes, sill levels,

[4] SIC = Simulation of Irrigation Canals

check wall lengths and crest levels, possible maximum openings, and spindle zeros was collected.

ii) **A** levelling survey was done from the sluice to the last Broad Crested Weir (BCW) situated just upstream of the Karambagas wewa and bench marks recorded. This will help to modify the parameter database if any physical change occurs.

iii) Current metering is frequently done to estimate the coefficient of discharge of gated structures.

iv) Comprehensive data collection forms were created for GO's as well as for WS. Each gate operator has been given a booklet of forms on which: to collect and record data. Data is collected and recorded twice a day for each gate with upstream and downstream water levels and spindle heights observed and recorded. GOs report water levels and spindle heights to WSs who prepare a summary of water levels and gate settings in a message form to deliver to the manager. This form, which includes data on the previous evening's positions and the day's morning positions, is delivered by hand to the manager every day before noon.

Another form has been prepared to record gate operations at each gate for the purpose of running the simulation model. These forms are not much used, though.

Regular training is given to operators to enable them to read gauges and record data properly and they have been encouraged to record the correct time by using wrist watches given to them.

v) An incentive of Rs 1500 per month was paid to two messengers (WSs from the far Tracts) at both ends of the Main Canal to collect Tract summary forms and hand them over to the RE's office. The messengers conveyed back operational instructions to the field.

This incentive scheme played a big role in ensuring the transmission of messages on time. The same or some other method has to be continued in the future. Because all four WSs are involved in the process of data collection and maintaining records, it is strongly recommended an incentive be paid to all WSs.

vi) Display boards were given to the Unit offices and to the RE's office.
The Unit Office display board is capable of displaying seven days d/s water levels for each turnout in the tract together with target levels. The RE's office has a white board which is capable of displaying eight days of discharge information at each offtake together with target discharges.

vii) **A** topographic file for the SIC model was prepared and the **IMIS** software for database management was developed. The software is also used for data processing and

evaluation. A laptop computer has been provided to the RE's office and an office worker has been trained in entering and processing data.

viii) Opportunities have been created for sharing experiences with local and international experts in computer modelling associated with irrigation and hydraulics.

ix) Automatic Level Recorders have been provided at the head and tail end of the Main Canal which enable the checking of recorded data.

Benefits Accruing from the Research Work

Many direct and indirect benefits have accrued to the project from the research work as follows:

i) After the topographic survey was done, the physical parameters of the structures and canal topography was updated. The situation at gated regulators versus the filling capacities of ponds between the gated regulators were worked out using these data. This information has helped managers make decisions on how much the water is to be lowered to fill downstream reaches.

ii) The estimation of discharge coefficients for gated structures has been significantly improved due to frequent current metering. Greater accuracy may be expected when estimating required gate settings to deliver target discharges.

iii) A low cost but satisfactory solution has been provided to solve problems i and ii listed under Section 3.1.11 "Major Problems in Main System Management". The manager is able to visualize water levels in the main canal as well as at offtakes and is informed of gate settings morning and evening. This is a great help to the manager in managing the canal since he is able to pinpoint trouble areas which require more attention, to make better decisions and to maintain reasonable equity in water distribution.

iv) There is better control over field staff and ad hoc operations are minimized. Since there is a daily monitoring program, field staff also have to improve their operations and make accurate readings. Inaccurate data would be noted when compared with information at adjacent structures.

v) Since there is proper maintenance of records, field personnel are able to handle situations confidently. If there are illegal operations by outsiders, quick detection as well as quick readjustment is possible.

vi) The third problem listed under major problems may be solved to some extent by using the same messengers to send operational instructions to the field at least once a day.

vii) Due to the upstream and downstream information flow, more collective responsibility is felt and a better working environment created. Tract level coordination is improved.

viii) Many discussions have been held among project personal as well as with outsiders, creating opportunities to share similar experiences.

ix) Computer literacy of office workers has increased due to the availability of a computer in the office.

Problems in Implementation

The following problems may be expected for continuing this program in implemented in the future:

i) The source of funding for paying allowances to WSs who transmit field data to the RE's office is uncertain.

ii) Entering data takes about one hour if the data are coming from all four Tracts. The present office worker who has been trained to enter data is a casual employee and may quit the Department anytime. If at least two draftmens are not employed, entering data will become a problem.

iii) After IIMI withdraws from the Project, the availability of a computer at the RB office is not ensured. If a computer is not available, the whole program will ***cease.***

iv) If funds allocated to employ TAs are limited, especially after the distributary canals are handed over to farmer organizations, data collection will become a problem.

v) The difficulty in finding a solution to problems iv and v may erode confidence in computer models.

vi) The collection of data twice a day may be included in the normal workload of TAs if a mutually acceptable agreement can be reached.

Recommendations

i) Collection of data twice a day, transmission to the manager's office and provision of necessary tools to process data and maintain a database is very useful. This must be continued.

ii) The application of mathematical simulation models to irrigation canal management is difficult and so these models can only be used as training tools. Hence collecting data on each and every operation is not very useful.

iii) Payment of allowances to WSs to cover the cost of travelling incurred in data transmission is recommended.

iv) Current metering should be increased to include all offtakes.

v) The study of six operational scenarios on how tertiaries as well as the main system can be operated is recommended. This can be done by scrutinizing past records on operations under steady or near steady conditions.
The following conditions may be studied:

* Very high flow conditions - peak land preparation period under dry conditions.
* High flow conditions - peak land preparation period under average conditions.
* Normal flow conditions - average irrigation period under dry conditions.
* Low flow conditions - irrigation period with slight rainfall.
* Very low flow conditions - irrigation period with rainfall.
* No flow conditions - tertiary system.

Testing for canal steadiness and recording of spindle heights of all gates on the days when the canal is operated under the above mentioned conditions should be studied during the current season and in the future.

3.1.12 Left Bank Main Canal Operation

Improvements in main canal operation effected in the RBMC prompted project authorities to expand activities to the LBMC. Work was initiated at the beginning of the 1992 yala season.

Operating the Left Bank Main Canal During Yala 1992

Since water issues were not made during yala 1992 to the LB area, the following preliminary activities were initiated to implement main canal improvement during the next maha season:

* Collection of data on physical features of the main canal. Data were limited to the physical features required to calculate discharge at all strategic locations and were collected by the IE (O&M) of the LB Office and entered into the computer.

* Development of formats for data collection and tabulation and display of water deliveries. Most of these formats were similar to those used in the RB.

* Acquisition of display boards for the RE's office and Unit offices.

* Initial discussions with field staff to introduce activities aimed at improving main canal operations.

* Initiation of modification to the already developed RB computer software.

Operations in the Left Bank Main Canal During Maha 1992/93

The methodology used in the RBMC during the maha 1991/92 season was adopted in the LB to improve monitoring and feedback of information through a new data collection program.

However, WSs were not paid for transmitting data to RE's office. The IMIS program was modified to suit the physical characteristics of the LBMC but could not be tested and made operable without additional refinements. Also, there were problems with regular data transmission.

In applying the improved canal operation procedures, a number of constraints were faced:

* The table-top computer supplied by IIMI to the LB Resident Engineer was slow and needed a considerable amount of time to come up with the required output.

* The efforts put in by the research team and the resources provided for introducing the changes needed for improvement were not sufficient to create a sense of commitment and interest on the part of implementing personnel.

Since the RID works were under progress in the Ellegala, the RE could not devote much time to understanding and implementing the IMIS.

The main lesson learned from this replication of proven innovation is that any innovation introduced in an irrigation project will not itself get internalized. Even if it is internalized, it will not be successful unless the environment is conducive. Interest, commitment and incentives play a major role in determining whether an innovation is successful or not. This is equally true of the sustainability of any innovations.

3.2 WATER BALANCE AND ELLEGALA IRRIGATION SYSTEM OPERATIONS

3.2.1 Objectives

The Water Balance Study is intended to contribute to developing a Water Allocation Policy for the Kirindi Oya Imgation and Settlement Project (KOISP) and to develop management tools for water allocation and delivery in the Ellegala Irrigation System (EIS).

The specific objectives of the Water Balance Study are:

i) Assess individual tank storages before the start of each season;

ii) Request minimum but sufficient quantity of water from the Lunugamvehera reservoir and distribute it efficiently and equitably among the five tanks;

iii) Determine optimum water level for each individual tank to start a season;

iv) Determine drainage and runoff contributions to the individual tanks under various conditions of imgation in the new area;

v) Maximize usage of local catchment run-off water;

vi) Monitor, evaluate and communicate daily to tank operations to make necessary management decisions;

vii) Establish a useful data bank to develop empirical rules for future operations; and

viii) Develop and implement a data collection program with a user friendly computer program to provide useful information and operational guidance for the system managers.

3.2.2 The Physical System

The Ellegala Imgation System, comprising five ancient tanks and having its command area in the flat alluvial coastal plain, is located downstream of the Lunugamvehera reservoir (Figure 3.2.1). The Ellegala System feeds the Pannegamuwa and the Weerawila on the right bank of the Ellegala Anicut. These two tanks receive drainage water from Tracts 1 and 2 of the Lunugamvehera RBMC and the inflow of the "Weerawila Ara" which comes from the natural catchment of the Weerawila.

The Ellegala feeder canal on the LB of the Ellegala Anicut feeds the Gamunupura, the Debara wewa, the Tissa wewa and the Yoda wewa. The left bank feeder canal receives drainage water from Tract 1 and part of Tract 2 of the Lunugamvehera LBMC and local catchment water of the "Tammanna Ara". The Tissa wewa is fed by the left canal of the bifurcation and in addition

receives water from its local catchment and drainage from part of Tract 2 of the LB. The Yoda wewa gets it irrigation supply from the Tissa wewa, drainage waters from a part of Tracts 2 and 3 of the LB and local catchment water of the "Delkanu Ara".

3.2.3 Water Resources of the System

The Ellegala Imgation System receives its water from four sources: 1) water released from the Lunugamvehera, 2) runoff from its own catchments, 3) substantial drainage water from Tract 1 of the RB and Tracts 1 and 2 of the LB new areas and 4) rainfall on the service area. Presently, the contribution from rainfall and from the Lunugamvehera is quantifiable while contributions from the other two sources are not quantifiable.

Table 3.2.1 indicates that during years when rainfall is above normal (during the 1988/89 maha season) and when the amount of storage in the tanks comfortable, withdrawal for the Ellegala is minimal (0.44 meters per ha). During years of low rainfall and insufficient storage in tanks, like during the 1987/88 maha season, water supplied to the Ellegala is considerably higher (1.40 meters per ha).

Table 3.2.1. Water supplied from the Lunugamvehera to the Ellegala during Maha 1987/88, Maha 1988/89 and Yala 1989 seasons.

Season	Extent of cultivation (ha)	Requirement as estimated (mcm)	Release from reservoir (mcm)	Rainfall (mm)	Duty m/ha
Maha 1987/88	3,530	40.2	49.4	413	1.40
Maha 1988/89	3,710	41.7	16.3	754	0.44
Yala 1989	3,778	42.5	34.2	325	0.91

This is understandable because when there is heavy rainfall, water supply from tank catchments is higher and there is a copious supply to tanks from rainfall and drainage. During dry years, much of the water from the Lunugamvehera is directed to the Ellegala, allowing little water for the new settlement areas.

The present system of water allocation between the old and new systems creates numerous problems for planning water distribution and for scheduling irrigations from season to season. Increasingly, a need has been felt for a detailed Water Balance Study of the Ellegala to enable the development of a seasonal water allocation policy for water supplied from the Lunugamvehera.

Allocation of water from the Lunugamvehera to the Ellegala tanks must be fixed taking into consideration water available in the tanks and water available from other sources such as rainfall and drainage. The two sources of water which should be effectively used are rainfall and drainage water. Under the study program, water scheduling to the Ellegala gave utmost importance to these two components. Particular attention was paid to the start of cultivation to make maximum use of drainage water from upper tracts.

3.2.4 Water Allocation to the Ellegala Irrigation System Prior to this Study

Ellegala farmers were used to cultivating the four-month paddy varieties. At the beginning of the season, they used to fill the Ellegala tanks to full tank level for the early start of water issues. Because of the priority rights claimed by Ellegala farmers, the ID was not reluctant to fill the tanks. This led to spilling of tanks during the months of November and December when heavy rains occurred.

Since sufficient water was available, Ellegala farmers cultivated two crops in the entire command area until 1989 when the project management attempted to establish water equity between the old and new systems. They proposed zoning for water distribution with certain areas from both the new and old systems to be cultivated depending on water availability. Hence, there arose the necessity for a water allocation policy between the old and new systems and for distributing water to the various subsystems within the Ellegala Irrigation System. The water allocation policy and details on the framing of seasonal plans are described in Chapter 2. This section concentrates on the Water Balance Study of the Ellegala tanks which was undertaken with the aim of optimizing water allocation and operation of the Ellegala tanks and the Lunugamvehera reservoir.

3.2.5 Climatic Factors

The project area is tropical: average annual evaporation is 2100 mm and mean annual rainfall is 1000 mm. The amount of rainfall during the maha season (October to February) is approximately three times the amount of rainfall during the yala season (March to August).

Average daily and monthly evaporation values are given in Table 3.2.2. These values plotted in Figures 3.2.2. and 3.2.3 show enormous variation between months as well as between years.

The aggregated monthly values for 1991 are remarkably lower than the average value and aggregated monthly values for 1992. The aggregated monthly values for 1993 are very close to the long-term average value.

Monthly rainfall and the number of rainy days per month, given in Tables 3.2.3 and 3.2.4, are plotted in Figures 3.2.4 and 3.2.5. Cumulative rainfall for 1992 is significantly lower than the mean annual rainfall. The ratio of evaporation to rainfall during cultivation (Table 3.2.5) indicates the magnitude of the drought which prevailed through the study period.

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Month	Average Eo (mm/day)			Cumulative Eo (mm/month)		
	1991	1992	1993	1991	1992	1993
January	5.1	5.4	4.9	122.6	151.0	153.2
February	5.9	6.6	6.8	154.2	185.3	190.0
March	6.1	7.4	5.3	183.7	222.3	164.0
April	3.9	6.4	4.6	46.9	161.2	138.0
May						
June	5.0	7.7	6.3	120.8	216.9	189.7
July	6.4	7.2	6.6	184.5	222.1	203.2
September	7.4	8.2	8.8	223.2	239.0	262.7
October	5.4	6.4	5.0	134.0	184.8	153.7
November	3.1	3.7	3.4	70.5	110.7	102.5
December	3.3	3.9	3.5	98.2	116.8	109.9
Total				1612.1	2216.2	2080.8

Table 3.2.3. Total rainfall per month (in mm).

Month	1991	1992	1993
January	142	17	31
February	16	0	0
March	8	0	71
April	64	74	31
May	123	119	120
June	103	18	33
July	27	13	46
August	42	11	0
September	18	55	24
October	145	63	259
November	278	392	321
December	219	99	219
Total	1185	861	1156

Table 3.2.4. Number of rainy days per month.

	1991	1992	1993
Month	Rainy days	Rainy days	Rainy days
January	7	7	6
February	3	0	0
March	2		
April	8		
May	5	10	10
June	7	2	S
July	3	5	6
August	6	3	0
September	4		
October	15	9	17
November	19	17	24
December	14	13	17
Total	93	75	101

Table 3.2.5. Ratio of rainfall to evaporation.

Period	Yala			Maha		
	RF (mm)	Eo (mm)	RF/Eo %	RF (mm)	Eo (mm)	RF/Eo %
1991	317	456	70	-	-	-
1991/92	-	-	-	530	529	1.00
1992	182	568	32	-	-	-
1992/93	-	-	-	342	629	0.54
1993	151	924	16	-	-	-

The impact of climatic factors on cropping is indicated in Table 3.2.6. Extreme variations in rainfall and evaporation in different seasons have an intimate bearing on determining supply and demand during a particular season and play a crucial role in planning and implementing seasonal allocation plans in the Kirindi Oya System.

3.2.6 Description of the Water Balance Study

The study comprised implementation of a data collection program and development of a computer model to operate the tanks in an effective and efficient manner.

A computer program which had been developed previously was tested with data available, but this proved unsatisfactory as the available data was neither consistent nor reliable. New data had to be collected for the program.

A field inspection was carried out to check flow measuring sites and to identify suitable locations for additional or alternate flow measuring with officers from the ID. Additional sites were chosen with reference to available human and other resources.

For discharge computations, the undershot controlling gate (sluice or diversion gate) was considered an orifice and the standard orifice equation was used.

For free flow condition : $Q = C_d \, aw \sqrt{2gH_1}$

For submerged condition : $Q = C_d \, aw \sqrt{2g\,(H_1 - H_2)}$

Where
C_d = Coefficient of discharge
Q = Discharge (m^3/s)
a = Gate opening (m)
w = Gate width (m)
H_1 = Upstream depth (m)
H_2 = Downstream depth (m)

If downstream depth is less than two-thirds upstream depth from the sill of the sluice, the canal is assumed to be under free flow conditions, otherwise it is submerged.

As a ***start,*** a ***coefficient of discharge*** value of ***0.65*** was assumed which was later modified (based on current metering) and re-established for each structure.

Tabh 3.2.6

Cultivation Calender and Climatic Conditions During Studv Period

YEAR	Month	YALA			MAHA		
		Cultivation Period	Total Rainfall	Total Evaporation	Cultivation Period	Total Rainfall	Total Evaporation
1991	JANUARY						
	FEBRUARY						
	MARCH						
	APRIL						
	MAY	01.04.91					
	JUNE	PADDY	317 mm	455 mm			
	JULY						
	AUGUST	01.08.91					
	SEPTEMBER				20.09.91		
	OCTOBER						
	NOVEMBER				PADDY	530 mm	529 mm
	DECEMBER						
1992	JANUARY				30.01.92		
	FEBRUARY						
	MARCH						
	APRIL	22.04.92					
	MAY	PADDY					
	JUNE	Failuer	182 mm	568 mm			
	JULY	23.07.92					
	AUGUST						
	SEPTEMBER						
	OCTOBER						
	NOVEMBER				15.11.92		
	DECEMBER						
1993	JANUARY				PADDY	342 mm	629 mm
	FEBRUARY						
	MARCH				20.03.93		
	APRIL						
	MAY	04.05.93					
	JUNE	PADDY /					
	JULY	OFC	151 mm	924 mm			
	AUGUST						
	SEPTEMBER	13.09.93					
	OCTOBER						
	NOVEMBER				01.11.93		
	DECEMBER						
1994	JANUARY				Paddy	752 mm	607 mm
	FEBRUARY						
	MARCH				25.03.93		
	APRIL						
	MAY						
	JUNE						
	JULY						
	AUGUST						
	SEPTEMBER						
	OCTOBER						
	NOVEMBER						
	DECEMBER						

At any given time, tank storage can be expressed by the following equation:

$$S_2 = S_1 + I_1 + RF - O_1 - E - L$$

Where	S	=	Tank storage
	I	=	Inflow to the tank
	RF	=	Rainfall contribution
	E	=	Evaporation
	O	=	Outflow (discharges) from the tank
	L	=	Other losses
	1 and 2	=	Timeperiods

Using available data with regard to head (H) versus tank water-spread area (A) and head versus tank capacity (C), the regression analysis was used to develop the following equations:

Tissa wewa	A	=	$1.85H^{2.13}$;	C	=	$0.214^{H3.5}$
Pannegamuwa	A	=	$102.87 + 43.89H$;	C	=	$0.056H^{4.45}$
Debara wewa	A	=	$19.06 + 27.23H$;	C	=	$4.96\,H^{2.38}$
Weerawila	A	=	$268.59 + 1000.08H$;	C	=	$321.48H^{1.38}$
Yoda wewa	A	=	$65.79H^{1.21}$;	C	=	$9.25H^{2.69}$

Units used in the above equations are feet, acre, and acre feet.

The computer program developed by the SIE to compute discharges uses specific data such as data on controlling gate widths, sill levels, spill crest levels, tank area-elevation and tank capacity-elevation. Spindle heights were measured to determine the height of gate openings. Gate opening height, depth of water upstream and downstream of structures, rainfall and evaporation constitute daily variable data required for the model. The program was developed using Lotus 1-2-3.

A baseline survey was conducted by the SIE and his staff to update data. Considerable variation was found in sill levels, zero levels of stage gauges and width of structures. Since accurate measurement of water levels on both sides of the gates was needed, ceramic gauges with metric scales were installed at measuring locations.

Spindle heights and water levels were recorded twice daily and the times of measurements were noted by GOs. Each measuring location was given a simple code name for easy identification. A special form for recording data and transmitting them to the ID was formulated. Data thus collected were tabulated on another form and sent to the SIE on a weekly basis.

An orientation program on data collection and recording was held for GOs on 31 August 1991 at the IE's office at Tissamaharama. At this meeting, the importance of systematic and accurate measurement of data was stressed. Senior staff from the ID and IIMI visited measuring

locations with GOs to demonstrate to them how accurate measurements should be taken and recorded.

Data collected between 16 September and 28 September 1991 were fed into the computer for verification. There were certain discrepancies in the data collected, especially in the unit of measurement. Modifications were made to the data collection procedure and another training session organized for data collectors.

By the beginning of the 1991/92 maha season, basic hydraulic data for the tanks in the Ellegala had been updated. Ceramic gauges in metric scale were fixed at 26 measuring locations and care was taken to fix gauges to enable measurement of maximum depth of water. A better flow measuring system and communication network was established during the season.

Analysis of Data on the Weerawila

Figures 3.2.6 to 3.2.11 are graphs illustrating different aspects of the analysis of data collected on the Weerawila, one of the Ellegala tanks, by the computer model. **Figure 3.2.6** shows how water level in the Weerawila responds to rainfall. **Figure 3.2.7** shows how inflow from the feeder canal responds to rainfall and **Figure 3.2.8** shows drainage into the tank from the Kirindi Oya new areas and runoff from the Weerawila catchment and how these two components respond to rainfall.

The three graphs indicate that the Weerawila gets the major portion of its inflow from rainfall and drainage rather than from the Lunugamvehera. **Figure 3.2.9** shows drainage inflows and spill from the Weerawila. It is noticed that the Weerawila spills quite heavily at times. **Figure 3.2.10** shows the relationship between spill and water levels in the Weerawila. **Figure 3.2.11** shows tank water level, inflow and outflow through the main canal from the Weerawila. These graphs, which were made available to managers for the first time, brought to light some interesting facts:

* In a water short system like the Kirindi Oya, tanks like the Weerawila spill during the maha season.
* During heavy rain (more than 20 mm a day), the main canal sluice discharging from the tank is closed completely.
* Even when there is no sluice discharge and the tank is almost at its full supply level (FSL), there is supply in the feeder canal (possibly from drainage) which contributes to surpluses through the spill.

As shown in **Table 3.2.7** the active storage of Ellegala tanks is around 17,350 acft. At the beginning of the maha 1991/92 season (late September), tanks were partially filled from the Lunugamvehera. This filling did not take into account likely inflow from the catchment as the amount of rainfall runoff and drainage from the new irrigated area was unknown.

Table **3.2.7.** Storage capabilities **in** Ellegala Irrigation System.

Tank	TWL at #		Capacity at		Active storage (acft)	System A. Storage (acft)
	MOL (ft)	FSL (ft)	MOL (ft)	FSL (acft)		
RB System						
Pannegamuwa	5	8.1	93	817	724	-
Weerawila	6	12.5	3966	11083	7117	7841
LB System						
Debara wewa	5.5	8	305	750	445	-
Tissa wewa	9	15.5	479	3209	2730	-
Yoda wewa	7	12.3	1769	8103	6334	9509
						17350

TWL = Tank Water Level
MOL = Minimum Operation Level
FSL = Full Supply Level

Table **3.2.8** shows that water releases from the Lunugamvehera to the Ellegala were made between **21** October and 28 January. But there was considerable runoff and drainage to the feeder canal system from areas located at higher elevations. These areas comprise the natural catchment of the Kirindi Oya and part of the newly developed ***areas.*** Analysis of the data as indicated in Table **3.2.8** shows that **9,697** acft of runoff received by the feeder canal system was distributed among the five tanks during this period.

In addition, as illustrated by Figures **3.2.6** to **3.2.7,** every **tank** received runoff from its catchment ***area.*** From the Tables and Figures, it can be inferred that Ellegala tanks spill often because of rains in local catchments.

Table **3.2.9** summarizes water balances for the individual tanks in the Ellegala System. As is clearly evident in Figure **3.2.1,** spills from the Pannegamuwa Tank and the Tissa Tank are credited as inflow to the Weerawila and the Yoda wewa, respectively. In calculating surplus in the Ellegala System, spillage from the Debara wewa is also considered as drainage inflow to the Tissa wewa. Wastage occurs only when spilling occurs in the Weerawila and the Yoda wewa. According **to** the analysis, total outflow or wastage in the Ellegala Irrigation System during the period under study was **5,944** acft.

The analysis clearly indicates that spilling can be avoided and the system operated more efficiently by maintaining minimum operational levels in the **tanks** at the commencement of the season. MOL is defined as that depth which would have at least two weeks supply for its command **area.**

Table 3.2.8. Feeder canal discharges distributed among Ellegala tanks.

Ellegal ,Feeder (d Discharges (acft)								
Period	RF (mm)	Lunu. Res.	Gamu.	F.Debara (acft)	F.Tissa	E.LB Total	E.RB Total	Total
21 Oct to 30 Oct	33	0	0	62	336	399	2240	2639
31 Oct to 9 Nov	121	0	24	120	144	287	0	287
10 Nov to 19 Nw	153	0	3	185	570	758	68	826
20 Nov to 29 Nov	10	0	165	39	66	ro	0	270
30 Nov to 9 Doc	4	0	155	311	70	535	6	541
10 Doc to 19 Dec	210	0	197	279	1481	1958	25	1983
20 Dec to 29 Dec	10	0	145	142	1%	483	22	505
30 Doc to 8 Jan	15	0	262	392	501	1155	72	1227
9 Jan to 18 Jan	2	0	289	331	585	1205	12	1217
19 Jan to 28 Jan	0	0	7	90	103	200	3	203
Total	557	0	1246	1950	4053	7250	2447	9697

RF	=	Rainfall
Lunu.	=	Release from Lunugamvehera Reservoir
Gamu.	=	Supply to Gamunupura
F.Debara	=	Feeder canal supply to Debara wewa
F.Tissa	=	Feeder canal supply to Tissa wewa
E.LB	=	Total supply of Ellegala LB feeder canal
E.RB	=	Total supply of Ellegala RB feeder canal

Table 3.2.9. Water balances for individual tanks in the Ellegala Irrigation System.

	Command	Tank Inflow		Tank Outflows			System		
	Area (ac)	Feeder (acft)	Drainage (acft)	M.canal (acft)	Release (acft)	Spill (acft)	Losses # (acft)	Surplus (acft)	Balance (acft)
Ellegala RB System:									
Pannegamuwa	560	2447	1145	948	2788		- 115		
Weerawila	2301	2788	10765	8797		1898	- 464		
Sub-Total			14357	9745			- 579	1898	3293
Ellegala LB System:									
Debara wewa	945	1950	5106	5647		1945	- 144		
Tissa wewa	2750	4053	13397	8081	10173		- 182		
Yoda wewa	3267	10173	2425	6839		4046	- 642		
EIS Total			24986	20567			- 968	4046	1341
EIS Total	9823		39343	30312			-1547	5944	4634

Drainage Analysis

A significant factor which was brought to light by the analysis is Drainage Contribution for Unit Rainfall (Table **3.2.10).** The Ellegala System is located at the tail end of the Kirindi Oya System. Runoff and drainage water originating from the higher new settlement **areas** flow through the catchment **area** of the Ellegala and reduce the System's irrigation demand from the Lunugamvehera.

This should be considered when allocating water from the Lunugamvehera. Catchment runoff for the individual tanks in the Ellegala differ from each other **because** some of the catchment **areas** include newly developed lands under the Lunugamvehera. Drainage flows from these **areas** vary according to the irrigation supply to new project **areas.**

Drainage in the Ellegala varies according to whether:

* water is **issued** to the entire new **areas** or not,
* water is issued to Tract 1 of the RB and Tracts 1, 2 and 3 of the LB and
* water is issued *to* Tracts 2, **5,** 6 and 7 of the RB.

During the 1991/92 maha season, water was issued to the entire new **areas.** The quantity of drainage received on a particular day was divided by the quantity of rainfall for the corresponding day when calculating drainage contribution for unit rainfall. These values were tested against the exceedance probabilities of 90 percent, **75** percent and 50 percent. The results of this analysis are given in Table **3.2.10.**

Table **3.2.10.** Drainage contribution for unit rainfall.

Conditions: **Water issue to entire New *Area*.**
Water issue to RB Tract 1, LB Tracts 1, 2 and 3.
Water issue to RB Tract 2, Tracts 5, 6 and 7
No water issue to New Area
Result under condition (a)

Tank	Drainage Flow Exceedance Probability (acft/mm)		
	90%	75%	50%
Pannegamuwa			
Weerawila			
Debara wewa			29
Tissa wewa		13	46
Yoda wewa	3	9	19

It can be Seen from **Table 3.2.10** that drainage contribution for unit rainfall in the Pannegamuwa, Debara wewa and the Yoda wewa is somewhat equal. This is because the catchment areas of these tanks are small compared to those of the Weerawila and the Tissa wewa.

Drainage Contribution for Unit Rainfall can be calculated in this manner for other conditions as well and the results used to develop rules for water allocation and operations. A Pre-Seasonal Allocation Plan can be drawn up based on probable drainage contribution calculated on the basis of probable rainfall and probable water available during the season. The area to be cultivated during a particular season can be decided on the basis of this analysis. Drainage Contribution for Unit Rainfall can be used as a guideline for deciding appropriate minimum operational levels for the individual tanks.

Water Duty in the Ellegala Irrigation System

An analysis of water duty during the maha 1991/92 is given in **Table 3.2.11.** The Pannegamuwa showed the lowest duty at 1.7 acft per acre for the crop growth period. This is due mainly to the location of the Pannegamuwa command area, some parts of which benefit from seepage water from the Weerawila Tank. Other reasons for the low duty include the short canal system and efficient water control.

Table 3.2.11. Tank duties for the crop growth period (21 October 1991 to 28 January 1992).

Name of system	Command areas (ac)	Main canal discharges (acft)	Tank duty (acft/ac)
Release from Lunugamvehera		0	
Ellegala RB System:			
Pannegamuwa	560	948	1.7
Weerawila	2301	8797	3.8
Ellegala LB System:			
Debara wewa	945	5647	6.0
Tissa wewa	2750	8081	2.9
Yoda wewa	3267	6839	2.1
Total	9823	30312	3.1
Irrigation Duty (Ex-Sluice) for DC 5 Sub. RB Tract 1			3.2

The highest duty of 6.0 acft per acre was reported from the Debara wewa. Though the command area is moderate (945 ac) compared to other tanks, it has a longer RBMC. In addition, there is less reuse of drainage water than in the other tanks.

The Tissa wewa and the Yoda wewa have large command areas but duty was low. This is due to high reuse of drainage water in the command areas of these tanks.

3.2.7 Management of the Ellegala Irrigation System

A management study of the Ellegala was undertaken as a research activity to supplement the findings of the Water Balance Study. The main objectives were:

* To understand decision-making processes for water allocation and system operation. This was specially required as the Ellegala tanks started spilling during the maha season, raising the question of just how effective the current water management process was.

* To collect information to prepare the 1992 yala program to be implemented with the participation of the ID and the IMD.

The study indicated that decisions concerning water allocation were not based on reliable information on the water needs of crops. Instead, water was allocated and distributed largely on the request of Ellegala farmers and the IE at Tissa.

It also indicated that irrigation schedules were not prepared for either individual tanks or the whole Ellegala system. As a result, there was no way to determine water issues to individual tanks. The Manager simply filled the tanks on farmer demand.

This practice was an incentive to waste water and is true not only for water issues to the tanks but also for water issues to distributaries under Ellegala tanks. In addition, the physical system was dilapidated and very likely to create problems when implementing rotations in these systems. Prior to the construction of the Lunugamvehera, Ellegala farmers started the maha cultivation in mid October and the yala cultivation in March, after the beginning of rains. It is possible to make maximum use of rain in the catchments if management decided to go back to this practice. Tank spilling too could perhaps be avoided.

Development of a Seasonal Wafer Release Plan for the Lunugamvehera

Before the study, seasonal water release from the Lunugamvehera to the Ellegala tanks has been done in an ad hoc manner. Requests for water by FRs and the IE from Tissa formed the basis for discussion at the PMC and decisions were taken with little technical analysis of the water situation in the tanks and reservoir, probable inflow to these storage systems or the water needs of crops. This has created considerable problems for both farmers and the system manager in carrying out their activities.

The experience gained during the 1991/92 *maha* season has revealed that the Ellegala System is not being operated in a systematic manner. Large quantities of water are spilled into the sea without being used mainly because of poor management. To overcome this problem, the concept of operating tanks at or near MOLs was used to develop a procedure to prevent wastage of spill from the Ellegala tanks.

The Water Balance Study has also generated useful information which has been used as a first approximation in developing an operations plan. The plan can be further refined as more data is collected. The two activities, the Water Balance Study and the operational plan, were undertaken with the intention that operations plans developed and implemented in the coming seasons would provide additional information to further refine procedures and planning processes.

In preparing the operations plan, inflow such as drainage, rainfall-runoff and reservoir releases were taken into consideration. In estimating drainage and rainfall contribution, it was difficult to determine the respective coefficients. However, as a first approximation, these figures were selected using the limited information available and local knowledge. Similarly, water demand for crops was calculated using a uniform value for the whole project area given by the ID.

The following section details the procedure adopted in calculating rainfall-runoff contribution, drainage flows into the system and losses from the system. Water balancing for individual subsystems was done keeping tanks at or near MOLs to minimize. spillage.

Methodology

The method used to develop the operations plan and the various computational assumptions made are as follows:

Time Period and Week Numbers. A time interval of seven days was used for water balancing. The first week started on the first day of January. The Tables give details of the month, date and week number.

Rainfall. In analyzing rainfall contribution, two sets of rainfall data representing dry and wet conditions were used and is designated as expected rainfall in this computation. Using data made available by Dr. C.R. Panabokke, dry and wet condition rainfall figures were computed as 75 percent and 50 percent, respectively, probable rainfall. (Rainfall data for 1872 to 1967 was provided by the Tissamaharama Station.) Wet condition rainfall figures turned out to be rather high during certain months so these figures were replaced with 70 percent probability rainfall. Monthly rainfall figures were proportionately distributed among the weeks, using local knowledge of rainfall distribution.

Runoff Coefficient. The coefficient of catchment runoff depends on many factors including antecedent precipitation, topography, soil type, soil moisture status, vegetation and climate. There are empirical formulae to determine this coefficient. Based on the intensities of rainfall

and its distribution and on climatic factors, a time varying coefficient ranging from 0.05 to 0.80 for the season was arrived at. These coefficients need to be further refined using information generated by the Water Balance Study.

Drainage Coefficients. This coefficient is used to calculate drainage contribution from the newly developed areas above the respective subsystems. In the past, an ID officer (Mr. **B.K.** Jayasundara) had established this coefficient as **30** percent of irrigation issue to the drainable area. However, on a monthly or weekly basis, water balancing cannot be done using such an average value because of its variability over time. Further, it cannot be used as a management information index to operate the system on a weekly basis. Therefore, it is necessary to establish this coefficient on a weekly basis depending on the nature of water issue to the newly developed areas, soil moisture status, types of soils, etc. As an initial approximation, a variable value for this factor was assigned using the limited information available. This figure was **taken** to vary from 0.0 to 0.4. At the end of the Water Balance Study, these values were updated.

Evaporation Losses. Evaporation losses were taken from the cultivation planning exercise as these values were available on a monthly basis. Weekly values were obtained by distributing monthly values among the number of weeks of that month. No adjustments were effected using climatological data since losses are insignificant from the operational point of view.

Flow Computations and Water Balancing

Inflows

Inflows into the subsystems come from rainfall-runoff, drainage and the Lunugamvehera Reservoir. Rainfall contribution is calculated by multiplying expected rainfall by the size of the catchment area and the runoff coefficient. Similarly, drainage contribution is calculated by multiplying irrigated area by irrigation water issues and the drainage coefficient. The drainage coefficient was established using data obtained from the Water Balance Study and other information available with the ID. The value of reservoir release was computed **as** water requirement plus evaporation losses minus rainfall-runoff plus drainage contribution. The water requirement used in this computation takes line losses into consideration.

Outflows

Outflows from the subsystems include water released for crops, spills and evaporation losses. Water required **for** crops is calculated by the ID which takes into account operational such as seepage and percolation. Using this figure, unit water required was calculated. Total release was calculated by multiplying unit water required by cropped area. For calculation of evaporation losses, the water surface at MOL was multiplied by a weekly evaporation rate.

Water Balancing

Water release from the reservoir was calculated to minimize or prevent spill. Throughout the season attempts were made to keep tank water levels around MOLs. This was done by trial and error using Lotus spreadsheets.

When water levels in the tanks exceeded MOLs or the tanks started to spill, releases from the reservoir were reduced. When inflows were less than outflows and the capacity of the tanks became negative, the program was adjusted to bring values to zero.

Water balancing for all five tanks and the Gamunupura was done separately and is indicated in Tables **3.2.12** ***to*** **3.2.17**. The water balance for EIS tanks during dry and wet conditions are shown in separate tables. Water releases to the Yoda wewa are accounted for in the Tissa wewa releases. Releases from the Lunugamvehera were varied to keep tank water levels around MOLs. This was done by trial and error. Summaries of releases to the Ellegala are given in **Tables 3.2.18 and 3.2.19** and in **Figures 3.2.12 and 3.2.13.**

Under dry conditions, **75** percent probability rainfall was used and very little cultivation in the newly developed areas was assumed. In the ***case*** of wet conditions, ***50*** percent probability rainfall and substantial cultivation in the newly developed areas were assumed.

Details of the water release plan for the entire Ellegala have been worked out for both wet and dry conditions. **Table 3.2.20** summarizes water releases **to** each tank and for the entire system.

Results

The most important outcome of this activity has been the development of a more systematic operations procedure than has been adopted in previous years. The following are results achieved:

* The development of operations plans for the Ellegala **tanks** and a composite operations plan for water releases from the Lunugamvehera.
* The introduction of the concept of **MOLs** in the Ellegala with the view to maximizing rainfall contribution particularly during the maha season.
* The creation of an awareness among farmers and agency officials of operational procedures.
* The fact that the Weerawila Tank was not able to store total runoff during the maha season. It would appear that by augmenting the storage capacity of this **tank,** an additional 5,000 acft of water could be stored. Also, it was discovered that the full extent of the Yoda wewa and the Weerawila could be cultivated using their own catchment inflows during wet years while the Weerawila can be cultivated even during dry seasons.

Table 3.2.12(a). Water Balance for EIS (Dry)

Name : Debarawewa (dry) Season: 1992/1993 Maha
Catchment Area: 1.05 Sq.Mls. Service area 1000 Acs. MOL Capacity 305 Acft
New Area above: 0 Acs. Area at MOL 130 Acs. FSL Capacity 750 Acft
Week No.1 Starts from 1st January

Month	Dates	Week	Ex.Rain mm/week	RF Cf.	Dr.Cf.	Eva.mm/ week	Water Demand Acft	Inflows Rain Acft	Drain. Acft	Reser. Acft	Total Acft	Outflows Sluice Acft	Evapo Acft	F–OF Acft	Capacity Start Acft	End Acft	Spill
September	3 to 9	36	2	0.05	0	40	0	0	0	0	0	0	17	0	0	0	0
	10 to 16	37	2	0.05	0	40	0	0	0	0	0	0	17	0	0	0	0
	17 to 23	38	3	0.05	0	40	0	0	0	0	0	0	17	0	0	0	0
	24 to 30	39	3	0.05	0	40	0	0	0	0	0	0	17	0	0	0	0
October	1 to 7	40	7	0.1	0	16	0	2	0	0	2	0	6	0	0	0	0
	8 to 14	41	13	0.1	0	16	0	3	0	0	3	0	6	0	0	0	0
	15 to 21	42	16	0.1	0	16	0	4	0	0	4	0	6	0	0	0	0
	22 to 28	43	20	0.3	0	16	0	13	0	0	13	0	6	6	0	6	0
	29 to 4	44	25	0.3	0	16	0	17	0	0	17	0	6	9	6	14	0
November	5 to 11	45	30	0.5	0	0	0	33	0	0	33	0	0	33	14	47	0
	12 to 18	46	35	0.5	0	0	0	39	0	0	39	0	0	39	47	86	0
	19 to 25	47	40	0.5	0.1	0	212	44	0	400	444	223	0	221	86	307	0
	26 to 2	48	50	0.5	0.1	0	309	56	0	400	456	326	0	130	307	437	0
December	3 to 9	49	42	0.6	0.2	13	381	56	0	300	356	401	6	−51	437	387	0
	10 to 16	50	25	0.6	0.3	13	244	33	0	300	333	256	6	71	387	458	0
	17 to 23	51	15	0.7	0.3	13	221	23	0	300	323	233	6	85	458	543	0
	24 to 31	52	12	0.7	0.4	13	225	16	0	300	316	237	6	76	543	619	0
January	1 to 7	1	12	0.8	0.4	31	234	21	0	300	321	247	13	61	619	680	0
	8 to 14	2	11	0.8	0.4	31	240	19	0	300	319	253	13	53	680	734	0
	15 to 21	3	10	0.8	0.3	31	244	18	0	200	218	257	13	−53	734	681	0
	21 to 28	4	9	0.8	0.3	31	250	16	0	300	316	263	13	40	681	721	0
	29 to 4	5	9	0.8	0.3	31	259	16	0	200	216	273	13	−70	721	651	0
February	5 to 11	6	8	0.6	0.3	40	282	11	0	200	211	276	17	−82	651	568	0
	12 to 18	7	7	0.6	0.2	40	282	9	0	200	209	276	17	−83	568	485	0
	19 to 25	8	0	0.6	0.2	40	254	0	0	200	200	267	17	−84	485	401	0
	26 to 4	9	0	0.6	0.2	40	166	0	0	200	200	175	17	8	401	409	0
March	5 to 11	10	0	0.4	0.2	43	78	0	0	0	0	82	18	−101	409	308	0
	12 to 18	11	0	0.4	0.2	43	0	0	0	0	0	0	18	−18	308	290	0
	19 to 25	12	10	0.4	0	43	0	8	0	0	8	0	18	−10	290	280	0
	26 to 1	13	28	0.4	0	43	0	25	0	0	25	0	18	6	280	287	0
							3840	484	0	4100	4584	4042	337				0

Table 3.2.12(b). Water Balance for EIS (Wet)

Name : Debarawewa (wet) Season: 1992/1993 Maha
Catchment Area: 1.05 Sq.Mls. Service area 1000 Acs. MOL Capacity 305 Acft
New Area above: 0 Acs. Area at MOL 130 Acs. FSL Capacity 750 Acft

Week No.1 Starts from 1st January

Month	Dates	Week	Ex.Rain mm/week	RF Cf.	Dr.Cf.	Eva.mm/ week	Water Demand Acft	Inflows Rain Acft	Drain. Acft	Reser. Acft	Total Acft	Outflows Sluice Acft	Evapo Acft	F–OF Acft	Capacity Start Acft	End Acft	Spill
									97								
September	3 to 9	36	7	0.05	0	40	0	1	0	0	1	0	17	0	0	0	0
	10 to 16	37	8	0.05	0	40	0	1	0	0	1	0	17	0	0	0	0
	17 to 23	38	10	0.05	0	40	0	1	0	0	1	0	17	0	0	0	0
	24 to 30	39	14	0.05	0	40	0	2	0	0	2	0	17	0	0	0	0
October	1 to 7	40	14	0.1	0	16	0	3	0	0	3	0	6	0	0	0	0
	8 to 14	41	25	0.1	0	16	0	6	0	0	6	0	6	0	0	0	0
	15 to 21	42	40	0.1	0	16	0	9	0	0	9	0	6	1	0	1	0
	22 to 28	43	46	0.3	0	16	0	30	0	0	30	0	6	23	1	24	0
	29 to 4	44	50	0.3	0	16	0	33	0	0	33	0	6	25	24	49	0
November	5 to 11	45	54	0.5	0	0	0	60	0	0	60	0	0	60	49	109	0
	12 to 18	46	54	0.5	0	0	0	60	0	0	60	0	0	60	109	168	0
	19 to 25	47	41	0.5	0.1	0	212	45	0	300	345	223	0	122	168	290	0
	26 to 2	48	46	0.5	0.1	0	309	50	0	300	350	325	0	25	290	315	0
December	3 to 9	49	37	0.6	0.2	13	381	49	0	400	449	401	6	43	315	358	0
	10 to 16	50	33	0.6	0.3	13	244	44	0	300	344	256	6	82	358	440	0
	17 to 23	51	35	0.7	0.3	13	221	54	0	300	354	233	6	116	440	556	0
	24 to 31	52	36	0.7	0.4	13	225	56	0	300	356	237	6	113	556	669	0
January	1 to 7	1	26	0.8	0.4	31	234	46	0	200	246	247	13	−14	669	655	0
	8 to 14	2	25	0.8	0.4	31	240	44	0	200	244	253	13	−22	655	633	0
	15 to 21	3	20	0.8	0.3	31	244	35	0	200	235	257	13	−35	633	598	0
	21 to 28	4	18	0.8	0.3	31	250	32	0	300	332	263	13	56	598	653	0
	29 to 4	5	19	0.8	0.3	31	259	34	0	300	334	273	13	47	653	701	0
February	5 to 11	6	13	0.6	0.3	40	282	17	0	200	217	276	17	−76	701	625	0
	12 to 18	7	16	0.6	0.2	40	282	21	0	200	221	276	17	−71	625	554	0
	19 to 25	8	14	0.6	0.2	40	254	19	0	200	219	267	17	−66	554	488	0
	26 to 4	9	16	0.6	0.2	40	166	21	0	0	21	175	17	−171	488	317	0
March	5 to 11	10	16	0.4	0.2	43	78	14	0	0	14	82	18	−86	317	231	0
	12 to 18	11	17	0.4	0.2	43	0	15	0	0	15	0	18	−3	231	227	0
	19 to 25	12	18	0.4	0	43	0	16	0	0	16	0	18	−2	227	225	0
	26 to 1	13	22	0.4	0	43	0	19	0	0	19	0	18	1	225	226	0
							3840	834	0	3700	4534	4042	337				0

Next >>

Table 3.2.13 (a): Water Balance for EIS Tanks (Dry)

Name :	Tissawewa (dry)		Season: 1992/1993 Maha		
Catchment Area:	7.64 Sq.Mls.	Service area	2750 Acs.	MOL Capacity	479 Acft
New Area above:	0 Acs.	Area at MOL	186 Acs.	FSL Capacity	3209 Acft

Week No.1 Starts from 1st January

Month	Dates	Week	Ex.Rain mm/week	RF Cf.	Dr.Cf.	Eva.mm/ week	Water Demand Acft	Inflows Rain Acft	Drain. Acft	Reser. Acft	Total Acft	Outflows Sluice Acft	Evapo Acft	Yoda Acft	IF-OF Acft	Capacity Start Acft	End Acft	Spl
September	3 to 9	36	2	0.05	0	40	0	2	0	0	2	0	24	0	0	0	0	
	10 to 16	37	2	0.05	0	40	0	2	0	0	2	0	24	0	0	0	0	
	17 to 23	38	3	0.05	0	40	0	2	0	0	2	0	24	0	0	0	0	
	24 to 30	39	3	0.05	0	40	0	2	0	0	2	0	24	0	0	0	0	
October	1 to 7	40	7	0.1	0	18	0	11	0	0	11	0	11	0	0	0	0	
	8 to 14	41	13	0.1	0	18	0	21	0	0	21	0	11	0	10	0	10	
	15 to 21	42	18	0.1	0	18	0	29	0	0	29	0	11	0	18	10	28	
	22 to 28	43	20	0.3	0	18	0	98	0	0	98	0	11	0	85	28	114	
	29 to 4	44	25	0.3	0	18	0	120	0	0	120	0	11	0	109	114	223	
November	5 to 11	45	30	0.5	0	0	0	241	0	0	241	0	0	0	241	223	464	
	12 to 18	46	35	0.5	0	0	0	281	0	0	281	0	0	0	281	464	744	
	19 to 25	47	40	0.5	0.1	0	583	321	0	300	621	614	0	0	7	744	751	
	26 to 2	48	50	0.5	0.1	0	849	401	0	300	701	893	0	0	-192	751	559	
December	3 to 9	49	42	0.6	0.2	13	1046	404	0	700	1104	1102	8	0	-5	559	554	
	10 to 16	50	25	0.6	0.3	13	870	241	0	700	941	705	8	0	227	554	781	
	17 to 23	51	15	0.7	0.3	13	808	188	0	700	888	640	8	0	221	781	1002	
	24 to 31	52	12	0.7	0.4	13	818	135	0	700	835	651	8	300	-124	1002	878	
January	1 to 7	1	12	0.8	0.4	31	644	154	0	900	1054	678	19	300	57	878	936	
	8 to 14	2	11	0.8	0.4	31	661	141	0	900	1041	686	19	500	-173	936	782	
	15 to 21	3	10	0.8	0.3	31	671	128	0	900	1028	707	19	500	-197	782	565	
	21 to 28	4	9	0.8	0.3	31	687	116	0	1400	1516	723	18	700	73	565	639	
	29 to 4	5	9	0.8	0.3	31	713	118	0	1400	1518	751	19	700	46	639	685	
February	5 to 11	6	8	0.6	0.3	40	721	77	0	1400	1477	759	24	700	-6	685	679	
	12 to 18	7	7	0.6	0.2	40	720	67	0	1400	1467	758	24	800	-115	679	564	
	19 to 25	8	0	0.6	0.2	40	698	0	0	1500	1500	735	24	800	-59	564	505	
	26 to 4	9	0	0.6	0.2	40	457	0	0	1500	1500	481	24	800	195	505	700	
March	5 to 11	10	0	0.4	0.2	43	215	0	0	500	500	227	26	200	47	700	747	
	12 to 18	11	0	0.4	0.2	43	0	0	0	0	0	0	26	200	-226	747	521	
	19 to 25	12	10	0.4	0	43	0	64	0	0	64	0	26		38	521	559	
	26 to 1	13	28	0.4	0	43	0	180	0	0	180	0	26		154	559	713	
															0			
							10561	3620	0	15200	16720	11117	479	6500				

Note: Yodawewa supply also indicated in this table and the release from Lunugamwehera to Tissawewa includes the Yodawewa requirement also.

Table 3.4.13 (b): Water Balance for EIS Tanks (Wet)

Name :	Tissawewa (wet)		Season: 1992/1993 Maha		
Catchment Area:	7.64 Sq.Mls.	Service area	2750 Acs.	MOL Capacity	479 Acft
New Area above:	820 Acs.	Area at MOL	186 Acs.	FSL Capacity	3209 Acft

Week No.1 Starts from 1st January

Month	Dates	Week	Ex.Rain mm/week	RF Cf.	Dr.Cf.	Eva.mm/ week	Water Demand Acft	Inflows Rain Acft	Drain. Acft	Reser. Acft	Total Acft	Outflows Sluice Acft	Evapo Acft	IF-OF Acft	Capacity Start Acft	End Acft	Spill
September	3 to 9	36	7	0.05	0	40	0	6	0	0	6	0	24	0	0	0	0
	10 to 16	37	8	0.05	0	40	0	6	0	0	6	0	24	0	0	0	0
	17 to 23	38	10	0.05	0	40	0	8	0	0	8	0	24	0	0	0	0
	24 to 30	39	14	0.05	0	40	0	11	0	0	11	0	24	0	0	0	0
October	1 to 7	40	14	0.1	0	18	0	22	0	0	22	0	11	12	0	12	0
	8 to 14	41	25	0.1	0	18	0	40	0	0	40	0	11	29	12	41	0
	15 to 21	42	40	0.1	0	18	0	64	0	0	64	0	11	53	41	94	0
	22 to 28	43	48	0.3	0	18	0	221	0	0	221	0	11	210	94	304	0
	29 to 4	44	50	0.3	0	18	0	241	0	0	241	0	11	230	304	534	0
November	5 to 11	45	54	0.5	0	0	0	433	0	0	433	0	0	433	534	967	0
	12 to 18	46	54	0.5	0	0	0	433	0	0	433	0	0	433	967	1400	0
	19 to 25	47	41	0.5	0.1	0	583	329	18	0	347	614	0	-267	1400	1133	0
	26 to 2	48	45	0.5	0.1	0	849	361	25	200	586	893	0	-308	1133	826	0
December	3 to 9	49	37	0.6	0.2	13	1046	356	58	400	814	1102	8	-296	826	530	0
	10 to 16	50	33	0.6	0.3	13	870	318	74	300	692	705	8	-21	530	509	0
	17 to 23	51	35	0.7	0.3	13	808	393	73	300	766	640	8	118	509	627	0
	24 to 31	52	38	0.7	0.4	13	818	404	100	200	704	651	8	46	627	673	0
January	1 to 7	1	28	0.8	0.4	31	644	334	104	200	638	678	19	-59	673	614	0
	8 to 14	2	25	0.8	0.4	31	661	321	110	200	631	686	19	-84	614	530	0
	15 to 21	3	20	0.8	0.3	31	671	257	86	400	742	707	19	17	530	547	0
	21 to 28	4	18	0.8	0.3	31	687	231	87	400	718	723	18	-24	547	523	0
	29 to 4	5	19	0.8	0.3	31	713	244	89	500	833	751	19	63	523	586	0
February	5 to 11	6	13	0.6	0.3	40	721	125	89	500	714	759	24	-69	586	517	0
	12 to 18	7	16	0.6	0.2	40	720	154	60	600	814	758	24	32	517	549	0
	19 to 25	8	14	0.6	0.2	40	698	135	60	600	794	735	24	36	549	585	0
	26 to 4	9	16	0.6	0.2	40	457	154	55	300	509	481	24	4	585	589	0
March	5 to 11	10	16	0.4	0.2	43	215	103	30	100	232	227	26	-21	589	569	0
	12 to 18	11	17	0.4	0.2	43	0	109	12	0	121	0	26	95	569	664	0
	19 to 25	12	18	0.4	0	43	0	116	0	0	116	0	26	89	664	754	0
	26 to 1	13	22	0.4	0	43	0	141	0	0	141	0	26	115	754	869	0
							10561	6089	1129	5200	12399	11117	479				0

Table 3.2.14 (a): Water Balance for EIS Tanks (Dry)

Name : Yodawewa (dry) | Season: 1992/1993 Maha
Catchment Area: 23.2 Sq.Ms. | Service area 3300 Acs. | MOL Capacity 1769 Acft.
New Area above: 0 Acs. | Area at MOL 680 Acs. | FSL Capacity 8103 Acft.

Week No.1 Starts from 1st January

Month	Dates	Week	Ex.Rain mm/week	RF Cf.	Dr.Cf.	Eva.mm/week	Water Demand Acft	Inflows Rain Acft	Drain. Acft	Reser. Acft	Total Acft	Outflows Sluice Acft	Evapo Acft	F-OF Acft	Capacity Start Acft	End Acft	Spill
September	3 to 9	36	2	0.05	0	40	0	5	0	0	5	0	89	0	0	0	0
	10 to 16	37	2	0.05	0	40	0	5	0	0	5	0	89	0	0	0	0
	17 to 23	38	3	0.05	0	40	0	7	0	0	7	0	89	0	0	0	0
	24 to 30	39	3	0.05	0	40	0	7	0	0	7	0	89	0	0	0	0
October	1 to 7	40	7	0.1	0	18	0	34	0	0	34	0	40	0	0	0	0
	8 to 14	41	13	0.1	0	18	0	63	0	0	63	0	40	23	0	23	0
	15 to 21	42	16	0.1	0	18	0	88	0	0	88	0	40	48	23	71	0
	22 to 28	43	20	0.3	0	18	0	292	0	0	292	0	40	262	71	323	0
	29 to 4	44	25	0.3	0	18	0	365	0	0	365	0	40	325	323	646	0
November	5 to 11	45	30	0.5	0	0	0	731	0	0	731	0	0	731	646	1379	0
	12 to 18	46	35	0.5	0	0	0	862	0	0	862	0	0	862	1379	2231	0
	19 to 25	47	40	0.6	0.1	0	700	974	0	0	974	736	0	238	2231	2469	0
	26 to 2	48	50	0.5	0.1	0	1019	1218	0	0	1218	1072	0	146	2469	2615	0
December	3 to 9	49	42	0.6	0.2	13	1258	1228	0	0	1228	1322	28	-123	2615	2492	0
	10 to 16	50	25	0.6	0.3	13	804	731	0	0	731	846	29	-145	2492	2347	0
	17 to 23	51	15	0.7	0.3	13	729	511	0	0	511	787	29	-285	2347	2082	0
	24 to 31	52	12	0.7	0.4	13	742	409	0	300	709	781	29	-101	2082	1981	0
January	1 to 7	1	12	0.8	0.4	31	773	468	0	300	768	814	69	-115	1981	1846	0
	8 to 14	2	11	0.8	0.4	31	793	429	0	500	929	834	69	25	1846	1871	0
	15 to 21	3	10	0.8	0.3	31	808	390	0	500	890	848	69	-27	1871	1843	0
	21 to 28	4	9	0.8	0.3	31	825	351	0	700	1051	868	69	114	1843	1957	0
	29 to 4	5	9	0.8	0.3	31	856	351	0	700	1051	901	69	81	1957	2038	0
February	5 to 11	6	8	0.6	0.3	40	865	234	0	700	934	910	69	-68	2038	1972	0
	12 to 18	7	7	0.6	0.2	40	864	205	0	800	1005	909	69	6	1972	1978	0
	19 to 25	8	0	0.6	0.2	40	837	0	0	800	800	882	69	-171	1978	1807	0
	26 to 4	9	0	0.6	0.2	40	546	0	0	800	800	577	69	134	1807	1941	0
March	5 to 11	10	0	0.4	0.2	43	258	0	0	200	200	272	96	-168	1941	1773	0
	12 to 18	11	0	0.4	0.2	43	0	0	0	200	200	0	96	104	1773	1877	0
	19 to 25	12	10	0.4	0	43	0	195	0	0	195	0	96	99	1877	1976	0
	26 to 1	13	26	0.4	0	43	0	546	0	0	546	0	96	450	1976	2426	0
							12673	10688	0	6500	17188	13340	1780				0

Table 3.2.14.(b): Water Balance for EIS Tanks (Wet)

Name : Yodawewa (wet) | Season: 1992/1993 Maha
Catchment Area: 23.2 Sq.Ms. | Service area 3300 Acs. | MOL Capacity 1769 Acft.
New Area above: 2838 Acs. | Area at MOL 680 Acs. | FSL Capacity 8103 Acft.

Week No.1 Starts from 1st January

Month	Dates	Week	Ex.Rain mm/week	RF Cf.	Dr.Cf.	Eva.mm/week	Water Demand Acft	Inflows Rain Acft	Drain. Acft	Reser. Acft	Total Acft	Outflows Sluice Acft	Evapo Acft	F-OF Acft	Capacity Start Acft	End Acft	Spill
September	3 to 9	36	7	0.05	0	40	0	17	0	0	17	0	89	0	0	0	0
	10 to 16	37	8	0.05	0	40	0	19	0	0	19	0	89	0	0	0	0
	17 to 23	38	10	0.05	0	40	0	24	0	0	24	0	89	0	0	0	0
	24 to 30	39	14	0.05	0	40	0	34	0	0	34	0	89	0	0	0	0
October	1 to 7	40	14	0.1	0	18	0	68	0	0	68	0	40	28	0	28	0
	8 to 14	41	25	0.1	0	18	0	122	0	0	122	0	40	82	28	110	0
	15 to 21	42	40	0.1	0	18	0	196	0	0	196	0	40	155	110	264	0
	22 to 28	43	46	0.3	0	18	0	672	0	0	672	0	40	632	264	896	0
	29 to 4	44	50	0.3	0	18	0	731	0	0	731	0	40	691	896	1587	0
November	5 to 11	45	54	0.5	0	0	0	1315	0	0	1315	0	0	1315	1587	2902	0
	12 to 18	46	54	0.5	0	0	0	1315	0	0	1315	0	0	1315	2902	4218	0
	19 to 25	47	41	0.6	0.1	0	700	999	61	0	1060	736	0	324	4218	4541	0
	26 to 2	48	45	0.5	0.1	0	1019	1098	87	0	1183	1072	0	110	4541	4652	0
December	3 to 9	49	37	0.6	0.2	13	1258	1081	198	0	1281	1322	29	-70	4652	4582	0
	10 to 16	50	33	0.6	0.3	13	804	985	257	0	1222	846	29	346	4582	4928	0
	17 to 23	51	35	0.7	0.3	13	729	1193	251	0	1445	767	29	649	4928	5576	0
	24 to 31	52	36	0.7	0.4	13	742	1228	348	0	1574	781	29	764	5576	6340	0
January	1 to 7	1	26	0.8	0.4	31	773	1013	361	0	1375	814	69	492	6340	6832	0
	8 to 14	2	25	0.8	0.4	31	793	974	380	0	1354	834	69	451	6832	7282	0
	15 to 21	3	20	0.8	0.3	31	808	779	296	0	1076	848	69	158	7282	7441	0
	21 to 28	4	18	0.8	0.3	31	825	701	302	0	1003	868	69	86	7441	7507	0
	29 to 4	5	18	0.8	0.3	31	856	740	307	0	1048	901	69	78	7507	7585	0
February	5 to 11	6	13	0.6	0.3	40	865	380	307	0	687	910	69	-312	7585	7272	0
	12 to 18	7	16	0.6	0.2	40	864	469	209	0	676	909	69	-322	7272	6950	0
	19 to 25	8	14	0.6	0.2	40	837	409	207	0	616	882	69	-355	6950	6595	0
	26 to 4	9	16	0.6	0.2	40	546	469	192	0	659	577	69	-7	6595	6588	0
March	5 to 11	10	16	0.4	0.2	43	258	312	102	0	414	272	96	46	6588	6635	0
	12 to 18	11	17	0.4	0.2	43	0	331	43	0	374	0	96	278	6635	6913	0
	19 to 25	12	18	0.4	0	43	0	357	0	0	351	0	96	255	6913	7168	0
	26 to 1	13	22	0.4	0	43	0	429	0	0	429	0	96	333	7168	7500	0
							12673	18431	3909	0	22339	13340	1780				0

Table 3.2.15.(a): Water Balance for EIS Tanks (Dry)

Name : Panragamuwa (dry) — Season: 1992/1993 Maha
Catchment Area: 0.32 Sq.Mls. — Service area 580 Acs. — MOL Capacity 93 Acft
New Area above: 0 Acs. — Area at MOL 106 Acs. — FSL Capacity 817 Acft

Week No.1 Starts from 1st January

Month	Dates	Week	Ex.Rain mm/week	RF Cf.	Dr.Cf.	Eva.mm/ week	Water Demand Acft	Inflows Rain Acft	Drain. Acft	Reser. Acft	Total Acft	Outflows Sluice Acft	Evapo Acft	F-OF Acft	Capacity Start Acft	End Acft	Spill
September	3 to 9	36	2	0.05	0	40	0	0	0	0	0	0	14	0	0	0	0
	10 to 16	37	2	0.05	0	40	0	0	0	0	0	0	14	0	0	0	0
	17 to 23	38	3	0.05	0	40	0	0	0	0	0	0	14	0	0	0	0
	24 to 30	39	3	0.05	0	40	0	0	0	0	0	0	14	0	0	0	0
October	1 to 7	40	7	0.1	0	18	0	0	0	0	0	0	6	0	0	0	0
	8 to 14	41	13	0.1	0	18	0	1	0	0	1	0	6	0	0	0	0
	15 to 21	42	18	0.1	0	18	0	1	0	0	1	0	6	0	0	0	0
	22 to 28	43	20	0.3	0	18	0	4	0	0	4	0	6	0	0	0	0
	29 to 4	44	25	0.3	0	18	0	5	0	0	5	0	6	0	0	0	0
November	5 to 11	45	30	0.5	0	0	0	10	0	0	10	0	0	10	0	10	0
	12 to 18	46	35	0.5	0	0	0	12	0	0	12	0	0	12	10	22	0
	19 to 25	47	40	0.5	0.1	0	118	13	0	300	313	125	0	188	22	210	0
	26 to 2	48	50	0.5	0.1	0	173	17	0	300	317	182	0	135	210	345	0
December	3 to 9	49	42	0.6	0.2	13	213	17	0	300	317	224	5	88	345	433	0
	10 to 16	50	25	0.6	0.3	13	138	10	0	0	10	144	5	−138	433	295	0
	17 to 23	51	15	0.7	0.3	13	124	7	0	0	7	130	5	−128	295	167	0
	24 to 31	52	12	0.7	0.4	13	128	6	0	300	306	133	5	169	167	336	0
January	1 to 7	1	12	0.8	0.4	31	131	6	0	300	306	138	11	158	336	494	0
	8 to 14	2	11	0.8	0.4	31	135	6	0	0	6	142	11	−146	494	347	0
	15 to 21	3	10	0.8	0.3	31	137	5	0	0	5	144	11	−149	347	198	0
	21 to 28	4	9	0.8	0.3	31	140	5	0	300	305	147	11	147	198	345	0
	29 to 4	5	9	0.8	0.3	31	145	5	0	300	305	153	11	141	345	486	0
February	5 to 11	6	6	0.6	0.3	40	147	3	0	0	3	154	14	−165	486	321	0
	12 to 18	7	7	0.6	0.2	40	147	3	0	0	3	154	14	−165	321	155	0
	19 to 25	8	0	0.6	0.2	40	142	0	0	300	300	150	14	136	155	292	0
	26 to 4	9	0	0.6	0.2	40	93	0	0	0	0	98	14	−112	292	180	0
March	5 to 11	10	0	0.4	0.2	43	44	0	0	0	0	46	15	−61	180	119	0
	12 to 18	11	0	0.4	0.2	43	0	0	0	0	0	0	15	−16	119	104	0
	19 to 25	12	10	0.4	0	43	0	3	0	0	3	0	15	−12	104	92	0
	26 to 1	13	28	0.4	0	43	0	8	0	0	8	0	15	−7	92	84	0
							2151	147	0	2400	2547	2264	274				0

Table 3.2.15.(b): Water Balance for EIS Tanks (Wet)

Name : Panragamuwa (wet) — Season: 1992/1993 Maha
Catchment Area: 0.32 Aq.Mls. — Service area 580 Acs. — MOL Capacity 93 Acft
New Area above: 0 Acs. — Area at MOL 106 Acs. — FSL Capacity 817 Acft

Week No.1 Starts from 1st January

Month	Dates	Week	Ex.Rain mm/week	RF Cf.	Dr.Cf.	Eva.mm/ week	Water Demand Acft	Inflows Rain Acft	Drain. Acft	Reser. Acft	Total Acft	Outflows Sluice Acft	Evapo Acft	F-OF Acft	Capacity Start Acft	End Acft	Spill
September	3 to 9	36	7	0.05	0	40	0	0	0	0	0	0	14	0	0	0	0
	10 to 16	37	8	0.05	0	40	0	0	0	0	0	0	14	0	0	0	0
	17 to 23	38	10	0.05	0	40	0	0	0	0	0	0	14	0	0	0	0
	24 to 30	39	14	0.05	0	40	0	0	0	0	0	0	14	0	0	0	0
October	1 to 7	40	14	0.1	0	18	0	1	0	0	1	0	6	0	0	0	0
	8 to 14	41	25	0.1	0	18	0	2	0	0	2	0	6	0	0	0	0
	15 to 21	42	40	0.1	0	18	0	3	0	0	3	0	6	0	0	0	0
	22 to 28	43	46	0.3	0	18	0	9	0	0	9	0	6	3	0	3	0
	29 to 4	44	50	0.3	0	18	0	10	0	0	10	0	6	4	3	7	0
November	5 to 11	45	54	0.5	0	0	0	18	0	0	18	0	0	18	7	25	0
	12 to 18	46	54	0.5	0	0	0	18	0	0	18	0	0	18	25	43	0
	19 to 25	47	41	0.5	0.1	0	119	14	0	300	314	125	0	189	43	232	0
	26 to 2	48	45	0.5	0.1	0	173	15	0	300	315	182	0	133	232	365	0
December	3 to 9	49	37	0.6	0.2	13	213	15	0	0	15	224	5	−214	365	151	0
	10 to 16	50	33	0.6	0.3	13	136	13	0	300	313	144	5	165	151	316	0
	17 to 23	51	35	0.7	0.3	13	124	16	0	300	316	130	5	182	316	498	0
	24 to 31	52	36	0.7	0.4	13	128	17	0	0	17	133	5	−120	498	378	0
January	1 to 7	1	28	0.8	0.4	31	131	14	0	0	14	138	11	−135	378	243	0
	8 to 14	2	25	0.8	0.4	31	135	13	0	300	313	142	11	161	243	404	0
	15 to 21	3	20	0.8	0.3	31	137	11	0	300	311	144	11	156	404	560	0
	21 to 28	4	18	0.8	0.3	31	140	10	0	0	10	147	11	−148	560	412	0
	29 to 4	5	19	0.8	0.3	31	145	10	0	0	10	153	11	−153	412	259	0
February	5 to 11	6	13	0.8	0.3	40	147	5	0	300	305	154	14	137	259	395	0
	12 to 18	7	16	0.6	0.2	40	147	6	0	300	306	154	14	138	395	533	0
	19 to 25	8	14	0.6	0.2	40	142	6	0	0	6	150	14	−158	533	376	0
	26 to 4	9	16	0.6	0.2	40	93	6	0	0	6	98	14	−106	376	270	0
March	5 to 11	10	18	0.4	0.2	43	44	4	0	0	4	46	15	−57	270	213	0
	12 to 18	11	17	0.4	0.2	43	0	5	0	0	5	0	15	−10	213	203	0
	19 to 25	12	18	0.4	0	43	0	5	0	0	5	0	15	−10	203	193	0
	26 to 1	13	22	0.4	0	43	0	6	0	0	6	0	15	−9	193	184	0
							2151	254	0	2400	2654	2264	274				0

Table 3.2.16.(a): Water Balance for EIS Tanks (Dry)

Name : Weerawila (dry)
Catchment Area: 28.3 Sq.Mls. Area at MOL 869 Acs.
New Area above: 0 Acs. Service area 2300 Acs.
Season: 1992/1993 Maha
MOL Capacity 3966 Acft.
FSL Capacity 11083 Acft.

Week No.1 Starts from 1st January

Month	Dates	Week	Ex.Rain mm/week	RF Cf.	Dr.Cf.	Eva.mm/week	Water Demand Acft	Inflows Rain Acft	Drain. Acft	Reser. Acft	Total Acft	Outflows Sluice Acft	Evapo Acft	F-OF Acft	Capacity Start Acft	End Acft	Spill
September	3 to 9	36	2	0.05	0	40	0	6	0	0	6	0	114	0	0	0	0
	10 to 16	37	2	0.05	0	40	0	6	0	0	6	0	114	0	0	0	0
	17 to 23	38	3	0.05	0	40	0	9	0	0	9	0	114	0	0	0	0
	24 to 30	39	3	0.05	0	40	0	9	0	0	9	0	114	0	0	0	0
October	1 to 7	40	7	0.1	0	18	0	42	0	0	42	0	51	0	0	0	0
	8 to 14	41	13	0.1	0	18	0	77	0	0	77	0	51	26	0	26	0
	15 to 21	42	18	0.1	0	18	0	107	0	0	107	0	51	56	26	82	0
	22 to 28	43	20	0.3	0	18	0	357	0	0	357	0	51	305	82	387	0
	29 to 4	44	25	0.3	0	18	0	446	0	0	446	0	51	394	387	781	0
November	5 to 11	45	30	0.5	0	0	0	891	0	0	891	0	0	891	781	1672	0
	12 to 18	46	35	0.5	0	0	0	1040	0	0	1040	0	0	1040	1672	2712	0
	19 to 25	47	40	0.5	0.1	0	488	1188	0	0	1188	513	0	675	2712	3388	0
	26 to 2	48	50	0.5	0.1	0	710	1486	0	0	1486	747	0	738	3388	4126	0
December	3 to 9	49	42	0.6	0.2	13	875	1497	0	0	1497	921	37	539	4126	4665	0
	10 to 16	50	25	0.6	0.3	13	560	891	0	0	891	590	37	264	4665	4929	0
	17 to 23	51	15	0.7	0.3	13	508	624	0	0	624	535	37	52	4929	4981	0
	24 to 31	52	12	0.7	0.4	13	517	486	0	0	486	544	37	0	4981	4981	0
January	1 to 7	1	12	0.8	0.4	31	539	570	0	0	570	567	88	0	4981	4981	0
	8 to 14	2	11	0.8	0.4	31	553	523	0	0	523	582	88	0	4981	4981	0
	15 to 21	3	10	0.8	0.3	31	561	475	0	0	475	591	88	0	4981	4981	0
	21 to 28	4	9	0.8	0.3	31	575	428	0	0	428	605	88	0	4981	4981	0
	29 to 4	5	9	0.8	0.3	31	596	428	0	0	428	628	88	0	4981	4981	0
February	5 to 11	6	8	0.6	0.3	40	603	285	0	0	285	634	114	0	4981	4981	0
	12 to 18	7	7	0.6	0.2	40	602	250	0	0	250	634	114	0	4981	4981	0
	19 to 25	8	0	0.6	0.2	40	584	0	0	0	0	614	114	0	4981	4981	0
	26 to 4	9	0	0.6	0.2	40	382	0	0	0	0	402	114	0	4981	4981	0
March	6 to 11	10	0	0.4	0.2	43	180	0	0	0	0	190	123	0	4981	4981	0
	12 to 18	11	0	0.4	0.2	43	0	0	0	0	0	0	123	0	4981	4981	0
	19 to 25	12	10	0.4	0	43	0	238	0	0	238	0	123	116	4981	5096	0
	26 to 1	13	26	0.4	0	43	0	686	0	0	686	0	123	543	5096	5639	0
							8833	13037	0	0	13037	9288	2249				0

Table 3.2.16.(b): Water Balance for EIS Tanks (Wet)

Name : Weerawila (wet)
Catchment Area: 28.3 Sq.Mls. Area at MOL 869 Acs.
New Area above: 3184 Acs. Service Area 2300 Acs.
Season: 1992/1993 Maha
MOL Capacity 3966 Acft
FSL Capacity 11083 Acft

Week No.1 Starts from 1st January

Month	Dates	Week	Ex.Rain mm/week	RF Cf.	Dr.Cf.	Eva.mm/week	Water Demand Acft	Inflows Rain Acft	Drain. Acft	Reser. Acft	Total Acft	Outflows Sluice Acft	Evapo Acft	F-OF Acft	Capacity Start Acft	End Acft	Spill
September	3 to 9	36	7	0.05	0	40	0	21	0	0	21	0	114	0	0	0	0
	10 to 16	37	8	0.05	0	40	0	24	0	0	24	0	114	0	0	0	0
	17 to 23	38	10	0.05	0	40	0	30	0	0	30	0	114	0	0	0	0
	24 to 30	39	14	0.05	0	40	0	42	0	0	42	0	114	0	0	0	0
October	1 to 7	40	14	0.1	0	18	0	83	0	0	83	0	51	32	0	32	0
	8 to 14	41	25	0.1	0	18	0	149	0	0	149	0	51	97	32	129	0
	15 to 21	42	40	0.1	0	18	0	238	0	0	238	0	51	188	129	315	0
	22 to 28	43	46	0.3	0	18	0	820	0	0	820	0	51	769	315	1084	0
	29 to 4	44	50	0.3	0	18	0	891	0	0	891	0	51	840	1084	1924	0
November	5 to 11	45	54	0.5	0	0	0	1604	0	0	1604	0	0	1604	1924	3529	0
	12 to 18	46	54	0.5	0	0	0	1604	0	0	1604	0	0	1604	3529	5133	0
	19 to 25	47	41	0.5	0.1	0	488	1218	69	0	1287	513	0	774	5133	5907	0
	26 to 2	48	45	0.5	0.1	0	710	1337	97	0	1434	747	0	687	5907	6594	0
December	3 to 9	49	37	0.6	0.2	13	875	1319	224	0	1543	921	37	584	6594	7178	0
	10 to 16	50	33	0.6	0.3	13	560	1177	288	0	1465	590	37	838	7178	8016	0
	17 to 23	51	35	0.7	0.3	13	508	1456	282	0	1738	535	37	1166	8016	9182	0
	24 to 31	52	36	0.7	0.4	13	517	1497	389	0	1886	544	37	1305	9182	10487	0
January	1 to 7	1	28	0.8	0.4	31	539	1236	405	0	1641	567	88	986	10487	11083	389
	8 to 14	2	25	0.8	0.4	31	553	1188	426	0	1615	582	88	945	11083	11083	945
	15 to 21	3	20	0.8	0.3	31	561	851	332	0	1283	591	88	604	11083	11083	604
	21 to 28	4	18	0.8	0.3	31	575	856	338	0	1194	605	88	501	11083	11083	501
	29 to 4	5	19	0.8	0.3	31	596	903	345	0	1248	628	88	532	11083	11083	532
February	5 to 11	6	13	0.6	0.3	40	603	463	345	0	808	634	114	60	11083	11083	60
	12 to 18	7	18	0.6	0.2	40	602	570	234	0	804	634	114	57	11083	11083	57
	19 to 25	8	14	0.6	0.2	40	584	499	232	0	731	614	114	3	11083	11083	3
	26 to 4	9	16	0.6	0.2	40	382	570	215	0	786	402	114	270	11083	11083	270
March	5 to 11	10	16	0.4	0.2	43	180	380	115	0	495	190	123	183	11083	11083	183
	12 to 18	11	17	0.4	0.2	43	0	404	48	0	452	0	123	330	11083	11083	330
	19 to 25	12	18	0.4	0	43	0	428	0	0	428	0	123	305	11083	11083	306
	26 to 1	13	22	0.4	0	43	0	523	0	0	523	0	123	400	11083	11083	400
							8833	22483	4384	0	26867	9288	2249				4577

Table32.17. Water Balance for EIS Tanks

Name : Gamunupura (wet and dry)
Season: 1992/1993 Maha
Catchment Area: 0 Sq.mls
Service area 450 Acs.
New Area above: 0 Acs.
Area at MOL. 0 Acs
MOL Capacity 0 Acs.
FSL Capacity 0 Acs.

Week No.1 Starts from 1st January

Month	Dates	Week	Ex.Rain mm/week	RF Cf.	Dr.Cf.	Eva.mm/week	Water Demand Acft	Inflows Rain Acft	Drain. Acft	Reser. Acft	Total Acft	Outflows Sluice Acft	Evapo. Acft	F-OF Acft	Capacity Start Acft	End Acft	Spill
September	3 to 9	36	2	0.05	0	40	0	0	0	0	0	0	0	0	0	0	0
	10 to 16	37	2	0.05	0	40	0	0	0	0	0	0	0	0	0	0	0
	17 to 23	38	3	0.05	0	40	0	0	0	0	0	0	0	0	0	0	0
	24 to 30	39	3	0.05	0	40	0	0	0	0	0	0	0	0	0	0	0
October	1 to 7	40	7	0.1	0	18	0	0	0	0	0	0	0	0	0	0	0
	8 to 14	41	13	0.1	0	18	0	0	0	0	0	0	0	0	0	0	0
	15 to 21	42	18	0.1	0	18	0	0	0	0	0	0	0	0	0	0	0
	22 to 28	43	20	0.3	0	18	0	0	0	0	0	0	0	0	0	0	0
	29 to 4	44	25	0.3	0	18	0	0	0	0	0	0	0	0	0	0	0
November	5 to 11	45	30	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
	12 to 18	46	35	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
	19 to 25	47	40	0.5	0.1	0	95	0	0	100	100	100	0	0	0	0	0
	26 to 2	48	50	0.5	0.1	0	139	0	0	146	146	146	0	0	0	0	0
December	3 to 9	49	42	0.6	0.2	13	171	0	0	180	180	180	0	0	0	0	0
	10 to 16	50	25	0.6	0.3	13	110	0	0	115	115	115	0	0	0	0	0
	17 to 23	51	15	0.7	0.3	13	99	0	0	105	105	105	0	0	0	0	0
	24 to 31	52	12	0.7	0.4	13	101	0	0	107	107	107	0	0	0	0	0
January	1 to 7	1	12	0.8	0.4	31	106	0	0	111	111	111	0	0	0	0	0
	8 to 14	2	11	0.8	0.4	31	108	0	0	114	114	114	0	0	0	0	0
	15 to 21	3	10	0.8	0.3	31	110	0	0	116	116	116	0	0	0	0	0
	21 to 28	4	9	0.8	0.3	31	112	0	0	118	118	118	0	0	0	0	0
	29 to 4	5	9	0.8	0.3	31	117	0	0	123	123	123	0	0	0	0	0
February	5 to 11	6	8	0.6	0.3	40	118	0	0	124	124	124	0	0	0	0	0
	12 to 18	7	7	0.6	0.2	40	118	0	0	124	124	124	0	0	0	0	0
	19 to 25	8	0	0.6	0.2	40	114	0	0	120	120	120	0	0	0	0	0
	26 to 4	9	0	0.6	0.2	40	75	0	0	79	79	79	0	0	0	0	0
March	5 to 11	10	0	0.4	0.2	43	35	0	0	37	37	37	0	0	0	0	0
	12 to 18	11	0	0.4	0.2	43	0	0	0	0	0	0	0	0	0	0	0
	19 to 25	12	10	0.4	0	43	0	0	0	0	0	0	0	0	0	0	0
	26 to 1	13	28	0.4	0	43	0	0	0	0	0	0	0	0	0	0	0
							1728	0	0	1819	1819	1819	0				0

Table 3.2.18. Water Release Plan for the EIS Tanks

Season 1992/1993 Maha with a very little extent cultivated in tho new area

Month	Dates	Week	Water release from Lunugamvehera						
			Pannegamuwa	Weerawila	Oebarawewa	Tissawewa	Yodawewa	Gamunupura	Total
September	3 to 9	36	0	0	0	0	0	0	0
	10 to 18	37	0	0	0	0	0	0	0
	171023	38	0	0	0	0	0	0	0
	24 to 30	39	0	0	0	0	0	0	0
October	1 to 7	40	0	0	0	0	0	0	0
	8 to 14	41	0	0	0	0	0	0	0
	15 to 21	42	0	0	0	0	0	0	0
	22 to 28	48	0	0	0	0	0	0	0
	28 to 4	44	0	0	0	0	0	0	0
November	5 to 11	45	0	0	0	0	0	0	0
	1210 18	46	0	0	0	0	0	0	0
	19 to 25	47	300	0	400	300	0	100	1100
	28 to 2	48	300	0	400	300	0	150	1150
December	3 to 8	49	300	0	300	700	0	180	1480
	10 to 16	50	0	0	300	700	0	120	1120
	17 to 23	51	0	0	300	700		110	1110
	24 to 31	52	300	0	300	700		110	1710
January	1 to 7	1	300	0	300	800		110	1810
	8 to 14	2	0	0	300	900		120	1620
	16 to 21	3	0	0	200	800		120	1720
	21 to 28	[illegible]	300	0	300	1400		120	2820
	29 to 4	5	300	0	200	1400		130	2730
February	5 to t t	6	0	0	200	1400		130	2430
	12 to 18	7	0	0	200	1400	800	130	2530
	19 to 25	8	300	0	200	1500	800	120	2920
	28 to 4	9	0	0	200	1500	800	80	2680
March	6 to 11	10	0	0	0	500		40	740
	12 to 18	11	0	0	0	0	200	0	200
	19 to 25	12	0	0	0	0		0	0
	28 to 1	13	0	0	0	0	0	0	0
									0
Total			2400	0	41010	15200	6500	1830	23530

Note: Since the Yodawewa inflows are not directly from Lunugamvehera the total values in this table exclude those inflows.
These values are accounted for in the Tissa inflows.

Table 3.2.19. Water Release Plan for the EIS Tanks

Season 1992/1993 Maha with full extent cultivated in the new area

Month	Dates	Week	Water release from Lunugamvehera						
			Pannegamuwa	Weerawila	Debarawewa	Tissawewa	Yodawawa	Gamunupura	Total
September	3 to 9	36	0	0	0	0	0	0	0
	10 to 16	37	0	0	0	0	0	0	0
	17 to 23	38	0	0	0	0	0	0	0
	24 to 30	39	0	0	0	0	0	0	0
October	1 to 7	40	0	0	0	0	0	0	0
	8 to 14	41	0	0	0	0	0	0	0
	15 to 21	42	0	0	0	0	0	0	0
	22 to 28	43	0	0	0	0	0	0	0
	28 to 4	44	0	0	0	0	0	0	0
November	5 to 11	45	0	0	0	0	0	0	0
	12 to 18	46	0	0	0	0	0	0	0
	19 to 25	47	300	0	300	0	0	100	700
	28 to 2		300	0	300	200	0	150	950
December	3 to 9	49	0	0	400	400	0	180	980
	10 to 16	50	300	0	300	300	0	120	1020
	17 to 23	51	300	0	300	300	0	110	1010
	24 to 31	52	0	0	300	200	0	110	610
January	1 to 7	1	0	0	200	200	0	110	510
	8 to 14	2	300	0	200	200	0	120	820
	15 to 21	3	300	0	200	400	0	120	1020
	21 to 28	4	0	0	300	400	0	120	820
	29 to 4	5	0	0	300	500	0	130	830
February	5 to 11	6	300	0	200	500	0	130	1130
	12 to 18	7	300	0	200	600	0	130	1230
	19 to 25	8	0	0	200	800	0	120	920
	26 to 4	9	0	0	0	300	0	80	380
March	5 to 11	10	0	0	0	100	0	40	140
	12 to 18	11	0	0	0	0	0	0	0
	19 to 25	12	0	0	0	0	0	0	0
	28 to 1	13	0	0	0	0	0	0	0
								0	0
Total			2400	0	3700	5200	0	1870	13170

Note: Since Yodawewa inflows are not directly from Lunugamvehera the total value in this table excludes those inflows. These values are accounted in Tissawewa inflow.

Subsystem	Water release (acft)		Spillage (acft	
Pannegamuwa	2400	2400	0	0
Weerawila	0	0	0	4577
Debara wewa	4100	3700	0	0
Tissa wewa	8700	5200	0	0
Yoda wewa	6500	0	0	0
Gamunupura	1870	1870	0	0
Total	23570	13170	0	4577

Operation of the Ellegala Tanks During Yala 1992

At the end of the maha 1991/92 season, all the **tanks** in the Ellegala except the Weerawila were empty. Drainage water from Tracts 1 and 2 of the **RB** and the catchment of the Weerawila Tank filled the Weerawila to full supply level by the end of maha 1991/92. The tank started spilling in mid February.

The period from March to August is generally regarded as the yala season. The dry weather which had prevailed during the latter part of the previous maha season continued during yala 1992. Table **3.2.21,** in which rainfall for the two previous maha seasons is compared with that of yala 1992, indicates that rainfall during maha 1991/92 and yala 1992 was low. Table **3.2.22** and Figure **3.2.14** show that there was no rain during February and March 1992.

Table **3.2.21.** Total rainfall for seasons.

Year	Season	
1990	351.4	-
1990/91	-	839.5
1991	366.9	-
1991/92	-	676.6
1992	235.6	-

[a] March, April, May, June, July and August
[b] September, October, November, December, January and February

Table **3.2.22.** Weerawila Agricultural Research Station monthly total rainfall.

Month	1990	1991	1992
January	106.1	142.0	17.1
February	8.9	16.3	0.0
March	101.6	7.6	0.0
April	161.3	63.8	73.9
May	71.2	122.5	119.3
June	17.3	103.3	17.9
July	0.0	27.4	13.3
August	0.0	42.3	11.2
September	59.6	18.2	54.8
October	8.2	145.0	63.0
November	286.1	277.5	391.9 ~~391.9~~
December	327.3	218.8	98.6
Total	1147.6	1184.7	861.0

In spite of the ID warning that water in the reservoir was not sufficient for cultivating a yala paddy crop in the whole of the Ellegala, some prominent FRs from the system mislead farmers into thinking there was sufficient water for a yala paddy crop. As farmers wanted to take the risk and cultivate paddy, the decision was made on 1 May 1993 to issue water.

Data on discharges from the main reservoir show that 13,308 acft of water, 32 percent of total issues during the yala season, was issued to the RB. The LB received 428 acft for other field crops during this period. The remaining 27,542 acft of water consisting of 67 percent of total volume was issued to the Ellegala Irrigation System.

Water in the tanks in the Ellegala was used by farmers in an attempt to save crops in the face of severe water scarcity during yala 1992, In spite of this, yala 1992 was a season of crop failure. It must be mentioned at this stage that data on the storage capacity of the Ellegala tanks were not accurate due to the heavy sedimentation of the tanks. Though readings of water levels in the tanks gave a somewhat higher estimate of water available and actually available was very much less.

Storage figures for the Lunugamvehera Reservoir from 1 January to 23 February are given in **Table 3.2.23**. The water situation in the main reservoir during yala 1992 is given in **Table 3.2.24. As** indicated in **Table 3.2.24,** the water level in the main reservoir at the beginning of March was 162.5 ft (15,423 acft). Water issues for the late maha paddy crop in the RB and for other field crops in Tract 3 **of** the LB continued until 10 May 1992. **A** portion of the inflow received by the reservoir during yala 1992, as shown in **Figures 3.2.15,** was used for this purpose.

Date	Water Level (ft)	Water Issues		
		RB (acft)	LB (acft)	Ellegala (acft)
4 January	170.7	4821	2994	0
14 January	169.5	5510	1711	0
24 January	168.1	5057	865	0
3 February	166.7	4869	216	0
13 February	165.1	4316	220	0
23 February	163.7	3317	182	0
Total		27890	6188	0

Yala 1992 and the plight of the Ellegala farmers highlighted the necessity for re-establishing stage-capacity and stage-area curves for the Ellegala tanks. It was also realized, after water balancing based **on** available stage-capacity relations had been done, that they were not suitable for estimating drainage contributions from the newly developed area and surface runoffs from their own catchments. **A** column had to be introduced in the Water Balance Sheet to indicate error in balancing.

Conveyance Losses in the Ellegala Feeder Canals

Due to the dry weather which prevailed during this period, conveyance losses were high. When water issues from the main reservoir and total water received by the Ellegala System for the season are compared **(Table 3.2.25)**, a total loss of 4,053 acft (15 **per** cent) **is** observed. Drainage and runoff contributions to feeder canals kept values at,a somewhat low level.

Table 3.2.24 Lunugamwehera Water Levels and Issues
March To End of July 1992

Date	Water level ft	Issues RB acft	LB acft	Ellagala acft
04–Mar	162.5	2895	125	–
14–Mar	161.4	2934	81	–
24–Mar	160.0	2562	222	–
03–Apr	159.0	2356	0	–
13–Apr	158.0	1226	0	224
23–Apr	159.0	917	0	2081
03–May	159.8	418	0	2723
13–May	160.3	0	0	3572
23–May	159.9	0	0	3960
02–Jun	158.8	0	0	4047
12–Jun	156.9	0	0	3936
22–Jun	155.9	0	0	2297
02–Jul	154.0	0	0	1287
12–Jul	153.5	0	0	2970
22–Jul	152.1	0	0	446
Total		13308	428	27542
Issues %		32	1	**67**

Table 3.2.25 Conveyance Losses in Feeder Canals in EIS
1992 Yala

Date	Water Issued to Ellegala acft	mount re(lved to EIS FC–LB acft	FC – RB acft	Total acft	Conveyence Losses in EIS acft
04–Mar	–	–	–	–	–
14–Mar	–	–	–	–	–
24–Mar	–	–	–	–	–
03–Apr	–	–	–	–	–
13–Apr	224	–	–	–	224
23–Apr	2081	202	1041	124:	838
03–May	2723	2314	50	236‹	359
13–May	3572	3175	137	331'	261
23–May	3960	3171	173	334:	617
02–Jun	4047	4785	285	507(	–1023
12–Jun	3936	4303	422	472!	–789
22–Jun	2297	1282	182	146!	832
02–Jul	1287	289	38	32/	960
12–Jul	2970	1305	195	150(	1470
22–Jul	446	122	19	14'	305
Total	27542	20947	2541	2348!	4053
		Losses %			15

Weerawila Wewa

When Weerawila farmers started cultivation on 1 March 1992, the tank was spilling. The last date of water issue to the command area was 30 June 1992, according to decisions made at the Kanna meeting. Although Weerawila farmers did not face a severe water shortage, they were not able to manage with tank water alone and had to be supplemented with 1,940 acft of water. This included leakage from the Pannegamuwa feeder canal and 750 acft issued to the tank toward the end of the season on the request of FRs. The behavior of feeder canal inflow can be observed in Figure **3.2.16.** Table **3.2.26** and Figure **3.2.16** indicate water balances for the Weerawila during the season.

A total of 137 acft of water was spilling from the tank at the beginning of the season. The hydrography for the Weerawila main canal shown in Figure **3.2.16** indicates the pattern of water issues and indicates high discharge at the beginning and at the end of the season. Rain during the latter part of April and early May was the key factor for reduced discharge.

Table **3.2.26.** Summary.

Tank/ Scheme	Water issuing		Rainfall	Evapo-ration	Feeder canal supply (acft)	Tank issues (acft)	Tank Releases (acft)	Losses (acft)	Spilling (acft)	Error balance (acft)
Weerawila	1 Mar '92	10 Jul '92	224	891	1940	12838		22542	137	2906
Pannegamuwa	23 Apr '92	23 Jul '92	182	591	2541	1581	1940	226		1011
Debara wewa	5 May '92	23 Jul '92	182	591	3680	3332		184		165
Tissa wewa	10 May '92	23 Jul '92	182	591	16278	3825	5898	278		6278
Gamunupura	23 Apr '92	23 Jul '92			988					

Pannegamuwa Wewa

The Pannegamuwa wewa received water from the Lunugamvehera on 23 April to start yala cultivation before the other four subsystems. Though water issues continued until 2 August, cultivation suffered due to severe water scarcity during the latter part of July (Figure **3.2.17**). The Pannegamuwa wewa is heavily silted up and farmers had to dig canals in the tank bed to move water remaining in some parts of the tank to the sluice gate. Figure **3.2.17** shows that the water level dropped below the MOL.

The hydrography of discharges in Figure **3.2.17** shows that farmers attempted to save water by closing the canal for several days towards the end of the season. The Water Balance Sheet in Table **3.2.26** shows that 1,581 acft of water was issued to the command area. The tank released

Table 3.2.26 shows that 1,581 acft of water was issued to the command area. The tank released 1,940 acft to the Weerawila Tank during the season. A relatively high error balance was obtained in this tank compared to the other tanks (Table 3.2.26).

Debaru Wewa

When water issues to the command area were made on 5 May 1992, the water level in the tank was below MOL. This tank was supplemented with water from the Lunugamvehera until the end of the yala season. Attempts by farmers to save water by closing the tank sluice for long periods is evident from the hydrography (Figure 3.2.18).

Tissa Wewa

The water level in the Tissa wewa was a little above MOL when water issues started. As water is supplied to the Yoda wewa via the Tissa wewa spillway, the Water Balance Sheet shows that the highest supply through feeder canals was made to the Tissa wewa. The hydrography in Figure 3.2.19 shows that water releases were made from the Tissa wewa until the last week of June. The hydrography also shows that Tissa wewa farmers implemented strict rotations by closing the sluice gates of the tank for long periods. It can also be observed from Table 3.2.26 that the Tissa wewa has the highest error balance for the 1992 yala season. The tank released 5,898 acft of water to the Yoda wewa.

Yoda Wewu

The Yoda wewa is the tailmost tank in the Ellegala LB System, Water supply to this tank is made via the Tissa wewa spill canal. Because of this, the Tissa wewa has to fill to at least nine feet in order to make water issues to the Yoda wewa. The Yoda wewa also received water from the Lunugamvehera when water issues were initially made to the four tanks and Gamunupura. The tank could not receive a substantial quantity of water when issues were made for the second time with the State Secretary's approval because the water level in the Tissa wewa had dwindled in July. From the beginning to the end of water issues, water levels in the tank were below MOL (Figure 3.2.20).

Gamunupura Scheme

The Gamunupura Scheme is located on the LB Feeder Canal of the Ellegala Anicut. Since it does not have a storage tank, it is fed directly from the Ellegala Anicut through a canal network and is supplied with water only when the LB Feeder Canal has water in it. During yala 1992, farmers in Gamunupura cultivated paddy for which they were issued 988 acft of water (Figure 3.2.21).

Ellegala **Tank** Operation During Maha 1992/93

Planning *for* Malta *1992/93*

The yala 1992 crop failure experienced by Ellegala farmers due to water shortage raised serious questions concerning the efficacy of the whole process of seasonal agricultural decision-making at the Project Management Committee (PMC). This incident demanded that a more rational planning process for water allocation be designed and also that guidelines be developed for the operation of the system. Moreover, the FRs did not agree to the recommendation of the Ministry level committee which had been looking into the water problems in the whole system and also into conflicts over water rights between the new and old system farmers. All these incidents resulted in establishing of a project level TC comprising the project level higher officers of the ID, the DOA, the IMD and IIMI to make specific recommendations on crop planning and seasonal water allocations to the subsystems. The committee held several meetings before maha 1992/93 to design a comprehensive agricultural plan for the season which was finally discussed at the PMC to arrive at a decision on implementation.

The guidelines proposed by the TC included, among other recommendations, that before the commencement of each maha season, the Lunugamvehera reservoir should have at least 10,000 acft of water above MOL. In addition, the TC recommended that the five **tanks** in Ellegala should reach their MOLs with the runoff from their local catchments.

The agricultural plan prepared by the TC is based on a number of assumptions with regard to probabilities of rainfall, inflow and water availability in the reservoir during any particular period of a year. According to these calculations, the main reservoir and the five **tanks** in the **EIS** normally reach their desired water level during mid November before they can be thrown open for irrigation. The plan also recommended the allocation of 25,000 acft of water from the Lunugamvehera reservoir to the EIS for cultivating its entire extent with paddy during maha 1992193.

At the beginning of September 1992, the water level in the Lunugamvehera reservoir had dropped to **151.8** ft above minimum spill level (MSL) (the sill level of the outlet sluice is **150** ft above MSL and most of the EIS **tanks** were empty as a result of attempts made to save the 1992 yala crop. Also the rainfall during September and October 1992 was less than anticipated (55 and 64 mm respectively). **As** a result, the PMC could not make a decision in advance with regard to commencement of the seasonal agricultural activities even though they had decided the areas of priority to receive water and the cropping plan for the subsystems. With tne onset of rain, the Ellegala farmers started complaining that their cultivation season had already been delayed and requested that water issues be made to their system without waiting until their **tanks** reached MOLs. In response to this, the PMC which met on 10 November 1992 decided to issue water to the EIS after holding a cultivation meeting in the old **tank** area. The cultivation calendar agreed upon at the Kanna meeting is given in Table 3.2.27.

Table 3.2.27. Cultivation dates for 1992/93 Maha Ellegala Irrigation System.

Tank	Date of start	Date of end
Debarawewa	15 Nov '92	15 Mar '93
Tissawewa	20 Nov '92	20 Mar '93
Yodawewa	20 Nov '92	20 Mar '93
Weerawila	20 Nov '92	20 Mar '93
Pannegamuwa	16 Nov '92	11 Mar '93
Gamunupura	20 Nov '92	20 Mar '93

A depression in the Bay of Bengal brought heavy rains to the reservoir catchment as well as to the catchment of the five tanks, bringing the tank water levels closer to their MOLs after the first week of November. This situation enabled the farmers to start the maha cultivation from mid November 1992.

Water Issue from Lunugamvehem Reservoir

The 10-day daily water issued from Lunugamvehera reservoir during maha 1992/93 is presented in **Table 3.2.28.** Along with this, the flow received at the feeder canal, the accretion/losses within the section from reservoir to feeder canal and 10-daily rainfall are also included. It is interesting to note the following:

i) The accretion due to drainage and rainfall runoff is more than the Lunugamvehera reservoir release and in terms of percentage of release from the Lunugamvehera it is 140 percentage.

ii) Comparing the rainfall and drainage flow pattern, most of the contributions is from drainage water (rainfall is concentrated only in November and drainage contribution is less in that period compared to the other periods).

iii) There is a lag of about one month before a steady drainage is established. The 10-day daily average steady drainage flow works out to about 3400 acft.

Table 3.2.28. Issues from Lunugamvehera Reservoir to Ellegala Irrigation System: 1992/93 Maba season.

Date (10 days)	Rainfall (mm)	Issued from Lunugamvehera LBMC (acft)	Ellegala Irrigation System	
			Received in Feeder Canals (acft)	Conveyance Losses (acft)
15 Nov	82	3465	3737	-272
25 Nov	114	2526	3138	-611
5 Dec	18	780	708	72
15 Dec	22	873	400	474
25 Dec	19	1281	1710	-429
4 Jan	24	59	3016	2957
14 Jan	0	0	2713	-2713
24 Jan	7	1188	4857	-3669
3 Feb	0	1818	3153	-1335
13 Feb	0	1780	6170	-4390
23 Feb	8	1901	3179	-1278
5 Mar	45	1764	3817	-2053
15 Mar	18	30	2602	-2572
25 Mar	0	0	2789	-2789
Total	357	17466	41988	-24522

Water Balancing of EIS Tanks

The water balancing of EIS tanks for the maha 1992/93 is presented in **Table 3.2.29**. The drainage and rainfall runoff of contribution in terms of Lunugamvehera reservoir release works out to 233 percent. The tank water level variations and inflow-outflow details are presented in **Figures 3.2.22 to 3.2.32.**

Ellegala Irrigation System Duty

An analysis of water duty for the 1992/93 maha is given in **Table 3.2.30**. The highest duty of 5.65 acft/acre was observed in the Weerawila wewa. The duty in the Debara wewa was also on the high side when compared to the other tanks. This pattern is generally observed in the Ellegala Irrigation System. The overall duty is 3.24 acft/acre with 1.17 ft of rainfall for the season, while the figure for the previous season was 3.1 acft per acre with rainfall of 1.83 ft.

Table 3.2.29. Balancing of Ellegala Irrigation System,

	Command area (ac)	Inflows to tank		Outflows from tanks				Balance (acft)
Ellegala RB System		Feeder (acft)	Drainage (acft)	Main canal (acft)	Release (acft)	Spill (acft)	Losses (acft)	
Pannegamuwa wewa	560	3450	5373	1525	6742	0	273	283
Weerawila wewa	2301	6742	10070	12994	0	0	1094	2734
Total	2861	10192	15443	14519	6742	0	1357	3017
Ellegala LB System:								
Gamunupura	450	1350		1350				
Debara wewa	1000	3288	1701	4138	0	423	206	222
Tissa Wewa	2750	13325	3097	5633	8855	0	398	1537
Yoda wewa	3267	8855	967	7824	0	0	779	1219
Total	7467	26818	5765	18945	8855	423	1383	2978
Ellegala Irrigation System Total	10328	37010	21208	33464	15597	423	2740	5995

Table 3.2.30. Ellegala Irrigation System tank duties.

	Command area (ac)	Main canal issues (acft)	Duty (acft/ac)
Pannegamuwa wewa	560	1525	2.72
Weerawila	2301	12994	5.65
Ellegala LB System:			
Debara wewa			
Tissa wewa	2750	5633	2.05
Yoda wewa	3267	7824	2.39
Gamunupura scheme	450	1350	3.00
Rainfall (15 Nov '92 to 31 Mar'93)			1.17 A

Drainage Contribution to *Unit Rainfall* *(DCUR)*

Table 3.2.31 shows the Drainage Contribution to Unit Rainfall (DCUR) for the individual tanks with their respective rainfall data. This estimation comes under the condition (a) which corresponds to the water supply to the entire area. Though DCUR values for this season were lower than for the previous maha **season** due to the rainfall variation, the trend was similar to that of maha 1991/92.

Tank	Drainaage flow exceedance probability (acft/mm)		
	90%	75%	50%
Pannegamuwa wewa	1.4	3.5	12.0
Weerawila wewa	**5.4**	9.5	24.0
Debarawewa	2.3	8.5	9.5
			11.0
Yodawewa	1.8	4.5	10.0

Improvements in Tank Operations During Maha 1992193

i) One of the recommendations made by the Study Subcommittee for Water Balance was to operate the five tanks in the Ellegala to maintain their respective water levels just above **MOLs** in order to accommodate runoffs from catchment areas. **Figures 3.2.22, 3.2.24, 3.2.28 and 3.2.30** indicate that the **tanks** were maintained close to their MOLs during the season. **Figure 3.2.26** of the Debara wewa shows that the tank spilled **five**

times during the season. The spill did not receive much attention from IEs as the spilled water was collected in the Tissa tank located below the Debara wewa and was therefore not wasted.

Tanks located at the tail did not spill during the season as they did during previous seasons. This contributed in a significant way to water savings in the main reservoir thus helping to extend cultivation area in the new system.

ii) The display board in the office of the RE of the LB was used to display water levels and storage in the individual tanks (Figure 3.2.33) and helped the RE make more informed operational decisions.

iii) Farmers in the Debara wewa, the Tissa wewa and the Pannegamuwa managed to cultivate with water issued to them five days per week and helped the ID keep main sluices to the tanks closed one or two days every week. This can be seen by studying Figures 3.2.23, 3.2.27 and 3.2.29, In the Pannegamuwa, the number of days of water issue to its command area was reduced to four through the effort of FRs.

Ellegala farmers were able to Save 7,534 acft (Table 3.2.28) of water from their seasonal allocation of 25,000 acft through this kind of management effort and by using drainage water from the RB Tract 1 and the LB Tracts 1 and 2 to which water issues are made for a late maha paddy crop. Table 3.2.29 shows that drainage contributions to the tanks in the Ellegala RB system was 15,443 acft and 5,765 acft in the LB system. Total drainage (to feeder canals and to the tanks) collected in the Ellegala during the maha 1992/93 season was estimated at 40,700 acft. This includes drainage contributions to the reach between Lunugamvehera reservoir and the feeder canal.

iv) In general, farmers were satisfied with the irrigation supply during the season. However, 5 to 10 day extensions of water issues had to be made to all the tanks except the Pannegamuwa. This was due to the cultivation of longer duration paddy varieties by farmers who found it very difficult to obtain the three to three. and a half month varieties. Seeds were difficult to come by because of crop failure during the previous yala.

iv) In general, farmers were Satisfied with the irrigation supply during the season. However, 5 to 10 day extensions of water issues had to be made to all the tanks except the Pannegamuwa. This was due to the cultivation of longer duration paddy varieties by farmers who found it very difficult to obtain the 3-3½ month varieties. Seeds were difficult to come by because of crop failure during the previous yala.

Though management innovations such as maintaining minimum operating levels (MOLs) had a positive impact on water saving, there were complaints from farmers of increasing salinity in their paddy fields during this period. FRs pointed out that salinity levels were rising because of drainage water from the new system and requested that more fresh water from the Lunugamvehera be issued to their tanks to offset this.

The Research Officer (RO) from the Agricultural Research Station at Weerawila undertook to test tank water and soil for salinity in several locations to determine whether there was a salinity problem in the old system. **His** study revealed that there was a salinity problem in the old system but that this could be controlled through greater management efforts and improvements in on-farm management. A detailed report on salinity management is given under Section 3.4.

Ellegala System Operation During Yala 1993

Water Availability and Seasonal Planning

Farmers in the **EIS** harvested their maha 1992/93 crop toward the end of March and in early April 1993. At the time, there was a standing paddy crop in Tract 1 of the RB and also in Tracts 1 and 2 of the LB in the New Area. Water availability data as of 22 April 1992 are shown in Table **3.2.32.**

On this date the water level in the main reservoir was 160.6 ft and the corresponding active storage value 10,100 acft. Of this, 5,000 acft had been reserved for standing crops and the balance 5,100 acft was to be utilized **or** starting the yala season. Anticipated inflows for the remaining part of April, and for May and June were being estimated at about 25,400 acft. The drainage contribution to the EIS from the cultivated areas in the new system was estimated to be 1,000 acft.

The Ellegala FRs agreed at the PMC to give 6,500 acft to the farmers in Tracts ***6*** and **7** of the RB to cultivate OFCs on compassionate grounds as these farmers had not been able to cultivate **for** several seasons. Another 4,500 acft was to be reserved to compensate **for** reservoir losses. The anticipated water balance at the main reservoir was calculated to be 19,500 acft.

Table **3.2.32 also** shows that the active storage capacity in the EIS tanks on that day was 7,450 acft. Losses from the individual tanks had been estimated to be 3,400 acft. Thus the final figure for the anticipated water availability for the season was 24,500 acft.

The PMC met on 22 April 1993 and made a decision on the possible cultivation plan as given in Table **3.2.33.** Also, the decisions made at the Kanna meetings held in the first week of May with regard to the extent to be cultivated, the starting date and last date for water issue are presented in Table **3.2.34.** However, the actual areas cultivated that were different from the Kanna meeting decisions are given in Table **3.2.35.**

Data collection for water balancing was carried out between May 1993 and 13 September 1993 during this season. The weekly rainfall and evaporation recorded at Weerawila Research Station during the water balancing period are shown in Table **3.2.36.**

Table 3. 2.32 1993 Yala Cultivation Program

	Quantity in ac ft			
Active Storage in Lunugamvehera Reservoir on 93/04/22			10100	
Req. for existing cultivation on LB 1,2 and RB1			3500	
Req. for existing cultivation on LB 2 DC 9 and 10			1500	
Balance for Yala Cultivation				5100
Anticipated inflows				
April (22/04/93 to 30/04/93)		14000		
May		8300		
June		3100		
Total		25400		
Expected Drainage from New Area		1000		
Anticipated Balance		26400		31500
Evaporation losses (expected)		4500		
Req. for RB 6&7 for OFC (6 issues)		6500		
Total			11000	
Anticipated Balance for Yala 1993				20500
Active Storage at Ellegala Tanks on 22/04/93				
Tissa Wewa	2800			
Yoda Wewa	1700			
Debera Wewa	250			
Weerawila Wewa	2350			
Pannagamuwa Wewa	350			
Total	7450			
Evaporation losses (expected)		3400		
Balance		4050		
Total anticipated balance for Yala				24550

Table 3.2.33 Possible Phn: Yala 1993

System	Command Area (acres)	Allocation (acft)	Paddy/OFC		Paddy Only (ac)
			DFC (ac)	Paddy (ac)	
Tissa Wewa	3000	7000	2000	1000	1400
Debera Wewa	1100	2550	750	350	500
Yoda Wewa	3200	7450	2150	1050	1500
Pannagamuwa	550	1300	350	200	260
Weerawila	2300	5350	1550	750	1100
Gamunupura	400	900	275	126	180
Total	10550	24550	7075	3475	4940

Table 3.2.34 Kanna Meeting Decisions

System	Extent to be cultivated		Data of first water issue	Final date fa planting/sowin	Date of last water issue
	OFC (ac)	Paddy (ac)			
Tissa Wewa	2000	1000	07.06.1993	31.05.1993	31.08.1993
Debera Wewa	750	350	04.05.1993	30.05.1993	30.08.1993
Yoda Wewa	2160	1050	10.05.1993	05.06.1993	05.09.1993
Pannagamuwa	360	200	06.05.1993	31.05.1993	31.08.1993
Weerawila	1560	750	07.05.1993	02.06.1993	02.09.1993
Gamunupura	275	125	09.05.1993	03.06.1993	03.09.1993

Table 3.2.35 Target6 and Achievements

		Gamunupura	Deberawewa	Tissawewa	Yodawewa	Pannagamuwa	Weerawila	Total
Target	Paddy (ha)	50	140	400	420	80	300	1390
	(Paddy %)	(31)	(32)	(33)	(33)	(36)	(33)	(33)
	OFC (ha)	110	300	800	860	140	620	2830
	(OFC %)	(69)	(68)	(67)	(67)	(64)	(67)	(67)
	Total (ha)	160	440	1200	1280	220	920	4220
	(Total %)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
Achievement	Paddy (ha)	60	270	520	520	114	330	1814
	(Paddy %)	(38)	(61)	(43)	(41)	(52)	(36)	(43)
	OFC (ha)	54.3	49.2	129.3	524.8	55.3	96.5	909.4
	(OFC %)	(34)	(11)	(11)	(41)	(25)	(10)	(22)
	Total (ha)	114.3	319.2	649.3	1044.8	169.3	426.5	2723.4
	(Total %)	(72)	(72)	(54)	(82)	(77)	(46)	(65)

Table 3.2.36 Rainfall & Evaporation Weekly Distribution (1993)

Standed Week No	Days		RF mm/week	E I mm/week
16	16–Apr	22–Apr	0.0	44.5
17	23–Apr	29–Apr	28.3	15.3
18	30–Apr	06–May	53.5	23.7
19	07–May	13–May	22.2	31.9
20	14–May	20–May	19.5	31.8
21	21–May	27–May	25.0	26.8
22	28–May	03–Jun	0.0	41.2
23	04–Jun	10–Jun	17.0	37.6
24	11–Jun	17–Jun	0.0	52.2
25	18–Jun	24–Jun	8.6	49.2
26	25–Jun	01–Jul	7.6	40.7
27	02–Jul	08–Jul	9.5	35.8
28	09–Jul	15–Jul	0.5	57.2
29	16–Jul	22–Jul	36.0	37.8
30	23–Jul	29–Jul	0.0	46.4
31	30–Jul	05–Aug	0.0	66.4
32	06–Aug	12–Aug	0.0	59.6
33	13–Aug	19–Aug	0.0	72.1
34	20–Aug	26–Aug	0.0	63.7
35	27–Aug	02–Sep	0.0	57.9
36	03–Sep	09–Sep	0.0	65.8
37	10–Sep	16–Sep	0.0	67.3
38	17–Sep	23–Sep	13.0	49.4
39	24–Sep	30–Sep	0.0	0.0
	Total		240.7	1074.3

Lunugamvehera Reservoir Operation

It was decided to start cultivation in most areas in the EIS during the first week of May. As shown in **Table 3.2.36,** rainfall in the command area was minimal and did not improve the water situation in the Kirindi Oya System in any significant way **(Table 3.2.37).**

Table 3.2.37. Water levels in the Lunugamvehera Reservoir and the five tanks (1993).

Tank	Water level (ft)	
	On 22 April	On 1 May
Lunugamvehera Reservoir	160.5	162.5
Pannegamuwa wewa		
Weerawila wewa	7.4	7.7
Debara wewa	7.3	8.0
Tissa wewa	14.6	14.1
Yoda wewa	9.0	9.8

Table 3.2.38 and **Figure 3.2.34** show Lunugamvehera Reservoir operations. At the beginning of the yala season, water issues were made to the standing late maha paddy crop in the upper tracts of the New Area. Inflow received into the main reservoir raised the water level to 163.9 ft by 22 May 1993. For sometime it remained at this level. Water issues from the main reservoir to the tanks in the EIS started on 9 May 1993. After intermittent issuing of water for a period of four months, the water level in the main reservoir dropped to the MOL on 22 August 1993 as shown in Figure **3.2.34.** Water issues to the EIS from the main reservoir were stopped on 9 September 1993 on which date the water level in the reservoir had dropped to 153.9 ft, i.e. 2.3 ft below MOL. Thus about 3,899 acft of water between the MOL and zero level was utilized by farmers in the **EIS** to complete their cultivation season successfully. **Table 3.2.38** shows the water issues to the different subsystems during important periods while **Table 3.2.39** indicates allocation and actual water issued to the EIS tanks.

Ellegala Tank Operations

According to the water allocation plan, it was expected that 19,500 acft would come from the Lunugamvehera Reservoir during the season **(Table 3.2.32).** But due to the dry weather prevailing during the season and also due to Ellegala tapping of water and leakages in the LBMC, 28,921 acft of water had to be issued from the main reservoir. Of this, as shown in **Table 3.2.39)** 19,355 acft was supplied to the EIS for distribution among the five tanks.

Table **3.2.38** **Lunugamvehera** Reservoir Operations

Description	Date	Water Level ft	Active Capacity acft	Water issue to RB acft	LB acft	Ellagala acft
PMC decided Yala	22-Apı	160.5	1010:			
Lunu. reservoir issuing	09-May	162.9	16552			
Max. water level reache	22-May	163.9	1947:			
MOL on	22-Aug	156.0	(			
Last issue to EIS on	09-Sep	153.9	-3896			
				360	1234	
				2117	2443	2465
				347	0	428
Total issuings				2823	3677	2892

Table 3.2.39 Allocation and Actual Water Issue

Tank	Allocation acft	Active storage at start acft	Supply through F. canals acft	Releases acft	Issuing to command area acft	Tank losses acft
Pannagamuwa	1300	550	3041		1196	410
Weerawila	5350	1775		3720	6558	1765
Gamunupura	900		875		875	
Debera wewa	2550	450	3395		3762	376
Tissa wewa	7000	2050	12044		4256	543
Yoda wewa	7450	2800		1701	3916	1661
Sub Total	24550	7625	19355		20563	4755
Total	24550		26980			25318
Issues from Lunugamvehera (May 04 to September 13)			28674 acft			

At the beginning of the season, the active storage of the five tanks was 7,625 acft (Table **3.2.39**) with a receipt of 19,355 from the main reservoir, the total volume of water available for the season was 26,980 acft. Of this, 4,755 acft was accounted for by tank losses and only 20,563 acft was issued to the respective command areas for cultivation.

When the planned allocations are compared with actual issues, it becomes apparent that Pannegarnuwa, Gernunupura, Tissawewa and Yodawewa consumed less than what had been allocated. But Weerawila and Debarawewa used more than their respective allocations. In Weerawila, this was due to conflicts between the head and tail farmers. It can also be seen from Table **3.2.35** that the extent cultivated with paddy in Debarawewa was roughly twice that which was planned.

Pannegamuwa tank operations (Figure **3.2.35**) show that the tank water level was maintained between MOL and FSD most of the time. It can be clearly seen that when the feeder canal gate to Weerawila was open, water levels fluctuated heavily in the Pannegamuwa wewa (compare Figures **3.2.35** and **3.2.36**).

Figure **3.2.37** shows that the Wirawila Tank was operated most of the time below MOL during the season. Main canal issues were high as in normal seasons though cultivation under the tank was confined to a portion of the command area (Figure **3.2.28**).

At the beginning of the season, Debarawewa was spilling from the drainage water from Tracts 1 and 2 of the LB (Figure **3.2.29**). Paddy cultivation was confined to the Debarawewa Right Bank Low Level (DRL) canal. A small quantity of water was released for OFC cultivation in the Debarawewa Right Bank High Level (DHL) canal on a few occasions as shown in Figure **3.2.30.**

Tissawewa was full at the beginning of the season from drainage water as shown in Figure **3.2.41.** Paddy cultivation was confined mainly to the Tissawewa Left Bank Low Level (TLL) canal while a small area under the other two main canals were under OFCs. The water release for OFC cultivation is shown in Figure **3.2.42.**

Yodawewa was a little above MOL (Figure **3.2.43**) at the beginning of the season. Paddy was cultivated on the High Level (YHL) canal while construction work under RID was being carried out in the Low Level canal. Because of the low water level in the tank, water release could not be made through the High Level canal during the latter part of the season. To solve this problem, water supply through the Yodawewa Low Level canal was made as shown in Figure **3.2.44.**

The implementation of a mixed cultivation plan posed some difficulties in the EIS because of the complex nature of the on-farm system and also because farmers preferred to cultivate paddy. However, the team work approach adopted by the Project level agency officials to explain the plan to farmers at several meetings and the efforts made by them to make farmers aware of the water situation in the reservoir greatly contributed to the success of the program.

During implementation, special efforts were made by the ID officials to supply the allocated quantities of water to the tanks and manage water in such a way as to avoid crop failure due to water scarcity. The adverse impact of the crop failure during yala 1992 still lingered in the minds of the Ellegala farmers and FRs and this made them think in a more rational way in the season. Therefore, farmers were very cooperative with the ID officials in their attempts to regulate and supply equitable water. The outcome of cultivation during yala 1993, shown in Table 3.2.35 giving the target and achievement for OFC and paddy cultivation, demonstrates that the number of farmers who did not abide by the Kanna meeting decisions were few.

Development and Implementation of Reservoir Operation Simulation (Extended) System (ROSES) to Ellegala Irrigation Tanks

The Reservoir Operation Simulation (Extended) System is a computer program developed as an assistance tool for efficient operation of EIS tanks which will enhance the monitoring and controlling processes of tank operations.

It provides facilities to introduce and use the actual raw data collected from the field (physical dimensions, gate opening heights, etc.) without pre-processing for system simulation. As is usual in simulation modelling, the node-link concept is used here. In the mode-link concept, each hydrologically important structure such as a reservoir, diversion structure, confluence, cross-regulator, lateral feeder structure, etc., is considered as a node in the model and these nodes are interconnected by links. The links represent the water conveyance structures such as canals, streams, etc. This node-link structure along with other characteristics and parametric data relating to nodes and links and target requirements should be entered into the computer for processing.

In the model, the system is treated in a cyclic manner. The volumetric balance at each reservoir node is calculated with inflows while making necessary water releases in accordance with currently set targets and balance volume at the previous cycle of operation. The runoff inflow to a tank is calculated using the rainfall figures and the given runoff calculation formula. The losses are calculated with the given loss coefficients.

The results as well as given input data are recorded in history files so that the operation of the system can be reviewed later.

The program generates three types of reports:

i) Input data reports for checking purposes only.

ii) Reports on results of the current cycle.

iii) Reports on historical results.

Reports on results of the current cycle contain the following information:

* Reservoir status.
* Water releases through outlets.
* Flow in each link.
* Runoff volume to each reservoir.
* Losses of water volumes (evaporation, seepage, etc.).
* Gauging station discharge calculation sheets.

The program needs basically two types of input data:

* Fixed data, which include structure and other characteristics; parametric data including gauging structure definitions and equations.
* Variable data for each cycle including daily input data such as rainfall, evaporation, water levels (above and below the structure), gate openings, feeder inflows, loss factors, etc.

This time step for the model can be daily, weekly, or monthly.

The graphic outputs generatable by the program come under the following categories:

* History curves.
* Structure information.
* Comparison graphs.

The history curves relate to rainfall, link flows and reservoirs while comparison graphs relate to water level, water volumes, releases and rainfall between two or more stations.

Implementation

The simulation program is installed in the Kirindi Oya Project and demonstrated its utility to project level operating officials.

Discussion of Results

Tables 3.2.40 and **3.2.41** give a consolidated statement of results of output obtained from the water balance and operational studies carried out at the EIS. The results are summarized for individual **tanks** separately for the four seasons of research 1991/92 to 1993 yala; the tables give water issue periods, areas cultivated, seasonal rainfall and evaporation, inflow to tanks from feeder canal and drainage, outflow through main canal, spill and release to other tanks, tank losses and irrigation duty. The tables also indicate whether the season was a success of failure.

A number of interesting and important conclusions can be drawn from these tables.

1. Among the five tanks of EIS, Weerawila farmers used the highest amount of water per acre of paddy while Tissawewa and Yodawewa farmers used the least among of water per acre of paddy. The average duty in Weerawila was approximately 5.6 acft/ac while the same in Tissawewa and Yodawewa were about 2 acft/ac. A number of reasons may be attributed to these large variations. The Weerawila command area is situated in a sloping topography, has a large density of drainage channels, is short in length and empties into incised Kirindi Oya River. It does not get much unaccounted drainage water for reuse and has a larger proportion of well drained soils. On the other hand, both Tissawewa and Yodawewa are tail-end tanks, get a large proportion of unaccounted reuse water, and are situated in flat alluvial plains with minimal drainage provisions. Therefore, the water supply is only to take care of the ET requirement since the water table is very near the ground surface (no S and P losses).

2. Since maha 1992/93 after the MOL was introduced, there was virtually no spill from these **tanks** except in Debarawewa. In fact spill from Debarawewa reaches Tissawewa and, therefore, there is no wastage from the **EIS** System.

3. Comparing yala 1992 and 1993, it can be seen that for the same amount of water available, 1992 yala was a crop failure season while yala 1993 was a successful year. This is mainly because of the introduction of seasonal planning, mixing paddy with OFC in the cultivation calendar and skillful operation of the system.

4. Drainage and runoff water during maha season averaged roughly two-thirds of the total supply to these tanks when the whole New Area was irrigated. Only one-third was obtained from Lunugamvehera.

5. There is a general improvement in water use efficiency of these **tanks.** Although this improvement is not directly visible by comparing the duty of water indicated at the end of the tables, it is apparent when one compares the release of water from Lunugamvehera Reservoir to the old **EIS** in association with occurrence of rainfall in the command area. However, there is further opportunities to cut down water use and save water further by better management through involvement of FCs and DC operation and maintenance.

6. The EIS Study brings out the simple fact that any attempt to improve system performance must precede with a thorough understanding of the system behavior.

Table 3.2.40 Seasonal Summary for Individual Tank

Name of Tank :– Weerawila wewa

Season	Water issue period			Area Cultivated		Climatic Data		Inflow		Outflow				Duty
	date of start	date of end	Total days	Paddy ac	OFC ac	RF ft	Eo ft	Feeder acft	Drainage acft	M.Canal acft	Release acft	Spill acft	Losses acft	acft/ac
91 / 92 Maha	21–Oct–91	28–Jan–92	99	2301	0	1.8	1.2	2788	10765	8797		1898	–464	3.8
92 Yala	01–Mar–92	10–Jul–92	131	2301	0	0.7	2.9	1940	2906	12834		137	2252	5.6
92 / 93 Maha	20–Nov–92	20–Mar–93	120	2301	0	1.2	2.2	6742	10070	12994		0	1084	5.6
93 Yala	06–May–93	11–Sep–93	128	815	238	0.5	3.0	3720		6556		0	1765	6.2

* Duty for crop growth period only
** Paddy and OFC cultivation

Season	Water issue period			Area Cultivated		Climatic Data		Inflow		Outflow				Duty
	date of start	date of end	Total days	Paddy ac	OFC ac	RF ft	Eo ft	Feeder acft	Drainage acft	M.Canal acft	Release acft	Spill acft	Losses acft	acft/ac
91 / 92 Maha	21–Oct–91	28–An–82	99	560	0	1 6	1 2	2447	1145	948	2788		–115	1.7
92 Yala	23–Apr–92	23-All-82	91	560	0	0.6	1.9	2541	loll	1581	1940		226	2 6
92 / 93 Maha	16–Nov–92	11-Ma-83	115	560	0	1 2	22	3450	5373	1525	6742		273	2.7
93 Yala	15–May–93	13–sop–w	121	282	137	0.5	3.0	3041		1196			410	2.9

Name of Tank :– Tissa wewa

Season	Water issue period			Area Cultivated		Climatic Data		Inflow		Outflow				Duty
	date of start	date of end	Total days	Paddy ac	OFC ac	RF ft	Eo ft	Feeder acft	Drainage acft	M.Canal acft	Release acft	Spill acft	Losses acft	acft/ac
91 / 92 Maha	21–Oct–91	28–Jan–92	99	2750	0	1.8	1.2	4063	13397	8081	10173		–182	2.9
92 Yala	10–May–92	23–Jul–92	74	2750	0	0.6	1.9	16278	6278	3825	5896	276		1.4
92 / 93 Maha	20–Nov–92	20–Mar–93	120	2750	0	1.2	2.2	13325	3097	5633	8855		398	2.0
93 Yala	04–May–93	04–Sep–93	123	1264	319	0.5	3.0	12044		4256	1701		543	2.7

* Crop failure
* Duty for crop growth period only
** Paddy and OFC cultivation

Table 3.2.41 **Seasonal** Summary for Individual Tanks

Name of Tank :– **Debera wawe**

Season	Watu issue puiod			Area Cultivated		Cilmatic Data		Inflow		Outflow				Duty
	dab of start	dab of end	Total days	Paddy ac	OFC ac	RF ft	Eo ft	Feeder acft	Drainage acft	M.Canal acft	Release acft	Spill acft	Losses acft	acft/ac
91 / 92 Maha	21–Oct–91	28–An–92	99	1000	0	1.8	1 2	1950	5108	5647		1945	–144	5.6
92 Yala	0s–May–92	23–Jul–92	79	1000	0	0.6	1.9	3680	165	3332			184	3.3
92 / 93 Maha	15–Nov–92	15–Ma–83	120	1000	0	1 2	2 2	3288	1701	4138		423	206	4.1
93 Yala	04–May–93	12–Sap–83	131	667	122	0.5	3.0	3395		3762			376	4.8

Crop failure
* Duty for crop growth period only
** Paddy and OFC cultivation

Name of Tank :– **Yoda wewa**

Season	Water issue period			Area Cultivated		Cilmatic Data		Inflow		Outflow				Duty
	dab of start	date d end	Tobl days	Paddy ac	OFC ac	RF ft	Eo ft	Feeder acft	Drainage acft	M.Canal acft	Release acft	Spill acft	Losses acft	acft/ac
91 / 92 Maha	21–Oct–91	28–An–92	99	3267	0	1.8	1 2	10173	2425	6839		4046	–842	2.1
92 Yah	12–May–92	23–All–92	72	3267	0	0.6	1.9	5898	139	4935			756	1.9
92 / 93 Maha	20–Nov–92	20–Mar–93	120	3267	0	1 2	2 2	8855	967	7824			779	2.4
93 Yala	09–May–93	12–Sep–93	126	1284	1296	0.5	3.0	1701		3916			1661	1.5

Season	Water issue period			Area Cultivated		Cilmatic Data		M.Canal issue	Duty
	dab of start	dab of end	Total days	Paddy ac	OFC ac	RF ft	E0 ft	acft	acft/ac
91 / 92 Maha	21–Oct–91	28–An–92	99	450	0	1.8	1 2	1246	2.8
92 Yala	23–Apr–92	23–Jul–92	91	450	0	0.6	1.9	988	2.2
92 / 93 Maha	20–Nov–92	20–Ma–83	120	450	0	1 2	2 2	1350	3.0
93 Yah	09–May–93	09–Sop–83	123	148	134	0.5	3.0	876	3.1

Season	Period of water release from Lunugamvehera reservoir			Total issue	Crop Cultivated	Remarks
	dab d starte	dab d end	Total daya	acft		
91/92 Maha	21–Oot–el	28–Jan–%?	99	0	Paddy	*
92 Yala	23–A@–92	23–&l–82	91	27542	Paddy	Failure
92/93 Maha	15–Nov–92	16–Ma–83	120	17466	Paddy	
93 Yah	09–May–93	09–Sep–93	123	28921	Paddy/OFC	

• study cover crop growth period only

3.3 MAINTENANCE MANAGEMENT

3.3.1 Introduction

Maintenance is the management response to deterioration of the physical condition of irrigation systems which threatens to make it impossible to achieve operational targets. Maintenance is the process of keeping irrigation, drainage and other infra-structural facilities in good repair enabling managers to meet system objectives (Pereira and McCready, 1987). Yocom (1986) states that the intention of maintenance is to keep up physical facilities with the goals of efficient operations, minimum breakdown and good appearance. Despite these definitions there **is** frequently no direct relationship between maintenance and operations. Maintenance inputs are often uncoordinated with operational goals and separate staff and budgets are usually provided for maintenance.

In many industrial engineering enterprises, maintenance programs are developed to support operations in a cost-effective manner. There is little evidence, however, that in irrigation systems maintenance programs have been evaluated in terms of their impact on imgation system performance or their costs effectiveness. A recent study on maintenance management in five major Sri Lankan irrigation schemes demonstrates that funding levels are inadequate to achieve technically and socially desirable maintenance levels and that the present system of maintenance management does not use existing resources effectively and is not performance oriented (TEAMS 1991).

One of the primary factors which determines the success or failure of an operational plan is the physical condition of the conveyance and distribution infrastructure. Operational targets are based on assumptions of hydraulic conditions such as slope, roughness and cross-section, all of which affect the velocity of water in the canals and therefore head-discharge relationships. Adverse changes in the physical conditions of canals will eventually make it impossible to achieve operational targets.

A critical test of the effectiveness of a maintenance program is therefore useful whether or not the canal system is capable of meeting operational targets. There must be a set of measurements of physical parameters which determine whether the operational plan is feasible as well as a program of maintenance which ensures operational targets will continue to be met in the future. This involves monitoring both the conveyance capacity of canals which deteriorate continuously over time and the functioning of the control infrastructure to prevent the failure of gates and regulators.

Once the physical system is stabilized to a point where maintenance procedures are cost-effective, then there is an opportunity to address more carefully the overall efficiency of system performance.

Maintenance is important to achieving operational targets because it helps determine the level of water **loss** in conveyance through the system. If as **is** usual the operational targets are defined

at the points of transfer from agency to farmers, then higher conveyance efficiency will result in smaller releases into the system and thus result in overall savings in water which can productively be used at a later stage.

For this to be effective there has to be a good system of monitoring, evaluation and feedback on key parameters of system performance which identify when and where maintenance inputs are required. typical parameters are likely to include conveyance losses, time taken to re-establish water levels following closure and flow velocity.

As a pilot exercise the research work on maintenance during Phase II has focussed on the Weerawila in Tissa because the canal design and conditions are more typical of those in Sri Lanka than the newer designs incorporated into the RBMC. This report discusses the objectives, activities, method and approach, results and lessons learned, impact and conclusions.

3.3.2 Objectives

Initially, the overall objective was to identify ways to link maintenance to operational targets:

- by identifying acceptable levels for the physical condition of the canal system and control infrastructure which permit implementation of operational plans and
- by improving system performance through more effective maintenance procedures oriented toward water delivery.

In addition, during the research, emphasis was placed on the development of a strategy to overcome the lack of resources for maintenance through financial management, physical work management and farmer participation. The reorientation was made within the original objectives because of the vital importance of the issue at field level.

3.3.3 Proposed Intervention Activities

At the beginning of the study, the following research activities were selected to support the original research objectives.

Objective 1

i) Develop methods to assess whether existing physical conditions were compatible with expected operational targets for main and distributary canals based on physical observations of water conditions and on computer simulation.

ii) Develop standards for canal maintenance, including aspects such as depth of sediment, density of weed growth, cross-sectional shape and other physical conditions which permit operational targets to be fulfilled.

iii) Initiate procedures for estimating the rate of change in the physical condition of canals and control infrastructure to determine probable costs and manpower and equipment requirements to keep conveyance capacity and operational control within acceptable limits.

iv) Compare cost estimates with existing resources for maintenance to determine whether or not the physical system can be sustained.

v) Assess whether current procedures for maintenance require modification to maintain and improve the level of performance of the canal system and where required make recommendations on alternative maintenance procedures that will be more cost-effective with available resources.

Although activities i through iv are of vital importance from the point of research, the irrigation managers' priority is to effect changes in maintenance procedures and methodologies. Therefore the above activities were given less important than item v. These activities **need** to be given sufficient attention in future research programs in developing a more systematic and scientific approach to maintenance management.

Objective 2

i) Develop a set of parameters to assist system managers identify the impact of maintenance including aspects such as determinating conveyance losses and measuring flow velocity at sample locations to evaluate cross-sectional changes.

ii) Establish a long-term but simple monitoring program which periodically measures the values of selected parameters and which can be used to schedule maintenance inputs in relation to priority concerns.

ii) Develop a long-term program for maintenance based not on a available annual financial resource but on needs in relation to the performance of the conveyance system.

The main focus of the research was on financial and physical management of maintenance programs **and** not much on technical aspects. Research was directed toward obtaining tangible results by intervening in management. In fact this proved the correct approach because some financial procedural changes can be implemented with limited resources. To use the available limited resources allocated to this activity and to accommodate the requests *of* irrigation managers the research was limited to the above mentioned activities.

3.3.4 Approach and Methodologies

All activities were carried out with the participation of agency officials and farmers. At the **start,** participation was limited to meetings and formal and informal discussions. Nevertheless, at the later stages, they sensed that this **work** could generate tangible results and their

involvement became more interactive making the research more productive. The research demonstrated that, by carrying out day to day work in a methodical manner, better results could be achieved. The maintenance management research activities were carried out with the participation of the ID, the IMD, FRs and farmers.

The financial management activity was carried out using the past records of the ID through their staff since these documents are confidential. A few years' data was selected to use in the analysis to understand the rationale behind allocations under different investment intensities. During the analysis, efforts were made to separate administrative costs from physical maintenance costs to ascertain the amount of maintenance funds spent to cover under-invested administrative costs. Once the categorization (by subsystem and by subject) of expenditures was completed, a comparison of investments was done to examine the equity of investments.

Several procedures, formats and methodologies were developed to improve the performance in identifying, prioritizing, decision-making and monitoring maintenance. Most of the activities were done using a technique called "diagnostic walk-through." This walk-through exercise was followed by ratification meetings conducted with the participation of farmers and FRs. Work studies were carried out to establish realistic norms for weeding under different working conditions.

3.3.5 Activities Implemented

Financial Management

This activity was implemented to understand financial management related to maintenance management and to discuss issues undermining the effectiveness of the physical work program. A fact finding survey was conducted to explore existing financial regulation and policies in maintenance investments to suggesting future directions. Attempts were also made to establish a maintenance expenditure database to develop allocation principals among different categories of work and subsystems. Work was carried out to develop guidelines to minimize the waste of financial resources through redemarcation of imgation administrative boundaries.

Maintenance Funding

The main objective was to understand funding policies and regulations and to identify areas where interventions related to financial management could be implemented. Since financial documents are not readily accessible due to their confidential nature, it was decided this work be done by an independent group of ID officials not directly involved in maintenance activities.

Analysis of Maintenance Expenditure

This work was entrusted to two Imgation Engineers (IEs) attached to the Deputy Director's Office. The IE in Tissa provided documents such as measurement books, vote ledgers, cash books and check-roll registers. Expenditures under each sub-item were listed according to the

items given in the IMD's circular. Salaries of work supervisors and maintenance laborers were tabulated separately and expenditures under each sub-item were further classified according to subsystems.

According to this formula, the Tissa Division should have received allocations for each category of work as given in **Table 3.3.1.**

Irrigation Management Division Rates

These rates were calculated according to allocations received in 1985. Ratios for distribution of funds among the different categories were obtained using data collected from ranges and divisions. 1991 rates were calculated using an inflation rate of 10 percent.

Table 3.3.1. Allocation distribution according to 1985 figures.

Subsystem	Quantity and amount (Rs)	Irrigated area under H/W (acs)	CANALS				Total (Rs)
			CHAINS				
			Main	Branch	Distri-butary	Field	
Tissawewa	Q	3,025	363	228	248	1,436	
	A	15,125	45,375	17,100	12,400	71,800	161,800
Debarawewa	Q	1,067	177	123	81	425	
	A	5,335	22,125	9,225	4,050	2,125	42,860
Yodawewa	Q	3,326	384	56	691	997	
	Q	16,630	48,000	4,200	34,550	49,850	153,230
Pannegamuwa	Q	450	56	0	208	276	
	A	2,250	7,000	0	10,400	13,800	23,450
Weerawila	Q	2,200	444	0	619	1,154	
	A	11,000	55,500	0	30,950	57,700	155,150
Total							536,490

The following are the pro-rata costs of each category of maintenance:

	1985 Rs/Acre	1991 Rs/Acre
For dams	5.00	8.85
For main canals	125.00	221.00
For branch canals	75.00	133.00
For distributary canals	50.00	89.00
For field canals	50.00	89.00

For roads, 20 percent of canal cost of main canals, branch canals and distributary canals.

Most main canals in the Ellegala do not belong to the main canal category because the canals are quite small. Therefore, it was better to use the command area served by the canal or design capacity to classify canals for the research. Furthermore, the maintenance cost for field canals is high and is almost equivalent to distributary canal costs. Since field canals are maintained by farmers, it was better to delete this item from the budget.

Table 3.3.2 provides some suggestions which can be used for future maintenance allocations. **Table 3.3.1** was prepared on the basis of existing classification of canals using 1985 rates and **Table 3.3.2** gives allocations based on reclassification according to command area and canal capacities. This report suggests that irrigation networks should be classified using canal and system parameters so that financial allocations to each subsystem is more realistic and methodical. **Table 3.3.2** indicates that using the same quantity and rates, allocation requirements for systems are more than given in **Table 3.3.1.** Through adoption of this method, the physical implementation of work programs will not face serious financial difficulties.

Table 3.3.3 presents a summary of expenditures and allocations for 1980 and 1990. A review of expenditures reveals that 1980 expenditures were not charge according to the present breakdown. It should also be noted that no allocation for administration was provided in 1980.

Even under administrative costs, salaries of drivers, operators, watchers and office laborers were charged to this item only. However, the 1990 data shows salaries were charges to respective line items given in the IMD circular.

In 1990 administrative expenditure as a ratio of physical maintenance expenditure was 1.42 against the allocation ratio of 0.30. Expenditure ratios of administration costs and physical maintenance in 1980 was 0.22. According to IMD calculations, administrative costs for the Tissa Division should be Rs. 42/- per acre based on 1985 rates while the same based on 1991 costs should be Rs 421- x 1.771 = Rs 74/-. Based on the above rates, computed administrative costs for the Tissa Division for 1985 and 1991 should be Rs 500,0001- and Rs 881,999/-, respectively.

Table 3.3.2. Revised allocation distribution according to 1985 figures.

Subsystem	Quantity and amount (Rs)	Irrigated area under H/W (acs)	CANALS					Total (Rs)
			CHAINS					
			Main	Branch	Distributary	Inlet	Field	
Tissawewa	Q	3,025	-	203	537	237	1,426	
	A	26,771	-	26,999	47,793	23,700	28,720	153,983
Debarawewa	Q	1,067	-	113	294	220	425	
	A	9,443	-	15,029	26,166	22,000	8,500	81,138
Yodawewa	Q	3,326	-	440	691	53	997	
	A	29,435	-	58,520	64,499	-	19,940	169,394
Pannegamuwa	Q	450	-	56	208	78	176	
	A	3,983	-	7,448	18,512	7,800	5,520	43,263
Weerawila	Q	2,200	444	-	619	22	1,154	
	A	19,470	98,124	-	55,091	-	2,380	174,885
Total								622,633

Note: Q = Quantity
A = Amount in rupees
H/W = Headworks

Table 3.3.3. Expenditure and allocations.

Year	Administrative cost		Maintenance cost		Salaries		Total	
	Alloca. (Rs)	Expend. (Rs)	Alloca. (Rs)	Expend. (Rs)	Alloca. (Rs	Expend. (Rs)	Alloca. (Rs)	Expend. (Rs)
							-	821

compounded values for 1991 seem to be high compared to actual expenditure (Rs 559,0001-), which was very close to the calculated figure as per the IMD formula based on 1985 value. Allocations for each subsystem were obtained on the basis of command area. However, administrative costs were 1.99 times the allocation whereas maintenance expenditures were 0.41 times the allocation. This indicates the inappropriate use of maintenance funds to cover overhead costs. The analysis for 1990 reveals that the total allocation was not fully utilized (a substantial under-expenditure of Rs 238,000/-). Rather this money was expended on non-physical maintenance items.

Due to practical difficulties in making rational allocation decisions, the IMD recently decided that **40** percent of total maintenance allocation should be allocated to administrative costs (operational costs) with 60 percent going to physical maintenance.

Accordingly the allocation is:

	Percent
Operation cost	40.0
Headwork maintenance	12.0
Main system maintenance	23.0
Distributary maintenance	17.5
Roads maintenance	05.5
Vehicle repairs	02.0
Total	100.0

According to Deputy Director (O&M) of the IMD, the Division deducted the operation cost from the total allocation and distributed the balance on the rates given before. Accordingly the distribution was not based on actual requirements. He could not revise his procedure since most of the engineers did not follow the stipulated procedure. Had he obtained any feedback from the field officials he could have updated the rates, percentages, etc. for future allocations.

Allocations for Maintenance

Maintenance allocations in Kirindi Oya are quite low. These allocations are part of **a** total allocation for O&M provided throughout the IMD. The O&M allocation to the Tissa Division made available at the beginning of 1992 was Rs. 466,110/-. The sum was later increased to Rs 575,0001-. Since total irrigable land in this division is 10,433 acres, the allocation per acre is about Rs 55/-. As shown in **Table** 3.3.4, allocations to the other divisions in Kirindi Oya are lower. For the Southern Range as a whole there was a 16 percent increase in O&M allocation for 1992. It totalled Rs 3,090,500/- in 1992 compared to Rs 2,660,000/- in 1991. Within the Range, O&M allocations range from Rs 53/- per acre to Rs 87/- per acre. Old systems in Tissa and Rs 3,090,500/- Hambantota are most favored because it is felt that new systems need less

maintenance. Also, comparatively higher allocations are made to the Tissa Division to cover its higher overhead costs.

The O&M allocation does not cover salaries of maintenance staff. Salaries are covered from other ID allocations, The O&M allocation covers salaries of casual staff (typists, peons, watchers and drivers), travel and subsistence and vehicle repairs. Theoretically, costs should be more or less uniform across systems unless there are inherent difficulties in system operation which demand increased travel, human effort and machinery. Some differences between divisions may be due to a **fixed** numbers of casual staff attached to these divisions irrespective of **work** load.

Table 3.3.4. Distribution of allocation (Irrigation Management Division) Operation and Maintenance 1992.

Scheme	Command area (acs)	Maintenance (Rs)	Operation (Rs)	Total (Rs)	Main/Acre (Rs)	Operation/ Acre (Rs)	O&M/Acre (Rs)	1991 Allocation (Rs)
Hambantota	14906	665000	540000	1205000	44.61	36.23	80.84	940800
Tissa	10433	575000	335000	910000	55.11	32.11	87.22	704872
Badagiriya	2100	98000	52500	150500	46.67	25.00	71.67	120344
Right Bank	10408	34000	221000	561000	32.67	21.23	53.90	479175
Left Bank	4856	160000	104000	264000	32.95	21.42	54.37	236012
Southern Range	42703	1838000	1252500	3090500	43.04	29.33	72.37	2481203
Uda Walawe	29640	4675000		4675000	157.73			

The salaries of WSs from ID vote = **Rs** 532,850 - 12.48 per acre
The salaries of TOAs from ID vote = **Rs** 1,427,150 - 33.42 per acre
The salaries of TOAs of Uda Walawe = Rs 1,350,000 - 45.55 per acre

In comparison, the amount allocated by the MASL for the maintenance of 30,000 acres in the Uda Walawe Project is **Rs** 4,670,000/-. This works out to **Rs** 1561-per acre. The O&M of the headwork is funded separately. In addition, allocations for maintenance of roads, premises, buildings and vehicles are much higher. An analysis of the maintenance allocation to the Southern Range of the ID through the IMD and the total allocation to the Uda Walawe Project is given in **Table 3.3.4.**

These figures show that maintenance expenditure in Uda Walawe **is 2.82** times that of the ID. It is necessary to evaluate the performance of the physical system and also the effort required in operational activities to determine the significance of this difference. Operational costs as defined by the IMD cannot be easily separated in the budget. Overhead costs in the Mahaweli

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system include the salaries of irrigators only - about Rs 46/- per acre. The comparable figure for the ID is about Rs 33/- per acre. On the other hand, salaries of work supervisors provided by the ID amounts to Rs 12/- per acre.

If under-investment in maintenance is the main reason behind the need for rehabilitation at regular intervals, then most of the Mahaweli systems should have a longer life compared to the ID systems. In fact, the need for rehabilitation does not depend solely on maintenance. Other factors contributing to shorter rehabilitation cycles are: quality of original construction, compatibility of design and operation of the irrigation network and farmer participation. Proper maintenance with active farmer participation has resulted in longer lasting irrigation infrastructure in some schemes (e.g. Kimbulwana Oya). Therefore, appropriate levels of maintenance investments should be established taking into consideration both economic and management aspects. Also, close monitoring of maintenance should be established.

In deciding expenditure levels, attention should be paid to the work needed considering the size, nature and age of the system, the quality of input (skills and salaries of implementing staff) and level of farmer participation. Expenditure policies for O&M should be studied thoroughly with due consideration given to the above mentioned factors with the goal of achieving appropriate expenditure levels.

Overhead Costs

To arrive at the current overhead costs, a review of past expenditure records was undertaken. In this analysis, expenditures on O&M were split among administrative, O&M costs. In doing so, it was necessary to go into the details of each paid document to verify the nature of spending. The analysis was completed for 1987, 1988, 1989, 1990, 1991 and summarized results are tabulated in **Table 3.3.5.**

Year	Administration		Maintenance		Total		ID Operation		Total O&M		Expenditure/ Acre (Rs)
	Alloca (Rs)	Expend. (Rs)	Alloca. (Rs)	Expend. (Rs)	Alloca. (Rs)	Expend. (Rs)	Alloca. (Rs)	Expend. (Rs)	Alloca. (Rs.	Expend. (Rs)	
1987	406466	296216	704096	776062	1110562	1072278	339000	357844	1449562	1430122	120
1988	358650	249926	486850	673627	845500	923553	550400	506288	1395900	1429841	117
1989	290000	247501	585000	591102	875000	838603	318000	402644	1193000	1241246	104
1990	276026	518559	673556	407285	949582	985844	332894	408836	1282476	1394680	117
1991	250920	1056621	408460	147400	659380	1204021	388500	119539	1017880	1323560	128

Table 3.3.5 demonstrates that administrative expenditures were incurred at the expense of maintenance work. For instance, in 1991 the ratio of administrative expenditure to allocation provided was 4.21 compared to 0.85 and 2.10 during previous years. There seems to exist a trend to spend a greater part of available funds on administration with a corresponding detrimental effect on maintenance.

Table 3.3.6 shows that during some years, expenditure on physical maintenance work in the different subsystems was not uniform. For example, Tissawewa, Weerawila and Pannegamuwa were favored over the other tanks while the Ellegala headwork was given very little attention. Since these allocations are for routine work like desilting, weeding and repairing small structural problems (except under special conditions such as flood damage, breaches, etc.), there is little justification for non-uniformity in these allocations.

The detailed analysis of administrative costs for the Tissa Division presented in **Table 3.3.7** shows that expenditure should be **Rs** 511,200/- per year. This was more than 30 percent of funding for physical work recommended by Sheladia Associates for ISMP and more than the 40 percent recommended by the IMD. Subsistence rates for officers were increased substantially after this analysis and this change will further undermine the sustainability of irrigation infrastructure. **A** large portion of administrative costs (49 percent) is taken up by salaries paid to casual staff. **The** best possible way to reduce costs therefore lies in cutting down the number of staff. Other areas where reductions could be made in travelling expenses **(13** percent) and vehicle maintenance (17 percent).

Table 3.3.6. The ratios **and actual expenditure and allocation of maintenance budget of subsystems.**

System	1987	1988	1989	1990	1991	Expenditure
Tissawewa	0.91	1.17	0.77	0.74	0.21	-
Yodawewa	0.74	1.13	0.74	0.51	0.34	565345.4
Weerawila	1.14	1.76	0.92	0.92	0.84	382494.8
Debarawewa	1.00	0.79	0.69	0.26	0.09	290274.4
Pannegamuwa	1.90	2.91	2.40	0.88	0.06	31496.57
Gemunupura	0.93	0.41	0.61	0.00	0.23	23709.76
Ellegala	0.87	0.99	0.00	1.17	0.00	9259.20

If the IMD's overhead standards are used, it would appear that maintaining a separate division for Ellegala System **is** not economically justifiable. The recent amalgamation of the Ellegala System with the LB has had certain impacts in reducing administrative costs but has not resolved the problem.

The following calculations should be considered:

* If maintenance work in the LB and Ellegala System is funded at present levels, total allocation for administration based on the IMD's norms will be Rs 336,832/- (4,856 acres x Rs 55/- Rs/ac x 0.4 + Rs 575,000/- x 0.4).

* With the amalgamation of the LB and the Ellegala System, the total requirement for administration might increase. Taking the analysis in Table 3.3.7 as the base, the increased requirement could be estimated on an increased area basis. On this basis, estimated administrative costs of the new division would be Rs 749,136/- (Rs 511,200/- x 15,289 acres/10,433 acres).

* As indicated in Table 3.3.4, allocations for operations provided by the IMD for Tissa and the LB was Rs 335,0001- and Rs 104,000/-, respectively. After amalgamation the total available amount is Rs 439,000/-. Estimated administrative costs for Tissa is Rs 511,200/-, higher than the allocation.

It appears, therefore, that even this new division was not big enough to absorb all administrative costs.

Determination of a feasible size for a maintenance division requires attention. At current funding rates, these figures suggest that an economically feasible division should serve at least 24,000 acres (Rs 511,200/Rs 55/- per acre/0.4 - 23,236 acres), However, calculation of the administrative cost of the division shown in Table 3.3.7 was made on least number of staff and other facilities. It is quite possible that more area could be managed with this staff and facilities. Therefore a proper estimation of actual requirements needs to be made before deciding on size. Another possible conclusion is that division size below 24,000 acres is not. viable. A detailed analysis of these figures is required.

These computation suggest that Kirindi Oya needs only one irrigation division. Divisions of comparable size exist elsewhere and the Parakrama Samudra is a good example. However, because Kirindi Oya is new and suffers water short conditions, it may not be advisable to consolidate into one division until the system reaches stability. Of course, a short-term solution is to have part of this cost borne by construction or rehabilitation works. If political or administrative reasons dictate maintenance of smaller divisions, then norms for administrative costs may need to be revised.

Financially Viable Size of Irrigation Divisions

Administrative costs of irrigation divisions were not fully provided for in the budget. More often than not, when capital works were not in progress, irrigation managers were compelled to use maintenance allocations to cover administrative costs. A part of the administrative cost is fixed costs since it does not depend on the work load. The other part, the cost of works, is closely related to the work load, command area and other characteristics such as the nature of the irrigation system, spatial distribution of subsystems, etc. In allocating maintenance funds for administration, severe under-investment in physical maintenance work is encountered. This type of financial management certainly demands frequent rehabilitation.

S.I.	Description	Unit	Qty.	Rate	Frc.	Amount	Sub-Tot.	Percentage
2	Subsistence for Field Staff							
2.1	Irrigation Engineer	days	5	200.00	0.3	300.00		
2.2	Divisional Assistant	days	4	200.00	0.3	240.00		
2.3	Technical Assistants(4*4days)	days	16	150.00	0.3	720.00		
2.4	Work Supervisors(4*4days)	days	16	150.00	0.3	120.00		
2.5	Drivers(2*10days)	days	20	150.00	0.3	900.00		
2.6	Operators	days	5	150.00	0.3	225.00	3105.00	1.29
3	Travelling for Field Staff							
3.1	Irrigation Engineer	Miles	200	10.00	0.5	1000.110		
3.2	Divisional Assistant	Niles	150	10.00	0.5	750.00		
3.3	Technical Assistants(3*150Mls.)	Niles	450	10.00	0.5	2250.00		
3.4	Technical Assistant	Niles	300	1.25	0.5	187.50		
3.5	Work Supervisors(4*300Mls.)	Miles	1200	1.25	1	1500.00	5687.50	13.35
4	Overtime for Office Staff							
4.1	Clerks(4*40Hrs.)	Hours	160	7.50	0.5	600.00		
4.2	Draftsmen(2*40Hrs.)	Hours	80	7.50	0.5	300.00		
4.3	Store Keeper	Hours	40	7.50	0.5	150.00		
4.1	Typist	Hours	40	1.50	0.5	150.00		
4.5	Peons(2*40Hrs.)	Hours	SO	1.50	0.5	300.00	1500.00	3.52
5	Vehicals							
5.1	Tyres-Nissan (3sets/year)	sets	3	9400.00	0.6	1410.00		
5.2	Tyres-Daihatsu(3sets/year)	sets	3	8000.00	0.6	1200.00		
5.3	Fuel and Lubricants	Item	1	1500.00	0.6	4500.00	7110.00	16.69
6	Telephone Bills	Iten	1	4000.00	0.5	2000.00	2000.00	4.69
7	Electricity Bills	Item	1	2500.00	0.5	1250.00	1250.00	2.93
8	Stationary	Iten	1	2000.00	0.5	1000.00	1000.00	2.35
9	Rounding off	-				42.25	12.25	
	Total per month					42600.00	42600.00	
	Total for year					511200.00		

In almost all rehabilitation programs, it is strongly advocated to have well defined maintenance programs. Also, these programs have invested heavily in streamlining maintenance procedures. This research component has clearly identified the need for improving maintenance processes through revised financial management.

Using the information generated in the analysis, many strategies were tried out to overcome the misuse of maintenance allocations. These data were incorporated in the 1991192Maha Seasonal Report. The analysis ultimately led to the development of a method for checking financial viability of **an** irrigation division,. The fixed costs should be based on staff requirement, maintenance of vehicles, salaries, allowances and other office needs like telecommunications and electricity.

According to the cost analysis, the size of a financially viable imgation division can be calculated by using the following equation:

$$C = (A - I - P) / (M \times F)$$

Where	C	=	Financially viable size of the division in acres,
	A	=	Estimated administrative cost,
	I	=	Total overhead cost allowed in works other than maintenance,
	P	=	Administrative cost provided,
	M	=	Maintenance allocation per acre and
	F	=	Factor allowed for administrative cost.

Using data from Tissa, when $I = O$ and $P = O$, the size of an irrigation division will work out to about 25,000 acres. If allocations for administration are not adequate and the size of the division is not financially viable, then there is a tendency to use maintenance funds for administrative purposes which creates under-investment in maintenance. This equation needs to be field-tested in several irrigation divisions so as to validate the different cost components and the factor ***of*** administrative cost allowed. Administrative costs do not totally depend on irrigable extent but is directly related to spatial distribution and type of irrigation scheme. Therefore, it is recommended to test this equation in a wide range of irrigation systems in different parts of the country.

3.3.6 Management of Physical Work

Initial work started prior to yala 1991. Before beginning, formats and the walk-through method were field tested by **the** ID staff.

Planning of Maintenance Work

The section explains the process followed in planning maintenance activities. The diagnostic walk-through was used to identify needs, and farmer participation was considered the driving force in the implementation of the work program.

Identification

The planning of maintenance activities needs sufficient time since it has to go through several stages **of** refining. The process needs to be started at least four months before the start of the new financial year. This period coincides with the closure season between the dry and wet seasons. Since water is not being issued during this period, irrigation staff and farmers can afford to spend more time on this activity. Another advantage is that maintenance requirements *can* be inspected and necessary surveys and levelling done in dry weather. Unlike in the past, identification of maintenance activities was carried out in a participatory manner by a team comprising the TA, the WS, the IDO, IO, FRs and TOAs.

This team conducted the diagnostic walk-through along the canals and inspected maintenance requirements in canal sections, structures and service roads. The FR walk-throughs were used to stimulate discussions with FRs and to extract information on operations of that particular facility of the system. A lot of **useful** information was gathered because it was discussed on site with both upstream and downstream FRs. also, field level system operators had considerable opportunity to discuss operational difficulties caused by deficiencies in the facilities. While on the walk-through, the TA sketched maintenance requirements on a predesigned format with actual quantities of work to be done **(See Figure 3.3.1).** Use of these formats and the abbreviations used speeded up the process and resulted in neat sketches of maintenance work needed.

Prioritizing

The maintenance requirements submitted by the TA were carefully studied by the IE before his walk-through. Where large areas were involved, the IE had the option of visiting the most important locations. The purpose of these visits was to verify the quantities of work that has technical viability, to identify technical deficiencies in facilities and to heck work done in the past.

The prioritization panel comprises the IE, the **TA,** the **WS,** the IDO, the **YO** and FRs. In the tertiary' system, routine work is not inspected by the IE. Nevertheless, he personally inspects improvements works and large repairs before implementation.

Decision Making

After the inspection by the **IE** with the amended **list** of items, another walk-through **is** conducted by the decision-making team comprising the Deputy Director of Irrigation, the IE, the TA, the IDO and the IO.

In the tertiary system, the Deputy Director can delegate his function to the IE. These procedures have enhanced implementation **of** maintenance work.

Preparing of Estimates for the Weemwila Main Canal

A trial walk-through was conducted in May 1991 and estimate formats done by IIMI were utilized. Although the work program had a delayed start, the 1992 work plan was ready by the end of December. After identifying maintenance work, the IE prepared the draft cost estimate shown in Table 3.3.8.

These estimated figures seemed high compared to the IMD's allocation. With the maintenance funds provided, only two activities could be completed; therefore, the detailed estimate was discussed with FRs. Their priority was to invest money on desilting. However, officials preferred to give priority to other works mainly because of limited funds but also because they planned to use the Rectification of Irrigation Deficiencies's (RID) financial resources for desilting. Most irrigation officials believed that desilting could not be done bit by bit. On the other hand, farmers said that desilting at two locations would certainly improve conveyance of water to the tail-end. Accordingly, the entrances to the Warapitiya and the Uduwila tanks were successfully desilted.

The work plan was successfully implemented during the season and the program introduced officers to needs-based maintenance. Officers also used the diagnostic walk-through and consultations with farmers to determine maintenance needs in subsystems outside the pilot area. The successful implementation of this program indicates that this method is replicable.

Preparing of Estimates

The final estimate for repairs on the Weerawila Main Canal is shown in Table 3.3.8. This estimate was submitted to the Deputy Director as prescribed in the new procedure. The final estimate was Rs 285,000/- but the allocation made for this work was only Rs 40,000/-. Thereafter, the ID received an additional allocation. The expected increase for the Weerawila system will be between Rs 25,000 and Rs 30,000/-.

The Weerawila subsystem has been allocated only a fraction of the sum actually required for maintenance. This clearly indicates a substantial budget deficit. Ways and means to overcome this situation were completely studied. Part of the deficit was overcome by "Shramadana work" (self-help campaign). The IE proposed mobilizing the maintenance labor gang for certain items and the savings from this activity was Rs 59,925/-.

The Deputy Director set the priorities for implementation after consulting the IE. Desilting received the lowest priority not because it consumes money, but because the most essential items for conveyance of water are weeding, repairs to structures and other earthworks. The first three items were dealt with during the year.

The ID argues that desilting may be avoided if canal banks are raised to bring canal capacity up to design requirement. If desilting is selected but postponed due to lack of funds, the water level in the main canal will rise above the current full supply level (FSL). This may create conditions

which would lead to drawing more water through main canal offtakes. Therefore, repairs to control mechanisms at these offtakes are required to deliver the required quantity of water. Bank raising can be done in selected areas where the capacity is inadequate. Generally, desilting changes the hydraulic regime in a canal but there is a tendency to revert to original conditions leading to more desilting. Therefore, it may be advantageous in certain cases to improve canal capacities by raising banks at selected locations rather than undertaking expensive and recurrent desilting.

Table 3.3.8. Estimate of the expenses necessary to be incurred for physical maintenance to Weerawila main canal.

Subsystems	Quantity	Unit	Items	Rate Rs. Cts	Total Rs. Cts	Priority
1	149.80	sqs	Water weeding (WBD) in m/c (2 years)	8.00	1198.40	1
2	435.70	sqs	Water weeding (WBD) in m/c (2 years)	5.35	2330.99	1
3	294.40	sqs	Water weeding (WBD) in m/c bund (2 years)	8.00	2355.20	1
4	1442.35	sqs	Water weeding (WBL) in m/c (1 year)	5.35	7716.57	1
5	189.00	sqs	Water weeding (WBD) in m/c road (1 year)	4.00	756.00	1
6	1090.20	sqs	Water weeding (WBL) in m/c road (1 year)	3.20	3488.64	1
7	38.33	sqs	0.5" thick ct. plastering 1:3 ct. mortar	517.00	10816.61	2
8	32.09	cubic	E/E from borrow and back-fill around structure	337.25	10822.35	2
9	32.09	cubic	Placing and compacting fill material	45.50	1460.09	2
10	1.78	cubic	R/R masonry in 1:5 ct. mortar	4085.00	7271.30	2
11	0.40	sqs	9" rubble pitching in 1:5 ct. mortar	3028.00	1211.20	2
12	0.88	cubic	1:3:6 (1.5") ct. concrete m/c form work	7082.00	6232.16	2
13	1833.44	cubic	Desilting along the main canal	106.75	195719.72	4
14	54.91	cubic	E/E from borrow and filling washed-ways	337.25	18518.39	3
15	54.91	cubic	Placing an compacting fill material	45.50	2498.40	3
16	Item	Allow.	Contingencies	Sum	3603.98	
Total					285000.00	

Cost for priority 1 = 17,845.80
Cost for paddy 1 & 2 – 64,659.51
Cost for priority 1, 2 & 3 – 85,676.30
Cost for priority 1, 2, 3 and 4 = 281,396.02

Turnout Assistants (TOAs) for Maintenance Work

A plan to implement maintenance work through the regular maintenance gang was prepared before the end of 1991 and norms were fixed for these maintenance items. These norms, given as daily outputs, were useful in implementation and progress control. Details such as location and length of canal to be attended daily were given in the work plan, which was useful to inspecting and supervisory staff. Continuous monitoring was done on TOAs, which has improved their performance. Other reasons for improved performance are the special attention given by officials, appreciation expressed and recognition given by officers and the farmers. At the beginning, very few TOs performed well.

However, as time passed, quite a number began taking an interest in their work. This improvement can be seen in **Figures 3.3.2, 3.3.3 and 3.3.4.** With this activity, maintenance laborers were given record books to write down details of their daily work. Supervising and inspecting officers were advised to read these notes and make remarks as part of their inspection notes.

The data collected on daily output of the maintenance program was monitored during the season and an analysis was done. Results are given in **Figures 3.3.2, 333 and 3.3.4.** Using this information the mode for deployment of laborers and norms can be updated during the next year's program. The departmental norm for weeding irrigation reservations is 25 squares per man-day. This study suggests a higher norm of around 35 squares outside the canal section and a lower norm of around 15 squares inside the conveyance section. These figures are site-specific and cannot be directly used in other systems. However, this method can be used to establish norms where simple work studies of this nature can be carried out. This study revealed that an average monthly output of 200 and 600 squares of weeding can be expected from a TOA in canal and embankment sections, respectively.

Annual Maintenance Plans

Maintenance work needs to be planned well ahead to ensure that different activities are completed on time. Also, one has to be ready to monitor progress. Most imgation managers do not prepare annual maintenance plans because of the low priority given to maintenance as compared to construction. Since 1986, the participation of farmers in imgation activities has exerted heavy pressure on the irrigation agency with respect to repairing irrigation infrastructure. Thus there is substantial improvement in INMAS areas where maintenance work is being carried out on **a** more **or** less **as** needed basis with farmer involvement.

According to the research design, identifying, prioritizing and making decisions on maintenance requirements must be done with the active participation of farmers. In the pilot area, farmers participated to some extent but their participation during each stage of the process needs further strengthening and improvement. Attempts made by the **IE** of the Tissa Division is preparing the work plan were commendable. Even though this procedure was not field tested for replication, he prepared detailed work plans for the other subsystems as well.

The **Annexure 3.3.1** shows the 1992 overall maintenance plan. First, an annual program was prepared for the permanent maintenance gang and each one was assigned equal sections of the main canal. This program was prepared for both canal closure and water issue periods. The period of canal closure is utilized for heavy cleaning work inside the conveyance section. TOAs were assigned 175 ft of canal per day to weed in the first four miles of the main canal. During water issues ,they were assigned different sections and the norms was to weed 85 ft per day along with their water distribution duties. **Table 3.3.9** an example of a TQA assignment.

Implementing Maintenance Work

The closure season between maha 1991/92 and yala 1992 was very short because both farmers and officers felt that it was advisable to start yala cultivation using residual soil moisture. The first water issue was made on 1 March and maintenance work was possible only during February. Even though the canal was closed on 29 January, it was not possible to work inside the canal due to stagnant water. In most sections, cleaning started around the 10 February. The first four miles of the canal was distributed among six TOAs and the work was completed as specified in programmed schedule.

Training for Farmers and Officers

The planning workshop for the training program was developed in August and completed in mid November.

The number **of** staff needing training were as follows:

Irrigation Department		Irrigation Management Division		Farmer Representatives
Technical Assistants	17	Institutional Organizer	***36***	32
Work Supervisors	12			
Total	29		36	***32***

The ID and the IMD insisted that this training be given to all TOAs and WS's in the RB and the Tissa office in addition to the IOs in the project. FRs and officers were from the RB and Tissa area since they participated in tertiary maintenance management. Since this program was carried out for the three separate groups, all IOs participated. The training was carried out on different days for the three categories using resource persons from the ID, the IMD and IIMI.

Table 3.3.9

Allocation of Duties of TOAs - TM 1

Date	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
01	0.85	1M+17.50	17.75	27.85	44.85	1M+8.85	1M+25.85	1M+17.50	1M+35.00	1M+42.85	2M+8.85	2M+2.85
02	1.70	19.25	18.70	28.70	45.70	9.70	26.70	19.25	36.75	43.10	9.10	26.10
03	2.55	21.00	19.55	29.55	46.55	10.55	27.55	21.00	38.50	14.55	10.55	21.55
04	3.40	22.15	20.40	30.40	47.40	11.40	28.40	22.75	40.25	45.40	11.40	28.40
05	4.25	24.50	21.25	31.25	48.25	12.25	29.25	24.50	42.00	16.25	12.25	29.25
06	5.10	26.25	22.10	32.10	49.10	13.10	30.10	26.25	13.15	47.10	13.10	30.10
07	5.95	28.00	22.95	32.95	19.95	13.95	30.95	28.00	45.50	41.95	13.95	30.95
08	6.80	29.15	23.80	33.80	50.80	14.80	31.80	29.75	47.25	48.90	14.80	31.80
09	1.65	31.50	24.65	31.65	51.65	15.65	32.65	31.50	49.00	49.65	15.65	32.65
10	08.50	33.25	25.50	35.50	1M+8CH	16.50	33.50	33.25	50.75	50.50	16.50	33.50
11	9.35	35.00	26.35	36.35	17.35	34.35	52.50	51.35	11.35	31.35		
12	10.20	36.15	27.00	37.20	18.20	35.20	2M+00CH	2M+8CH	18.20	35.20		
13	11.05	38.50	38.05	19.05	36.05				19.05	36.05		
14	11.90	40.25	38.90	19.90	36.90				19.90	36.90		
15	12.15	42.00	39.10	20.15	37.75				20.15	37.75		
16	13.60	43.15	40.60	21.60	38.60				21.60	38.60		
11	14.15	45.50	41.45	22.15	39.15				22.45	38.60		
18	15.30	41.25	42.30	23.30	10.30				23.30	39.45		
19	16.15	49.00	43.15	24.10	11.15				24.15	10.30		
20	17.00	50.15	11.00	25.00	42.00				25.00	41.15		
21		52.50								2M+42.0		
22		2M+00CH										
23												
21												
25												
26												
27												
2%												
29												
30												
31												

The subjects covered were as follows:

Officers

1. Sources of allocation and limitations.
2. Maintenance process and prioritization.
3. Norms for maintenance work.
4. Importance of farmer participation in the maintenance process.

Fanner Representatives

1. Maintenance process.
2. Responsibilities of farmers in maintenance work.
3. Small scale contract management and responsibilities of each party.
4. Strategies to overcome resource deficits.

The training modules were prepared by resource persons and discussion was held before the training. At this discussion, each training module was discussed in detail and modified depending on feedback.

Officers and Fanner Representatives

Training was given on three separate one-day sessions on 9, 10 and 11 January 1992 at the Weerawila District Training Center. The objectives of the program were:

* to make field officers and farmers aware of the concept of needs-based maintenance,
* to motivate farmer participation in maintenance work and
* to mobilize and to make effective use of resources.

Resource persons were from the ID, the IMD and IIMI. ID staff arranged the program and IIMI provided financial assistance. On the first day, TOAs and WSs from both systems attended with their supervisors as observers and resource persons. Attendance and participation of all categories of staff was good. The subjects discussed were as follows:

* Sources and limitations of maintenance allocations.
* Importance of farmer participation in maintenance work.
* Strategies to overcome resource deficits.
* How to determine norms for maintenance work.

The next program was conducted for IOs and attendance was somewhat good. The subjects were different from the first day and included:

* Small scale contract management and responsibilities of each party.
* Duties of farmer organizations in maintenance work.
* Strategies to overcome resource deficits.

For the last program, the target group were the Weerawila FRs. Due to poor communication, attendance was poor. Some FRs from Yodawewa also attended. The subjects discussed and resource persons were the same as for the second program.

A questionnaire was administered to the trainees at the end of each sessions to evaluate the training. Responses included the fact that:

* General arrangements were good and the themes timely. 'They stated that this training will help the turnover program. All agreed that the training was comprehensive.
* There were divergent views on taking over O&M responsibilities by farmer organizations. None of the organizations were ready to take over full O&M responsibilities. According to 80 percent of the FRs, they cannot take over until distributaries are properly rehabilitated. IOs also said DCOs were not strong enough to take responsibility at this stage. Most organizations were only recently formed and needed more training and exposure to the program.
* Except for three field officers from the ID, all officers said that the proposed maintenance program was good and likely to solve farmer problems. The three officers who opposed this view said that they would have a lot of additional work if the program was implemented.
* DCO leaders and IOs generally complained they did not receive necessary assistance from the ID when they handle contracts. They suggested the ID make timely payments for contract work.

An assessment of the impact of training as well as of the progress of the maintenance program was attempted toward the end of the maha season. A questionnaire was administered to DCO leaders. However, none of them were aware of these programs and their impact. Therefore eight FRs from Weerawila were interviewed on their views of existing arrangements for maintenance in their systems.

The issues that emerged at these interviews are listed below:

* Out of the eight interviewed, only three had attended the training program. Even those who attended knew nothing about the proposed maintenance program.

* The FRs did not know that certain activities, for example, main canal cleaning done by farmer organizations through "Shramadanas" (self-help campaign) and deployment of TOAs for maintenance activities, was done under the pilot maintenance program. Most of the activities done under the program had been identified as work organized and done by the IE (Tissa).

* The FRs believed that main canal maintenance was the responsibility of the ID **so** that they could not participate in identifying maintenance needs at this level. Distributary canals are maintained by DCOs at present with or without funds from the ID.

* There existed a seemingly unresolvable conflict between the leaders of the four head reach distributaries and the leaders of the tail-end distributaries. The latter complained that the former were favored by the IE. They stressed the necessity for maintaining equity in the allocation of maintenance funds. DCO leaders in the tail-end identified their organizations with the IMD while leaders of the head reach DCOs showed a close relationship with the IE.

* Some tail-end leaders believed that they did not have a voice in the Subproject Management Committee because of pressure exerted by a certain farmer group in the process of making decisions on maintenance, etc. Also, according to them, they are not well represented at the PMC. They proposed the formation of the tank committees of "Wewa Sabhas" to bring an end to problems.

3.3.7 Impacts

This problem has not only produced direct results in the pilot area but also has made an impact on the entire project area. The main objective of this program was to develop and field test certain maintenance procedures and to prepare guidelines for maintenance. The following are identified as results and achievements.

* The internalization **of** the concept of the diagnostic walk-through **is** one **of** the key outcomes of this program. This term has become quite common among field staff and farmers. In fact, most engineers are using this method to ascertain maintenance requirements. More importantly, the recently implemented RID program in the Ellegala System followed this method to inventory rehabilitation requirements in the subsystems.

* The maintenance program in the RB subsystem prepared at the beginning of 1992 was published by the RE and contained the following information.

Total allocation	Rs 561,000/-
Allocation for tertiary systems	Rs 240,000/-
Estimated value of work in tertiaries	Rs 330,000/-
The difference in tertiary funding	Rs 90,000/-

The resource deficit between allocation and value of total work was over come by mobilizing free labor from farmers through self-help. This was the first time that the ID made this type of information transparent to farmers with details of actual work done in each canal and available financial resource. Both the procedure and the transparency have had an impact on physical system sustenance and strengthening farmer organizations. This report further suggests that other engineers could follow this procedure so that financial resources allocated for maintenance would be utilized on needs. Furthermore, this procedure has strengthened officer-farmer and officer-officer relationships.

* The use of maintenance laborers to carry out maintenance in a planned manner with established norms was found to be very effective. Some laborers are interested in improving their performance because of the recognition they received from superiors. **Also,** it was observed that the performance of laborers as a whole showed remarkable improvement.

* A complete analysis of maintenance funds generated a clear idea of expenditure and this can be used in financial planning in the future. In fact, when construction activities are diminishing, overhead costs should be readjusted to suit the work load. This is rather a difficult task because certain fixed costs like salaries, vehicle maintenance and electricity are essential, irrespective of the value of work in hand. This cost can be reduced to a certain extent. To overcome this situation and to minimize fixed expenditure this report suggests changing the norm for area of authority of irrigation divisions.

3.3.8 Lessons Learned and Findings

1. The suggested maintenance procedure and methods used in each stage of the process are implementable within the framework of ID and IMD.

2. A substantial difference exists in per acre allocations for maintenance between Mahaweli systems and ID/IMD systems; allocations for Mahaweli systems are about three times higher than those for the ID/IMD systems.

3. Maintenance funds are not allocated evenly in all subsystems, resulting in some being favored. To correct this, an equitable maintenance allocation program should be implemented.

4. Administrative overhead of maintenance work for the ID is high compared with the physical work; the administrative costs are covered by using the funds given for physical work. It was found that the administrative cost of the Tissa Division was not proportionate to the maintenance cost and need to be corrected. It is necessary to assess the actual administrative cost based on the manpower requirement.

5. The ID could reorganize its O&M divisions by bringing more command area under each division to maximize the manpower utilization; such rearrangement would lead to reduced per acre maintenance over head cost.

6. Recurrence of rehabilitation at closer intervals can be minimized by effective utilization **of** allotted funds for physical infrastructure maintenance.

7. Detailed work plans for maintenance were prepared well in advance enabled maintenance and implementation during the closure season to be completed successfully.

8. Norms and standards for different kinds of maintenance activities need to be revised after analyzing the progress of each activity.

9. The preparation of work estimates on the basis of needs **is** well accepted by agencies and farmers; mechanisms for farmer participation in this process need to be revised to get their active involvement. The assessment of work and preparation of work plans were found to be quite successful. This method could be adopted in other subsystems with few modifications. Presently, this procedure is adopted only in the main canals but should be. implemented in the distributaries also.

11. There is a very high potential for getting farmers' contribution in bridging the gap in resources; every effort should be taken to motivate and mobilize them through training and awareness.

12. It was noticed that the training provided for different groups had not yielded substantial impact; this was due to very poor communication between the farmers and FRs. Therefore it **is** suggested that an awareness program for the farmers **he** implemented at the DC level to help the main system. Both farmers and the field level staff need further training to achieve the desired goals.

3.3.9 Conclusion

* Fixed administrative costs should be ascertained considering staff requirements, office support and supplies, vehicle maintenance, salaries and other allowances. A cost analysis

can be carried out to determine the financially viable irrigation division using the following equation.

$$C = (A - I - P) / (M \times F)$$

Where
C = Financially viable size of the division
A = Estimated administrative costs
M = Maintenance allocation per acre
F = Factor allowed for administrative cost
P = Administration cost provided and
I = Total overhead cost allowed for works other than maintenance

The use of the above equation in the Tissa Division gives the size of a viable division as 25,000 acres.

* Resources for maintenance should be allocated based on actual requirements obtained through physical verification. However, it is advisable to set aside money for different categories of works (such as like main canals, headwork, distributary canals and roads) to minimize deterioration due to inequity in investments.

* Identification, prioritization and decision making walk-through surveys were found to be effective. Farmer participation increased as farmers felt their ideas and suggestions were being entertained. This environment strengthened relationships between users and operators.

* New formats were designed in consultation with irrigation staff and **used** in identification, quantification and preparation of cost estimates and were found to be effective, efficient and useful for needs-based maintenance.

* Procedural changes provided ample opportunity or high ranking irrigation managers to participate and supervise maintenance work. Their involvement improved the quality of the maintenance work and lower ranking field staff were motivated and encouraged to perform better when their work was appreciated by supervisors and users.

* Preparing of work plans for the work undertaken by the ID is a great stride in the direction of sustainability. These work programs help utilize limited resources in an effective manner.

* Departmental norms for weeding including the channel proper is 25 squares per day. Research results suggest a higher norm around 35 squares outside canal sections and 15 squares inside canal conveyance sections. These figures are site specific and have to be **used** continuously in other systems. The study also revealed that an average monthly output of 200 squares of weeding can be expected from a **TOA** inside canal sections and around 600 squares in reservations.

* With the training and awareness provided by the IMD under the participatory mode of management, it was easy implementing this research program. Nevertheless, considerable effort was put into providing extensive training for FRs on needs-based maintenance. It was expected that FRs and field staff would perform their tasks at distributary and field canal levels. In spite of these efforts, farmer participation was not forthcoming spontaneously. Additional training is needed to motivate and mobilize farmers to contribute.

3.3.10 Recommendations

1. Administrative overhead for maintenance work or the ID is high compared to the physical work accomplished; the administrative costs are covered by using the funds provided for physical work. It was found that the administrative cost of the Tissa Division was not proportionate to the maintenance cost and need to be corrected. When construction activities are diminishing in a project, administrative (overhead) costs should be readjusted to suit the workload. Under administrative costs, there are certain fixed costs like salaries, vehicle maintenance, electricity, telephone, etc., which are difficult to minimize.

   To overcome this situation and to minimize fixed expenditures, the ID should reorganize its O&M Division by bringing in more command area under each division to maximize the manpower utilization; such rearrangement would lead to reduced per acre maintenance overhead costs.

2. Preparing work estimates on the basis of needs is well accepted by agencies and farmers. Preparing of detailed work plans for maintenance well in advance enabled maintenance implementation during the closure season to be completed successfully.

   Identification, prioritization and decision making walk-through surveys were found to be effective. Farmer participation increased as farmers felt their ideas and suggestions were being entertained. The environment strengthened relationships between users and operators. New formats designed in consultation with irrigation staff and used in identifying, quantifying and preparing cost estimates were found to be effective, efficient and useful for needs-based maintenance. Procedural changes provided ample opportunity for high ranking Jrrigation Managers to participate and supervise maintenance planning work. Their involvement improved the quality of maintenance planning; lower ranking field staff were motivated and encouraged to perform better through the appreciation of superiors and users.

   It is recommended that: the concept of the diagnostic walk-through be internalized for the whole system to ascertain maintenance requirements and to prepare work plans, the suggested maintenance procedure and methods used in each stage of the process within the framework of the ID and IMD; and information be available at the beginning of the year, for each subsystem, on the total maintenance allocation,

allocation for main and tertiary systems, estimated value of work in tertiaries and shortfall in tertiary fundings to be supplemented by farmer organizations.

3. There exists a substantial difference in per acre allocations for maintenance between Mahaweli systems and the ID/IMD systems. This difference has to be reduced.

   It is recommended that: every effort be made to motivate and mobilize farmers through training and awareness for getting their contribution in bridging the gap of resources; norms and standards for different kinds of maintenance activities be revised after analyzing the process of each activity; and the existing maintenance laborers be used and monitored to carry out maintenance in a planned manner with established norms.

3.4 SALINITY MANAGEMENT IN THE ELLEGALA IRRIGATION SYSTEM

3.4.1 The Problem

Consequent to the construction of the Lunugamvehera Reservoir upstream of the old EIS in the Kirindi Oya Irrigation and Settlement Project, farmers in the old Ellegala (4,200 ha) began complaining that their paddy fields were being affected by salinity. The source of salinity they said was the soluble salts being leached out from the Kirindi Oya NIS (5,260 ha). These soluble salts they maintained were then collected in four major tanks and transported from them to the paddy fields through irrigation supply.

Their complaints reached a peak during the Maha season of 1992/93 when several isolated but visible patches of stunted young paddy plants could be readily observed in specific locations on lands situated in the flat alluvial plain of the old Ellegala. This paper attempts to provide an explanation to why the salinity problem became so acute during this particular maha season and to propose preventive measures based on a monitoring system which needs to be set in place.

3.4.2 Environmental Setting of the Old and New Irrigation Systems

The old Ellegala system is situated almost wholly within a flat alluvial plain. The Kirindi Oya cuts through the central portion of this plain. The main river course shows a distinct incised drainage. The river traverses the flat alluvial plain in a north-south direction in a slightly winding manner with two distinct meanders in the lower part of the flood plain just before the river enters the sea at the southern outfall (Figure **3.3.1).** The NIS in the Kirindi Oya in contrast, is situated almost wholly within the surrounding undulating, residual 'mantled plan' as shown in Figure **3.3.1.**

The four major reservoirs of the Ellegala - Weerawila, Debarawewa, Tissawewa and Yodawewa - are located in the transitional landscape between the undulating residual plain and the flat alluvial plain. It an be observed from Figure 3.4.1 that drainage waters from Tracts 1 and 2 of the New Areas of the RB flow into the major Weerawila and minor Pannegamuwa reservoirs **and** that drainage waters from Tracts 1 and **2** of the New Areas of the LB flow into the Debarawewa, the Tissawewa and Yodawewa. A schematic cross-section across the residual plain of the New Areas, the reservoirs, the flat alluvial plain of the Ellegala and the river is shown in Figure 3.4.2.

The soils **of** the undulating residual plain are 75 percent reddish brown earths (Chromic Luvisols LVx) and **25** percent solodized solonetz (Gleyic Solonetz SNg). The latter are sodic soils with an exchangeable sodium percentage of more than 15 percent of the exchange complex. The oils of the alluvial plain are made **up** of imperfectly drained, brown alluvial soils in the slightly higher aspects of the micro-relief and poorly drained, grey alluvial soils **in** the lower aspects. The path taken by soluble salts leached from the residual plain to the reservoirs and then to the flat alluvial plain is shown in Figure 3.3.2.

Mean annual rainfall in the project area (100 year average) is 970 mm with means annual evaporation (Class A open pan, ***20*** years) 2000 mm. The more reliable statistic of **'75** percent probability of monthly rainfall together with the average monthly evaporation is given in Tables **3.4.1(a)** and **3.4.1(b)**.

Month	Rainfall (1872-1987) Mean monthly mm	75% Probability mm	Evaporation (Penman) 20 years average mm
January	101	51	132
February	36	15	157
March	75	38	171
April	93	69	153
June	23	10	185
July	15	5	201
August	12	0	215
September	34	10	210
October	141	84	167
November	223	155	121
December	154	94	120
Total	968	562	1997

Table 3.4.1(b). Rainfall and Evaporation in Kirindi **Oya** during **1992.**

Month	Rainfall		Evaporation
	Rainfall total mm/month	Cumulative	Total mm/month
January	17.1	17.1	151
February	0.0	17.1	185
March	0.0	17.1	222
April	73.9	91.0	161
May	119.3	210.3	134
June	17.9	228.2	216
July	13.3	241.5	222
August	11.2	252.7	271
September	54.8	307.5	239
October	63.0	370.5	184
November	391.0	762.4	110
December	98.6	861.0	116

Evaporation exceeds precipitation every month except November, December and January. Strong dry westerly winds bring in cyclic atmospheric salts between June and September. As a result there is a net accretion of salts in this agroecological region of DL 5 which is a Semi-Arid Tropical environment.

For the last 100 years, the alluvial soils of the Ellegala have been irrigated with Class I irrigation water originating from the main Kirindi Oya and diverted to the command through the Ellegala Anicut. This coupled with the incised nature of the downstream Kirindi Oya prevented the build up of salts in the irrigated command area.

The Ellegala also had a good drainage network leading to several outfalls (Basnawas). These were disrupted following the 1969 floods and have not been repaired or properly maintained since then. It is from this time that farmers in the lower reaches of the Ellegala report incipient occurrences of salinity in their areas. Salts are however flushed out during exceptionally wet maha seasons which occur approximately once in six years.

The adjacent Badagiriya Irrigation System (850 ha) commissioned in 1961, is located wholly in the residual undulating plain of RBEs and solodized soils. By 1965, very high proportion of the command area, especially the lower topographical locations, were severely affected by salinity. Provision of proper landscape drainage and widening of the main natural drainage system coupled with annual irrigation and leaching over the last 25 years has subsequently helped to ameliorate these affected locations.

3.4.3 Translocation Pathways of Soluble Salts to the Ellegala

In January 1990, the DOA commenced a program to test, once every fortnight, the quality of water in the Lunugamvehera and in the five Ellegala tanks. The results of this analysis for the years 1990 to 1993 in respect of the Lunugamvehera and the Weerawila, the Tissawewa and the Yodawewa are shown in Figures **3.4.3** to **3.4.6.**

The normal pattern is reflected in the data for 1990 and 1991 which correspond to the modal seasonal pattern **of** rainfall in this environment. The seasonal pattern of rainfall and inflow for 1992 was very much below normal with the two main reservoirs of the Ellegala running dry between July and October.

As indicated in figures **3.4.3** to **3.4.6,** the quality of water in the Lunugamvehera was well below EC of 0.20 milli mhos per cm during the wet season from October to January and hovers around 0.25 for the rest of the year. Figure **3.4.4** indicates that water quality in the Lunugamvehera, which receives its total supply from the upstream Kirindi Oya, is Class I for almost all twelve months of the year.

In the case of the Tissawewa, electrical conductivity (EC) values increased to 0.75 milli mhos per cm between March and June and between August and October while EC values for the Weerawila exceeded 0.75 milli mhos per cm between March and June. Major inflow of drainage water charged with soluble salts from the New Areas to these reservoirs takes place during these two periods.

During 1992, EC values for the Weerawila peaked between August and September due to the reservoir not receiving inflows from the Lunugamvehera during this period. In 1993, trends were similar to 1991, with peak values for the Werawila recorded between June and July and between September and October, as shown in Figure **3.4.6.**

It can thus be observed that while the quality of water in the Lunugamvehera can be classified Class I, the quality **of** water in the reservoirs of the Ellegala fluctuate over a wide range during a season, depending on whether they have received considerable amounts of salt-enriched drainage water from the New Areas **or** not and depending on the amount of good quality water received from the Lunugamvehera via the Ellegala Anicut.

Because of the inadequate landscape drainage in the Ellegala which has now to cope with added accretion of soluble salts coming from the drainage water of the new system, the Ellegala presently acts as a sink for salts coming from both the upstream New Areas and normal cyclic salts and other accretions.

Present indications are that a Considerable amount of leaching of soluble salts is taking place from the New Areas. This rate of leaching may decrease with the passage of time through the continued leaching of salts, as happened in the adjacent Badagiriya system, provided drainage courses are kept in good working condition to flush out salts.

3.4.4. Location of Salinity Affected Areas in the Ellegala

The highest incidence of salinity was reported in November during the early stages **of** crop growth during the maha 1992/93 season. In the affected locations, paddy plants both transplanted and directly sown suffered retarded growth and yellowing.

Field examining of the affected locations indicated the following reasons for stunted growth

* the most severe stunting and yellowing of young paddy plants was observed immediately below the upwelling locations **of** the major tanks where upward seepage of tank storage water takes place,

* a high degree of stunning and yellowing was observed in the poorly drained micro-depressions of the flat alluvial plain where there is net inflow of both ground and surface water and

* continuous but small extents of stunting and yellowing were observed adjacent to the major drainage courses where there was drainage congestion or drainage blocks at the tail-end of the drainage system.

From these observations, it can be concluded that wherever there is upwelling or drainage congestion or impeded drainage and wherever upwelling or seepage water contains a high salt concentration, paddy plants are stunted. But since upwelling, impeded drainage and drainage congestion have all existed in the Ellegala to some extent, what then caused the severe manifestation **of** salinity during the maha 1992/93 seasons? The following section gives possible reasons.

3.4.5 Exceptional Increase in Salt Concentration During Maha 1992/93

a number of reasons can be adduced for the exceptional increase in salt concentration or salinity experienced during the early part of the 1992/93 maha season. Based on tank water quality data and measurements of soil salinity levels at nine selected locations within the command areas of the Weerawila. Tissawewa and Yodawewa made at fortnightly intervals from June through December 1993, the following reasons could be suggested.

* Very little irrigation was done in the ellegala during yala 1992 because **of** the exceptionally dry conditions experienced and the limited flow into the Lunugamvehera. There was no water in the Tissawewa, the Yodawewa, the Debarawewa and the Pannegamuwa from July to October.

  These conditions favored the capillary rise of groundwater in the flat alluvial plain resulting in the enrichment of surface soil with soluble salts. This was corroborated by regular monitoring of soil conductivity at the nine selected locations. Maximum values of **EC** of the soil saturated paste were recorded

between 18 September and 30 October. The highest values of between 0.87 and 1.26 milli mhos per cm were recorded in the poorly drained locations under the Weerawila and the Yodawewa. Lower values of between 0.23 and 0.35 were recorded for well drained locations. There was a sharp decline in these values in November and December due to heavy rainfall during November.

* During early maha, irrigation issues rom the Ellegala tanks were made exclusively from surface water runoff collected in these tanks at MOLs and not with good quality water from the Lunugamvehera. Therefore, needed dilution did not take place during the early phase of the season.

  The measured values of salinity of tank water during October and November indicate high values of EC as seen in **Figure 3.4.5.** Most of the water came from surface runoff originating in catchment areas rather than from drainage from the New Areas. Thus it is apparent that dissolved salts from surface runoff also contributes to enrichment of salts in the Ellegala tanks.

* There was very little surface flushing of salts during the period **up** to end October as only a cumulative rainfall of 370 mm was received from january to end October **Table 3.4.1(a)** as against a cumulative evaporation of nearly 2000 mm during the same period. In November, there was 390 mm of rainfall and this high rainfall could have flushed out salts from the catchments and brought these into the tanks.

Thus all three circumstances including the absence of irrigation during the previous yala season, the non-mixing with high quality water from the Lunugamvehera because of the decision to commence maha irrigation with rainfall and runoff water and the flushing of salts by the heavy November rains could have combined to contribute to increased salinity in the Ellegala.

Field inspections during November and December and interviews with farmers in the Tissawewa and Yodawewa command areas revealed other reasons for the stunted plants in the salinity affected areas were observed located in poorly drained grey alluvial soils and less in imperfectly drained brown alluvial soils. However, stunted paddy plants were mostly prevalent in locations where farmers had not applied Basal Phosphates irrespective of soil type, as shown in **Table 3.4.2.**

It **is** well **known** that paddy plants are adversely affected during the early stages **of** growth when phosphorus is deficient. This is most pronounced in poorly drained soils. In locations of drainage congestion, wherever farmers had applied the recommended dose of Basal Phosphatic fertilizer, healthy plant growth was observed.

Table 3.4.2. Effect of application of Basal Phosphate fertilizer.

	Soil drainage class	Applied fertilizer	Yield kg/ha
Tissawewa	Well drained	Basal No Basal	7000 4063
	Imperfectly drained	Basal No Basal	5650 4513
	Poorly drained	Basal No Basal	5547 3340
Yodawewa	Well drained	Basal No Basal	4427 3367
	Imperfectly drained	Basal No Basal	6930 3000
	Poorly drained	Basal No Basal	7067 1147

3.4.6 Influence of Landscape hydrology and drainage density on the occurrence and distribution of salinity in the Ellegala

A significant feature in the occurrence, severity and distribution of salinity in the Ellegala is the influence of the nature of the landscape hydrology and drainage density of the command areas.

Although the Weerawila tank water records the highest level of salinity throughout the year, the occurrence, severity and distribution of salinity in its command area is significantly less than in the Tissawewa and Yodawewa command areas.

This phenomenon can be explained by examining the nature of the landscape hydrology together with the drainage density of the respective command areas. The Weerawila command area is situated in a slightly uplifted and dissected alluvial plain which grades into the main Kirindi Oya in a convex-concave transverse profile with a gradient of 1.5 to 2.5 percent slope.

The morphology of this landscape determines the location of the main canal, distributaries, field channels and drainage ways. A high drainage density is self-evident in this type of landscape. This together with its drainage basis relative to the bed level of the incised Kirindi Oya permits a ready outflow of drainage water from the command area. Hence, its tolerance to the comparatively higher salinity levels of Class II water coming from Weerawila tank is greater.

In contrast, the Tissawewa and Yodawewa command areas are situated in a very flat alluvial plain with an average 0.5 percent slope. Natural drainage in this type of landscape is comparatively sluggish but it benefits from the incised nature of the main Kirindi Oya around its lower reaches where the bed level is around 5 meters below and land surface. On the other hand, as observed in irrigation and drainage system layout maps, irrigation drainage density in this area is very much lower than in the Weerawila command area. This explains the higher

Occurrence of salinity within these two systems as compared with the Weerawila irrigation system.

Monitoring of the quality of the drainage waters at four outfalls (Basnawas) located within the command areas of the Tissawewa and Yodawewa commenced in May 1993 and results are shown in **Table 3.4.3.** A clear trend of increasing salinity of drainage waters from the upper to the lower reaches of the command area was observe. The highest concentration of salts was recorded in the lowermost outfall near the sea, the Magama outfall which registered an EC of **1.78** milli mhos per cm for the same period in August 1993. There was a decline in EC values after November because of maha rains and irrigation, except at the maha Basnawa outfall, as Seen in **Table 3.4.3.**

Table 3.4.3. Electrical conductivity of drainage waters at the respective outfalls (Basnawas 1993).

Date	Yoda Ela Basnawa	Moda Ela Basnawa	Maha Basnawa	Magama Basnawa
23 May	-	-	1.72	0.92
16 June	0.71	0.77	1.72	0.90
30 June	0.56	0.73	1.48	0.89
16 July	0.67	0.73	1.48	1.26
4 August	0.63	0.67	1.70	1.46
24 August	0.63	-	1.64	1.78
9 September	0.75	0.73	1.63	
21 September	0.74	no flow	no flow	no flow
26 November	0.58	0.67	I.64	0.71
27 December	0.54	0.67	1.77	0.72

3.4.7 Proposed Solutions to the Salinity Problems of Ellegala

1. The quality of water used for irrigation during the critical crop growth period, namely seedling establishment and flowering, should be between the Class I and Class I category. Arrangements should therefore be made to release sufficient quantity of the Class I quality Lunugamvehera Reservoir water to the old Ellegala tanks during these periods.

2. Although the main emphasis up to now was to restrict the water supply to old Ellegala based on the quantity of water, the events that occurred during maha 1992/93 suggest

that water scheduling to old Ellegala must take into consideration the quality of the water in addition to the quantity to overcome the incipient salinity problems.

3. An inexpensive water quality monitoring of the five reservoirs should be sustained to release the required amount of Class I quality water from the Lunugamvehera reservoir to effect the necessary dilution.

4. One should take cognisance of the differences in the landscape hydrology and drainage density between the Weerawila irrigation system and that of the Tissawewa and Yodawewa systems in regulating the quality of tank waters. The Weerawila irrigation system can tolerate waters of Class II quality, while the Tissawewa and Yodawewa systems should be kept within the Class I quality.

5. Although farmers' perception that the construction of Lunugamvehera Reservoir has contributed to the increased salinity problems of old Ellegala is correct to a certain extent, farmers should be advised that salinity can still become a problem even without receiving the drainage water from the **NIS** as it happened in maha 1992/93.

6. There are two factors that are major contributors to the salinity problems of Ellegala. The first is the increased salinity contribution of tank water which can in the future, be modified by sufficient dilution from Lunugamvehera water by proper monitoring of water quality. The second is the drainage congestion in the Tissawewa and Yodawewa command areas and the poor drainage in miro-depressions and lower topographical locations which have poorly drained soils.

7. Early action should be taken to clear the drainage congestion and keep the drainage ways free from blockage and ensure that they are connected to the main arterial drains and eventually to the outfalls to the sea.

8. Farmers should be advised and trained about the provision and maintenance of the drainage facilities around their fields and also in the use of adequate dressing of Basal Phosphate- fertilizer is poorly drained soil locations.

9. As mentioned earlier in No.3 above, it is extremely important that the fortnightly monitoring of water qualities of all reservoirs and the four outfalls (Basnawas) be continued over the next five years. This would help to keep track of the trends in salinity over this period **and** it would thus form the basis for the appropriate corrective actions that would need to be taken.

10. Special note should be taken of the salinity levels of water during extraordinary dry years such as 1992, so that the necessary levels of dilution in the old Ellegala could be maintained at the critical threshold levels.

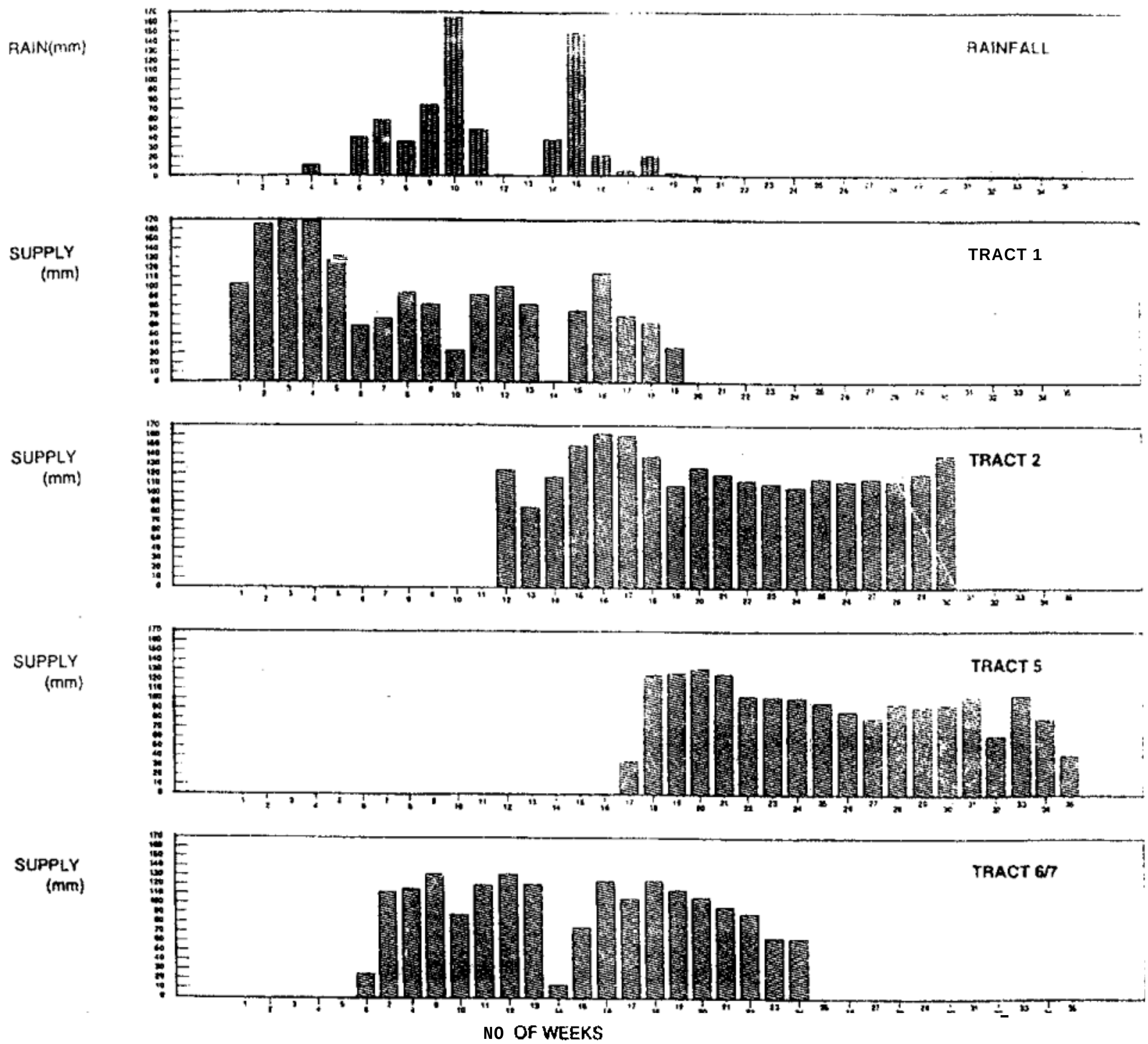
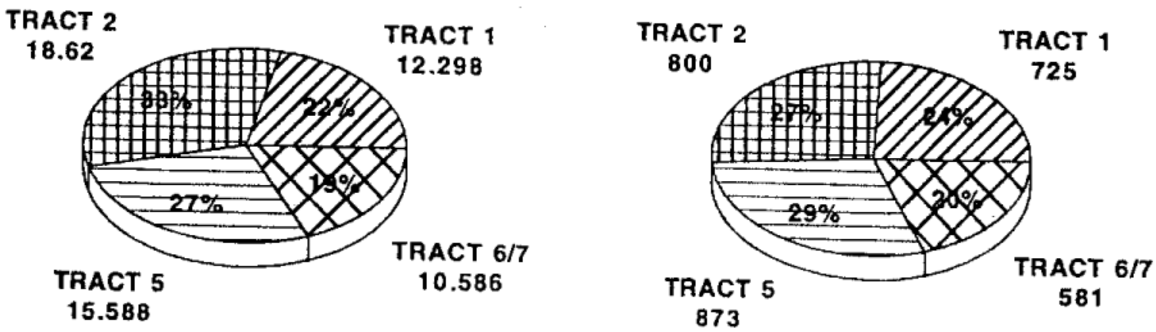


Figure 3.1.1. Weekly Pattern of Water Issues

WATER ISSUES IN THE DIFFERENT TRACTS



Water consumption (MCM)

Area distribution (ha)

Tract 1 - 15,182 ac-ft
Tract 2 - 22,986 ac-ft
Tract 5 - 19,244 ac-ft
Tract 6/7 - 13.069 ac-ft

Figure 3.1.2. Water Issues Tractwise

Next >>

Figure 3.1.3. Communication Network for the Right Bank Systems

Level I

<u>[illegible] Level</u>

Farmers communicate their problems to field canal Gate Operators through Farmer Renresentatives

Level II

<u>Field Canal Gate Operators</u>

Field canal Gate Operators communicate with Work Supervisors by providing daily discharges and making necessary adjustments to gates on their instructions

Level III

<u>Distributary Canal Level</u>

Communication between Work Supervisors and irrigators: discharges are either increased or decreased on the instruction of the Irrigation Engineer or the Resident Engineer

Level IV

<u>Main Canal Branch Canal Levels</u>

In[illegible] Work Supervisors, the Irrigation En[illegible]d the Resident Engineer maintain fre[illegible]munication. Communication with the [illegible] Engineer regarding changes in [illegible]

Note: The first **two** refer to management of the **tertiary system.**

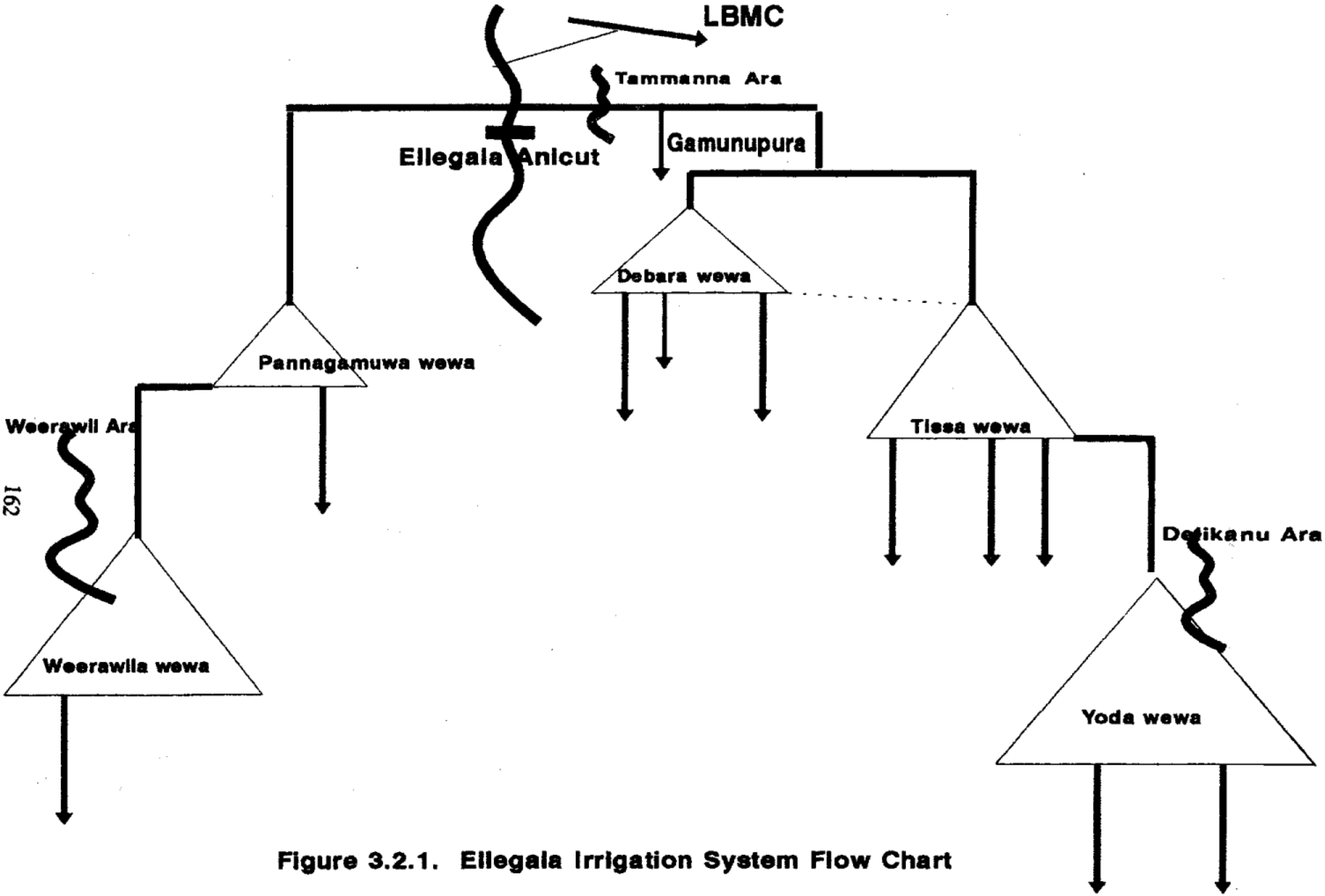


Figure 3.2.1. Ellegala Irrigation System Flow Chart

Open pan Evaporation
1991 to 1993 - Weeranila

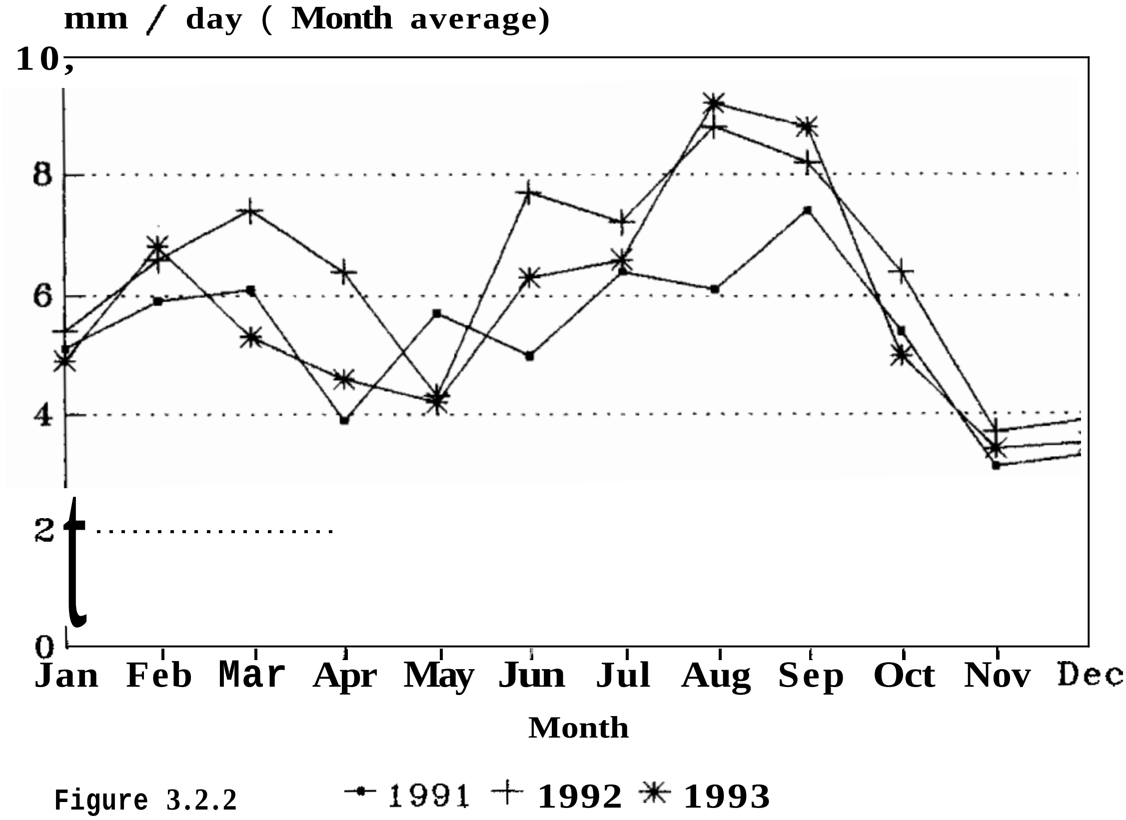


Figure 3.2.2

Open pan evaporation month aggregate
1991 to 1903 - Weerawila

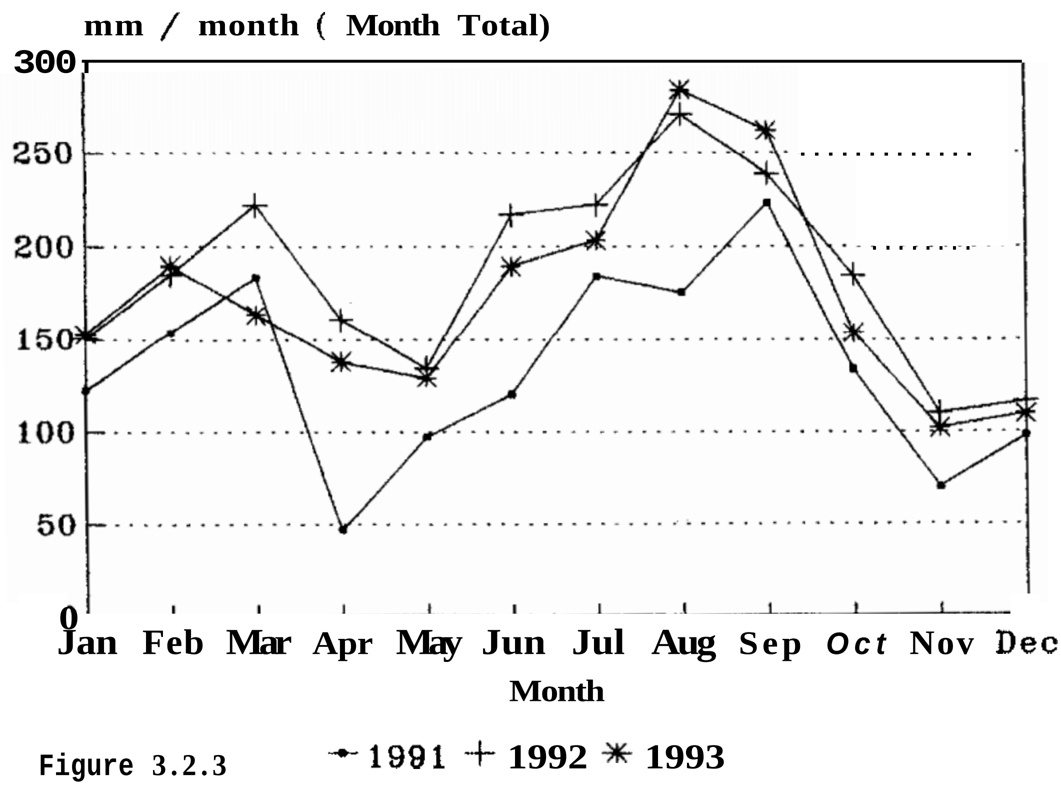


Figure 3.2.3

Rainfall at Weerawila
1991 to 1993

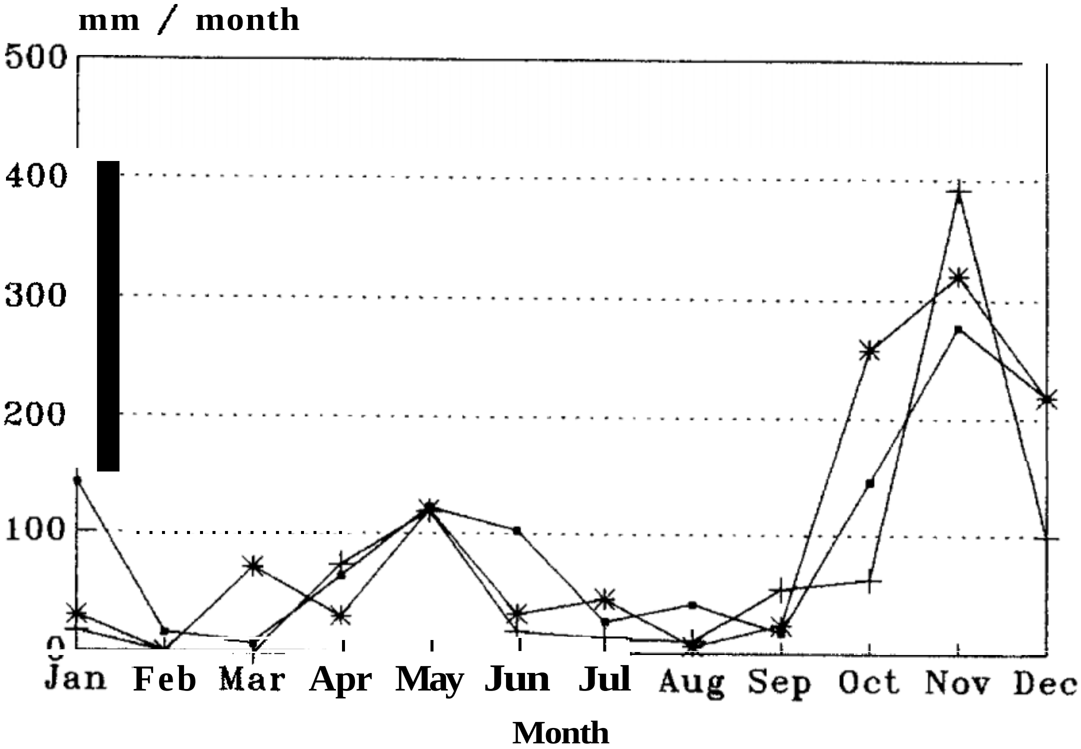


Figure *3.2.4* — 1991 + 1992 * 1993

Number of rain days per month
1991 to 1993 - Weerawila

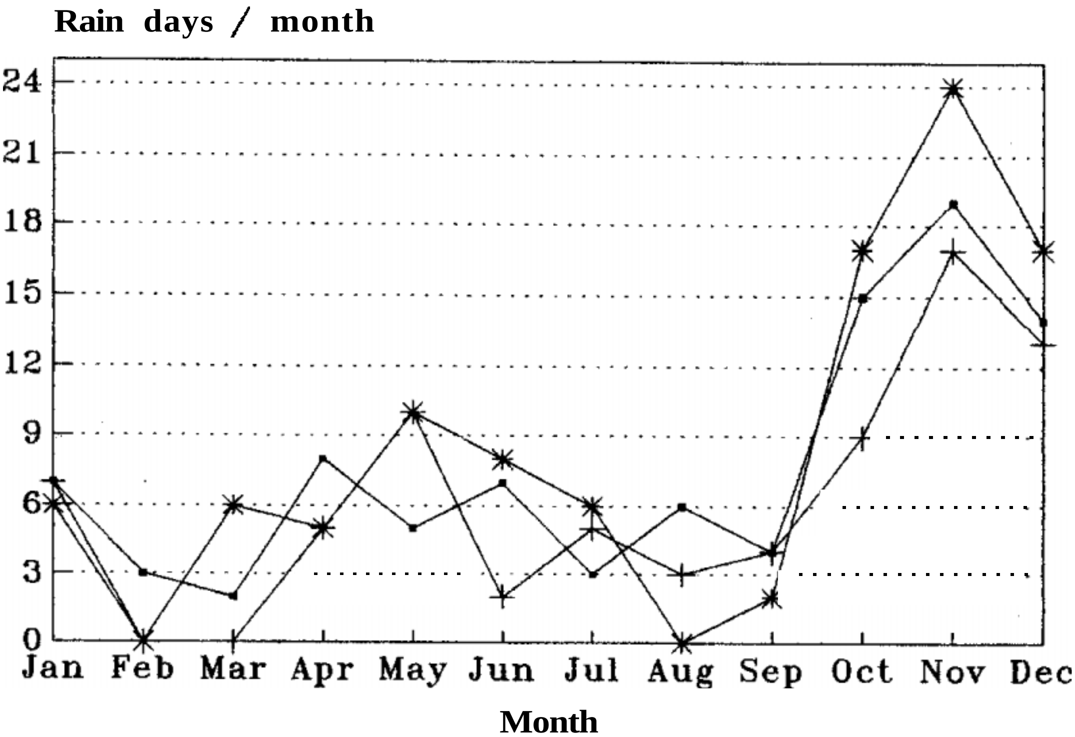


Figure *3.2.5* — 1991 + 1992 * 1993

Weerawlla Tank Water Level & Rainfall
199111992 Maha season

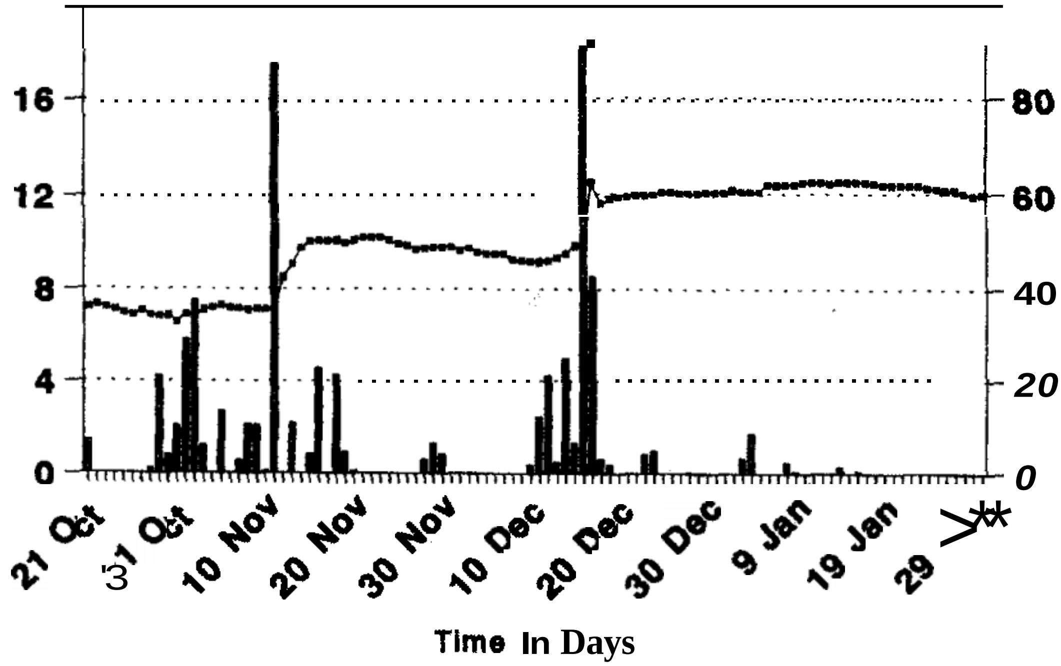


Figure 3.2.6 — WATER LEVEL ■ RAINFALL

Inflow to Weerawila Wewa & Rainfall
1991/1992 Maha season

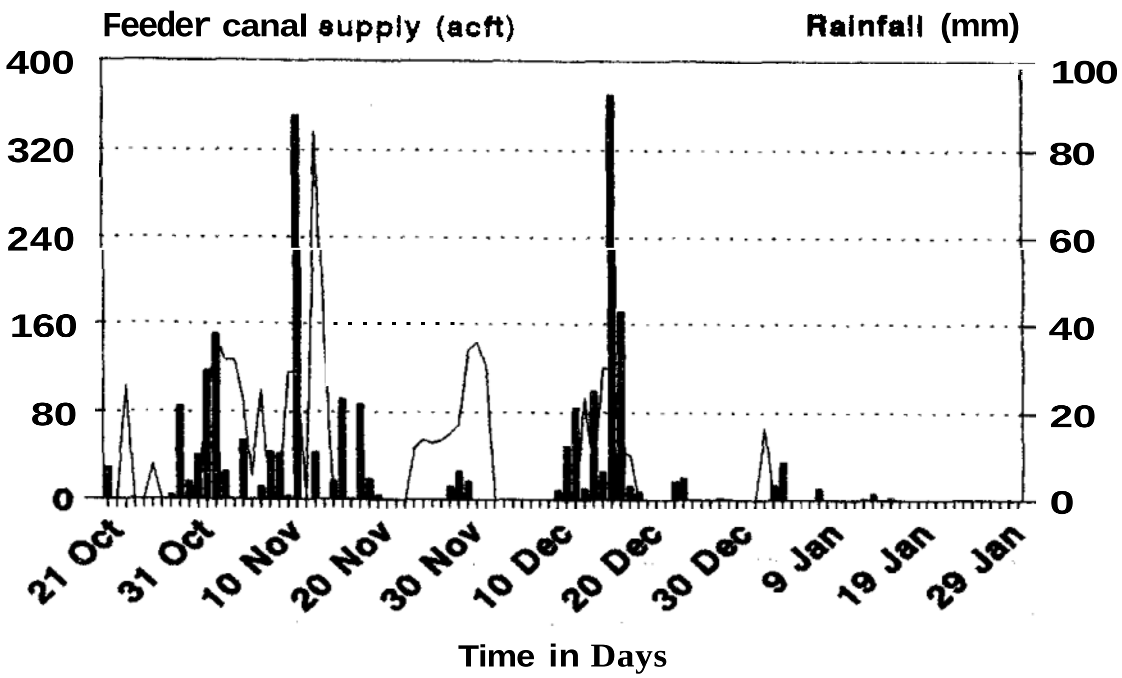


Figure 3.2.7 □ RAINFALL — INFLOW

Rainfall and Drainage with Runoff
1991/1992 Maha season

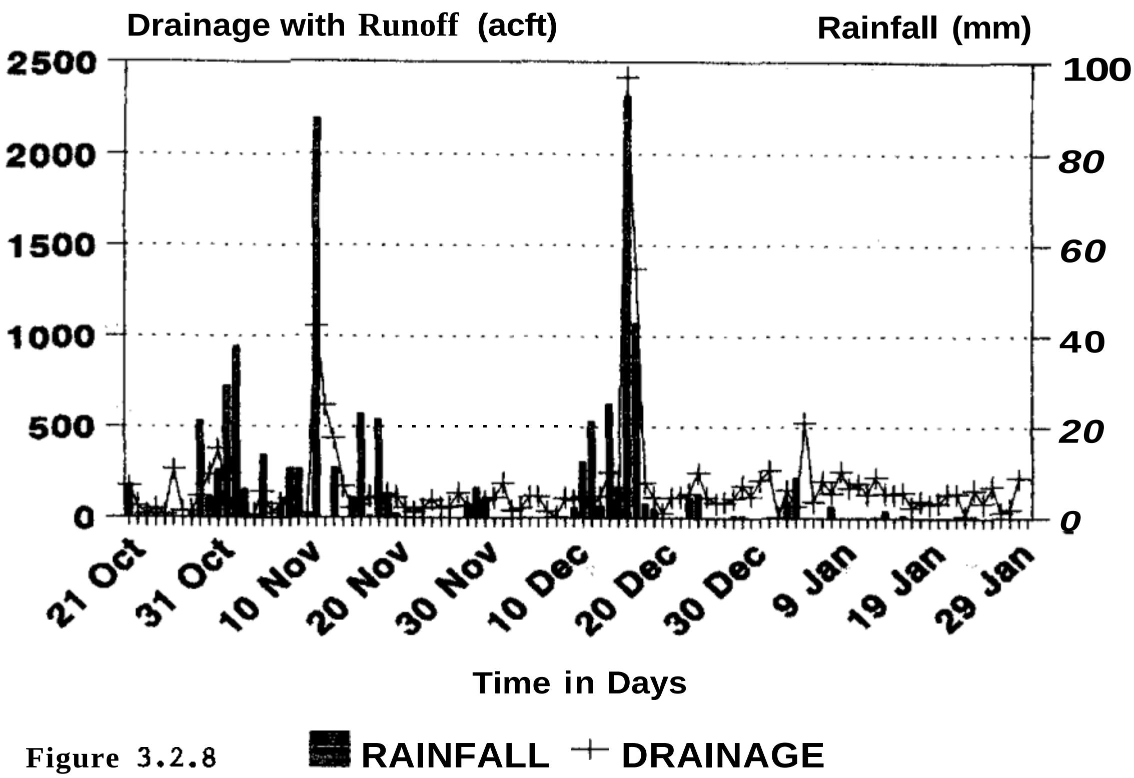


Figure 3.2.8

Surplus Drainage with Runoff
199111992 Maha season

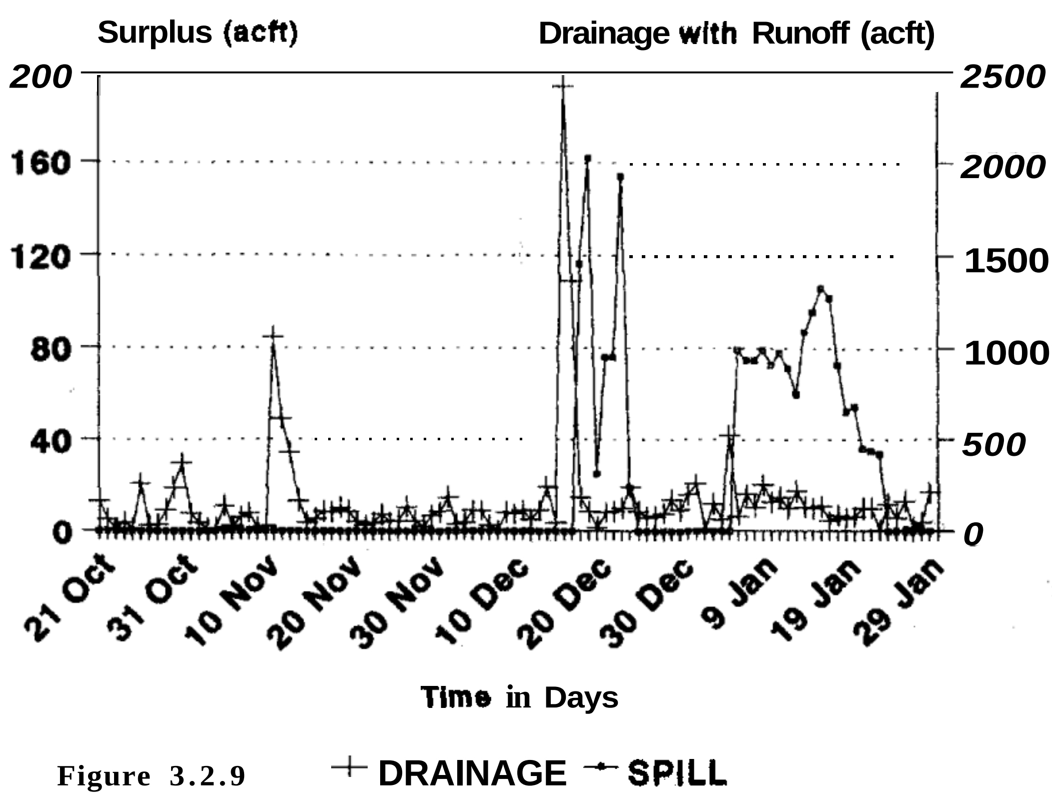


Figure 3.2.9

Surplus and Tank Water Level
1991/1992 Maha season

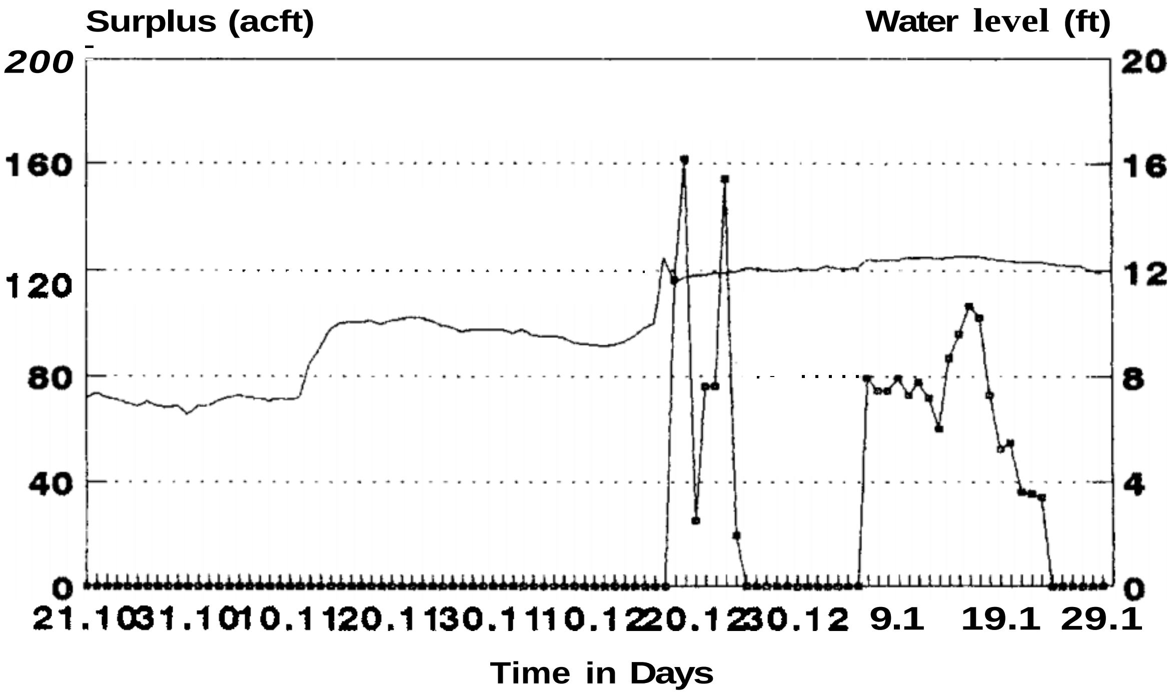


Figure 3.2.10 —WATER LEVEL ⁻▪⁻ SPILL

Figure 3.2.10

Inflow and Outflow for Weerawila Wewa
1991/1992 Maha season

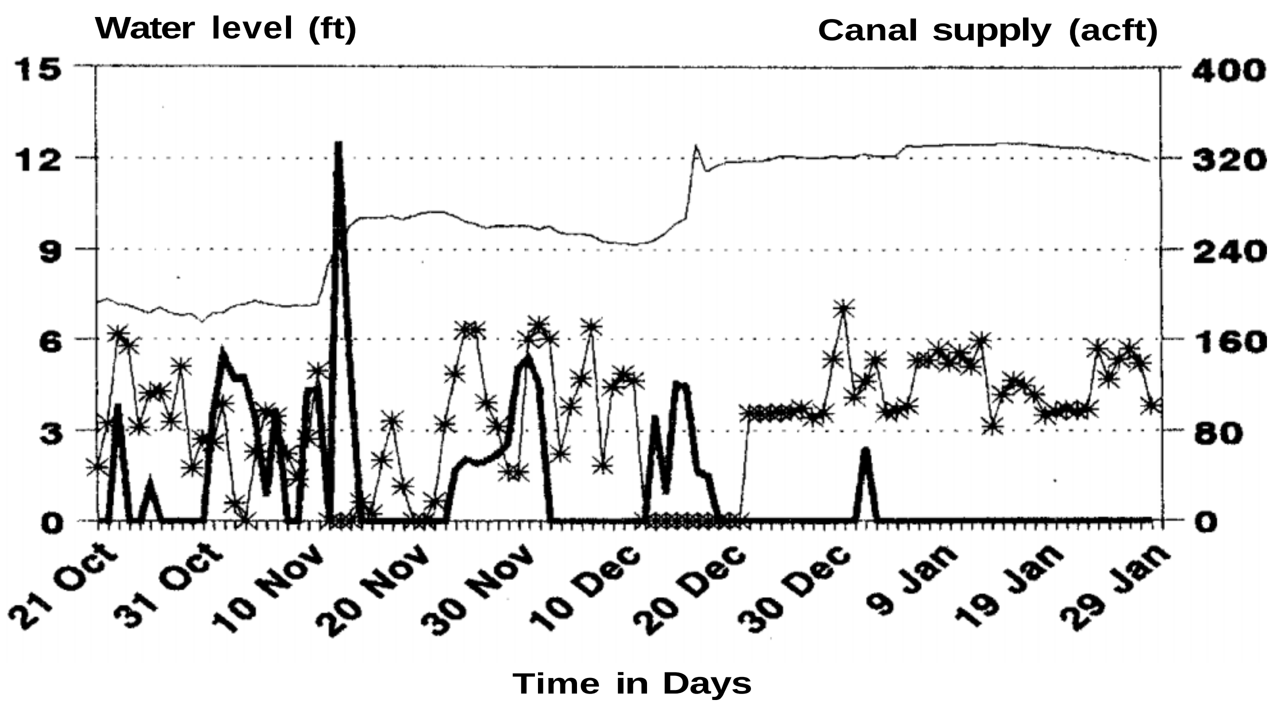


Figure 3.2.11 — WATER LEVEL — INFLOW ✳ MC- DIS

Weekly Operation Plan (dry)

Ellegala System

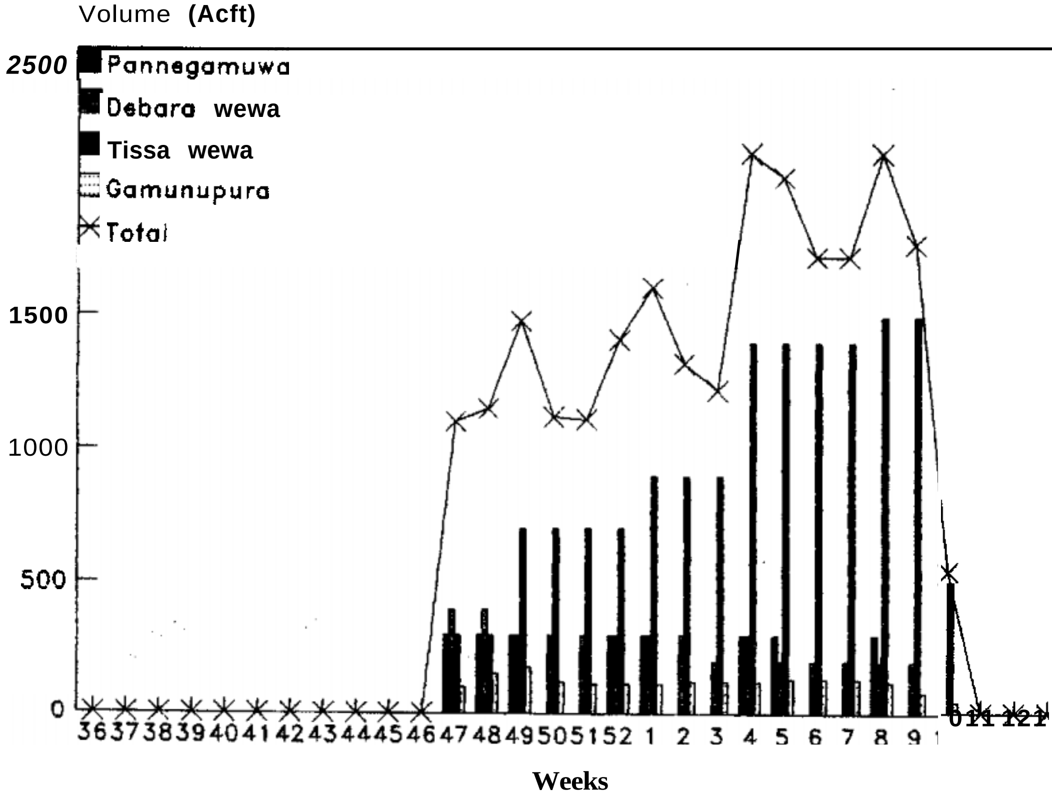


Figure 3.2.12

Figure 3.2.12 **Weekly Operation Plan (wet)**

Ellegala *System*

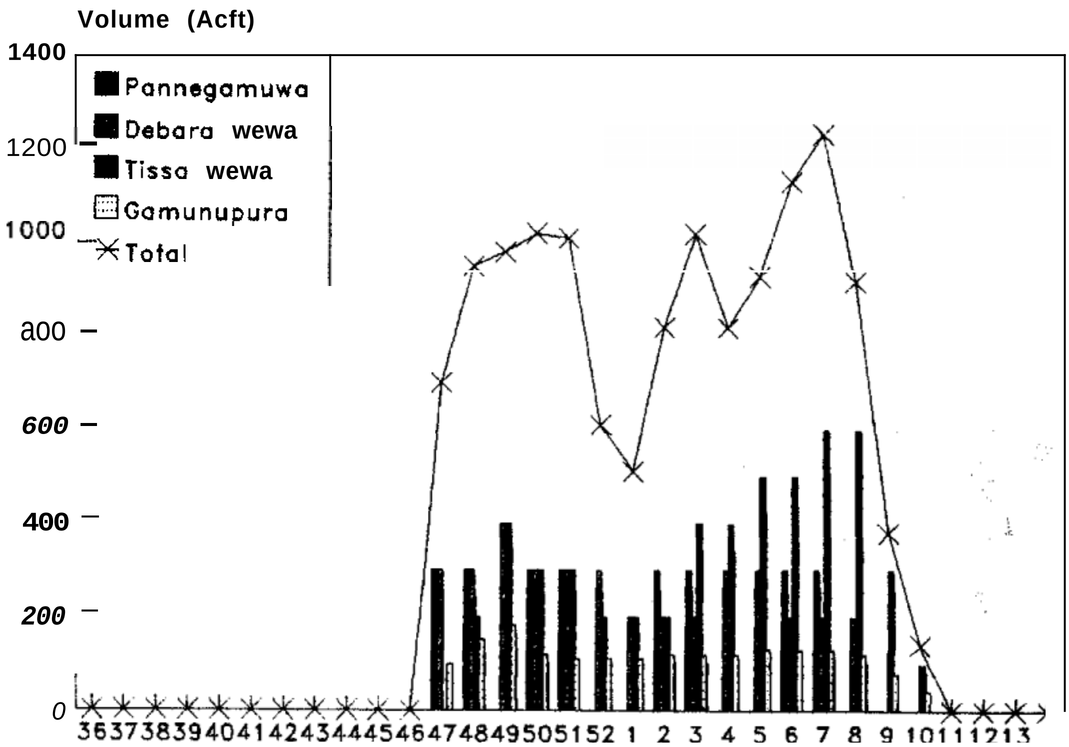


Figure 3.2.13 Weeks

Rainfall and Evaporation

Weerawila Agricultural Research Station

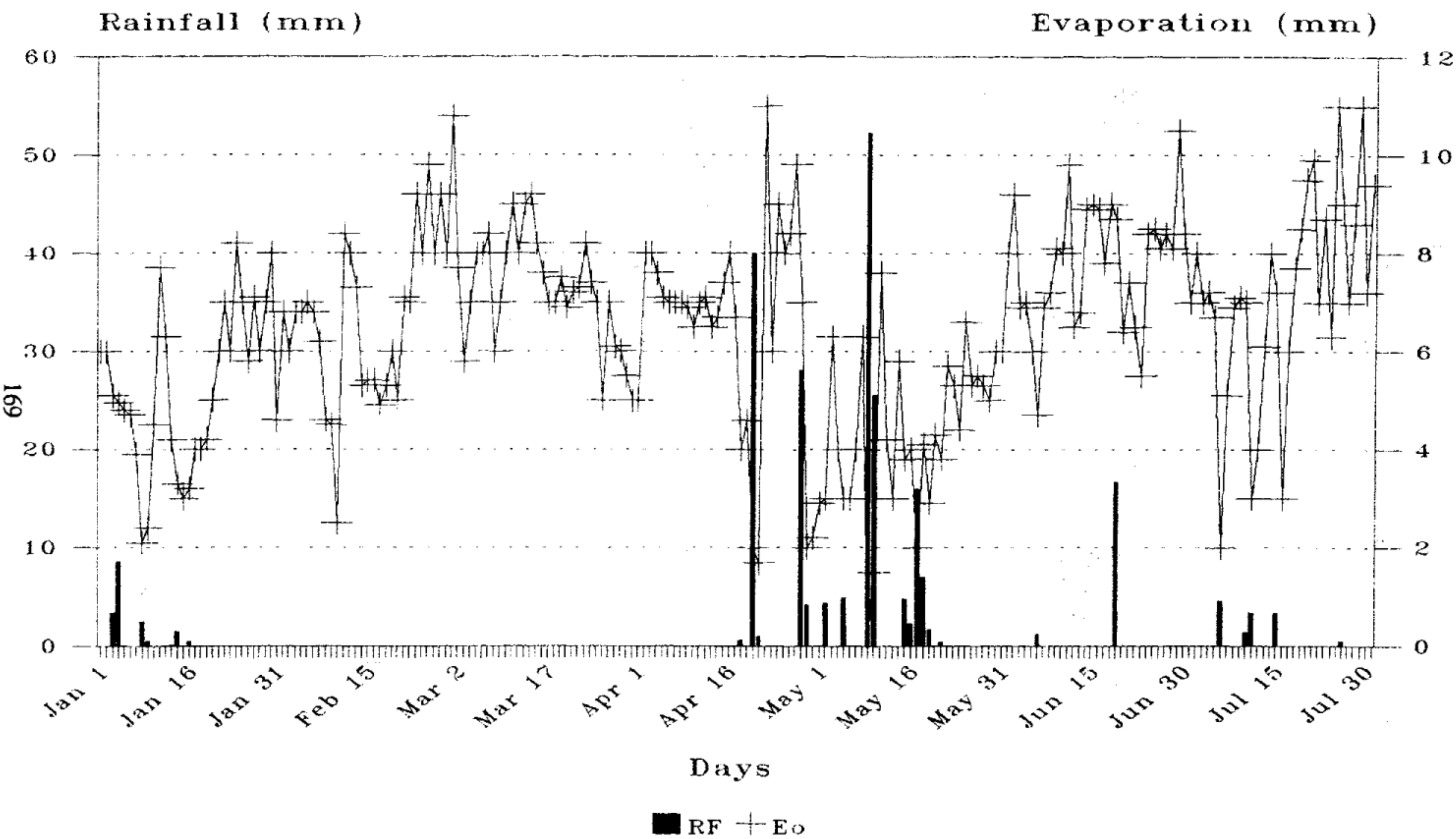


Figure 3.2.14

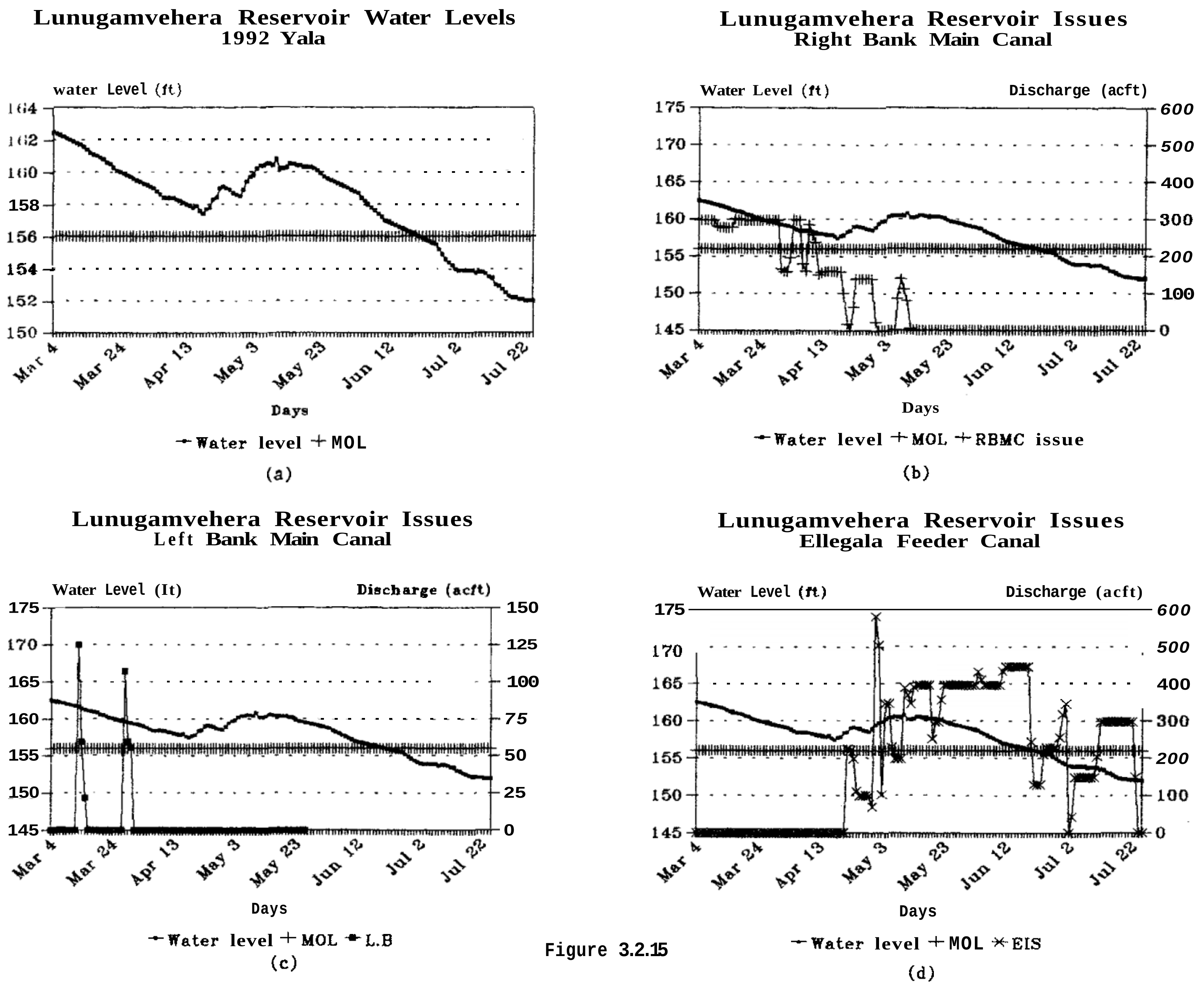
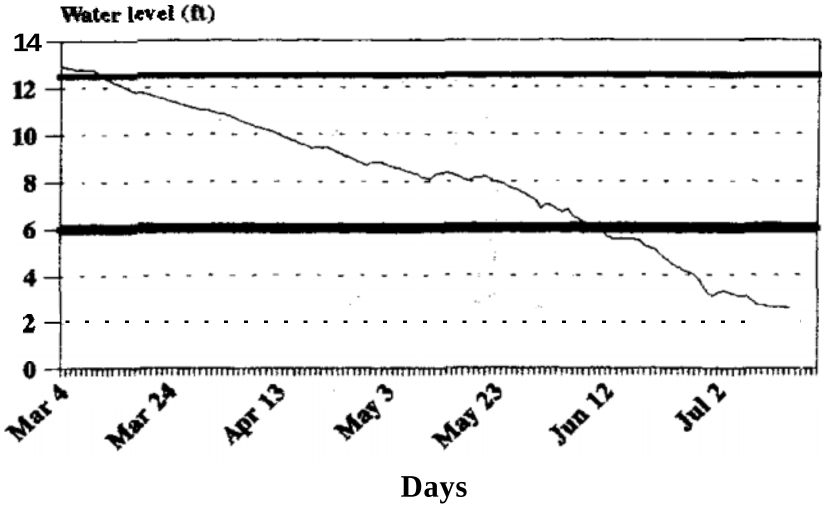

Lunugamvehera Reservoir Water Levels
1992 Yala
water Level (ft)
164
162
160
158
156
154
152
150
Mar 4
Mar 24
Apr 13
May 3
May 23
Jun 12
Jul 2
Jul 22
Days
Water level MOL
(a)
Lunugamvehera Reservoir Issues
Right Bank Main Canal
Water Level (ft)
Discharge (acft)
175
170
165
160
155
150
145
600
500
400
300
200
100
0
Mar 4
Mar 24
Apr 13
May 3
May 23
Jun 12
Jul 2
Jul 22
Days
Water level MOL RBMC issue
(b)
Lunugamvehera Reservoir Issues
Left Bank Main Canal
Water Level (It)
Discharge (acft)
175
170
165
160
155
150
145
150
125
100
75
50
25
0
Mar 4
Mar 24
Apr 13
May 3
May 23
Jun 12
Jul 2
Jul 22
Days
Water level MOL L.B
(c)
Lunugamvehera Reservoir Issues
Ellegala Feeder Canal
Water Level (ft)
Discharge (acft)
175
170
165
160
155
150
145
600
500
400
300
200
100
0
Mar 4
Mar 24
Apr 13
May 3
May 23
Jun 12
Jul 2
Jul 22
Days
Water level MOL EIS
(d)

Figure 3.2.15

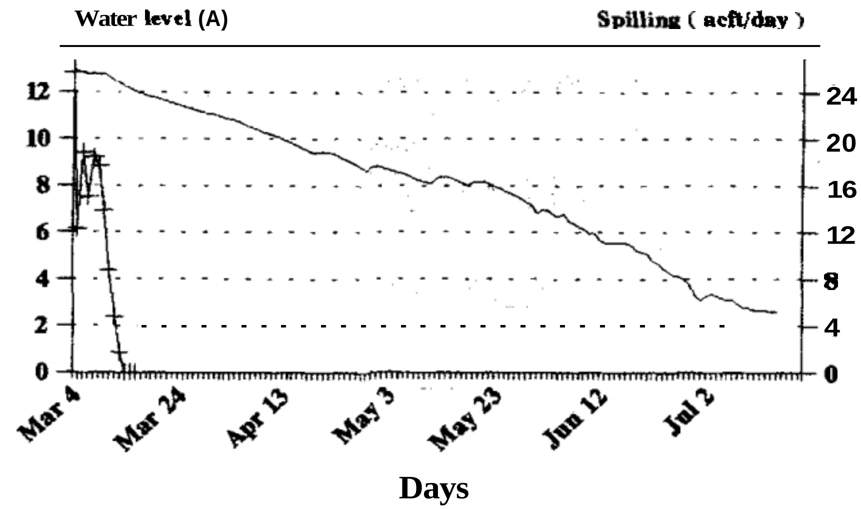
Water levels of Weerawila Wewa
1992 Yala



MOL (ft) — WL(ft) FSL(ft)

(a)

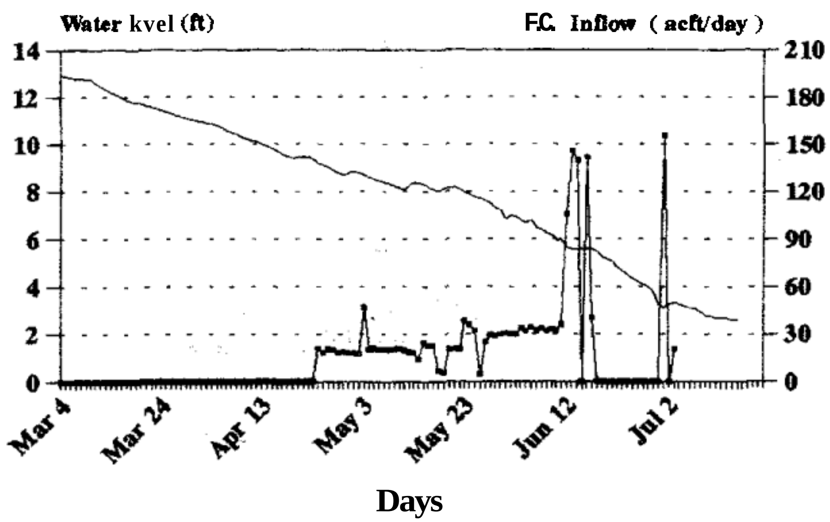
Weerawila Wewa
1992 Yala



+ Spill — Tank water level

(b)

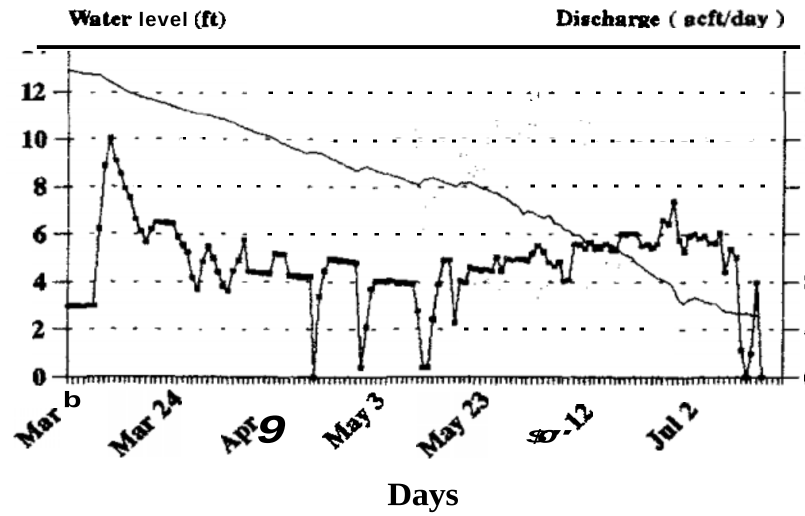
Feeder Canal Supply to Weerawila Wewa
1992 Yala



Inflow — Tank water level

(c)

Weerawila Wewa Issuings
1992 Yala



M.C Discharge — Tank water level

(d)

Figure 3.2.16

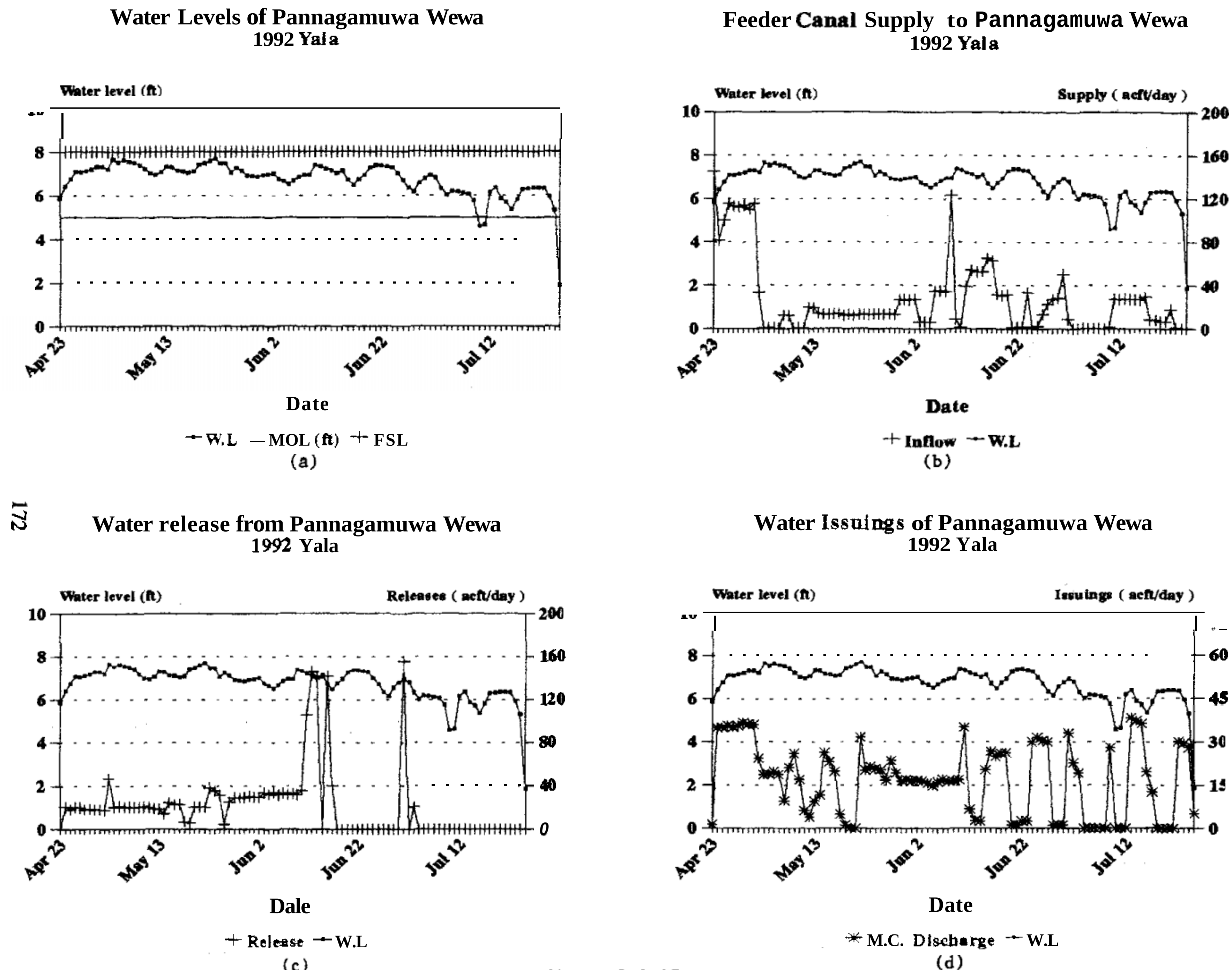

Water Levels of Pannagamuwa Wewa
1992 Yala
Water level (ft)
Date
W.L
MOL (ft)
FSL
(a)
Feeder Canal Supply to Pannagamuwa Wewa
1992 Yala
Water level (ft)
Supply (acft/day)
Date
Inflow
W.L
(b)
Water release from Pannagamuwa Wewa
1992 Yala
Water level (ft)
Releases (acft/day)
Dale
Release
W.L
(c)
Water Issuings of Pannagamuwa Wewa
1992 Yala
Water level (ft)
Issuings (acft/day)
Date
M.C. Discharge
W.L
(d)
Apr 23
May 13
Jun 2
Jun 22
Jul 12

Figure 3.2.17

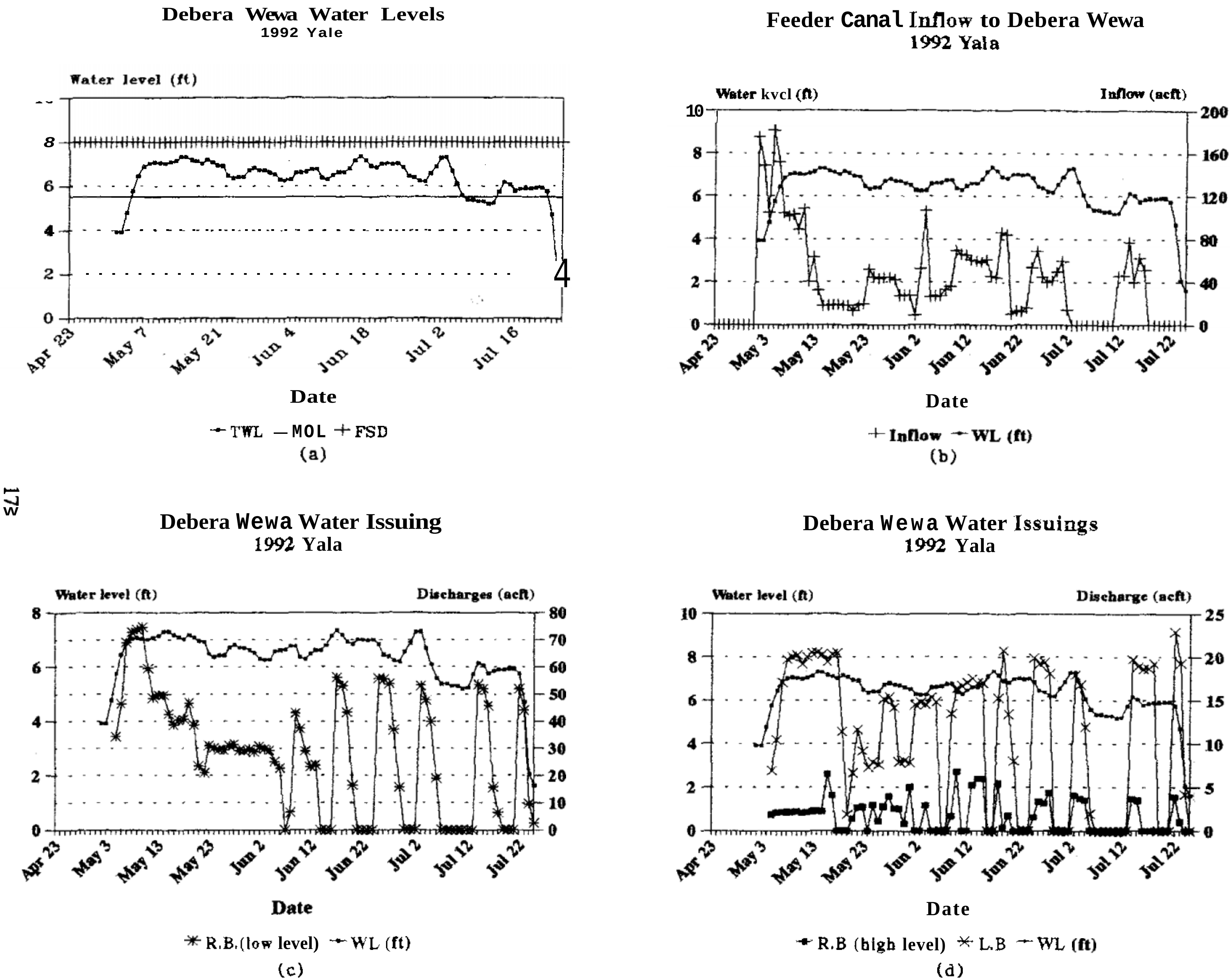
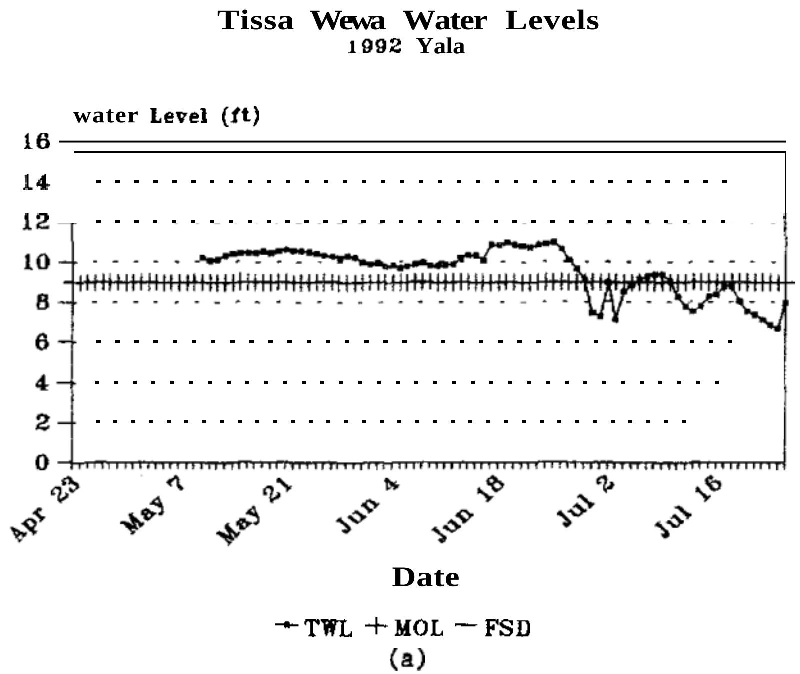
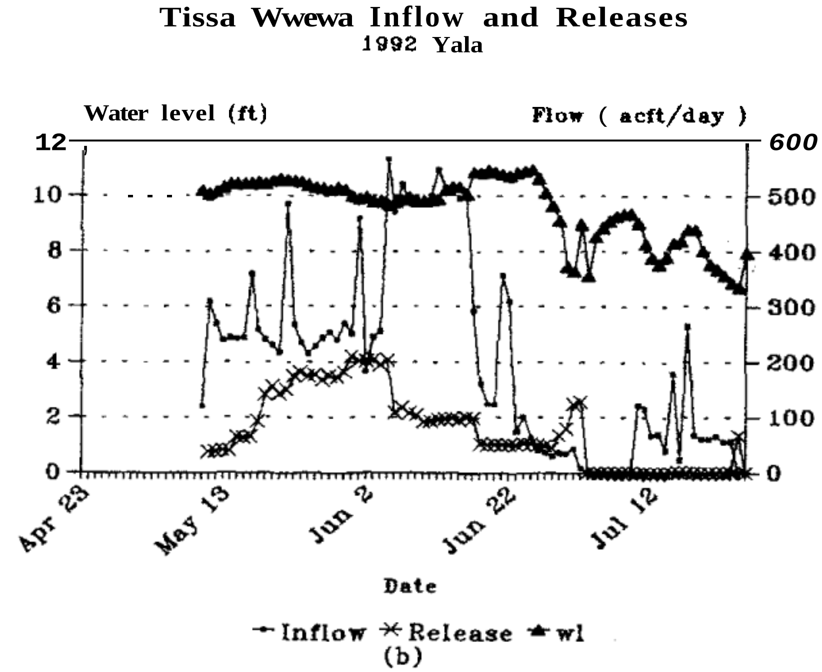
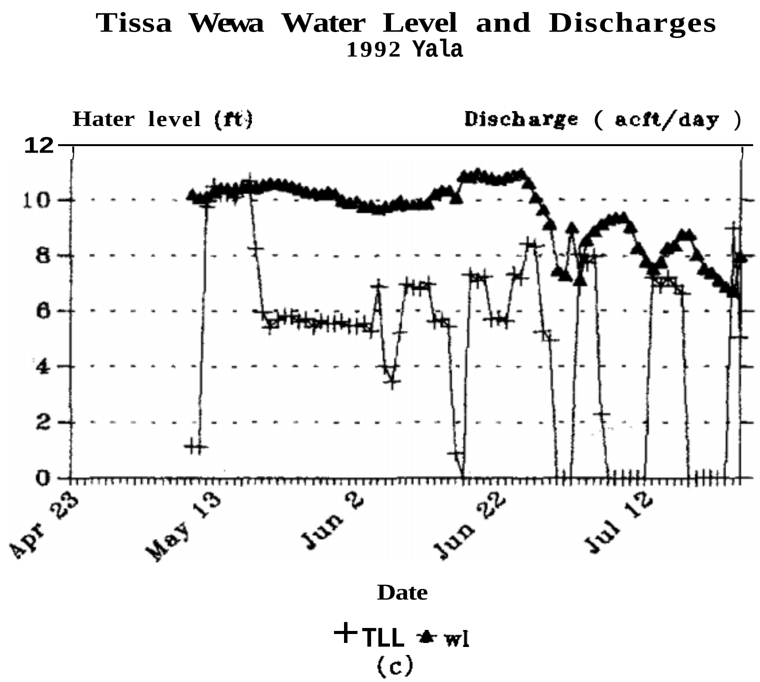

Debera Wewa Water Levels
1992 Yale
Water level (ft)
Date
TWL MOL FSD
(a)
Feeder Canal Inflow to Debera Wewa
1992 Yala
Water kvcl (ft)
Inflow (acft)
Date
Inflow WL (ft)
(b)
Debera Wewa Water Issuing
1992 Yala
Water level (ft)
Discharges (acft)
Date
R.B.(low level) WL (ft)
(c)
Debera Wewa Water Issuings
1992 Yala
Water level (ft)
Discharge (acft)
Date
R.B (high level) L.B WL (ft)
(d)

Figure 3.2.18


Tissa Wewa Water Levels
1992 Yala
water Level (ft)
Date
TWL
MOL
FSD
(a)


Tissa Wwewa Inflow and Releases
1992 Yala
Water level (ft)
Flow (acft/day)
Date
Inflow
Release
wl
(b)


Tissa Wewa Water Level and Discharges
1992 Yala
Hater level (ft)
Discharge (acft/day)
Date
TLL
wl
(c)

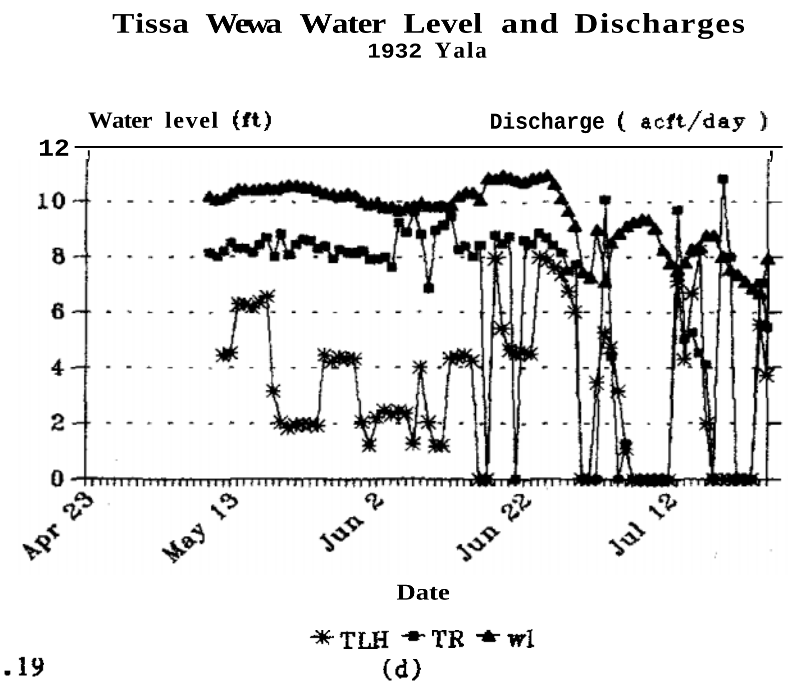

Tissa Wewa Water Level and Discharges
1932 Yala
Water level (ft)
Discharge (acft/day)
Date
TLH
TR
wl
(d)

Figure 3.2.19

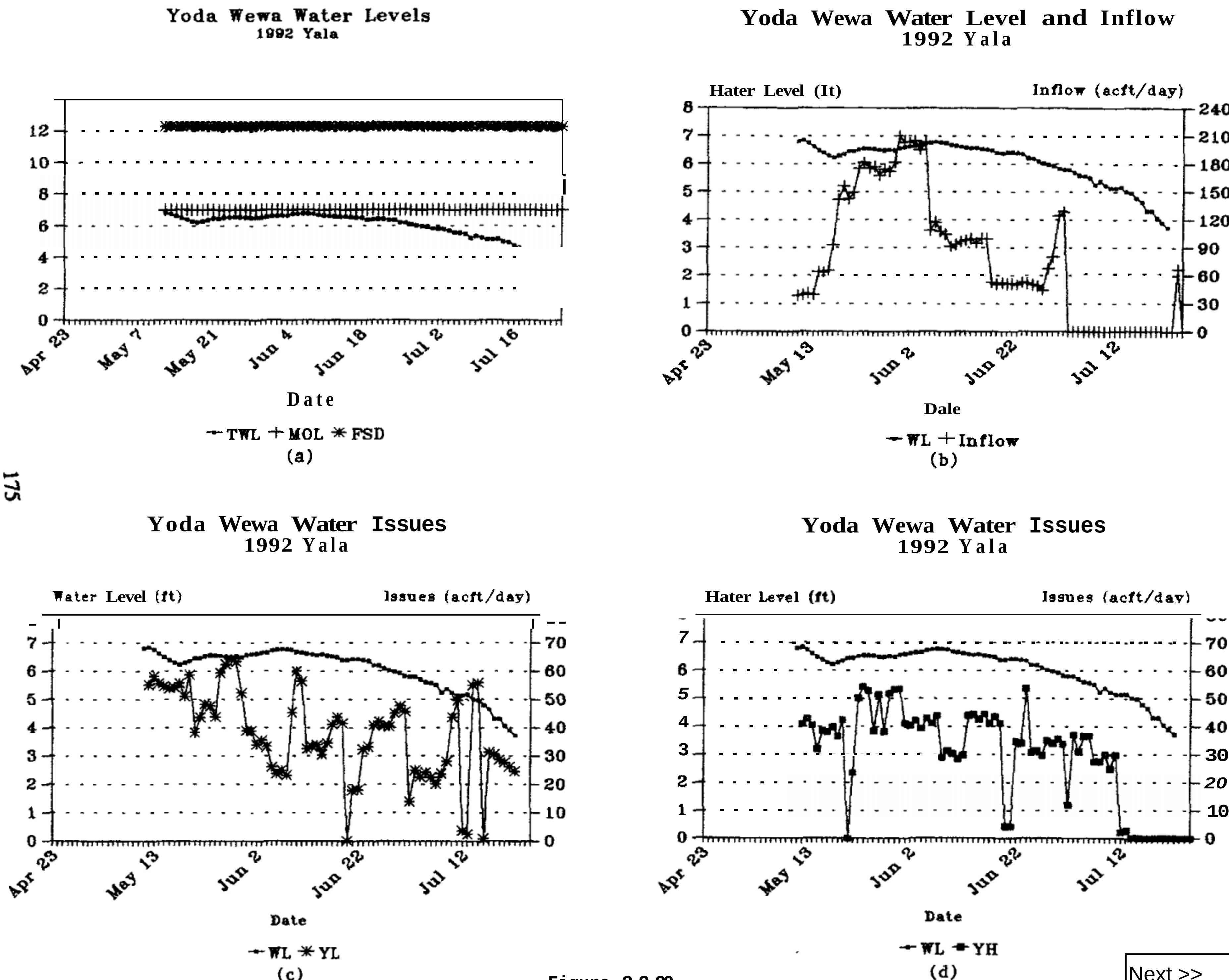


Figure 3.2.20

Next >>

Gamunupura Scheme
1992 Yala

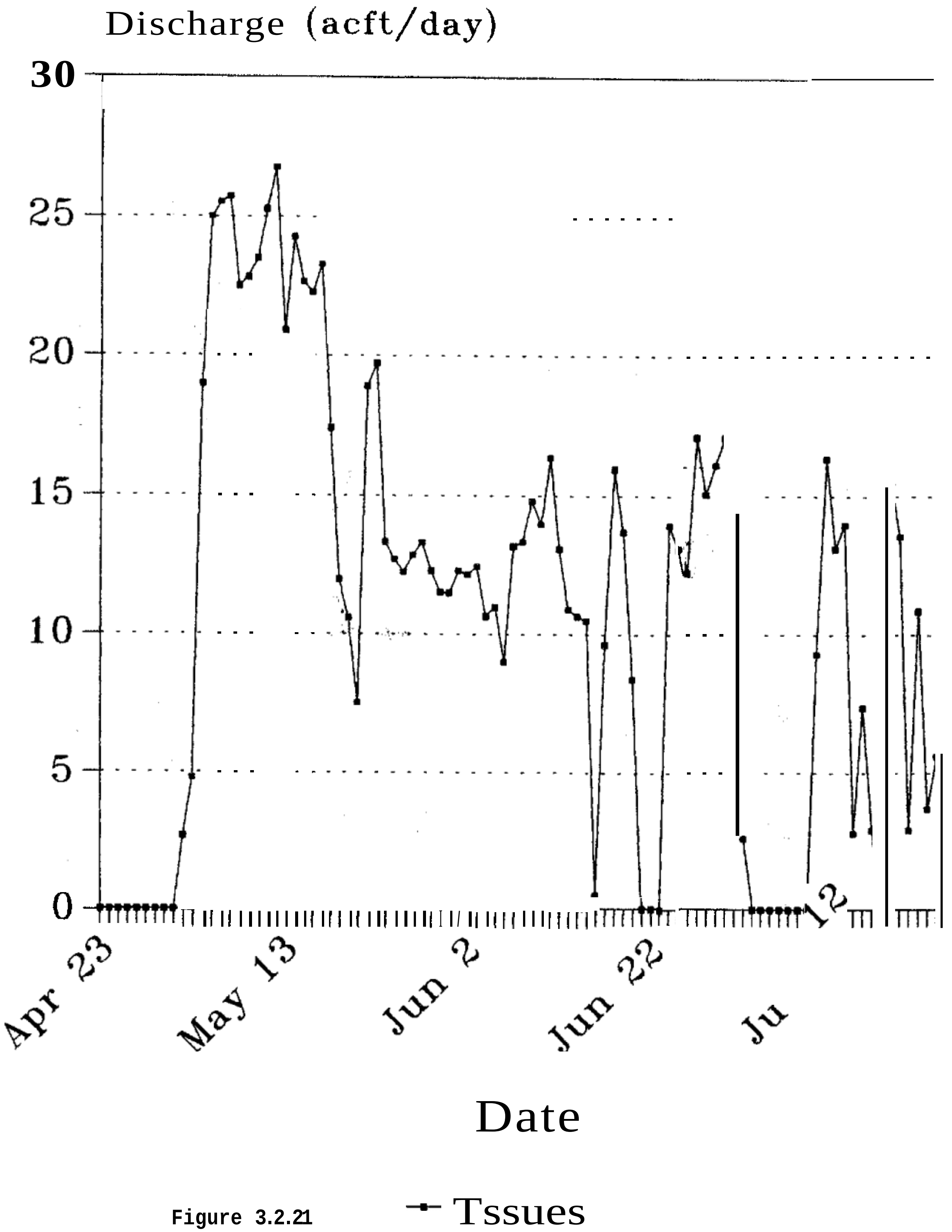


Figure 3.2.21

Pannagamuwa Wewa Water Levels
1992 / 93 Maha Season

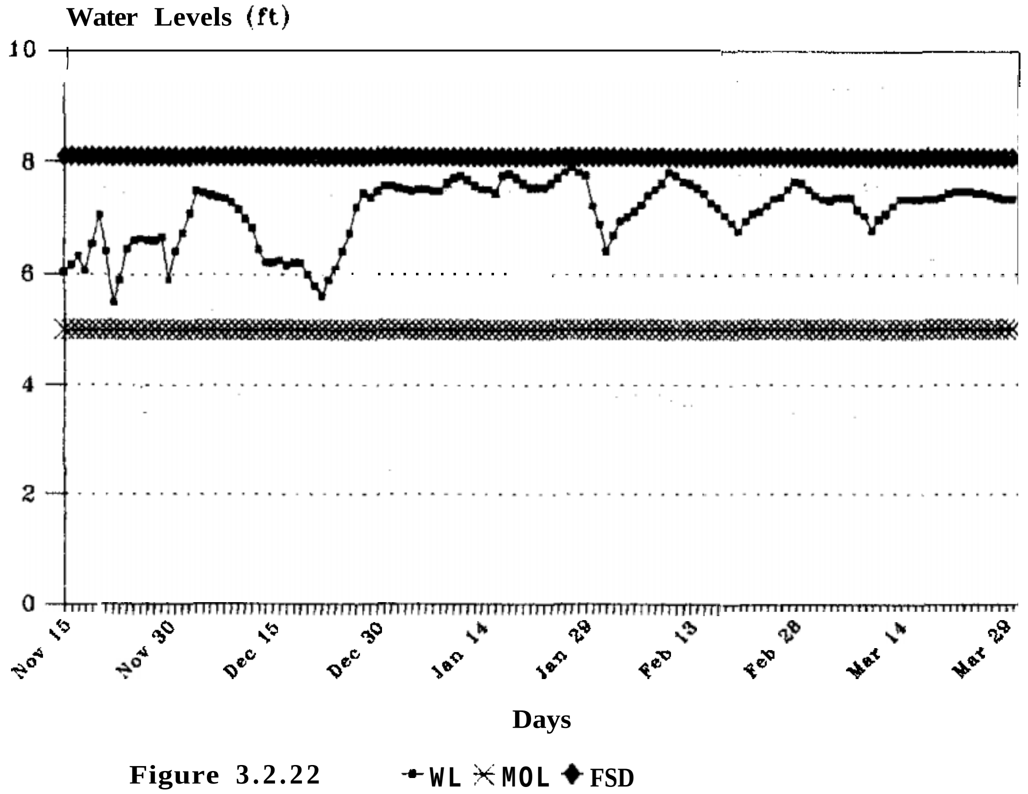


Figure 3.2.22

Pannagamuwa Wewa Inflow & Outflows
1992 / 93 Maha Season

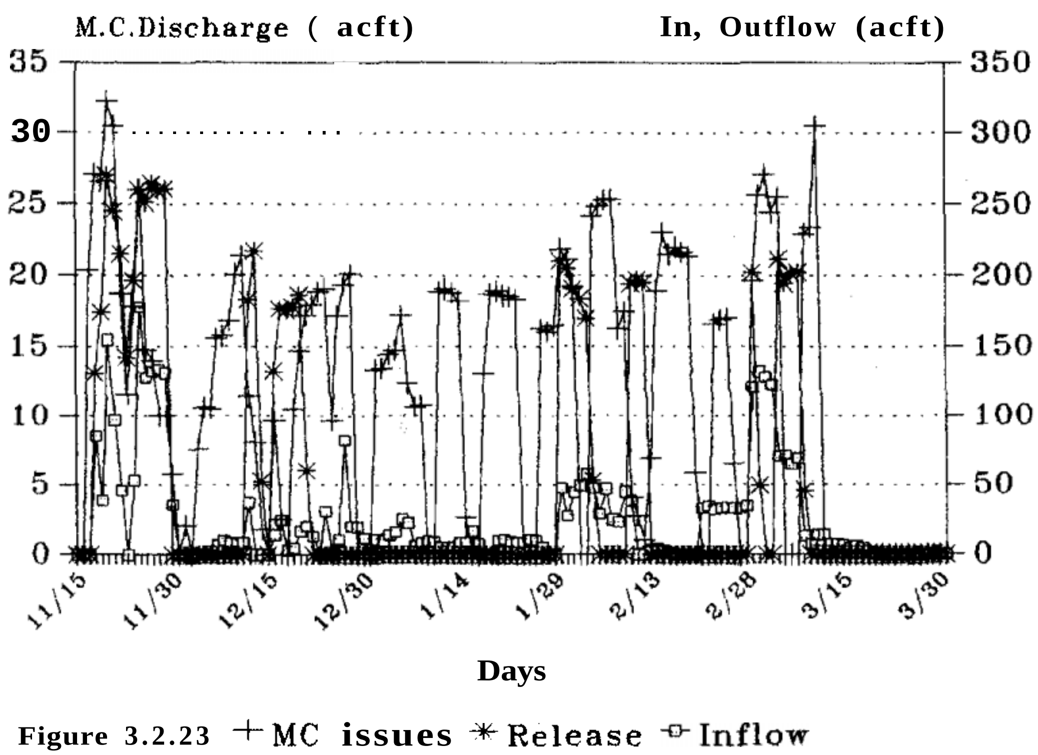


Figure 3.2.23

Weerawila Wewa Water Levels
1992 / 93 Maha Season

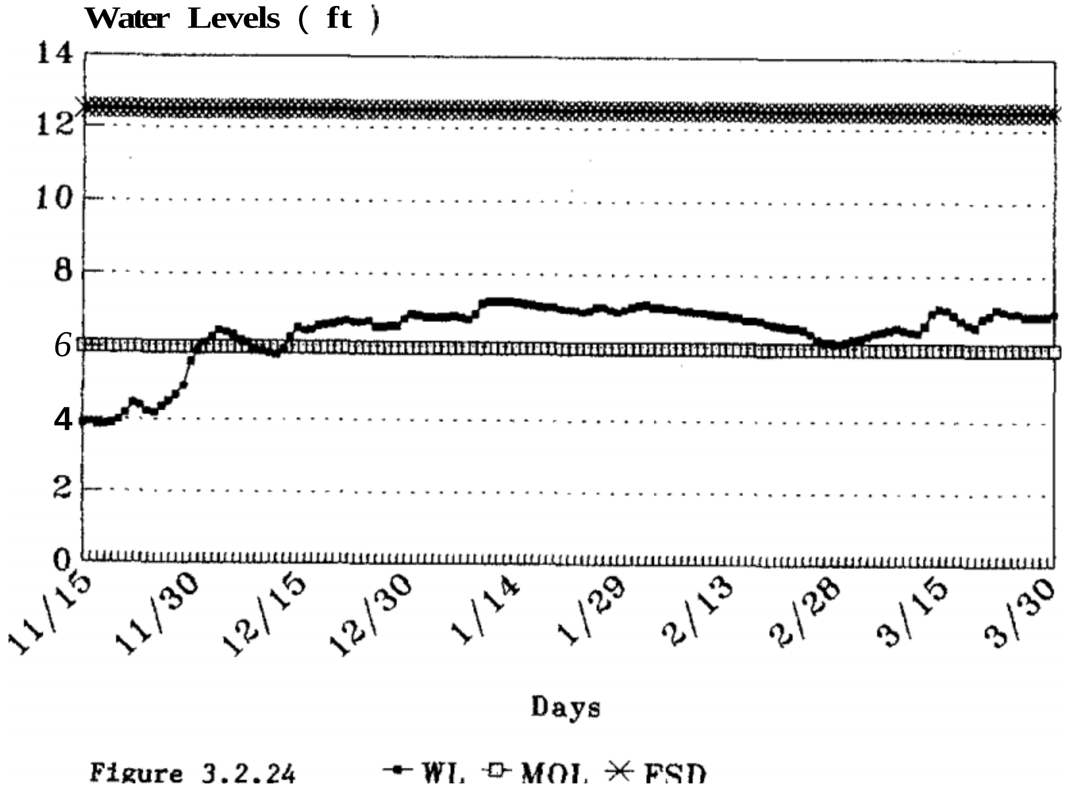


Figure 3.2.24

Weerawila Wewa Issues
1992 / 93 Maha Season

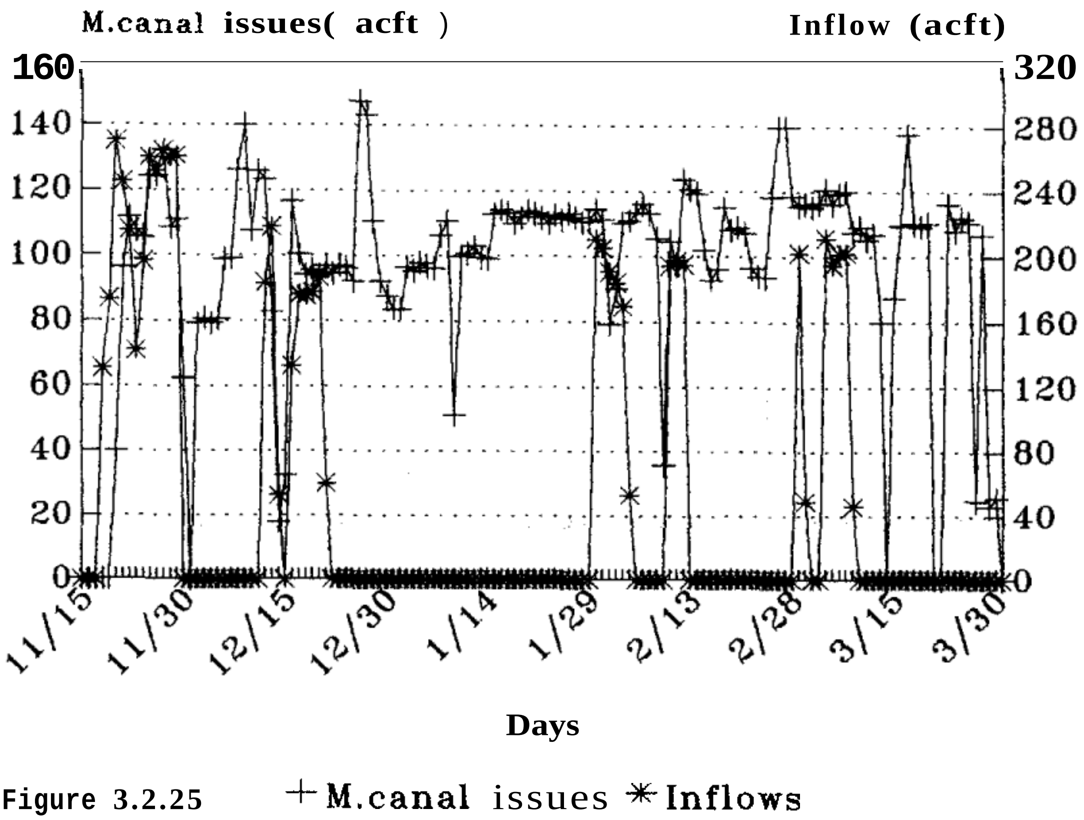


Figure 3.2.25

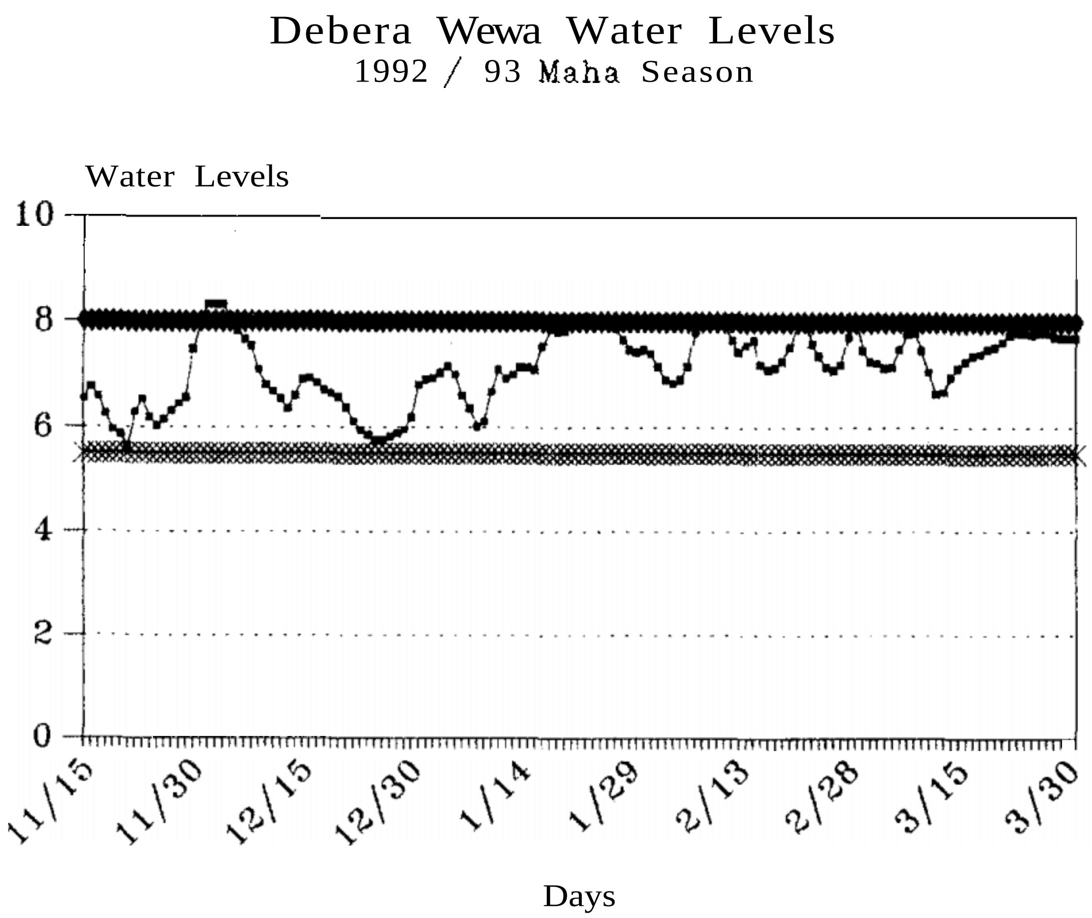


Figure 3.2.26 WL MOL FSD

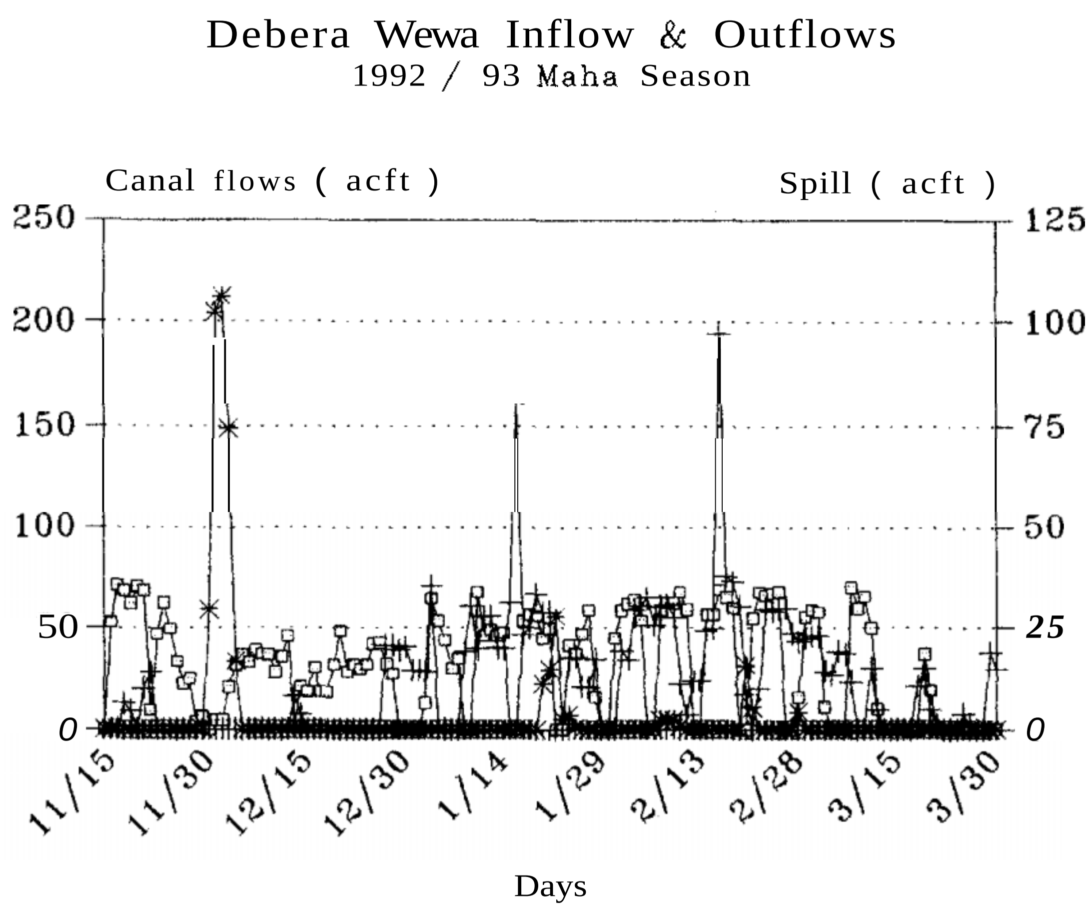


Figure 3.2.27 +Inflow Spill M.C. issues

Tissa Wewa Water Levels
1992 / 93 Maha Season

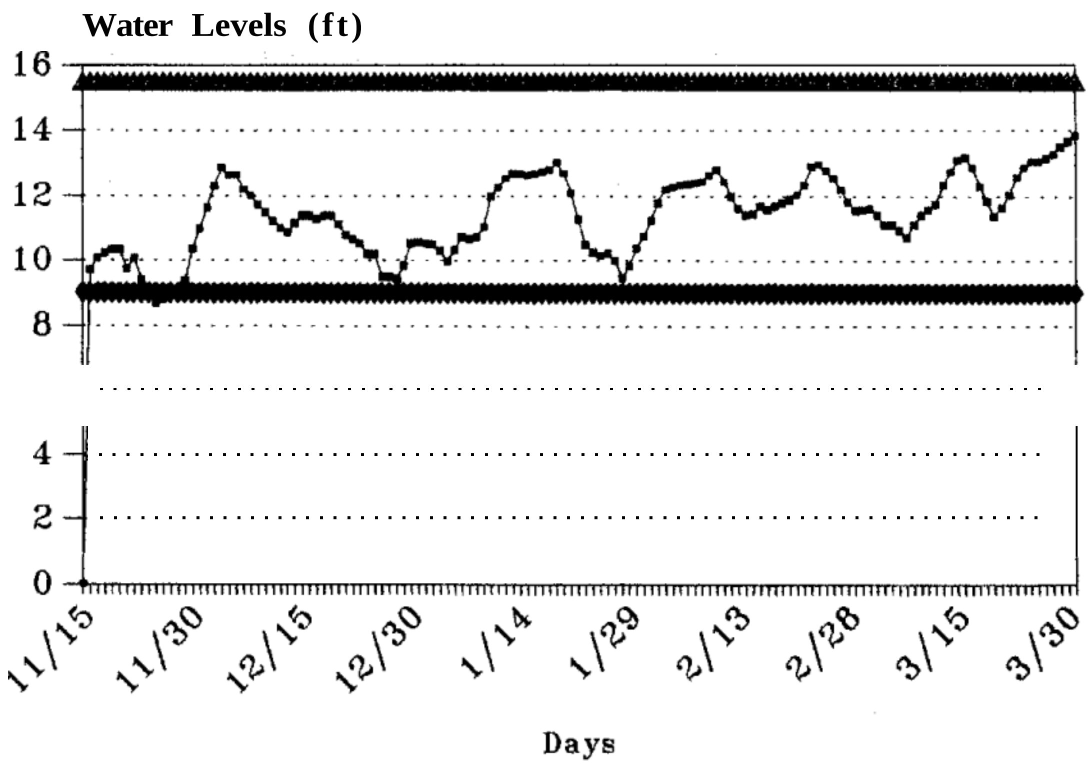


Figure 3.2.28

Tissa Wewa Issues
1992 / 93 Maha Season

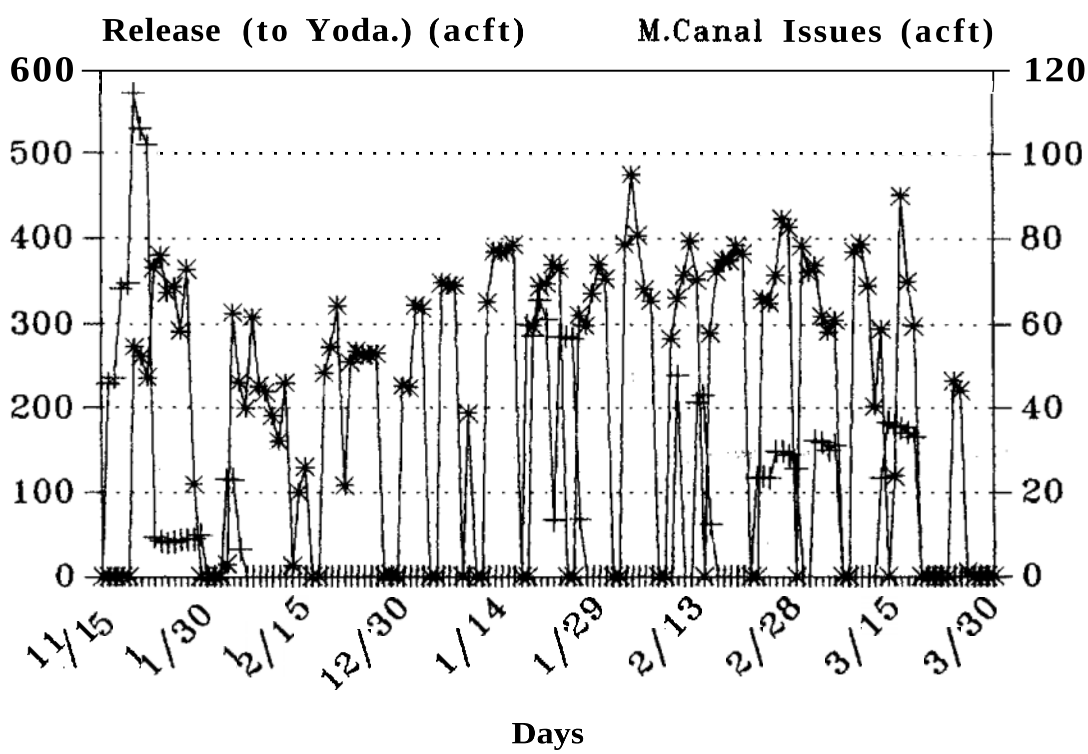


Figure 3.2.29

Yoda Wewa Water Levels
1992 / 93 Maha Season

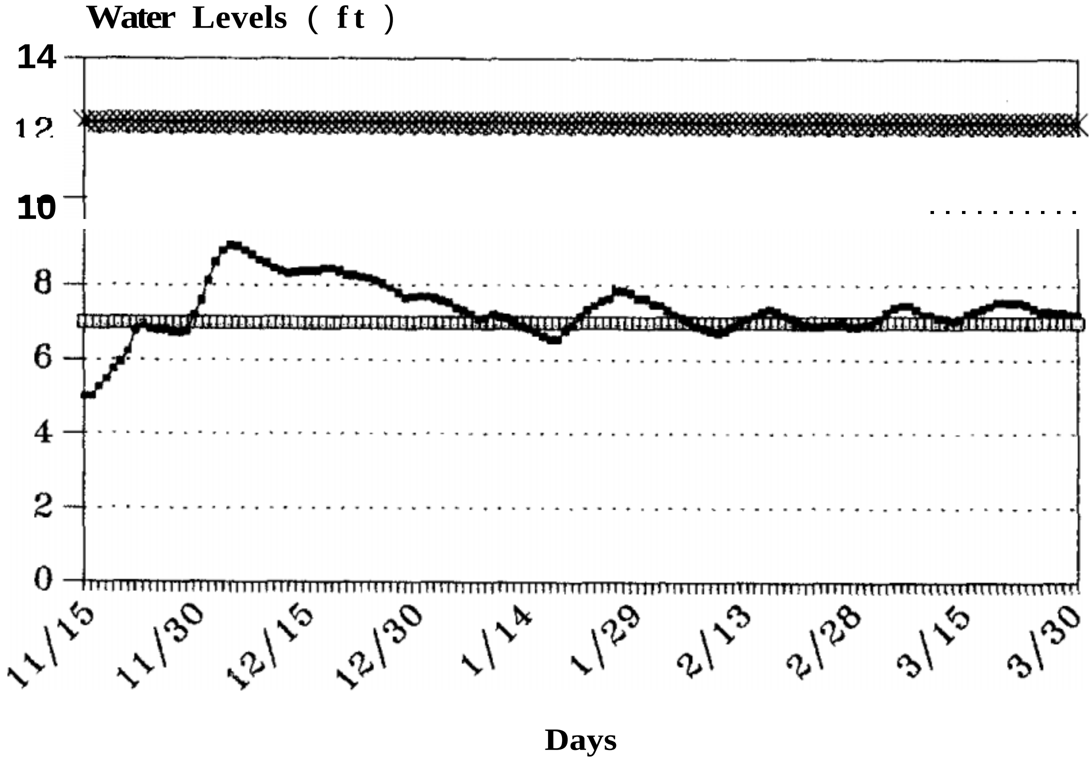


Figure 3.2.30 +Water level MOL FSD

Yoda Wewa Operations
1992 / 93 Maha Season

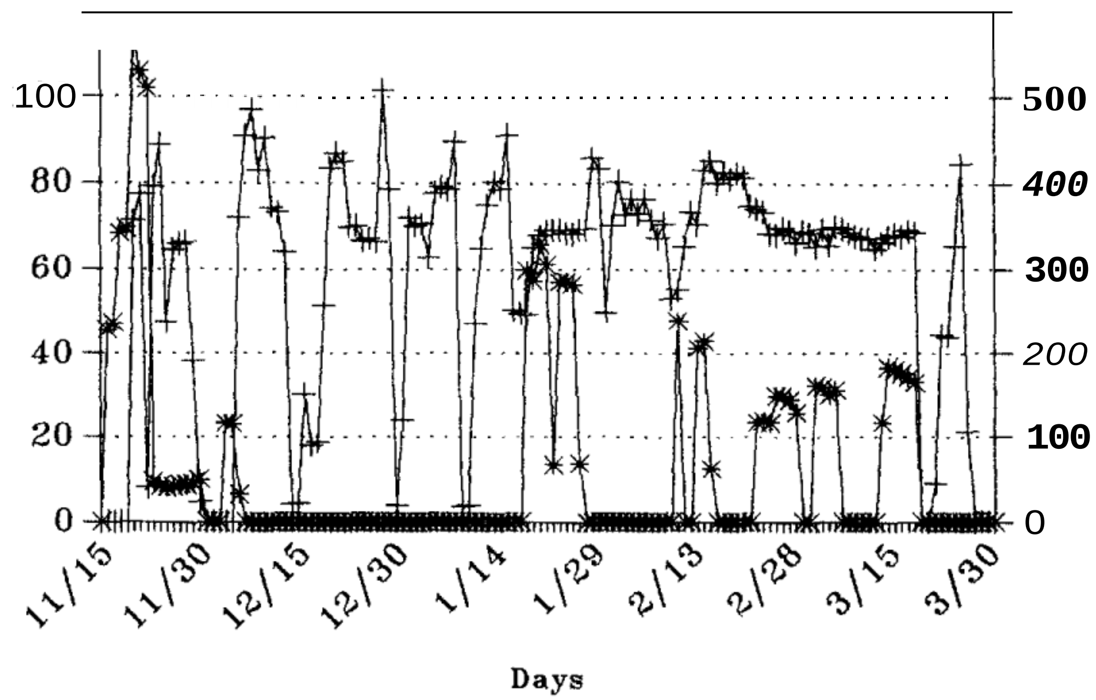


Figure 3.2.31 +M.canal issues ✳Inflows

Gamunupura Operations
1992 / 93 Maha Season

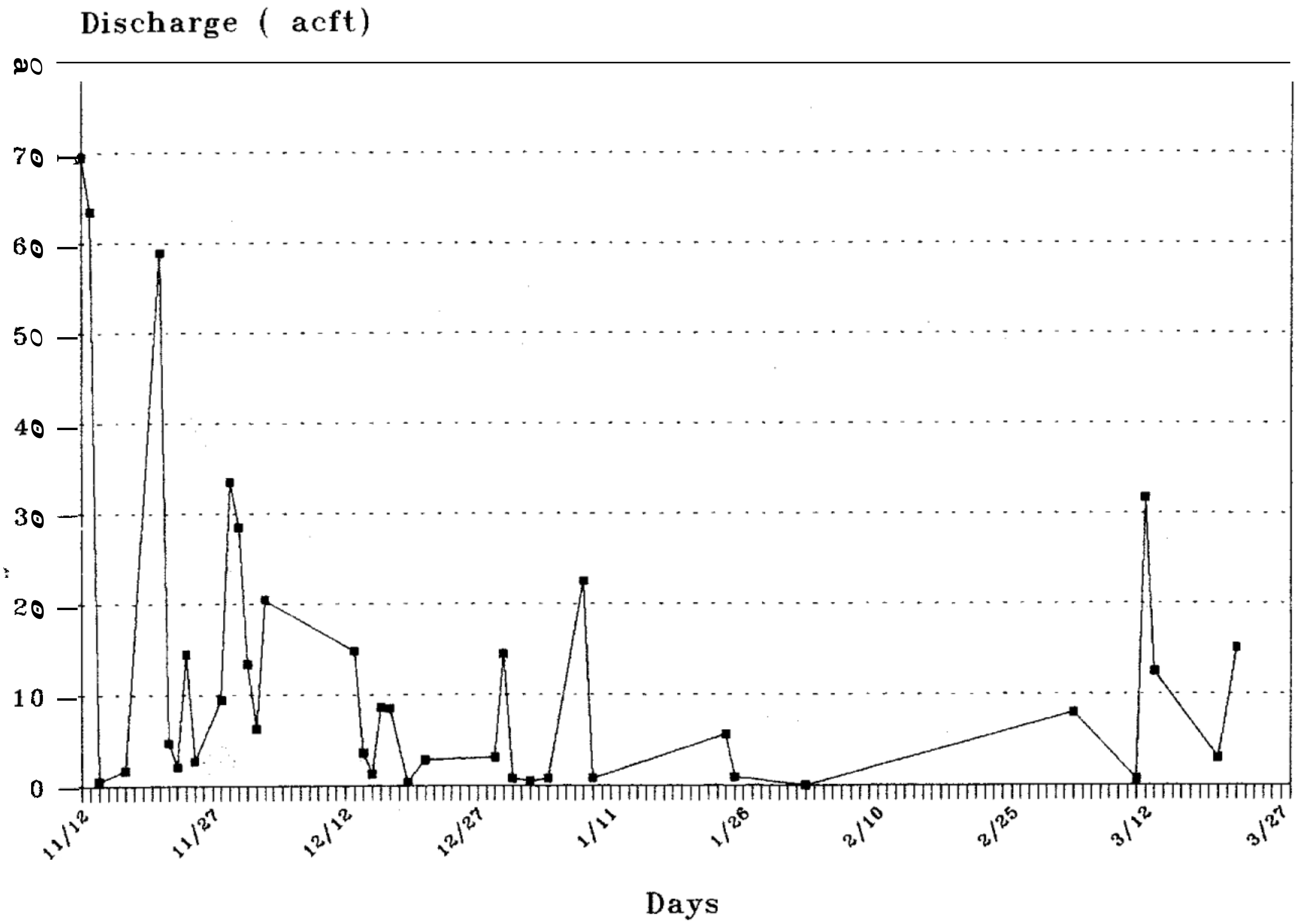


Figure 3.2.32

Date	LBMC				Ellegala RB				Ellegala LB				Ellegala Anicut				Tammanna Ara			
	Time		Discharge		Time		Discharge		Time		Discharge		Time		Discharge		Time		Discharge	
	From	To	Cusec	Acft	From	To	Cusec	Acft	From	To	Cusec	Acft	From	To	Cusec	Acft	From	To	Cusec	Acft
Total																				

Date	Pannagamuwa				Weerawila				Debera wewa				Tissa wewa				Yoda wewa			
	W.L	Storag	Dis.	Release	W.L	Storag	Dis.	Spill	W.L	Storag	Dis.	Spill	W.L	Storag	Dis.	Release	W.L	Storag	Dis.	Spill
	ft	acft	Cusec	Cusec	ft	acft	Cusec	Cusec	ft	acft	Cusec	Cusec	ft	acft	Cusec	Cusec	ft	acft	Cusec	Cusec
MOL	5	93	Cultivated ac.		6	3966	Cultivated ac.		5.5	305	Cultivated ac.		9	479	Cultivated ac.		7	1769	Cultivated ac.	
FSL	8.1	817			12.5	11083			8	750			15.5	3209			12.3	8103		
Commence on																				

Figure 3.2.33. Display Board

Lunugamvehera Reservoir Operation
Yala 1993

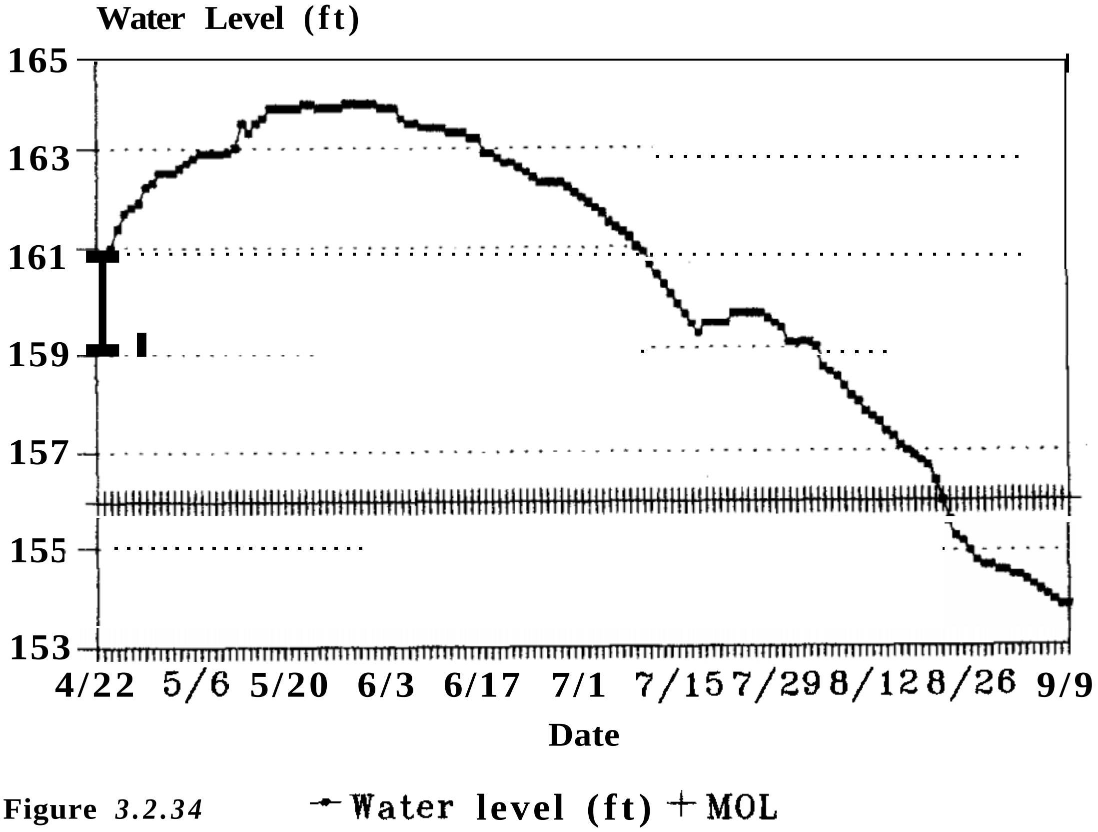
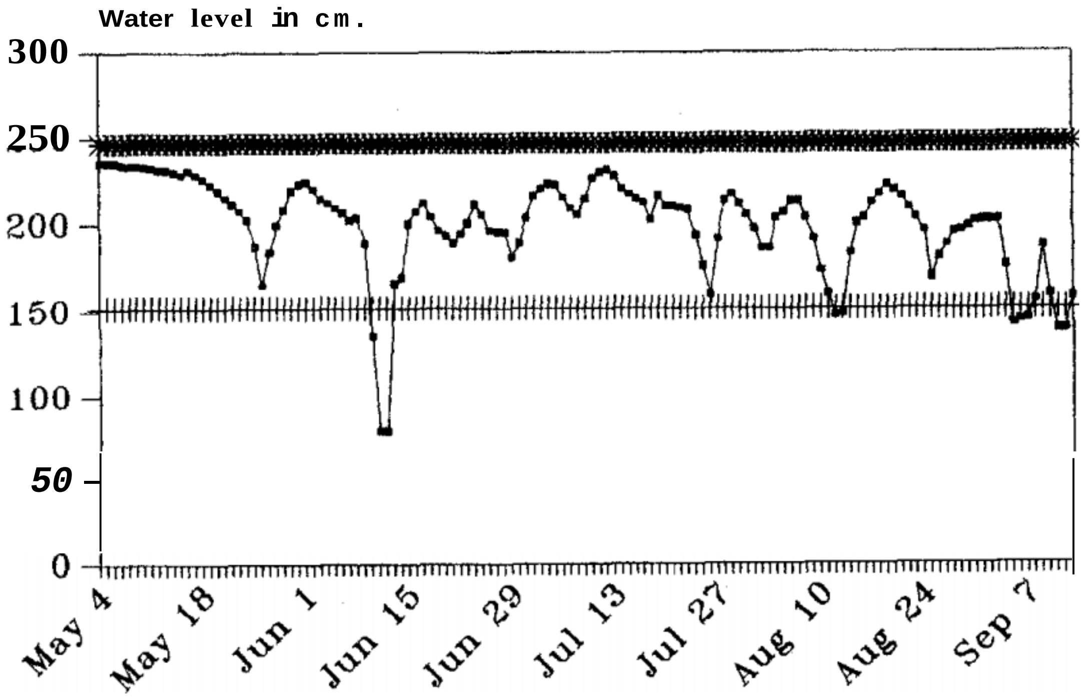


Figure *3.2.34*

Tank Operation
Pannagamuwa Wewa 1993 Yala



Pannagamuwa Wewa Tank Issues
1993 Yala

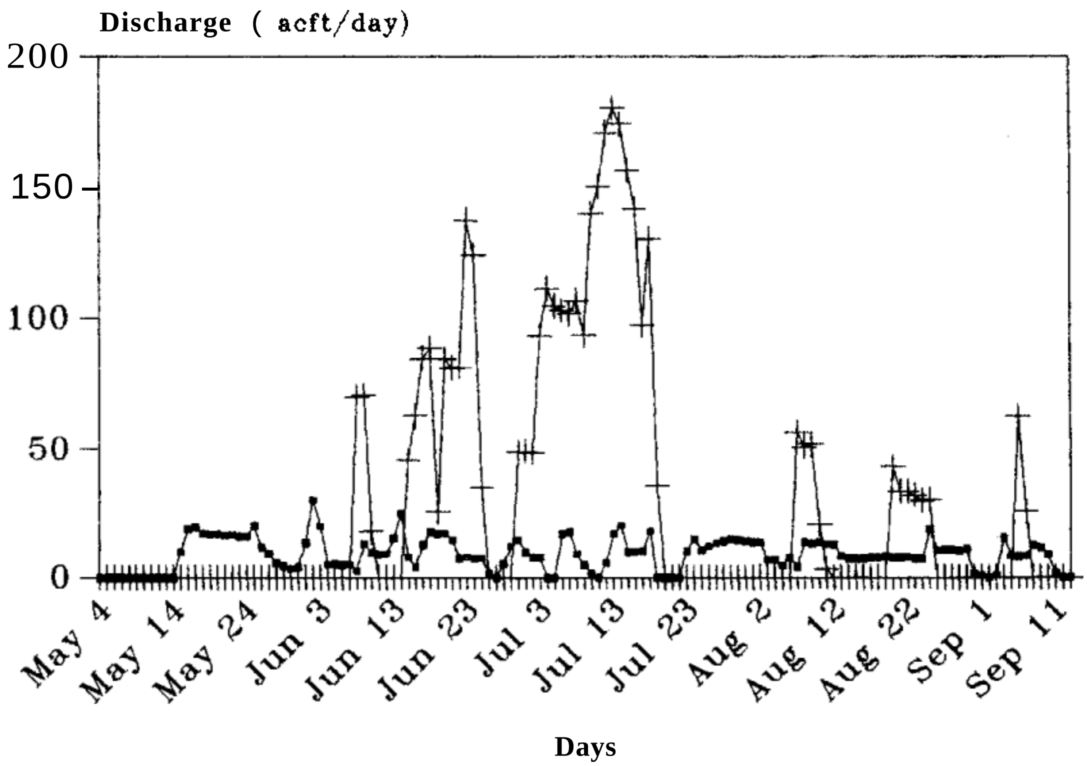


Figure 3.2.36 —•— M. Canal + F.C Weerawila

Tank Operation
Weerawila Wewa 1993 Yala

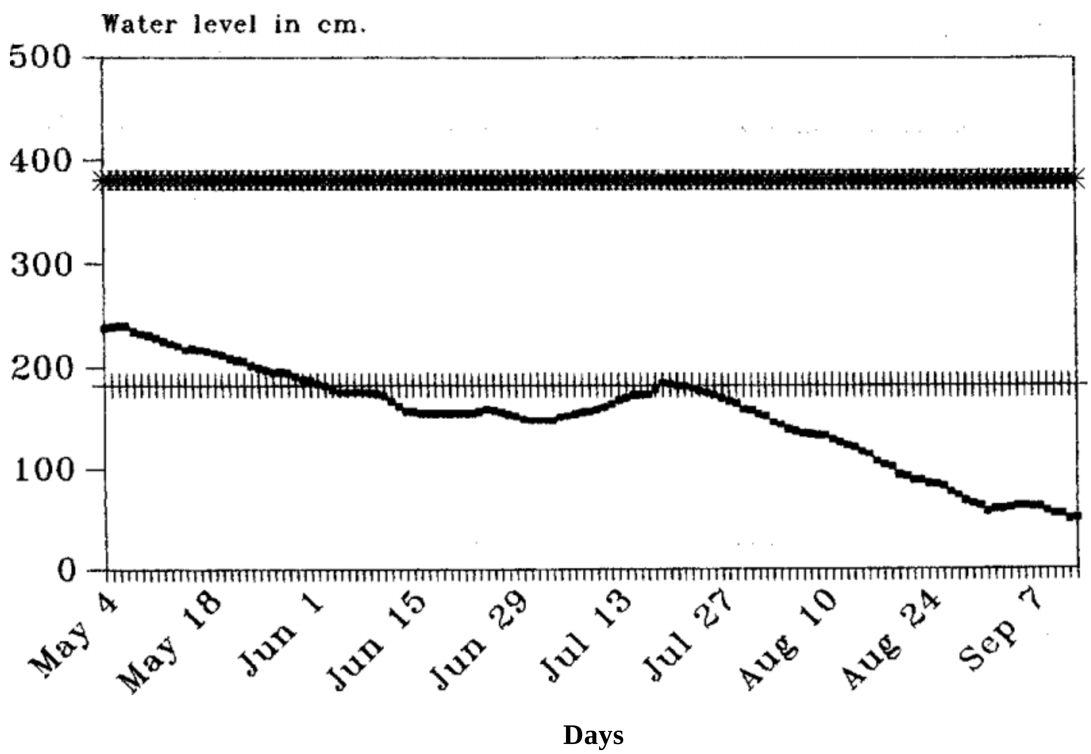


Figure 3.2.37 —•— WL + MOL ✳ FSD

Tank Issues
Weerawila Wewa 1993 Yala

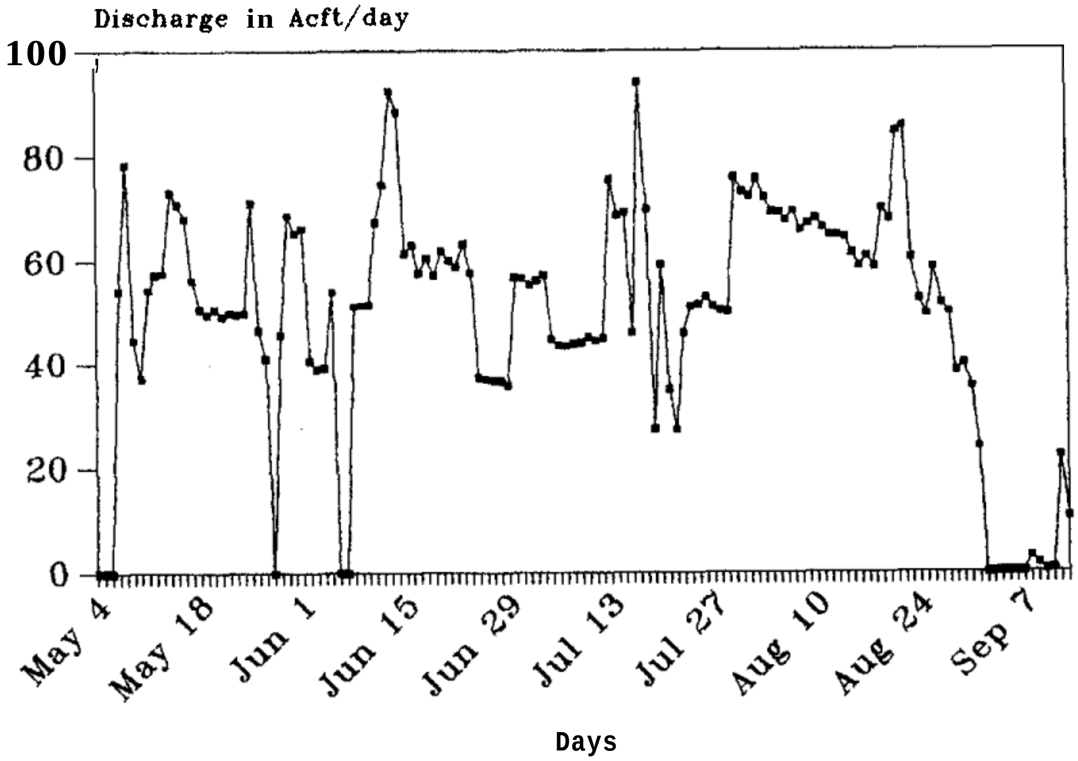


Figure 3.2.38 — M. **Canal**

Tank Operations
Debera Wewa 1993 Yala

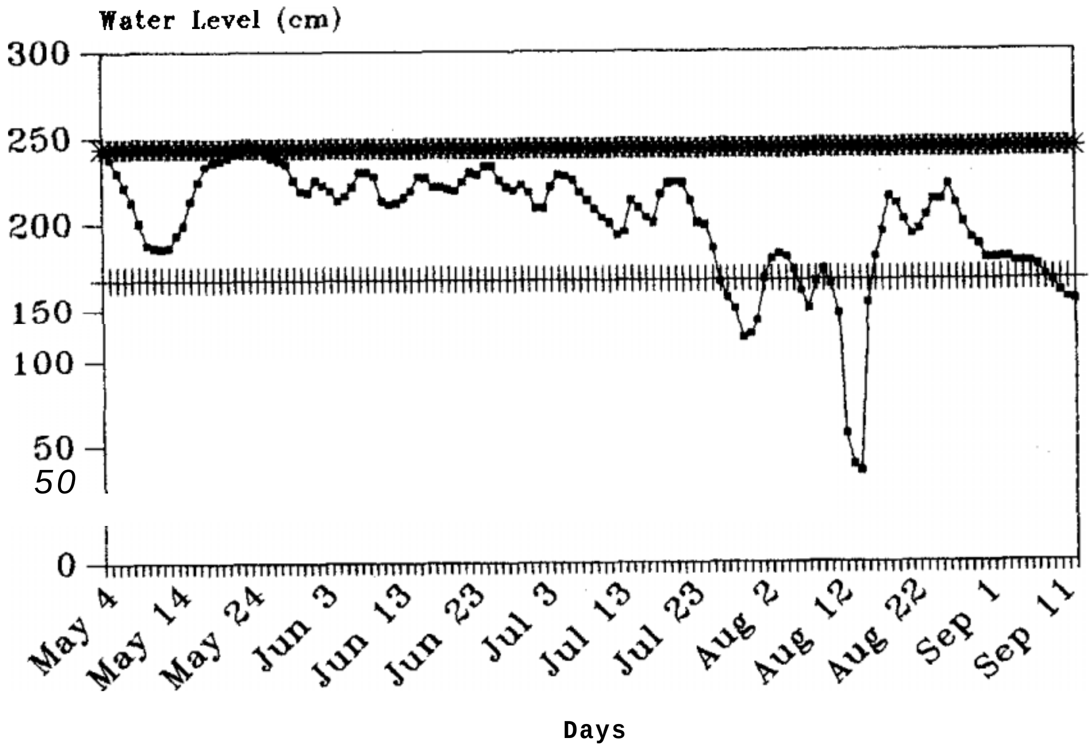


Figure 3.2.39 — WL + MOL * FSD

Debera Wewa Sluice Issues
1993 Yala

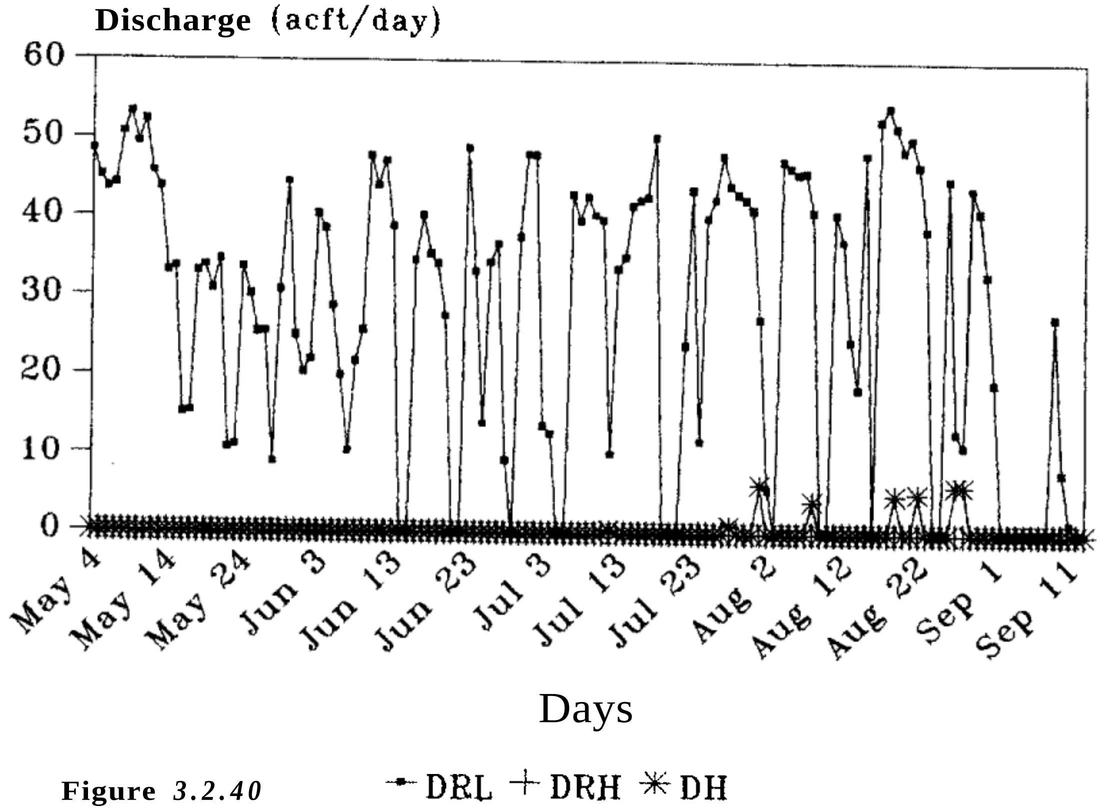


Figure *3.2.40*

Tank Operation
Tissa Wewa 1993 Yala

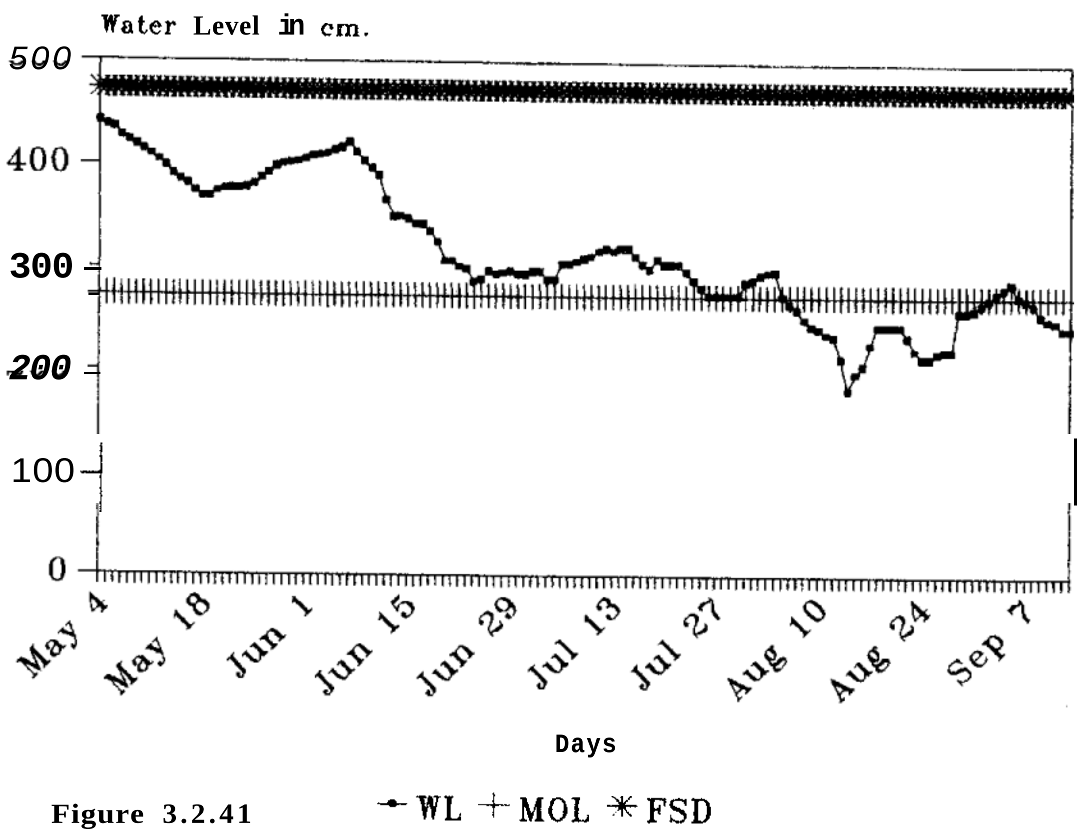


Figure 3.2.41

Tissa Wewa Water Issues
1993 Yala

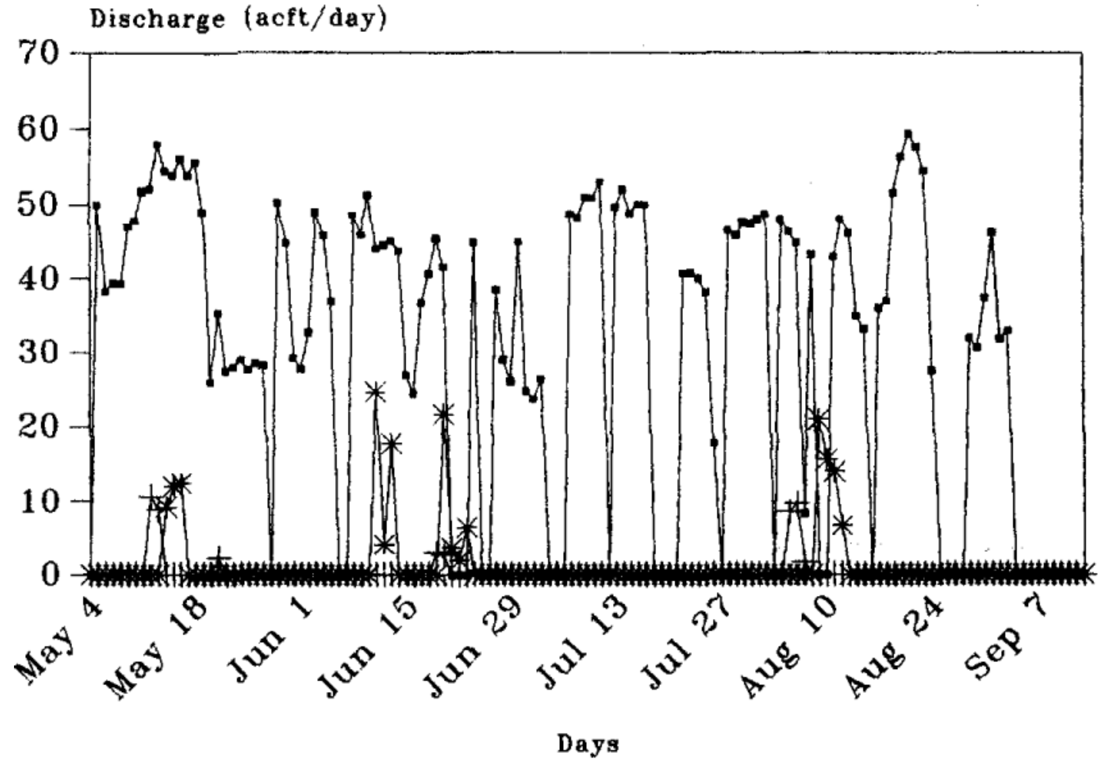


Figure 3.2.42

Tank Operation
Yoda Wewa 1993 Yala

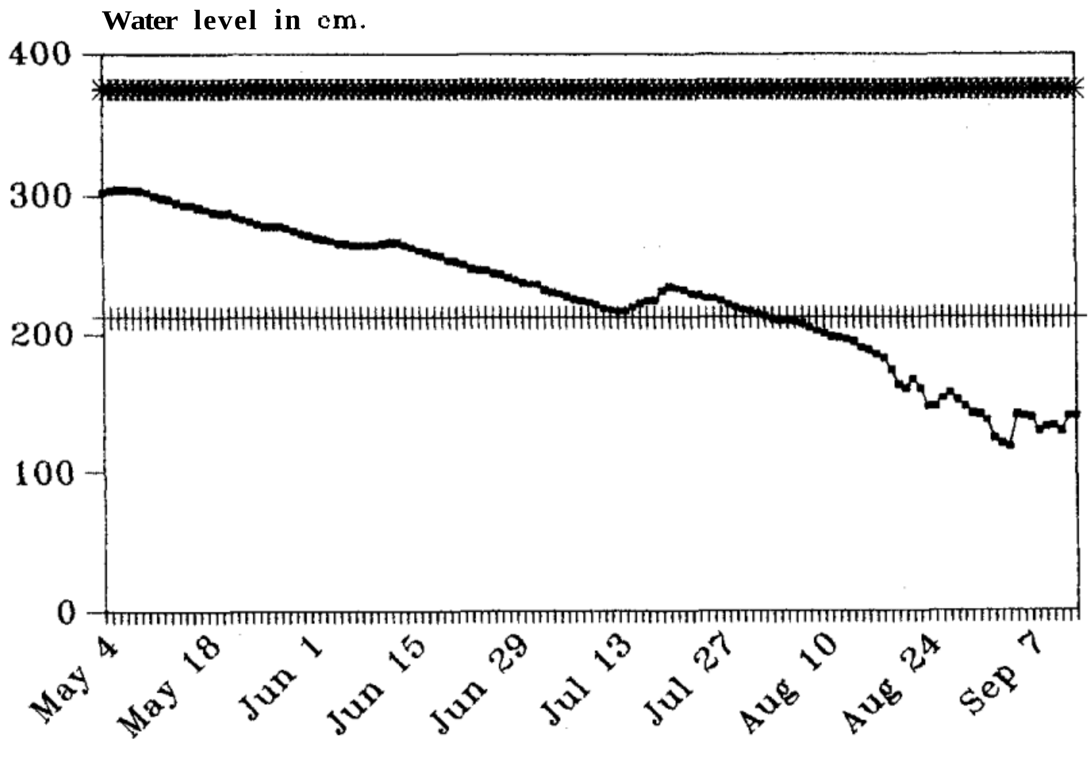


Figure *3.2.43*

Tank Issues
Yoda Wewa 1993 Yala

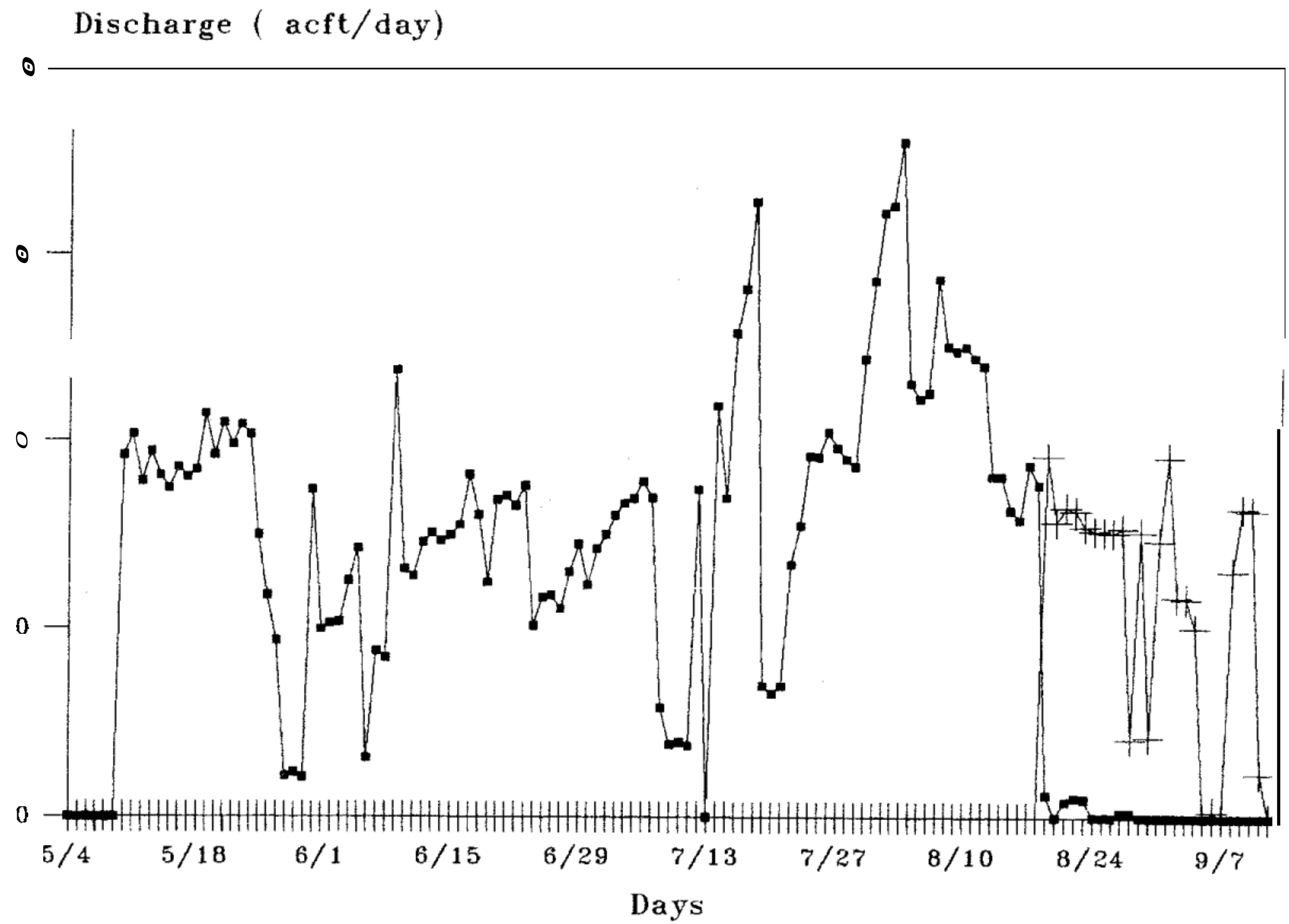
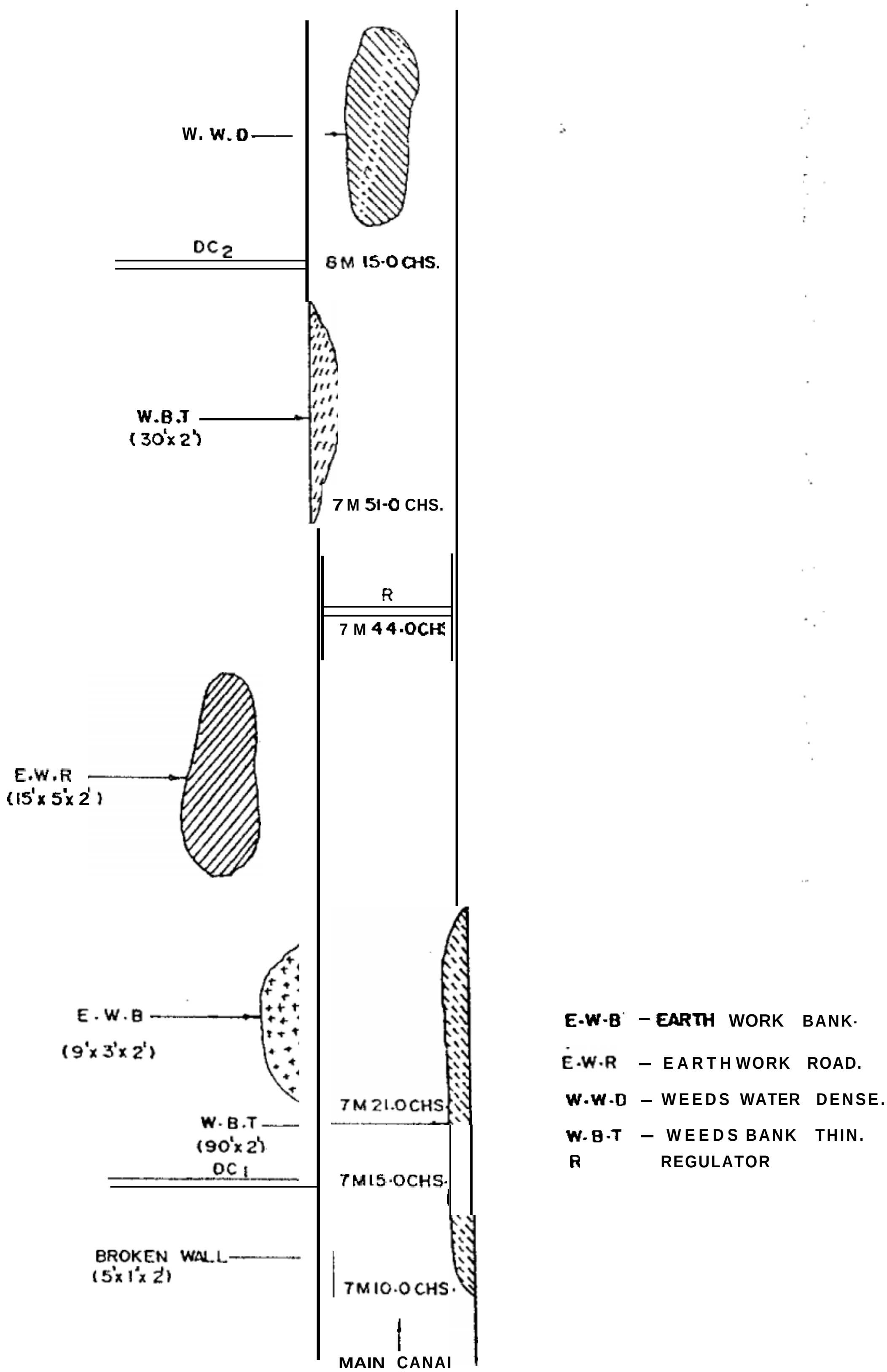


Figure 3.2.44

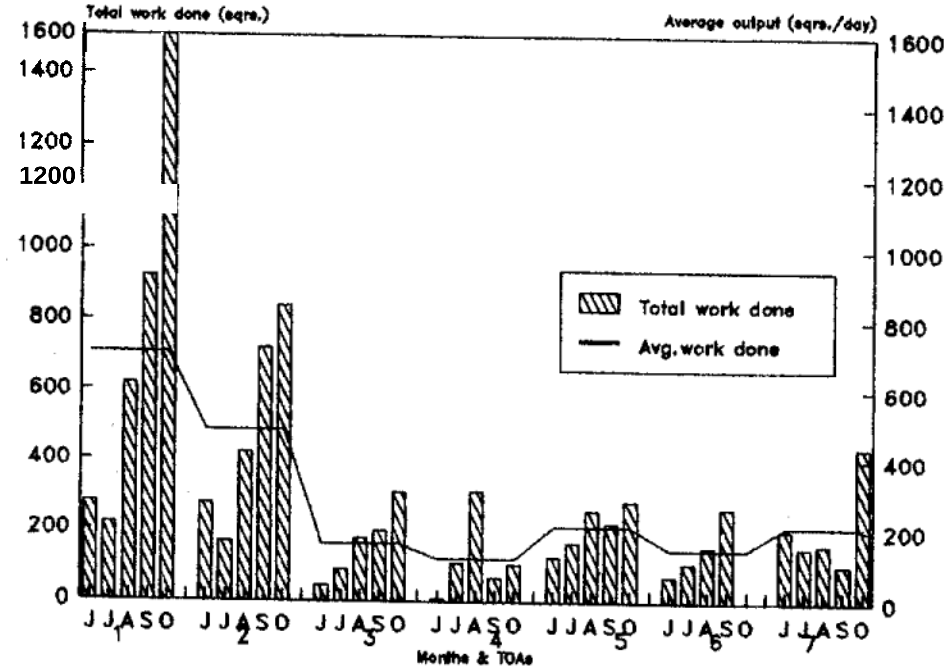
Next >>



SKETCH OF MAINTENANCE WORK.

Figure 3.3.1

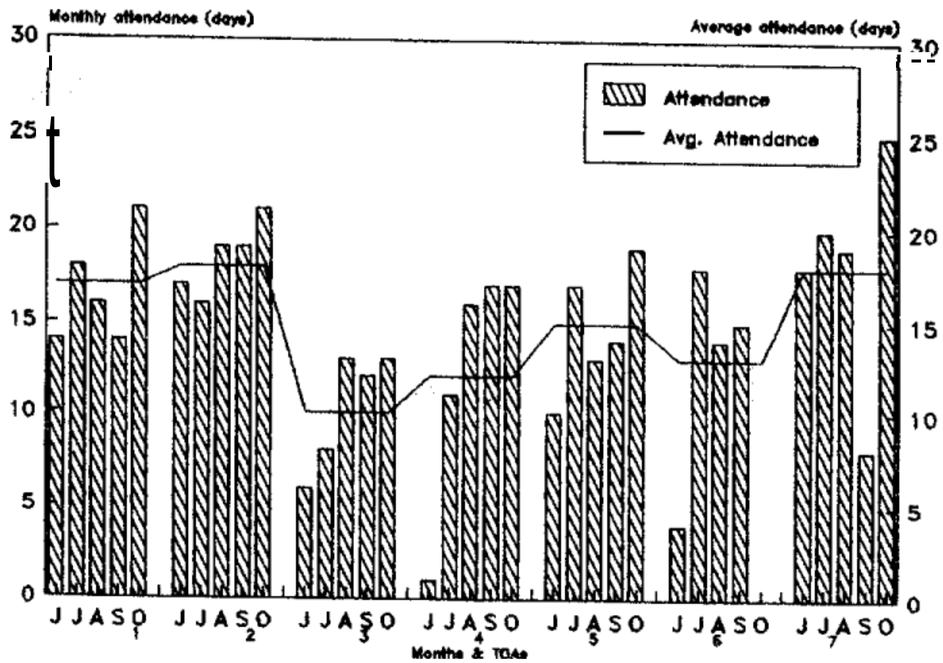
Progress of Maintenance Work
(Total work don and average)



Carried out by the TOAs

Figure 3.3.2

Progress of Maintenance Work
(Monthly attendance and average)



Carried rut by the TOAs

Figure 3.3.3.

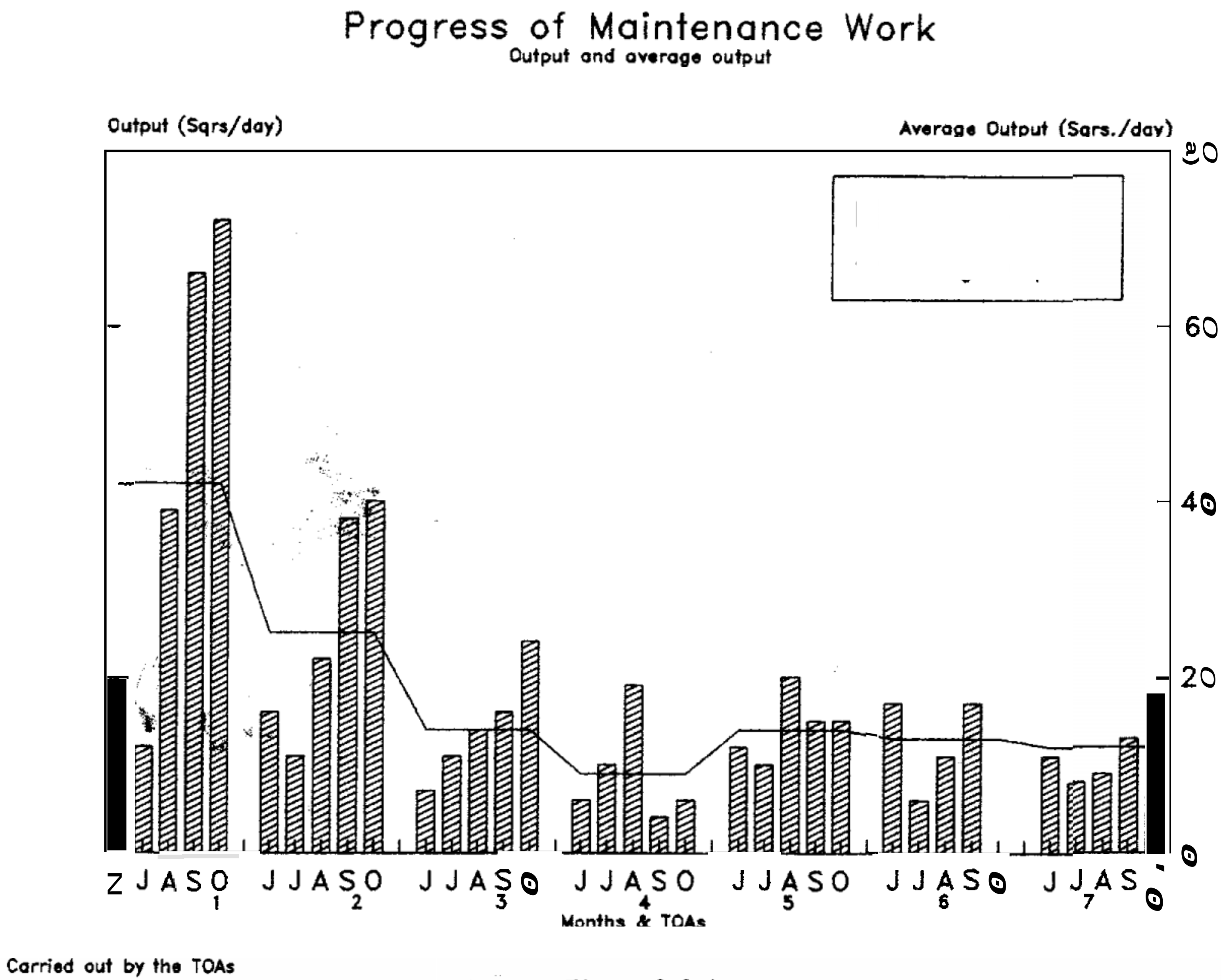
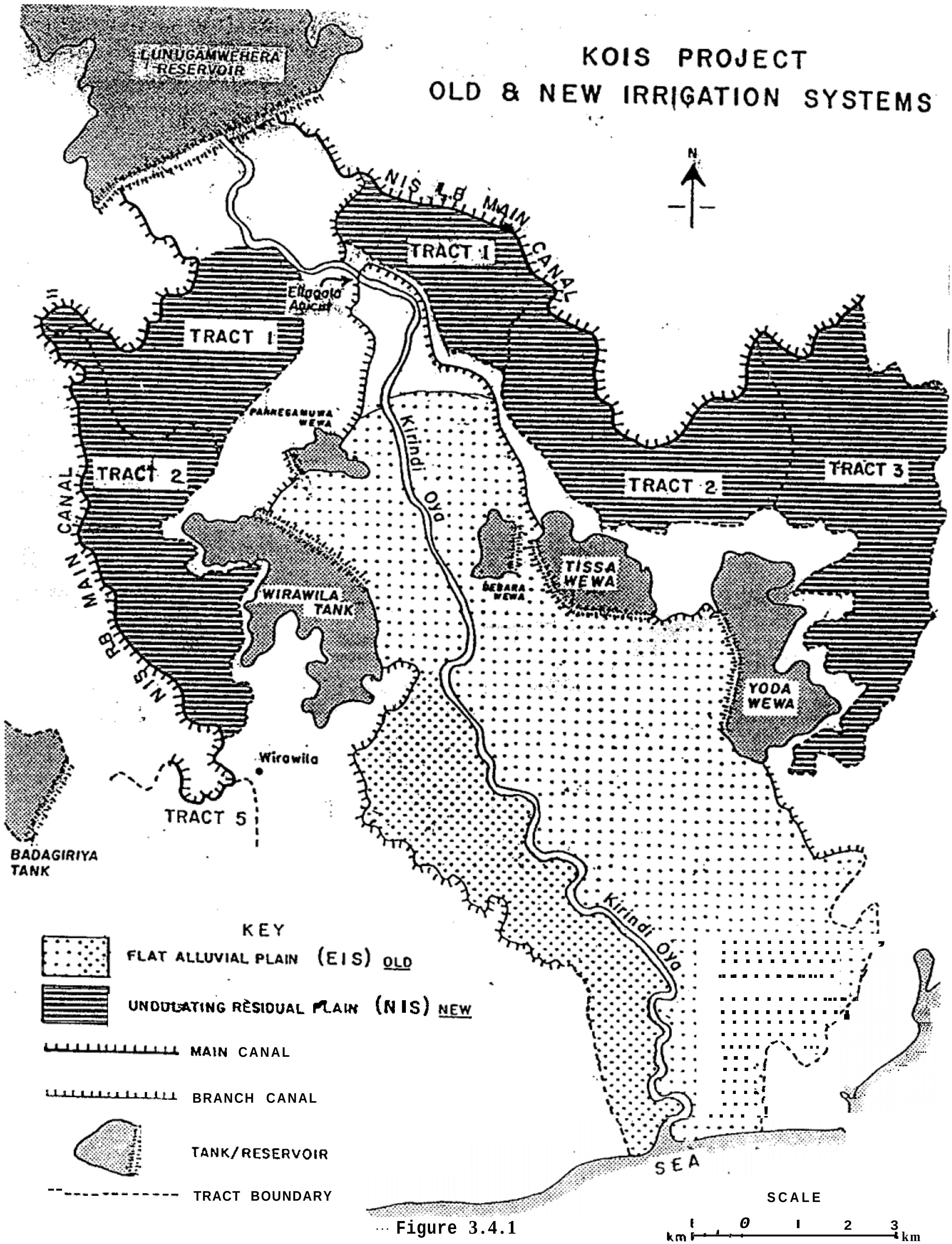

Progress of Maintenance Work
Output and average output
Output (Sqrs/day)
Average Output (Sqrs./day)
a)
0
20
40
60
Z J A S O 1 J J A S O 2 J J A S O 3 J J A S O 4 J J A S O 5 J J A S O 6 J J A S O 7
Months & TOAs
Carried out by the TOAs

Figure 3.3.4



KOIS PROJECT
OLD & NEW IRRIGATION SYSTEMS
N
LUNUGAMWEHERA RESERVOIR
NIS LB MAIN CANAL
TRACT I
Ellagala Anicut
TRACT I
PANNEGAMUWA WEWA
Kirindi Oya
TRACT 2
TRACT 2
TRACT 3
NIS RB MAIN CANAL
WIRAWILA TANK
DEBARA WEWA
TISSA WEWA
YODA WEWA
Wirawila
TRACT 5
BADAGIRIYA TANK
Kirindi Oya
SEA
KEY
FLAT ALLUVIAL PLAIN (EIS) OLD
UNDULATING RESIDUAL PLAIN (NIS) NEW
MAIN CANAL
BRANCH CANAL
TANK/RESERVOIR
TRACT BOUNDARY
SCALE
km 1 0 1 2 3 km

Figure 3.4.1

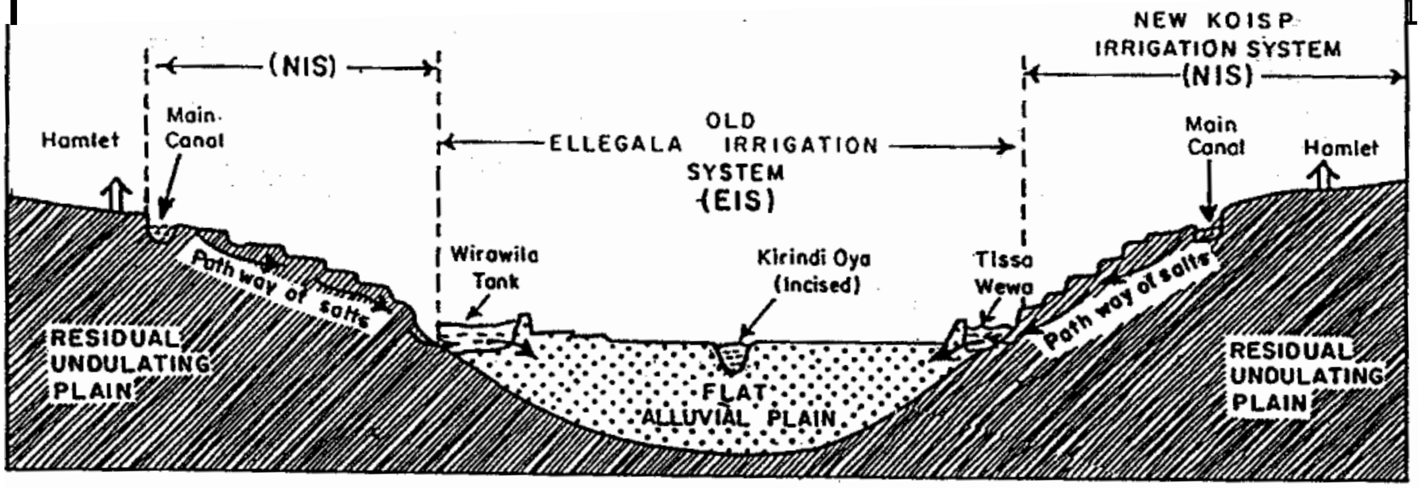
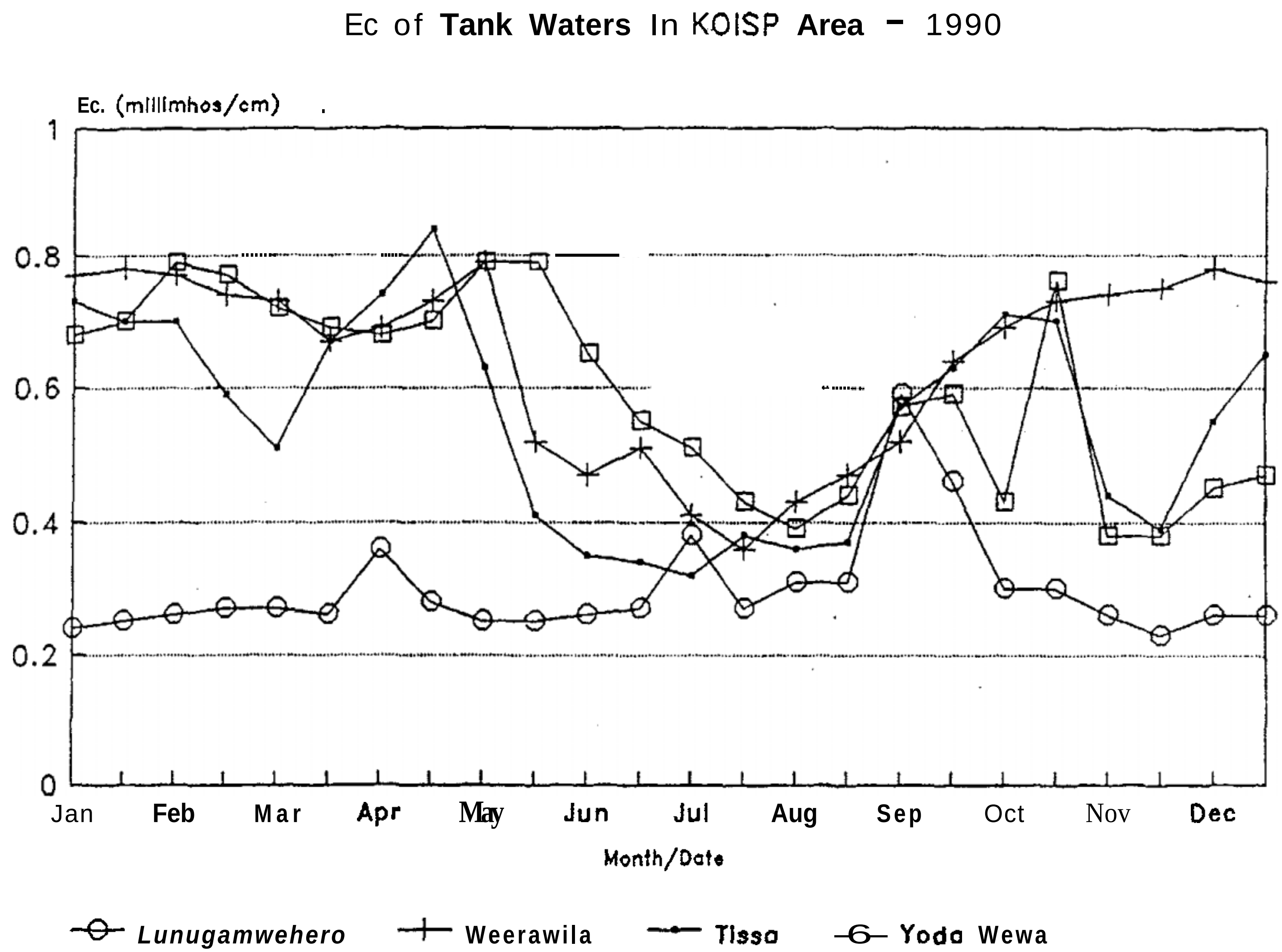


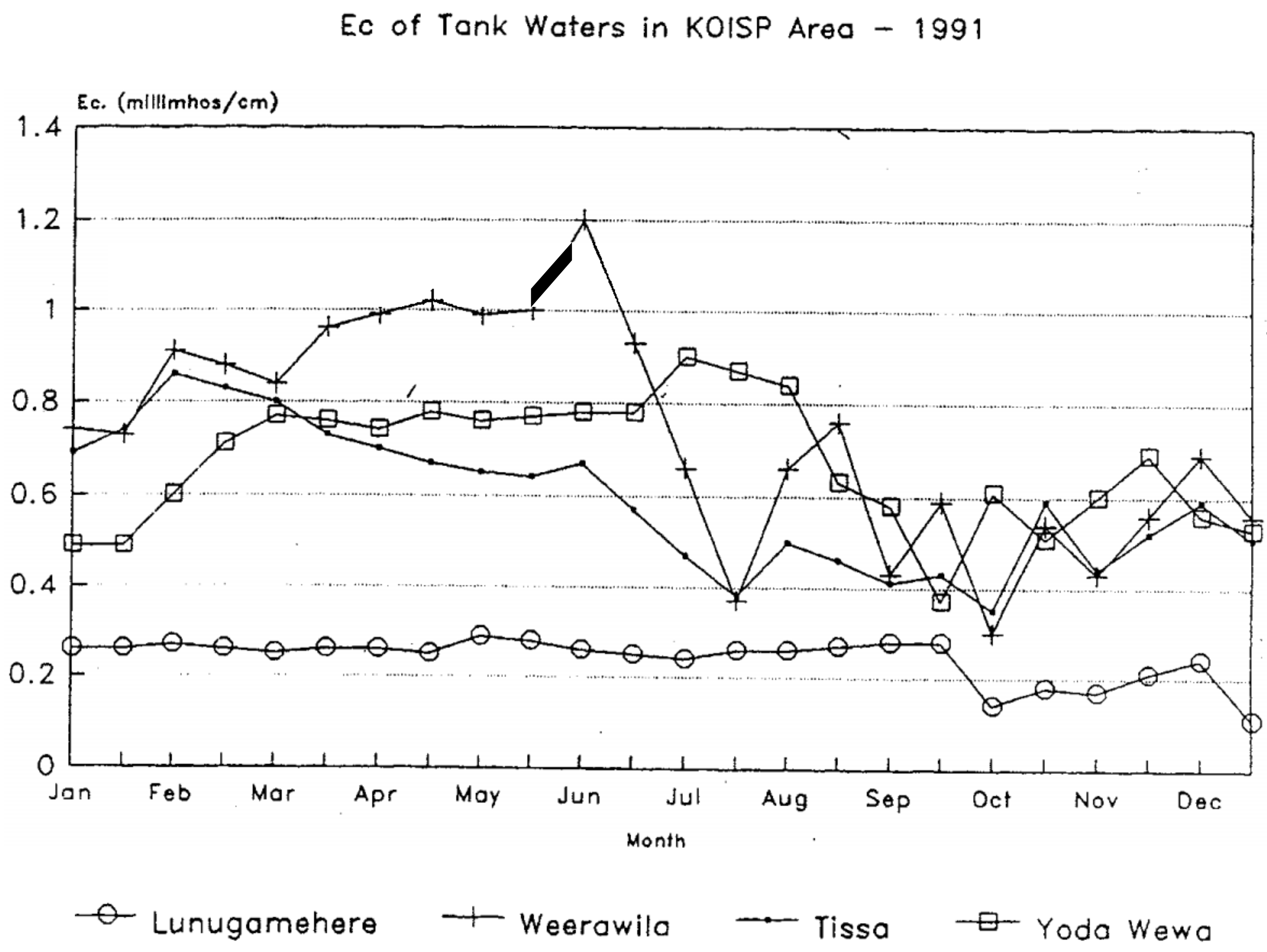
FIGURE 2. SCHEMATIC CROSS SECTION (EAST-WEST) ORIENTATION

Figure *3.4.2*



Ec of Tank Waters In KOISP Area - 1990
Ec. (millimhos/cm)
1
0.8
0.6
0.4
0.2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month/Date
Lunugamwehero
Weerawila
Tissa
Yoda Wewa

Figure 3.4.3



Ec of Tank Waters in KOISP Area - 1991
Ec. (millimhos/cm)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Lunugamehere
Weerawila
Tissa
Yoda Wewa

Figure 3⊂ ⊂

Ec of **Tank Waters** in KOISP **Area** - 1992

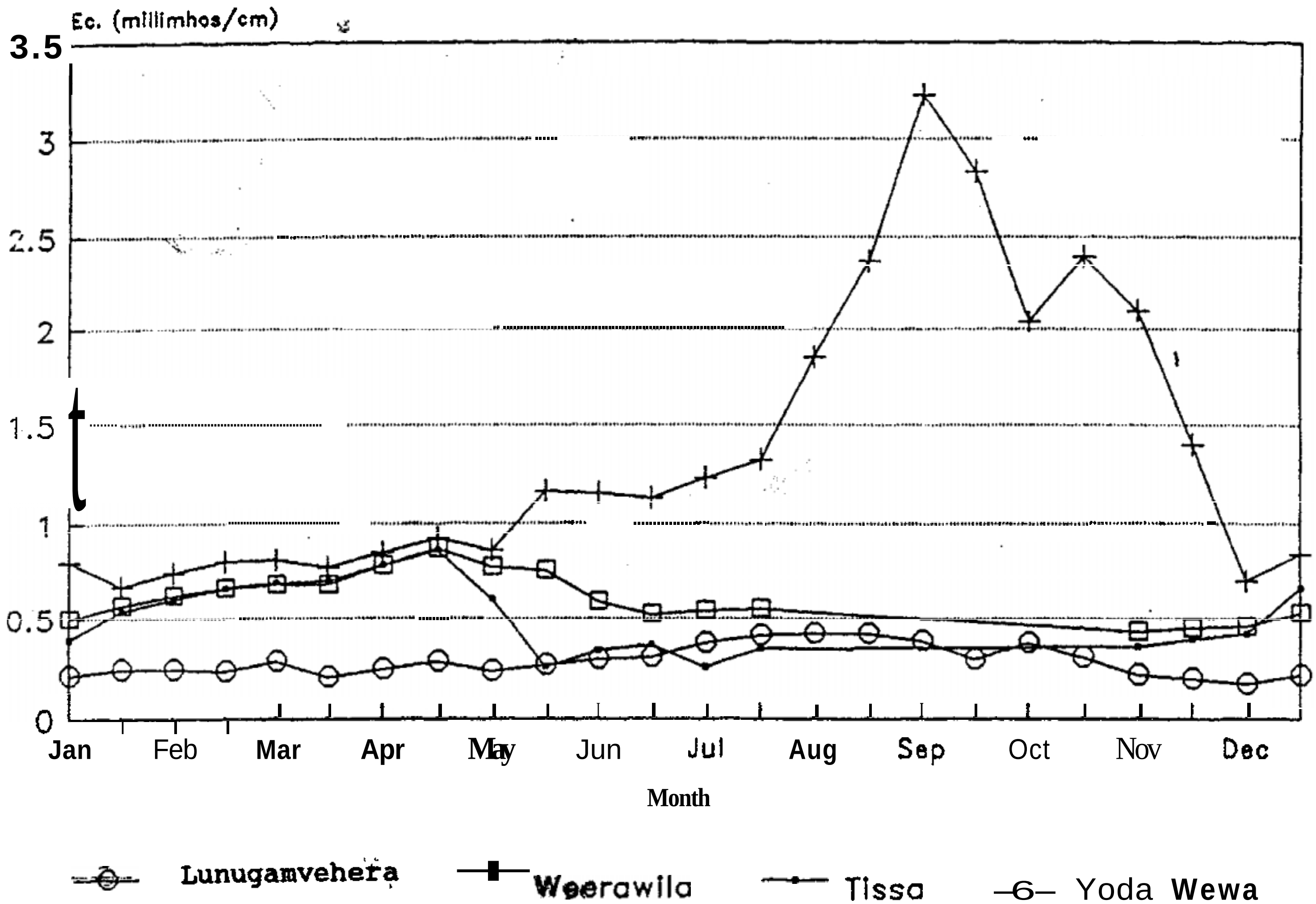


Figure *3.4.5*

Ec of Tank Waters in KOISP Area - 1993

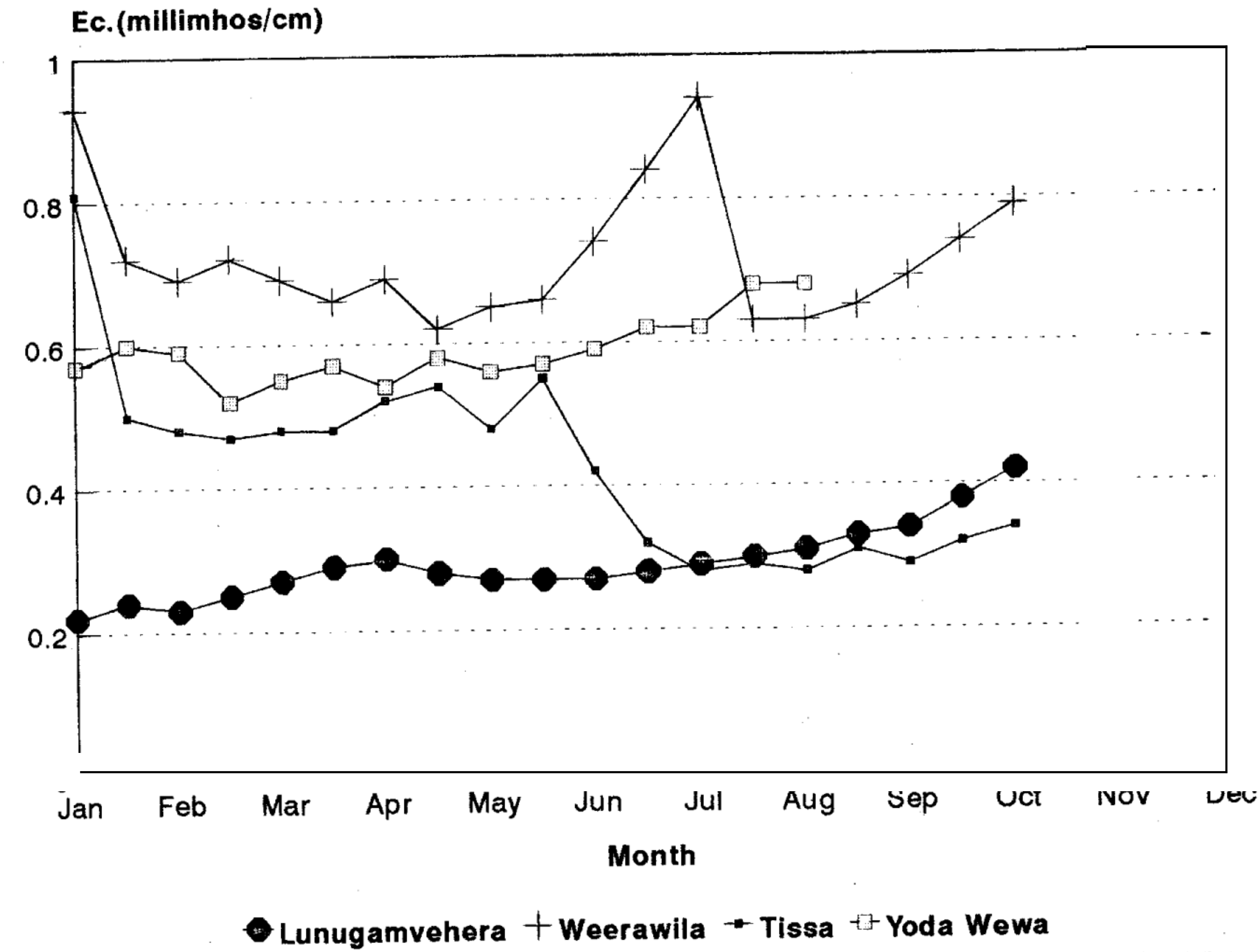


Fig 3.4

CHAPTER 4

Tertiary System Management

4.1 OBJECTIVES AND COMPONENTS OF THE TERTIARY SYSTEM MANAGEMENT COMPONENT

4.1.1 Origin and Purpose of the Component

The Phase I Study indicated that there was a great potential for the improvement in water use efficiency if tertiary system management could be improved, particularly if the land preparation period could be shortened. The term "tertiary system" here refers to all portions of the system below the distributary channel (DC) offtakes. Under the participatory management policy, the tertiary system is to be managed by the farmers organized into Distributary Canal Organizations (DCOs).

The Phase I Study highlighted specific management problems being caused by weaknesses in the newly formed DCOs. Strengthening farmer organizations through joint participation in management tasks appeared one possible solution to management problems at this level. It was also envisaged that in the process of getting the DCOs involved in management tasks, effective procedures for strengthening these organizations could be developed.

4.1.2 Objectives and Activities of the Component

As given in the Inception Report, the objectives of this component were:

* to develop and field test management procedures through which farmers and staff from supporting government agencies can improve the planning, coordination, and implementation of water management and agricultural planning at DC level within the framework of a participatory management system and
* to develop and test processes for institutional strengthening and turning over increasing operation and maintenance (O&M) responsibilities to farmers' organizations at DC level.

The activities proposed to achieve these objectives were:

a) institutional strengthening,

b) tertiary maintenance management,

c) seasonal planning and coordinated acquisition of agricultural inputs,

d) operations during land preparation and

e) operations during the crop growth period.

All of these together should result in efficient use of scarce water to maximize production.

Each is described in more detail below following a description of some of the social and economic features of the New Area farmers.

Because of the known weaknesses of the DCOs in the New Areas, at the beginning of Phase II it was presumed that this work should focus exclusively on the New Areas. However, during implementation of the Phase II Study as a whole, the importance of the management of Ellegala for the Kirindi Oya System as a whole became much clearer. Hence, investigations into tertiary system management in Ellegala were added to this component later. These investigations are discussed separately.

4.2 METHODOLOGY AND CHRONOLOGY OF THE RESEARCH

The research activities were to be conducted by the farmers and the agencies involved. It was expected that the field staff of the Irrigation Management Division (IMD) and the Irrigation Department (ID) would identify important variables and collect, record and make use of the key data as necessary. IIMI was to be responsible for collecting primary data on settlement and community matters and on decision-making by farmers at the tertiary level. IIMI was also responsible for recording the proceedings of meetings and documenting the management process through participant observation, interviews and validation questionnaire surveys.

The following describes the implementation process and major activities of the component.

4.2.1 Planning of the Tertiary System Management Component

The initial effort, during the early part of yala 1991, was directed at forming the Study Coordinating Committee (SCC) for Kirindi Oya and the Subcommittees to plan and oversee the activities of the different components. A Subcommittee for Tertiary System Management was appointed under the Chairmanship of the IMD Project Manager. Initially, the Committee consisted of the Agricultural Officer of the Department of Agriculture (DOA), the Irrigation Engineer (IE), O&M, the Resident Engineer (RE) of the Right Bank (RB) and the Institutional Development Officer (IDO). Membership was later extended to include field officers.

The Tertiary System Management portion of the Inception Report was prepared in draft by IIMI researchers, based on the findings of Phase I, and then discussed with the Subcommittee on several occasions. No objections nor comments were raised by the Subcommittee members. The Inception Report was finalized at a June 1991 workshop.

On the recommendation of the Subcommittee, following the finalization of the Inception Report, training and awareness programs were carried out for project and field level staff responsible for implementing the action research program.

A Planning Workshop was held on 5 August 1991 with the following objectives:

* Creating awareness of the research program in general and of the tertiary system management component in particular.
* Explaining the concept of participatory management to project officers.
* Guiding officers in the preparation of training modules for field staff, Farmer Representatives (FRs) and farmers.
* Motivating agency officials to support participatory management.

The workshop was attended by project officers, IIMI researchers and Colombo-based resource persons from the ID, the IMD and other departments. Discussions on tertiary system management led to endorsing the objectives and activities defined in the Inception Report. However, the RE, Left Bank (LB) pointed out that not enough consideration was being given to the temporary residence status of many settlers, which was a major problem affecting water management.

4.2.2 Implementation of the Program in Maha 1991/92

During August 1991, a meeting was held at the Land Commissioner's Department (LCD), Debarawewa, to discuss the training materials prepared by the line agencies. The discussion quickly revealed that the workshops held so far had not succeeded in orienting most of the officers as desired. IIMI had thus to prepare guidelines for officers to enable them to prepare training materials to make action research a participatory exercise.

A one-day workshop on implementing the tertiary system management program was held on 17 August 1991 for field staff from the LCD, the IMD, the ID and the DOA in Tracts 1 and 2 of the RB and Tract 3 of the Left Bank. The workshop included presentations by senior officers from all four agencies and IIMI.

Subsequently, the Subcommittee on tertiary system management met once a month to discuss progress and achievements.

It was assumed initially that the work should take place in the New Areas where it was known that the farmer organizations were very weak. The Inception Report proposed that research activities should take place in DC 2 Sub 1 in RB Tract 2. Work was to start in maha 1991/92 and continue for four seasons. Unfortunately, this program could not be followed.

OFCs. Work in Ellegala was confined to a diagnostic study and was taken up because of issues raised by IIMI. Work in Ellegala is discussed separately below.

To monitor IIMI's intensive study in the two subsystems, the Tertiary System Management Subcommittee was expanded to include the following: the IMD Project Manager, Chairman; REs and IEs of the respective systems; IDOs of the respective systems; TAs, WSs, AIs, FAs, IOs and Colonization Officers (CO) working in the distributaries; IIMI's research team working in Kirindi Oya; and one distributary canal leader from each DCO under intensive study.

Again, training for the farmers and FRs was a key element in working with the farmers. Since the majority of farmers and all six FRs in the selected DC did not live in the settlement prior to water issues, training could be organized only after they returned. Once begun, however, training for all six field canal groups was completed in three days. The training classes were conducted by the IE (Water Management) and IIMI researchers with the help of the IO. It focussed mainly on field canal cleaning and water sharing during the land preparation period.

After these initial training sessions, the IO did not participate further, though IIMI had expected him to take a leading role in organizing field canal groups and helping farmers follow rotations. He limited his activities to meeting the Secretary, President and Treasurer of the DCO once or twice a week and holding monthly meetings of FRs under the DCO.

There was no IO from the crop growth period up to the end of the season. However, IIMI researchers helped FRs prepare rotational schedules and organized field canal group meetings when farmers had problems over water sharing.

4.2.5 Implementation of the Program in Yala 1993

Drought prevented implementation of activities in the New Areas during yala 1993. However, some work was conducted in Ellegala. This work is discussed separately below.

4.2.6 Implementation of the Program in Maha 1993/94

At the request of the ADB, IIMI agreed to extend the program to February 1994, thus covering most of the maha 1993/94 season. However, for reasons to be discussed below, it was not felt worthwhile to continue the tertiary system management efforts in the New Areas. Studies were carried out
in Ellegala.

4.3 PHYSICAL CHARACTERISTICS OF THE NEW AREA SAMPLE CHANNELS

IIMI's intensive study was confined to two distributaries: Sub 1 in DC 5 in RB Tract 1 in maha 1991/92 and DC 7 in RB Tract 5 in maha 1992/93.

4.3.1 DC 5 in RB Tract 1

Sub 1 in DC 5 in RB Tract 1 consists of four field canals with a total command of 152 acres. The entire command is considered lowland for the preparation of irrigation schedules. As shown in **Table 4.1,** IIMI estimates that the command area consists of **74.2** percent LHG soils and **25.8** percent RBE soils.

Table 4.1. Soil classification of DC 5 command area.

Field Canal	Command Area (ac)	Soil			
		RBE (ac)	LHG (ac)	RBE %	LHG %
FC 51	40.00	15.00	25.00	37.50	62.50
FC 48	15.00	3.00	12.88	20.00	80.00
FC 49	60.00	14.00	46.00	23.00	77.00
FC 50	37.50	7.50	30.00	20.00	80.00
Sub DC	152.50	39.50	113.00	25.90	74.10

Note: Based on eye estimation by IIMI staff.

4.3.2 DC 7 in RB Tract 5

DC 7 in RB Tract 5 serves five standard field canals (discharge 8.5 cusecs) and one with a discharge of 1.4 cusecs. The total extent cultivated as per the ID's schedules is 215 acres. DC 7 originates from BC 2. Lands at the head of DC 7 are non-irrigable highlands. The canal crosses these highlands in a deep cut to irrigate the hill slopes in the command area. FC 36 is located on the left while FCs 38, 39, 40 and 41 are on the right. FC 37 is the tail most canal. **Table 4.2** gives the land distribution in DC 7 according to soil type. Nearly 86 percent of the land under this distributary consists of RBE soils.

Table **4.2.** Soil classification of **DC 7** command area.

Field Canal	Command Area (ac)	Soil			
		RBE (ac)	LHG (ac)	RBE %	LHG %
D c 7	215.20	184.80	30.40	85.9	14.1
FC 41	35.10	28.80	6.30	82.1	17.9
FC 40	32.50	25.00	7.50	76.9	23.1
FC 39	47.50	44.20	3.30	93.1	6.9
FC 38	30.00	26.00	4.00	86.7	13.3
FC 37	32.60	24.80	7.80	76.1	23.9
FC 36	37.50	36.00	1.50	96.0	4.0

4.4 SOCIO-ECONOMIC CHARACTERISTICS OF THE NEW AREA SAMPLE POPULATION

IIMI's intensive study was confined to two distributaries: Sub 1 in DC **5** in RB Tract 1 and DC **7** in RB Tract **5.** In addition, data on the socioeconomic characteristics of the farming communities in DCs **5** and 9 in **RB** Tract 2 and DC 11 in **RB** Tract **5** was collected to validate findings in the intensive samples.

4.4.1 Social Characteristics

Settlers in the newly developed area fall into two categories: alternative settlers and open kachcheri settlers. Alternative settlers are those who were resettled in the project after their lands were acquired. These people had been living in the project area depending mainly on rain, small tanks or lift irrigation for cultivation. Chena and other highland cultivation had been their main occupation. Open kachcheri settlers are those brought in from either adjoining electorates or from the Tissamaharama electorate.

As shown in Table **4.3,** non-residence, indebtedness and leasing out of lands in DC **5** in RB Tract 1, in which almost all farmers are alternative settlers, is very much less than in distributaries with more open kachcheri selectees. DC 11 in **RB** Tract **5** has been allocated to Muslims. Since the majority of selectees have not settled, these lands are now being cultivated by encroachers.

Table **4.3.** Non-residence, indebtedness and leasing lands (expressed in percentages).

	Tract 1		Tract 2		Tract 5
	DC 5	DC 6	DC 9	DC 7	DC 11
Defaulters of bank loans	72	60	65	70	Not known
Leasing out lands	52	70	50	40	Not known

Farmers in Sub 1 DC **5** in **RB** Tract 1 are settled in Hamlet 3. These settlers are mainly from **areas** surrounding the Lunugamvehera and were known to each other before coming to the settlement. Therefore, group interaction is more intimate here than in other hamlets.

It was observed that interactions between settlers from the same locality and members of the same caste are more intimate. For example, settlers from Hakmana living in one hamlet identify themselves to outsiders as "Hakmana People". In one hamlet, two castes dominate. When the villagers wanted to build a temple, the lower caste took the lead, built the temple and brought in a priest of their caste. Members of the higher caste did not get involved. Caste membership seems to affect selection of leaders also. However, the impact of caste on day-to-day interaction is not visible; seating of students at school and groups on festive occasions do not exhibit caste characteristics.

The development of an identity based on the hamlet was observed. Settlers call themselves Hamlet 11 or Hamlet 3 people but never refer to distributary canals for such identity. When farmers in two hamlets have lands under one distributary canal, they behave like two different groups and do not cooperate in distributary maintenance or other community activities at distributary level.

4.4.2 Lack of Cultivation in the New Areas

As shown in Table **4.4,** farmers in the new system have been able to cultivate an average about one crop a year. Between the first water issues in maha 1986/87 through maha 1991/92, the luckiest farmer (who cultivated every season Tract 1 had water) in the RB could have gotten at most 8 crops out of 11 seasons. The unluckiest (someone badly placed in Tract 1 or Tract 2) would have had at most 2 seasons out of 11. The median is probably around 7 seasons out of 11. Through necessity, settlers go back to their original villages during the off-season. They reside in the project only when water issues to raise crops are made.

Table **4.4.** Cultivation seasons in the Right Bank.

Season	Tracts Cultivated	Acreage	Issued on	Last issue	Remarks
Yala 1986		**No**	**Cultivation**		
Maha 1986187	**Tract** 1 **Tract** 2 **&** 5	1387.50	86.11.05 86.11.05	87.03.05	 **Failed**
Yala 1987		**No**	**Cultivation**		
Maha 1987188	**Tract** 1 **Tract** 2 **Tract 5**	1387.50 2027.50 2275.00	87.11.30 88.01.01 88.01.25	88.03.30 88.05.15 88.06.26	
Yala 1988	**Tract 1**	1387.50	88.05.27	88.09.27	
Maha 1988189	**Tract** 1 **Tract** 2 **Tract** 5	1722.50 2082.50 2312.50	88.11.25 88.09.27 88.09.27	89.03.28 89.01.27 89.01.27	
Yala 1989	**Tract** 2 **Tract 5**	2082.00 2312.50	89.03.15 89.03.15	89.07.28 89.07.28	
Maha 1989/90	**Tract** 1 **Tract** 2 **Tract 5**	1387.50	89.11.02 89.11.17 89.11.17	90.04.01 89.11.27 89.11.27	 **Dropped** **Dropped**
Yala 1990	**Tract** 1	**103.90**	90.05.05	90.09.14	**OFCs**
Maha 1990/91	**Tract** 1 **Tract** 2 **Tract 5**	2275.00 2082.50 1990.00	91.11.05 90.11.05 90.11.05	91.05.15 91.03.20 91.03.20	
Yala 1991	**Tract** 2 **Tract** 5 **Tract** 6 **&** 7	181.86 352.73 104.70	91.06.01 91.06.01 91.04.20	91.10.01 91.10.01 91.07.20	**OFCs** **OFCs** **OFCs**
Maha 1991192	**Tract** 1 **Tract** 2 **Tract 5** **Tract** 6 **&** 7	1885.00 2082.50 1990.00 1412.50	91.09.15 91.11.30 92.01.05 91.10.10	92.01.15 92.03.15 92.04.25 92.02.10	

Source: The Department of Irrigation.

Given the lack of water for crops, incomes are low and indebtedness is high. Table **4.3** shows that indebtedness is high among settlers irrespective of their residential status. **As** in many other settlements, these economic difficulties lead to leasing lands out to others. Both alternative and **open** kachcheri settlers have serious economic problems debarring them from cultivating their lands. The comparison of the two samples, DC **5** in RB Tract 1 and DC **7** in RB Tract 5,

implies that the rate of leasing lands is higher among settled farmers than non-settled or temporarily settled farmers.

Interviews and observations in the field substantiate widespread poverty among settled farmers. Over half of the farmers in the study samples had leased out their lands and were engaged in other activities. Interviews with farmers and the household surveys conducted toward the ends of the seasons showed that they do not depend on their allotments to make a living.

4.4.3 Economic Problems of RB Tract 1 DC 5 Farmers

The survey conducted in the DC **5** at the end of maha **1991/92,** showed that net returns for an owner operator ranged between Rs **1,826/-** to a maximum of Rs **17,9621-.** The average return was **Rs 9,432/-.** Based on net returns the **12** owner operators can be grouped as shown in **Table 4.5.**

Table 4.5. Net Returns to Owner Operators

Earning	Number
Earning less than Rs 5,000/-	2
Earning between Rs **5,000/-** and **Rs 10,000/-**	1
Earning above **Rs 10,000/-**	9

Nine of the **13** farmers who leased their lands received Rs **5,0001-** as land rent. Two farmers received a rent exceeding Rs 10,000/-. The non-owner operators increased **an** average loss of Rs 930/-. Their returns range from a profit of Rs **6,380/-** to a **loss** of Rs **20,563/-.** Six of the **12** non-owner operators reported losses.

Average yield in the area for maha **1991/92** was **3,000** kg per ha. The minimum was **865** kg/ha while the maximum was **4,200** kg/ha. Salinity and low fertilizer application were the main reported reasons for low yields. Owner operators spent an average of Rs **1,731/-** for fertilizer though 75 percent said they did not use the recommended quantity. No relation between yield and location on the canal could be discerned from analysis of yield data.

These farmers cannot depend solely upon irrigated farming for their incomes. Indebtedness had forced **52** percent of the sample allottees to lease out their lands. As shown in **Table 4.6,** irrigated agriculture was only one of the sources of the incomes for the **25** sample farmers.

Table 4.6. Reported sources of income in DC **5** of **RB Tract 1.**

Season	Description	Primary #	Primary %	Secondary	
Maha 1990/91	Imgated agriculture	8	32		
	Chena cultivation	7	28		
	Wage Labor	9	36		
	Other	1	4	0	6
Yala 1991	Imgated agriculture	4[a]	16	0	0
	Chena cultivation	1	4	0	0
	Wage Labor	4	16	0	0
	Other	0	0	0	0
	No employment	16	64	0	0
Maha 1991/92	Imgated agriculture	12	32	3	12
	Chena cultivation	3[b]	12	4	16
	Wage Labor	8	32	0	0
	Other	2	8	0	0

[a] = There were no authorized water issues. Illegal OFCs.

[b] = Chena lands formerly **used** by this group were closed to them from this year so the number was reduced.

Farmers in DC **5** have few employment opportunities other than wage labor. Formerly they had access to chena land but now the authorities keep them away. These various factors have contributed to the continued poverty of the majority of farmers in the sample area. The extreme form of this poverty is expressed by four farmers who have leased their lands to non-owner operators and now work on the same allotments as share-croppers.

4.4.4 Economic Problems of RB Tract 5 DC 7 Farmers

The DC 7 farmers face problems similar to those facing the Tract **1** DC **5** farmers. Because of the few cultivation opportunities (not more than one crop a year) farmers must supplement their income from imgated agriculture with income from other sources. **Table 4.7** shows that the most important secondary source is wage labor based on the survey conducted at the end of maha **1992/93.** This survey included **68** of the **84** farmers under the canal.

Table 4.7. Reported sources of income for DC 7 sample farmers (N=68) (expressed in percentages).

Rank Order	Farming	Wage Labor	Chena	Employment
First source	85	7	0	0
Second source	6	26	0	0
Third source	0	3	3	0
Fourth source	1	4	0	0
Fifth source	6	15	0	1
Sixth source	2	2	0	0

The survey showed that farmers generally consider a harvest of 3 tons of paddy from each allotment a good crop. However, reported yields for the past two years were considerably lower than that figure (Table 4.8).

Table 4.8. Reported harvest amounts (N=68) (expressed in percentages).

Amounts Harvested	1991192 Maha	1990/91 Maha
0-1500 kg	66	38
1500-2250 kg	22	34
2250-3000 kg	7	23
> 3000 kg	5	4

Fifty-one percent of farmers were indebted to banks and had therefore to depend on money lenders or lease their lands to others, as indicated in Table 4.9.

Table **4.9.** Farmer indebtedness.

Amount owed to banks (Rs)	No. of farmers	Percentage
Not indebted	33	49
1,000-5,000	12	18
5,001-10,000	15	22
10,001-15,000	5	7
> 15,000	3	4

Most farmers are frustrated and feel that their quality of life has badly deteriorated. Farmers' responses to the change in the quality of their life as a result of coming to the settlement are given in Table **4.10.**

Table **4.10.** Farmers' responses to change **in** quality **of life.**

Criteria	No.of Responses	Percentage
No change	16	24
Improved a little	2	**3**
Worsened	50	**73**

As shown earlier in Table **4.3,** farmers in DC **7** are either non-resident or temporary residents for economic reasons.

4.5 INSTITUTIONAL STRENGTHENING

4.5.1 Need for Institutional Strengthening

Phase I of the study highlighted the fact that farmer organizations in the New Areas suffered weaknesses in leadership, collective action, basic organizational skills and management abilities. The action research, therefore, was aimed at both strengthening the capacity of farmer organizations to take increasing levels of management responsibility and at increasing the capacity of the ID and the IMD to provide technical and management support to farmer organizations.

The basic plan for this activity, as spelled out in the Inception Report called for:

- * evaluation of the farmer organizations,
- * training farmers, FRs and IOs as needed and
- * planning meetings of DCOs and field channel groups.

Most of this work is a regular part of the work of the IMD. Therefore, most of it was to be done by the IMD's Institutional Organizers, supervised by the IDOs and the Project Manager, and assisted by ID field officers and field officers from other agencies as needed. The expected cooperation among field personnel was formalized during maha 1992/93 into task forces. IIMI's part was to document the effort, assist with the training, and to provide specific help for the other activities of the component.

In fact, however, the action research failed to significantly affect the strength and capacities of the farmer organizations in the New Areas. Below is given a short description of the two sample farmer organizations and of the major problems that inhibited attempts to strengthen these farmer organizations.

4.5.2 The Sample Farmer Organizations

The following gives a picture of the two farmer organizations:

DC 5 in RB *Tmct 1*

Once regarded as one of the strong farmer organizations in the RB, by the time the Phase II Study began the IMD had lost faith in the organization's President and had launched a process to replace him. The IMD felt that the leaders of the FOs had become corrupt, had developed bureaucratic tendencies, and were not accountable to farmers. The IMD encourages changing DCO officers every two years or less to prevent corruption and other deleterious problems. Also, farmers in this distributary live in Hamlets 2 and 3; the hamlets are separated by 3 kilometers and farmers from the two hamlets do not cooperate in joint activities.

DCs 1, 2 and 7 in RB Tmct 5

DC 7 belongs to the DCs 1, 2 and 7 farmer organization which has 22 field canals under its command. Of these, lands under two direct field canals originating from the Right Bank Main Canal (RBMC) and one from BC 2 belong to settlers in Hamlet 8, a predominantly Muslim village located three kilometers away from Hamlet 11, where the majority of farmers holding land under the DCO live. Hamlet 11 settlers have lands under 17 field canals coming under the DCO. Lands in two field canals belong to settlers in Hamlet 10, located about three km from Hamlet 11. The distance between the two hamlets makes social interaction between farmers difficult. Both the President and the Secretary of the DCO are from DC 2, while the Treasurer

belongs to DC 1. None of the key posts in the organization are held by representatives from DC 7. FRs from the two field canals rarely attend DCO meetings in Hamlet 11. This is also true of FRs from field canals belonging to Hamlet 8. The number of FRs attending DCO meetings during maha 1992/93 never exceeded 13.

4.5.3 Constraints to Farmer Participation in the DCOs

The following were identified as being the main constraints in organizing effective farmer organizations:

* Lack of incentives and benefits from participation.
* Settlement-related problems.
* Problems associated with IMD's program to organize farmers.
* Farmer-officer relationships and interagency cooperation.

These items are described below.

Lack of Incentives

When the farmer organization program began in 1986, many farmers rallied round farmer organizations to find solutions to the problems of a new irrigation system: land levelling, physical defects in irrigation structures, settlement and land related problems, etc. As these problems were solved, farmer participation decreased. As described in Section 4.4, the present major problems for farmers are the economic problems directly related to the scarcity of water for cultivation. The farmer organizations by themselves do not have a solution to these economic problems. Under the circumstances, it has been difficult to get farmers to remain in the area, much less get them involved in farmer organization activities.

The involvement of FRs is also weak. DCO committee meetings in the two sample areas were attended by less than half the FRs. Interviews show that FRs feel they should receive payment for such work. Only the President, Secretary and Treasurer are involved because of the prestige and the economic benefits offered by contract work from the ID.

Settlement Related Problems

The following problems were identified as major constraints for organization strengthening:

* Settlers identify themselves with their hamlets and not with their distributary canals. This creates problems for leaders of DCOs when they are not members of a particular hamlet community. For example, farmers in DC 7 reside in two hamlets: Hamlet 10 and Hamlet 11. DC 7 belongs to the DC 1, 2 and 7

Organization which has the majority of its members living in Hamlet 11. Farmers in Hamlet 10 having lands in the irrigated area under this DCO do not consider themselves members of the DCO, do not attend DCO meetings, and above all do not follow the advice of the DCO leaders.

* Relationships between alternative settlers and open kachcheri settlers are not amicable, leading to conflict in water sharing, elections, etc.

The IMD's Farmer Organization Program

The IMD started work in 1986 with first water issues to the new area during yala. Organizing farmers at the initial stage was done by Project Managers. Later, IOs and IDO were appointed to assist. The following problems were identified with the IMD's program:

* Since 1988, the IOs have been changed often - four different IOs have worked with farmers in DC 7 while DC 5 had only two for the entire period. The first IOs were graduates who left to take permanent positions elsewhere. Thereafter, young people from the project with Advance Level qualifications were appointed. Many officers believe that recruitment from farmer-families had an adverse impact on the program as many held views similar to the views held by farmers and proved a hindrance in bringing about attitudinal changes in the community. Many did not enjoy recognition among the settlers as they were children of settler families themselves. These changes, together with transfers of IOs, prevented the IOs from having the time needed to establish rapport and solve problems for the farmers.

* Most of the current IOs live in the hamlets in which their families reside and not with the communities with whom they work. This limits their involvement in many activities, especially in working with field canal groups to share water within field canals.

* The workload of an IO was excessive. The IO assigned to DCs 1, 2 and 7, had to work with farmers in Hamlet 10 and also at the office of the Project Manager preparing reports. This makes it impossible to implement an intensive program with the farmers.

* IMD believes that FRs should be changed every two years. Ostensibly, this is to allow all farmers their turn as leaders so they could better understand the various aspects of management. The IMD included a clause in all DCO constitutions empowering the DCO to change leaders who had served for two years. In 1991, IMD attempted to replace the FRs without taking the views of farmers into consideration. As a result, the DC 5 leaders who had training on the implementation of the action research program were changed. Except for two, all the new FRs were either non-residents or temporary residents. This made it

impossible for the IO to organize field canal maintenance work and was a constraint to implementing rotations within the field canals.

Most ex-FRs as well as those currently in office are against changing Representatives every two years. In their opinion, this practice will weaken the DCOs through inexperienced leadership. Recent interviews with leading FRs in RB Tract 1 indicates that IOs face stiff resistance from the farmers and the FRs.

* The IMD has also taken steps to safeguard organization funds. Attempts have been made to exercise control on withdrawals and to use IOs as auditors. This has made it difficult for IOs to maintain friendly relations with FRs.

* Most FRs are critical about the role of the IO. They said that IOs meet them once or twice a month at most. In the case of DC **7,** the present IO's activities are limited to meeting the President, Secretary and Treasurer once a week. Farmers had no guidance from the IO on water management, conflict resolution or other agriculture related problems.

The contribution of project level IMD staff to implementing innovations was minimal and limited to attending meetings. IOs did not participate for reasons which they did not want to disclose.

Fanner-Officer Relations and Interagency Cooperation

Though the majority of high level officers have friendly relations with farmer groups, relations between field level officers and farmers are not amicable. In many cases, problems arise between farmer organizations and officers over contract work, delays in providing services **and** inputs, etc. Table **4.11** throws light on farmers' perception of field level officers from the line agencies.

Farmers Responses (N=68)	Officers						
	FI	TA	WS	IO	IDO	AI	*CO*
Does not know the officer	**16**	3	3	**3**	**15**	**4**	**2**
Knows; officer indifferent	**54**	**46**	**47**	**12**	**12**	**19**	10
Officer useful, friendly	**25**	**37**	38	**13**	13	**48**	**88**
Officer not useful	**4**	14	12	60	**60**	27	**0**

Source: Survey in RB Tract 5 DC **7**

A second problem is that field level officers rarely cooperate with each other in assisting farmers. During maha 1992/93, when task groups of field officers were formed to provide integrated assistance to the farmer organizations all over the scheme, these groups rarely met. Virtually none planned and carried out joint activities. The IMD Project Manager was supposed to summon task group meetings; however, due to the various problems that arose during the season (see Chapter 2), he had little time to concentrate on this work. As a result, only some training classes for farmers were attempted.

4.5.4 Results of the Institutional Strengthening Effort

The Inception Report argued that the institutional strengthening work would result developing of a method for institutional strengthening. In fact, however, the economic problems of the farmers made such work virtually impossible. Solving the water scarcity problem is a precondition to the development of strong and viable farmer organizations in the New Areas. The various problems with the agency programs are of less importance than the basic problems caused by lack of cultivation opportunities and the consequent poverty and non-residence of the farmers. Discouragement at the lack of results is, in fact, one of the major causes for the poor performance of some field officers.

4.6 TERTIARY MAINTENANCE MANAGEMENT

4.6.1 Goals of the Tertiary Maintenance Management Activity

This activity was aimed at developing effective maintenance management at distributary and field canal levels for the efficient functioning and sustainability of the system and to minimize delays during land preparation resulting from the poor conveyance capacity of the canal system.

The procedure included a meeting of the DCO and the ID to discuss allocation of funds for maintenance at least two months prior to the commencement of cultivation and a diagnostic walk-through of the distributary by FRs and the TA to identify maintenance needs. The ID was then to prepare estimates for the work to be done but prioritizing maintenance items was to be carried out jointly by FRs and the ID. The cleaning and desilting of field canals was to be done by farmers prior to the commencement of the season to avoid delays in land preparation and water loss through leakage, weeds and silting.

4.6.2 Tertiary Maintenance During Maha 1991/92

When IIMI commenced work in RB Tract 1 DC 5 during maha 1991/92, preseason maintenance had already been done. Therefore, interventions could only be made when water conveyance problems emerged.

Held Channel Cleaning

Farmers did not carry out systematic maintenance; this was observed in the four field canals - FCs 48, 49, 50 and 51 - in Sub 1 DC 5 during maha 1991/92. Nearly half the farmers had completed weeding by the day of water issues but only 10 percent had attended to desilting. As a result, tail-end farmers in FCs 49, 50 and 51 had problems with water at the beginning of the season.

Field canal cleaning was delayed and sometimes not attended to for the following reasons:

* uncertainty over water issues,
* non-residence of farmers and leased-in farmers who, being outsiders, felt no responsibility for cleaning field canals,
* minimal involvement of FRs because of non-residence, farmer disobedience and lack of incentives for organizing farmers and
* lack of authority for taking action against farmers who failed to clean their sections of the canals.

Distributary Canal Cleaning

The President of the DCO, having failed to obtain farmer participation in distributary maintenance, hired 34 farmers as wage laborers to clean and desilt the canal. This was done without consulting the DCO Committee members. The wage laborers were paid with money allocated by the ID. Part of the distributary remained uncleaned on the first day of water issue, when funds ran out. Previously, the DCO had organized Shramadanas to do this work and payment for canal maintenance was deposited in the DCO account,

The relationship between the leaders of the DCO and the IMD was not amicable. DCO leaders saw the IO as an enemy trying to involve DCO committee members in the contract work program. Attempts to systematize account keeping was also viewed with suspicion.

4.6.3 Tertiary Maintenance During **Maha 1992/93**

During the second season of field work, IIMI personnel became involved well before preseason maintenance was carried out.

Field Canal Cleaning

In RB Tract 5 DC 7, as shown in Table 4.12, only 57.6 percent of canals had been cleaned when water issues commenced on 22 November 1992. Farmers had to be persuaded to clean the canals through group meetings and individual meetings with the IO and IIMI field assistant.

Ninety percent of the canals were cleaned during the first week after water issues but some areas remained uncleaned throughout the season. These areas belonged either to farmers who had leased out their lands, to encroachers, or to those whose lands had been affected by salinity.

Table 4.12. Percent field canal cleaning completed.

Date	FC 36	FC 37	FC 38	FC 39	FC 40	FC 41	Overall
22 Nov '92	20	42	99	68	66	51	57.6
23 Nov '92	30	75	99	74	68	53	66.5
24 Nov '92	61	83	100	89	87	76	82.6
25 Nov '92	69	100	100	89	87	76	86.8

Distributary Canal Cleaning

The ID Resident Engineer's attempt to get farmers and FRs involved in preseason maintenance planning for maha 1992/93 failed because most of them did not live in the settlement. After estimates for preseason maintenance work were prepared, the RE had a meeting with IOs to inform them of the amount of money allocated to each distributary canal and to request them to inform DCO representatives. The Project Management Committee (PMC) and other committees were also used to channel information to DCOs.

A DCO meeting was held in Hamlet 11 on 18 December 1992 and was attended by 13 of the 22 FRs. They were informed of the preseason maintenance contract work in DCs 1, 2 and 7. The amount estimated for the work was Rs 3,300/-, Rs 900/- and Rs 3,900/-, respectively.

Some FRs proposed that the work should be entrusted to a single FR. This was agreed, which made the exercise look more like a private contract than a participatory venture. The procedure also raises the question whether promoting farmer participation in organizational work and developing a sense in the farmers that the canal system is theirs can be achieved by offering contracts to farmer organizations.

4.6.4 Results of Work on Tertiary Maintenance Management

During maha 1991/92, as maintenance work had not been completed by the first day of water issue, most farmers and especially those in Sub 1 DC 5 and below suffered serious water problems. A Shramadana was organized on 21 September with the participation of about 150 farmers to clean the distributary canal. The Shramadana was successful because most farmers participated since they were affected by water shortage and could not begin land preparation.

During maha 1992/93, maintenance work in DC 7 and other distributaries was completed before water issues began. However, the method employed relied too much upon the ID to effectively promote farmer participation in distributary maintenance.

Although there was relatively little progress in improving the DCOs' capacity to manage preseason maintenance, a major achievement was the development of a systematic preseason maintenance program by the ID.

4.7 SEASONAL PLANNING AND INPUT COORDINATION

The objective of this activity was to assist farmers to maximize production by coordinating cultivation activities with the availability of water and other inputs. Farmers were to be helped to make rational decisions concerning time of planting and choice of crops.

Another constraint which had to be overcome was the delay in initiation and completion of land preparation which caused water to be wasted and the decreased cropping intensity. A major reason for delays was the inability to obtain inputs - credit, farm power, seed paddy and fertilizer when needed. The solutions to some of these problems lie at the national level. However, problems arising as a result of lack of local coordination, communication and follow up were addressed through this activity.

The Phase I Study had identified the lack of a coordinating mechanism at distributary level as a major input supply constraint. It was therefore felt necessary to train FRs to collect data on input needs so that the DCO could coordinate input supplies. At the beginning of maha 1991/92, each FR was provided with a format and trained to collect data.

During maha 1991/92, FRs did not collect data on the input needs of farmers and information had to be collected by IIMI field assistants. Collection of data through FRs failed for many reasons including:

- the lack of FRs as full-time cultivators,
- lack of incentives and
- uncertainty over water issues and non-residence of farmers and farmer leaders.

The farmer surveys carried out at the end of maha 1991/92 and maha 1992193 revealed the following about input supplies:

* Credit. Of the 25 farmers surveyed in maha 1991/92, 12 (48 percent) cultivated their allotments. The rest leased out their lands. Seven farmers (28 percent) were eligible for credit. Since bank loans were insufficient, six borrowed additional money. The five owner-operators not eligible for credit borrowed from friends, relatives and private money lenders. One farmer was provided with credit by Sarvodaya, a non-governmental organization.

  During maha 1992/93, 90 percent of farmers surveyed obtained bank loans as the Government decided to issue loans on concessionary terms even to defaulters. The majority of farmers (70 percent) failed to settle these loans.

* ***Tractors.*** Only three farmers (12 percent) experienced tractor problems during maha 1991/92. A tractor shortage was reported by 75 percent of the farmers at the beginning of the 1992/93 maha season.

* *Labor.* Only three farmers (12 percent) reported labor problems during maha 1991/92. Farmers say labor problems occur when water issues are made to several tracts in the RB and Ellegala simultaneously.

* ***Fertilizer.*** In maha 1991/92, only one farmer (4 percent) reported a shortage of fertilizer. Six farmers (24 percent) said they used the recommended quantities. Three of the six were non-owner operators. Fifteen farmers (60 percent) said they did not have money and two farmers (8 percent) said they did not need to apply the recommended quantity as new land is fertile. Two farmers (8 percent) said that they do not use the recommended quantity because their land is affected by salinity.

* ***Weedicide and Pesticide.*** Lack of these items has disappeared with the involvement of private traders in the business.

* ***Seeds.*** During maha 1991/92, six farmers (24 percent), complained of seed shortage. The seed problem came up again during maha 1992/93 as the seed variety required was not available from the DOA. Since seed supply is now being handled by the private sector, this problem should gradually disappear. Also, some DCOs are being persuaded to develop their own seed farms.

It is evident that input supply problems, except for credit, are not necessarily major problems. Input supply problems are minor when compared to the economic problems caused by lack of water. Interventions in input supply coordination are thus not likely to succeed until these other problems are solved.

4.8 TERTIARY OPERATIONS DURING LAND PREPARATION

4.8.1 Goal of the Activity

The Phase I Study indicated that water wastage is high during land preparation. The average time taken for land preparation in the New Areas was more than six weeks even though the time allowed by the Project Management Committee and the Kanna meeting was only one month. Though constraints such as input supply have to be addressed, it is important that farmer organizations develop and adhere to operational plans during land preparation. Such plans need to be based on water supply and delivery constraints in the main system, the carrying capacities of distributary and field canals, rainfall, etc. The purpose of this activity was to develop, test and spread an effective method for optimizing water use to shorten the time taken for land preparation.

4.8.2 Operations During Land Preparation for Maha 1991192

To restrict land preparation to four weeks and water duty to 6 acft, the following water sharing activities were developed in RB Tract 1 DC 5 Sub 1 during maha 1991/92:

* The 24 farmers grouped themselves in 4 groups of 6 farmers each.
* On the first day, each farmer of the first group was to receive water for 12 hours, taking 3 days to complete land soaking in the 6 allotments.
* On the fourth day, each farmer of the same group was to receive water for four hours to do second plowing one day is required for this operation.
* On the fifth day, the second group was to start land soaking and complete this in three days.
* On the eighth and ninth day, all six farmers of the first and second groups were to receive water for four hours each.

This procedure was to be followed until all four groups completed land soaking. With this schedule, farmers could complete the first plowing within 18 days and continue with other work by following this rotational plan even during very dry periods.

This innovation was attempted during maha 1991/92 in the sample area. Although FRs had been trained to prepare rotational plans for water distribution within field canals prior to water issues, they continued to use the rotation plan they had been using previously. Farmers in FC 49 followed three-hour rotations, farmers in FCs 50 and 51 followed six-hour rotations while farmers in FC 48, with only six allotments under the canal, practiced simultaneous sharing. Where the number of allotments exceeded 14, farmers tended to follow some rotation even during the land preparation period.

Very dry weather prevailed for about two and half months prior to and after first water issue on 15 September 1991. Farmers found it very difficult to soak the land within six hours. IIMI verified the high requirement **(Table 4.13)** at allotment no.742 in FC 51 on 23 September 1991.

Table 4.13. Measuring land soaking requirements.

Irrigation started	8.45 am
Irrigation stopped	20.00 pm
Water Supply rate	23.26 l/sec
Area soaked	0.55 ha
Allotment size	1.13 ha
Time taken for irrigation	11.75 hr
Percent of area soaked	48.67%
Water height in field	180 mm

The difficulty experienced by farmers in irrigating their allotments is explained by the climatic data for this period. Weekly rainfall and evaporation data from 15 September 1991 to 22 January 1992 is given in **Figure 4.1.** During this period farmers had to depend entirely on imgation water.

Data on water sharing within field canals shown in **Table 4.14** indicates that rotations were implemented in FCs 49, 50 and 51 during maha 1991/92 though not the rotation proposed by the subcommittee. FC 48, which has only six allotments, did not practice any rotation.

The farmer survey data indicated that rotations were practiced by 19 farmers (76 percent) during maha 1991192. Six farmers (24 percent) were satisfied with the rotations and **14** farmers (56 percent) said that rotations should be implemented during land preparation. Ten farmers (40 percent) complained of water problems, nine of these saying unreliable supply was their problem.

As shown in **Figure 4.2,** land preparation in DC 5 Sub 1 in Tract 1 took six weeks to complete in 90 percent of the command area during maha 1991/92. Completion of land preparation in FC 51 at the head within 5.5 weeks was the best performance.

Relative Water Supply (RWS) is used here as an indicator to measure the adequacy of irrigation supply to the sample subsystem. The RWS for land preparation period is defined as:

$$RWS = \frac{Water\ supply}{Water\ Requirement} = \frac{IW + RF}{Eo + S\&P + LSP}$$

where

LSP	=	Land soaking and ponded water
IW	=	Irrigation water delivery in mm
RF	=	Rainfall in mm
Eo	=	Open pan evaporation in mm
S&P	=	Weighted seepage and percolation (S&P) value for canal to represent the soil groups

Table 4.14. Total water use for land preparation period.

Date	Week	RF (mm)	ET (mm)	DC (mm)	FC 51 (mm)	FC 50 (mm)	FC 49 (mm)	FC 48 (mm)
15 Sep	1	0.00	55.40	58.40	99.11	41.04	25.40	116.06
22 Sep	2	3.20	56.20	115.80	126.16	132.96	88.73	109.96
29 Sep	3	18.10	33.10	108.36	133.67	106.69	87.12	137.06
6 Oct	4	4.10	45.40	111.85	141.43	106.74	84.71	116.12
13 Oct	5	59.40	23.20	70.48	77.27	79.27	54.13	43.57
20 Oct	6	40.00	35.00	72.38	58.58	58.58	62.01	79.44
27 Oct	7	103.10	8.30	39.54	47.51	35.31	37.11	42.48
Duty	mm	227.90	256.70	576.81	735.96	560.60	439.21	644.68
Duty	ft	0.75	0.84	1.89	2.42	1.84	1.84	2.12

If **RWS** equals 1 in any given week for a farm allotment, water supply and rainfall during that week exactly match actual requirements. For the purpose of this analysis, conveyance efficiency is assumed to be 93 percent, the value adopted in the water delivery schedules prepared by the **ID.** This results in **RWS** values of 1.07 and 1.15 at the head of a field canal and distributary canal, respectively, to achieve RWS values of 1.0 at the field.

A comparison of weekly **RWS** values in the sample subsystem for maha 1991192 with the critical **RWS** values as shown in **Figure 4.3** indicate that there was undersupply to all field canals except FC 50 during the first week of land preparation. **Figure 4.4** indicates that all field canals except FC **49** received more than 100 mm per week during land preparation. FC 49 received **a** supply of **80** mm per week.

Table 4.15 indicates that FCs 49 and 50 did not receive water for one day and two days, respectively during the first week. Irrigation supply was stopped in the fifth and seventh weeks for two days and three days, respectively. The area experienced considerable rainfall in the fifth week after commencement of land preparation. However, total consumption during land preparation is below the ID's design values.

Table 4.15. Number of days without flow per week during Maha 1991192.

Date	Sub DC	FC 51	FC 50	FC 49	FC 48
6 Sep			2	1	
15 Sep					
22 Sep					
29 Sep					
13 Oct	2	2	2	2	2
20 Oct	-				
27 Oct	3	3	3	3	3
3 Nov	-				
10 Nov	4	4	4	4	4
17 Nov	4	4	4	4	4
24 Nov	-				
1 Dec	-				
8 Dec	2	2	2	2	2
15 Dec	6	6	6	6	6
22 Dec	1	1	1	1	1
29 Dec	-				
5 Jan	1	1	1	1	1
12 Jan	3	3	3	3	3

Irrigation duty at the head of each field canal is shown in **Table 4.19** and indicates that field canals in the head of the subdistributary canals - FC 51 and **FC** 48 - used more water than those in the tail. FC 49, with a command area of 24 ha, had the lowest duty, 439.21 mm. These tail farmers used drainage water for land soaking and land preparation. FC 51, in the head, reported the highest duty of 735.96 mm. Water duty at subdistributary level was 576.81 mm during maha 1991/92 as against 880 mm in DC 2 in Tract 5 of the RB during yala 1989.

4.8.3 Operations During Land Preparation for Maha 1992/93

An attempt was made to implement a rotation during the maha 1992/93 land preparation period in RB Tract 5 DC 7. Training was given to the farmers to guide them in water sharing on a strict rotation which would allow one farmer the entire flow for twelve hours or two farmers the entire flow for 24 hours.

However, this rotation could not be implemented. When farmers were asked who would accept the first water and start plowing, none would accept. They said they could not pre-plan land preparation activities and maintained that rotations should not be implemented during land preparation.

The farmer survey data indicated that rotations were practiced by 18 farmers during maha 1992/93.

In 1992/93, as shown in **Table 4.16,** farmers in DC 7 completed over 90 percent of land preparation within five weeks and in the entire command area within six weeks mainly due to the decision made by the PMC not to extend water issues beyond the number of days decided at the Kanna meeting.

Table 4.16. Land preparation progress in DC 7 in Tract 5 of the Right Bank during Maha 1992/93 (expressed in percentages).

Date	Land Preparation Week			
	LP 1	LP 2	LP 3	Sowing
15 Nov	1			
22 Nov	49			
29 Nov	98	28		
	100	96	7	3
13 Dec		100	86	60
20 Dec			99	97
27 Dec			100	100

During maha 1992/93, water issues started on 22 November. As shown in **Table 4.17,** rain received during the first week of land preparation was 33.5 mm. Seven farmers started land preparation work during the week. The ID issued lower supplies to the canal to meet the requirements of the few farmers who had started land preparation.

Table 4.17. Weekly rainfall and evaporation - Maha 1992/93.

Week	Date	RF	E°
1	22 Nov	33.5	24.3
2	29 Nov	102.2	13.8
3	6 Dec	0.0	45.0
4	13 Dec	37.2	19.8
5	20 Dec	2.8	27.9
6	27 Dec	18.9	22.3
7	3 Jan	24.1	31.2
8	10 Jan	0.0	31.3
9	17 Jan	0.0	42.6
10	24 Jan	6.5	35.0
11	31 Jan	0.0	41.8
12	7 Feb	0.0	53.6
13	14 Feb	0.0	38.7
14	21 Feb	0.0	54.9
15	28 Feb	8.0	46.2
16	7 Mar	44.9	43.9
17	14 Mar	3.0	26.5
18	21 Mar	15.0	31.5
19	28 Mar	0.0	9.0
Total	mm	296.2	639.5
Total	ft	0.97	2.10

During the second week, the rainfall rose to 102.2 mm. There were no rains during the third week. The daily hydrograph for these weeks shows a higher incidence of canal fluctuation due to the release of water to the RBMC to meet farmer demands during the peak of land preparation and to interventions at cross regulators by farmers in Tract 1. It is during this period that the one single Occurrence of discharge above target was observed. All farmers completed first plowing during the week.

Rainfall during the fourth week was 37.2 mm. The RBMC was closed for a day after rains creating problems for farmers doing second or third plowing or sowing. A higher discharge was observed toward the end of the week and during most of the fifth week. As indicated in **Table 4.16,** land preparation in 90 percent of the command was completed during the week. Weekly RWS values are given in Figure **4.5** and show an undersupply in spite of the higher discharges

made to the distributary canals. There were differences between the heads and tails in water distribution as shown in Figures **4.6** in spite of interventions aimed at maintaining equity.

4.8.4 Results of Operations Planning During Land Preparation

Results from both seasons indicate a reduction in water duty in both samples against duties reported during the Phase I Study. However, there was no significant cooperation by the farmers to improve their operations and no significant reduction in the land preparation period.

The causes of the reduction in water use include the rain received in these two seasons, the soil stabilization which occurred during the past few years, rectifications of construction defects, development of skills in farmers as well as of the system operators, and the monitoring program implemented at the main system level along with, perhaps, some improvement in farmers' concern for reducing water use during land preparation.

The following conditions should be satisfied to successfully implement better rotations during land preparation:

* pre-planning of land preparation activities by field canal groups to fix a time for each farmer to receive water,
* credit to acquire farm power and necessary inputs,
* close interaction between the FR and farmers and among farmers,
* constant discharge to distributary canals and
* support and guidance from the field officers, particularly from a committed IO.

Most of these prerequisites are not found in the New Areas. Farmers also have a negative attitude towards rotations during land preparation for the following reasons:

* difficulty in practicing night irrigation due to the distance between house and field,
* water level fluctuations in the RBMC and
* water thefts by farmers.

Institutional strengthening and further work with farmers are needed.

4.9 TERTIARY OPERATIONS DURING TFIE CROP GROWTH PERIOD

4.9.1 Goal of Tertiary Operations

During the Phase I Study, it was observed that rotations were not implemented during the crop growth period. This had an adverse impact on water use efficiency and caused water scarcity in the tail-end. The objective therefore was to develop a methodology to help DCOs and the ID field staff plan and implement operational schedules for the crop growth period. It was proposed to implement rotations aimed at reducing water duty and avoiding problems caused by closure of the canals without warning.

4.9.2 Tertiary Operations During Crop Growth - Maha 1991192

During maha 1991/92, the ID planned to implement rotations on the RBMC from the beginning of the sixth week. Table 4.18 shows the schedule prepared by the Water Management Unit of the ID. However, the schedule was not implemented. During the whole season, the Department issued water continuously into the DCs from the RBMC except when they closed because of heavy rains.

Table 4.18. Schedule for crop growth period - Maha 1991192 (discharges in cusecs).

Canal	LHG	Flow time days	Open		Close		1	2	3	4	5	6	7
			Day No	Time	Day No	Time	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Sub DC		7.0					114	83	114	114	114	114	114
FC 51	37.5	6.5	3	6 am	2	6 pm	301	0.5	301	301	301	301	301
FC 50	10.1	4.0	5	6 am	2	6.m	301	0	0	0	301	301	301
FC 49	27.3	7.0	5	6 am	5	6un	1.7	1.7	1.7	1.7	1.7	1.7	1.7
FC 48	6.1	2.5	2	6 pm	5	6un	0	0.5	301	301	0	0	0

In the field canals, only the farmers in FC 49 practiced rotations during the crop growth period even though there was continuous discharge to the field canal. The rotation followed in FC 49 had been introduced by the former FR.

Results of operations were measured by using the following indicators which provide information on water duty and equity:

* relative water supply,
* water duty during crop growth period and
* mean RWS

As can be seen from **Figures 4.7,** RWS values were low during maha 1991/92. **Figure 4.6** shows that the ID maintained reasonable equity in the subsystem during the season.

Due to heavy rains, the canal was closed on many occasions during maha 1991/92 as shown in **Table 4.15** contributing to a reduced water duty. The canal duty varied from 1044.9 mm to 1571.2 mm during the crop growth period as shown in **Table 4.19.**

Table 4.19. Water duty for crop growth period during Maha 1991192.

Date	Week	RF	ET	Sub DC	FC 51	FC 50	FC 49	FC 48
3 Nov	8	43.70	15.10	80.54	91.21	59.10	79.10	98.81
10 Nov	9	126.00	21.80	37.16	43.67	43.33	35.9%	30.07
17 Nov	10	27.40	18.80	34.61	37.89	37.86	25.53	13.10
24 Nov	11	13.80	23.90	97.72	101.55	101.37	73.38	96.00
1 Dec	12	0.00	36.10	36.77	127.09	90.M	81.29	60.92
8 Dec	13	62.60	8.50	56.10	71.95	45.94	52.08	36.29
15 Ds	14	146.30	18.10	4.41	6.05	1.87	4.35	6.60
22 Dec	15	9.60	23.60	61.69	84.29	30.39	54.56	97.51
29 Dec	16	12.30	23.30	89.11	97.75	91.64	78.23	62.53
5 Jan	18	3.00	28.00	69.94	81.43	53.64	56.78	89.87
12 Jan		2.10	24.W	53.10	64.57	36.00	43.68	67.31
19 Jan	19	0.00	22.20	29.34	27.84	41.98	20.74	46.52
Duty	mm	446.80	263.40	710.48	835.29	632.94	605.70	705.52
Duty	ft	1.47	0.86	2.33	2.74	2.08	1.99	2.32
Total for Maha Season								
Duty[a]								
Duty[b]	mm	614.10	520.10	1287.29	1571.25	1193.53	1044.91	1350.20
	ft	2.21	1.17	4.22	5.16	3.92	3.43	4.43

[a] and [b] = Land preparation and crop growth period (from **Table 4.14).**

4.9.3 Tertiary Operations during Crop Growth - Maha 1992/93

In maha 1992/93, the ID attempted to implement rotational delivery to the field channels. Farmers in some field channels, like those in FCs 36, 37, 38 and 41 in RB3 Tract 5 DC 7, attempted to implement rotations on the field channels. However, the rotations were not systematically followed in any of the canals for the following reasons:

* frequent fluctuation in water levels and undersupply to distributaries as shown in **Figure 4.8,**
* reluctance of the ID to go for strict rotation,
* **FRs** not organizing rotations because they were not engaged in farming activities,
* temporary or non-residence of all or most **FRs** and farmers,
* water thefts and illegal canal operations,
* encroachers and leased-in farmers,
* lack of guidance from IO and
* lack of guarantee of regular supply to the head of distributary canals.

The period 13 January 1993 to end March 1993, during which rotational issues were made to field canals, is considered the crop growth period. This period was marked by a spell of dry weather from 10 January to 25 January 1993.

Fluctuations in the distributary canals were almost normal during the crop growth period. Supply was below target as during the land preparation period. There was greater variation between supplies to field canals, though. This indicates an unequal distribution within the distributary canals. Head-end field canals received higher supplies under unsteady flow conditions because of the cross regulators on the distributary canals that maintained the water depth at the head-end field canal offtakes.

RWS values for the crop growth period, as shown in **Figure 4.9,** also indicate an undersupply to DC 7. The cumulative RWS values shown in Figure 4.10 indicate that demand at the distributary level was not met during the season. However, drainage contributions to some tail-end allotments minimized the consequences of undersupply. The mean **RWS** values for the season shown in **Figure 4.11** substantiate the unequal distribution among the field channels within DC 7.

Table 4.20, which gives water supplies and duties, illustrates the differences between the targets at field and distributary canal levels and the actual amounts supplied. According to these

figures, DC 7 was undersupplied 96 percent of the time during the season. Duties during the land preparation and crop growth periods are 1.7 ft and 2.8 ft respectively during this period. When rainfall for the season is taken into consideration, duty is **5.47** ft, somewhat less than the target of 6 ft.

4.9.4 Results of Tertiary Operations During the Crop Growth Period

In neither maha 1991/92 nor maha 1992/93 can it be claimed that the intervention showed great success in implementing rotational deliveries during the crop growth period. The reasons are substantially the same as those given in the previous Section 4.9.3 for failure during maha 1992/93. Again, in large part these reasons **are** derived from the economic conditions that lead to disinterest on the part of the farmers and weakness on the part of the farmer organizations. The poor results were also a result of the ID's inability to control flows in the Main Channel and the distributary channels. These observations suggest that solving the problem of lack of water for cultivation is a prerequisite for making this kind of intervention a success.

Condition	DC 7	FC 41	FC 40	FC 39	FC 36	FC 38	FC 37
No water	5.5	10.2	14.1	12.5	12.5	22.7	10.94
0 < Actual > 0.25 Target	8.6	2.3	0	0	3.9	26.6	3.13
Target	28.1	1.6	2.3	2.3	0	31.3	15.63
	46.9	23.4	17.2	9.4	12.5	1.6	17.19
0.75 Target < Actual > Target	7.0	35.9	37.5	35.9	30.5	6.3	18.75
Actual = Target	0	0	0	0	6.3	2.3	0
Actual > Target	3.9	26.6	28.9	39.8	34.4	9.4	34.38
Duty							
LP period (acft/ac)	1.7	2	2.3	1.9	1.9	1.0	1.66
Crop growth (acft/ac)	2.8	3.1	3.6	3.9	2.7	0.8	3.22
Overall (acft/ac)	4.5	5.1	5.9	5.8	4.7	1.9	4.97

During both these seasons, water duty shows a declining trend. However, this cannot be attributed to tertiary canal interventions. Major factors which contributed to the reduction of water duty were rainfall and control of discharges to the distributaries by the ID.

4.10 OVERALL FINDINGS FROM TERTIARY LEVEL INTERVENTIONS IN THE NEW AREAS

The attempts to improve tertiary system management through the various innovations tried were not successful for a variety of reasons. The results of these interventions suggest the following main conclusion: it is essential to solve the water shortage problem before interventions at the tertiary level are likely to be successful.

Until farmers can predict with greater assurance when they will get water for irrigation and earn more income from irrigated agriculture, they are not likely to put greater effort into participating in tertiary system management.

Successful development of improved seasonal planning for the Kirindi Oya system thus is the key. As documented in Chapter 2, improved seasonal planning has been put in place, but it is still too early to be able to measure its impact on farmer organizations and tertiary system management.

Other important findings include the following:

1. The Kirindi Oya New Areas are new settlements that need time to form into communities. At this stage, social relations are still a barrier to innovations requiring community participation.

2. Water use efficiency in the tertiary systems improved in a small way over the period through more effective main system management including better control of discharges to the head of distributary canals and strict adherence to the cultivation calendar. This does not suggest that improvements in tertiary system management are not important but that improvements in both main system management and in tertiary system management should go hand in hand.

3. Strengthening farmer organizations requires, in addition to improving livelihoods, the following:

   * identification of benefits for farmers from farmer organizations,

   * development of incentives for FRs to do their work,

   * a more participatory approach by the IMD to organizing farmers, such as dispensing with attempts to control farmer organizations through IMD formulated constitutions and through reorganizations solely to change leaders and

   * providing assistance to the organizations in financial record-keeping, including accounting and reporting.

4. Findings on preseason maintenance suggest that:

* To help with field canal and distributary canal maintenance, DCOs need legal authority to take steps against defaulters.

* Paying the DCOs for distributary channel maintenance, as is now done, is likely to keep the farmers doing the work, but it is probably not sustainable and is contrary to the participatory management policy and some thought must be given to changing this practice.

5. Findings on seasonal planning and input coordination suggest that:

* Problems will be minimized if the farmers are notified of the date of first water issue well in advance.

* Most inputs can be obtained if farmers have their own money or access to credit facilities.

* Staggering between subsystems reduces demand for labor and tractors.

* Unpaid FRs are unlikely to collect the detailed information needed for effective input coordination by the DCO.

* Farmer organizations can be useful to their members through input supply business activities.

6. Findings on tertiary system operations during both the land preparation and crop growth periods suggest:

* The farmers need more advance warning of water issues to pre-plan land preparation activities.

* The farmers and FRs must work together to plan operations and to make adjustments when needed. This implies a stronger farmer organization.

* More guidance and technical advice from IOs and or other field officers would help.

* Main canal operations need to be well controlled to prevent fluctuations and undersupply which make rotations impractical.

* There is need to provide the DCOs with power to take effective actions against those who steal or misuse water or who operate the canal illegally.

4.11 TERTIARY MANAGEMENT IN THE ELLEGALA IRRIGATION SYSTEM

Over the course of the Phase II Study, it became more and more apparent that there was a need to determine the scope for improving water use efficiency in Ellegala. If water use efficiency in Ellegala could be improved, then it might be possible to divert some of the water allocated to Ellegala to the New Areas thus increasing cropping intensity in the New Areas. It was felt therefore that IIMI should look into tertiary management in Ellegala to determine the scope for improvements.

A diagnostic study of tertiary system management was carried out in the Eastern Higher Level Canal under the Tissa Tank during maha 1992/93. This included a survey of farmers, interviews with farmers and officers, and observations of DCO meetings and other irrigation management activities. This section describes the findings and their implications.

4.11.1 Physical System

The Eastern Higher Level Canal has one distributary canal consisting of six field canals and three direct field canals originating from the main canal. Most of the field canals lack regulating structures, making water distribution in the distributaries and the main canal very difficult. Some farmers are provided irrigation water directly from distributary canals while others irrigate from field canals. Farmers in FCs 6 and 7 depend solely on drainage water from the "Sadagiri Drain." Their main problem during some periods of the season is waterlogging due to drainage water coming from the command area under the lower level canal of the tank.

FC 3 is in the tail of the main canal and FCs 8 and 9 are in the tail of the distributary canal. FCs 8 and 9 suffered serious waterlogging in the past. After improvement of the "Kaccherigama Drain," which runs along the boundary of the command area, waterlogging has been considerably reduced. However, it has created a water shortage for farmers in these canals who had depended on drainage for their regular water supply.

There are no permanent turnout structures to the fields. Farmers cut the canal bund to irrigate their allotments. Some farmers have no access to distributary canals, field canals or drainage and have to depend on water from adjoining allotments. This problem has come about as a result of land fragmentation and is one which improvements to the canal system that bas not addressed.

The command area receives considerable amounts of drainage water and, therefore, does not depend solely on water supplies from the tank. It is difficult to measure these inflows, as they are used several times within the system by farmers.

4.11.2 Land Tenure and Settlement Pattern

There are 88 allotments under this canal, according to the land holding list available with the DCO. However, the accuracy of this list is questionable because of land fragmentation and the

complexity of land tenure and inheritance patterns. There are **80** farmers. Of these, a questionnaire survey was administered to **72** farmers. The other eight lived outside the community or were engaged in various kinds of business activities. Eighty-three percent of the sample farmers **are** sharecroppers registered under the Agrarian Services Act, while the rest are 'sinnakkara' (freehold) landowners. The size of land holdings is given in Table **4.21.**

Table **4.21.** Land holdings in the Eastern Higher Level Canal (in acres).

Size of allotments	No. of farmers	Percentage
1 - 2	**26**	**32.50**
2 - 4	**39**	**48.75**
4 - 6	**15**	**18.75**

The figures indicate that land fragmentation has brought paddy farming to unprofitable levels. The existence of various types of tenancies, payments to landlords, etc., further affects the situation. During the survey, lands in the sample area were cultivated by **84** people: **27** leasees, **40** owner-operators and **17** sharecroppers on land belonging to parents or in-laws.

Farmers in the canal area live in houses scattered over a large area; the settlement pattern forms a barrier to communication between farmers for irrigation related activities.

4.11.3 Economic Activities

The sample farmers' sources of income are shown in Table **4.22.** Seventy-two percent of the farmers are engaged in paddy farming.

Table **4.22.** **Sources** of income of Eastern Higher Level Canal farmers.

Source of income	No. of farmers	Percentage
Paddy cultivation	**76**	**72**
OFC cultivation (highlands)	**9**	**8**
Wage labor	**2**	**2**
Government jobs	**5**	**5**
Private sector employment	**6**	**6**
Employment by family members	**2**	**2**
Coconut cultivation	**5**	**5**

The comparison between farmer perception of good yield and actual yields realized is given in Table **4.23.** The table indicates that the majority of farmers' yields are below 3 tons per acre.

Table **4.23.** Perception of good yield and actual yield (expressed as percentages).

Yield	Good Yield	Actual Yield (kg/acre) 1991/92 Maha	1992 Yala
0-1500		56	100
		39	-
3000-4500		4	-
Above 4500		1	-

Farmers perceive that their situation in life has deteriorated due to the development scheme. They view yield reductions as being due to increasing salinity levels in the tank from drainage water received from the new system. Table **4.24** explains the situation.

Criteria	No. of Farmers	Percentage
No change	16	20
Deteriorated a bit	**26**	**35**
Worsened	34	43
Not known	2	2

Ellegala farmers do not differ from paddy farmers elsewhere in Sri Lanka in their indebtedness to state banks. According to the survey, 50 percent are defaulters and, therefore, not eligible for credit from banks. This forces them to depend upon money lenders, millers and other private persons, which may worsen their situation.

4.11.4 Strengths and Weaknesses of the DCO

The farmer organization in the sample area is the "Sadagiri Farmer Organization." The organization was reorganized in June 1992 when the President, who had **been** appointed under the Agrarian Service Act, was expelled. This man was a key figure in local level organizations.

However, most of the FRs disliked him for acting arbitrarily. The ex-President, helped by a group of supporters, created problems when attempts were made to organize farmers in the canal for maintenance and other activities.

The new President was a school teacher who was respected by most of the community members. The Secretary was a retired government servant who the farmers believed had capacity to deal with irrigation officials and other bureaucrats. The Vice President and the Treasurer were well-to-do farmers. Neither the President nor the Secretary cultivated land nor were engaged in farming activities, hence they lacked understanding of the day-to-day field problems experienced by farmers. The Vice President and Treasurer were engaged in farming.

The key figure in the organization was the President. It was he who intervened and solved disputes at all the field canals. Because of his acceptance in the community and commitment to organization work, the DCO functioned well and found solutions to some of the problems of farmers without receiving guidance from the IO assigned to this DCO. Towards the end of the maha 1992/93 season, he resigned because of a problem connected with trying to solve a dispute between farmers.

The survey carried out in the sample area threw light on the following:

* Ninety-nine percent of farmers considered themselves members of the organization. Thirty-three percent said they became members by filling out an application form while 54 percent said they were members because all farmers were considered members of the organization. One farmer said that he was not a member.

* Seventy-five percent of the farmers knew their FRs while 21 percent did not. Thirty-three percent of the farmers said their FRs were selected at field canal group meetings attended by all the farmers in the canal, while 23 percent said that FRs were selected at meetings attended by a small number of farmers. Forty-five percent did not know how they were selected.

* Fifty-nine percent of farmers believed that FRs were doing useful work; six percent said they were not useful. Twenty-eight percent did not know what FRs actually did so could not evaluate their usefulness.

* Sixty-nine percent of the farmers had met one of the IOs serving in their area by mid-October 1992 when the survey was conducted. The new IO was establishing herself in the field and meeting farmers during this period. Thirty percent had never met any of the IOs serving in their area.

* Seventy-three percent of the farmers had attended field canal meetings. Thirty-seven percent believed meetings were held once during a season; 45 percent did not know how often meetings were held. Only 61 percent of the farmers knew

about the DCO meetings while farmers who knew about the Subproject Committee (SPC) meetings and the PMC meetings were 34 percent and 29 percent, respectively.

4.11.5 Preseason Maintenance

At the Kanna meeting held for the Tissa Tank area on 14 November 1992, some farmers proposed that water issues be made from 15 November 1992. Some farmers pointed out that canal maintenance needed to be done and requested a postponement of the date of water issues to 20 November. The ID informed the FRs that preseason maintenance work in the distributary canals would be contracted out to the DCOs and requested them to carry out the work immediately. By 18 November 1992, farmers had cleaned 75 percent of the distributary canals. The ID made some payment for the work, although in the distant past the farmers had done this work by themselves.

Though the distributary canal cleaning work was completed satisfactorily before the commencement of the season, field canal cleaning was unsatisfactory. This was because the farmers do field canal maintenance along with liyadda bund construction since the boundary of the allotment is the field canal bund. They have to plaster these bunds with clay after receiving water to maintain them. In places where the field canal bund and allotment boundary bunds are not the same, farmers clean the field canals before water issues. However, the practice of not cleaning field canals before water issues creates problems for those in the tail-end.

Even though farmers had cleaned the distributary canals and also parts of the field canals, they complained that the main canal had not been cleaned by the ID prior to the commencement of the season shown by a thick layer of weeds in the canal. Overtopping of the canal during the land preparation period was observed. Farmers in FC 3 had to face water shortage problems during the land preparation period for this reason. The canal was weeded following the request of the DCO only after the main canal was closed to introduce rotations during the crop growth period.

4.11.6 Water Management Practices

The farmers in the canal did not start land preparation with rain as they usually do in years of good storage because of the uncertainty of water issues due to non-availability of sufficient water in the reservoir at the beginning of the season. Only 33.5 mm of rainfall fell during the first week of the land preparation period. This was not sufficient to commence land preparation after the long period of dry weather.

When water issues commenced, farmers in FCs 6 and 7 and FCs 8 and 9 in the downstream areas did not receive as much water as farmers in the head areas did. The downstream farmers did not have sufficient water during the land preparation period because of the overtopping of the main canal. FCs 6 and 7, though they did not receive water from DC 1, received an abundant supply from the "Sadagiri Drain." The main problem in these areas at certain periods

of the season was waterlogging due to too much water. FCs 8 and 9 in the tail did not get a reliable water supply either from the canal system or from the drains.

The problems appear very much related to the behavior of head-end farmers and to institutional weaknesses. The farmers in these two canals complained that they can do land preparation only after the head farmers have completed land preparation. During interviews, farmers said they have come to experience water shortages after improvements were made to the "Kachcherigama Drain" under the Rectification of Irrigation Difficulties program in the EIS.

The lack of control structures in the field canals and the generally dilapidated condition of the canal system created problems in regulating water flows. The ID responded to rainfall as well as to the requests of farmers and tried to manage water under the somewhat difficult conditions posed by the deteriorating canal system. The leading FRs communicated with the RE and the Irrigators and tried to find solutions to water problems even though the problems of FCs 8 and 9 were not addressed.

The practice adopted during the crop growth period was to keep the main canal closed for two days per week. When main canal rotations started on 28 December, farmers who had sprayed weedicide faced problems because of lack of water. Though the ID had informed DCO representatives of the canal closure, the message had not reached farmers. A compromise was reached with the ID and the canal was kept open for six hours a day.

4.11.7 Acquisition of Inputs

Though the DCO tried its best to obtain the seed desired by farmers, they could not get three and half month paddy varieties from the Department of Agrarian Services (DAS) as expected. The DAS could not obtain these seed varieties from the Seed Farm in BataAta. According to 54 percent of the farmers, seed is the only input that they cannot obtain easily when they have money.

4.11.8 Training

To help improve tertiary management, a one-day training session was organized for FRs and selected farmers. Officers from the IMD, the DOA, the ID and IIMI worked as trainers while IIMI organized the program with the collaboration of the IMD. Twenty-two FRs received instruction during the training session. In addition to the FRs from the canal, one FR from each subsystem in Ellegala participated. The President of the Badagiriya SPC helped as a trainer. The training covered the following:

* planning and implementation of the program for the Rectification of Irrigation Difficulties with farmer participation,

* a suitable cropping pattern for the Project,

* the committee system under INMAS and the functions of the committees, and
* the Lunugamvehera reservoir and EIS and
* the responsibilities of FRs in participatory irrigation management activities.

No impact from this training could be observed.

4.11.9 Results of Tertiary System Management Research in Ellegala

Investigation into tertiary system management in Ellegala showed that, in the sample area, reuse of irrigation water is quite high. Therefore, the potential for increased water savings through improved tertiary system management is low.

However, the farmers in the sample area face various irrigation difficulties caused by various design deficiencies and lack of effective control structures. Although a relatively effective Farmer Organization (FO) helps to resolve some of these difficulties, problems remain that can be addressed to make water distribution in Ellegala more equitable and effective. These must be addressed through improved maintenance and "essential structural improvement" programs.

4.12 OVERALL CONCLUSIONS AND RECOMMENDATIONS FROM THE TERTIARY SYSTEM MANAGEMENT RESEARCH

As shown by this research, the potential gains from improvements to tertiary system management and the factors that impede improvements in tertiary system management are quite different in the New Areas and Ellegala.

In the New Areas,

* Improvements in tertiary system management offer the possibility both of improving the equity and effectiveness of water distribution and of reducing water usage through cutting the time needed for land preparation and through making more efficient use of irrigation water.
* The interventions carried out under this component during maha 1991/92 and maha 1992/93 were largely ineffective because of the weaknesses of the Farmer Organizations. The necessary cooperation among the farmers could not be obtained. All other problems are of lesser importance. Most of the small improvements in water usage noticed can be attributed to changes in main system management.
* Although the weaknesses of the FOs have various causes, including lack of common experience among the settlers and lack of effectiveness of IOs, the basic cause is the

farmers' fundamental economic problem caused by lack of adequate and predictable water supplies. Many farmers are not willing to seriously invest in irrigated agriculture in the New Areas and thus are not willing to participate in the Farmer Organizations or in communal water management activities.

* Despite the problems, it was possible to get some of the farmers to innovate. This suggests that, if water supplies can be made adequate and predictable so that farmers are willing to invest more in irrigated agriculture, then working with farmers will succeed in improving tertiary system management. The limits to improvement are likely to be limits created by the difficulties faced by the ID in managing water deliveries to the DCs.

In *Ellegala*,

* Because of extensive reuse, it does not appear that improvements in tertiary system management offer much scope for improvements in water use efficiency in Ellegala.

* However, lack of structures and other complications make control of water flows very problematic in Ellegala. Although the FOs are reasonably effective, the physical and design problems appear to be beyond the capability of the FOs to solve on their own. Physical improvements, coupled as needed with improvements in the management capacity of the farmers and FOs, are likely to make improvements in the equity and effectiveness of water distribution.

Based on these findings, we make the following recommendations:

1. In the New Areas, the improvements in seasonal planning make irrigated farming more attractive to the allottees. Efforts at strengthening the FOs should now be renewed. These efforts should include work with the FOs to improve their capabilities in tertiary system management to make water distribution more effective and to help prepare the FOs for turnover.

2. In Ellegala, a program should be developed to rectify some of the tertiary level design deficiencies (lack of farm turnouts and other structures, etc.) under some version of "essential structural improvements." This should be linked both to the regular maintenance program and to efforts to raise a large part of the necessary funds from the farmers themselves.

Rainfall and Evaporation
Weerawila Agricultural Research Station
Maha 1991/92

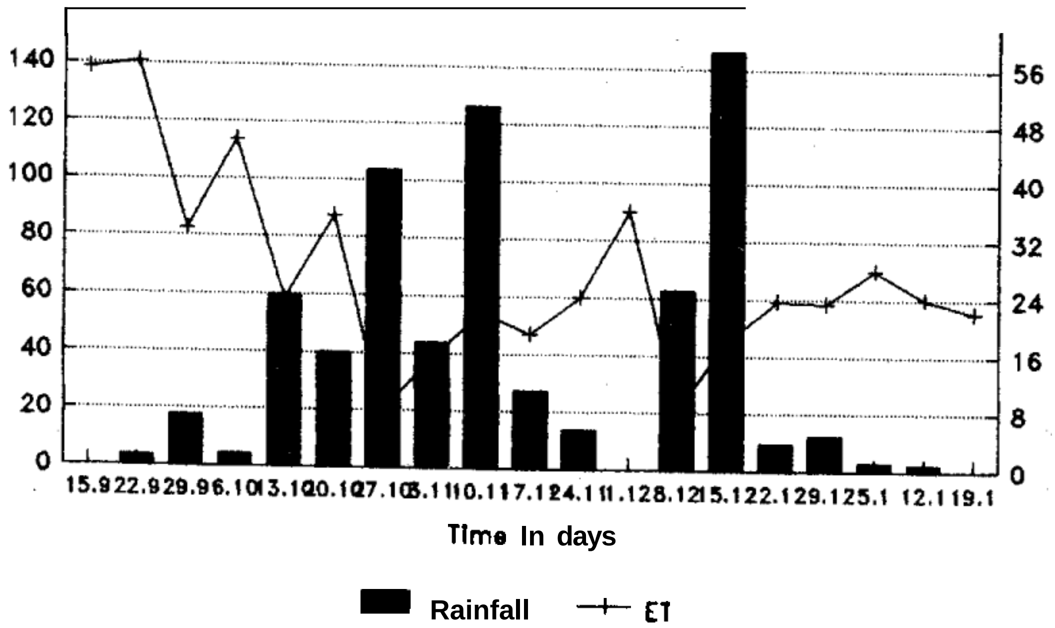
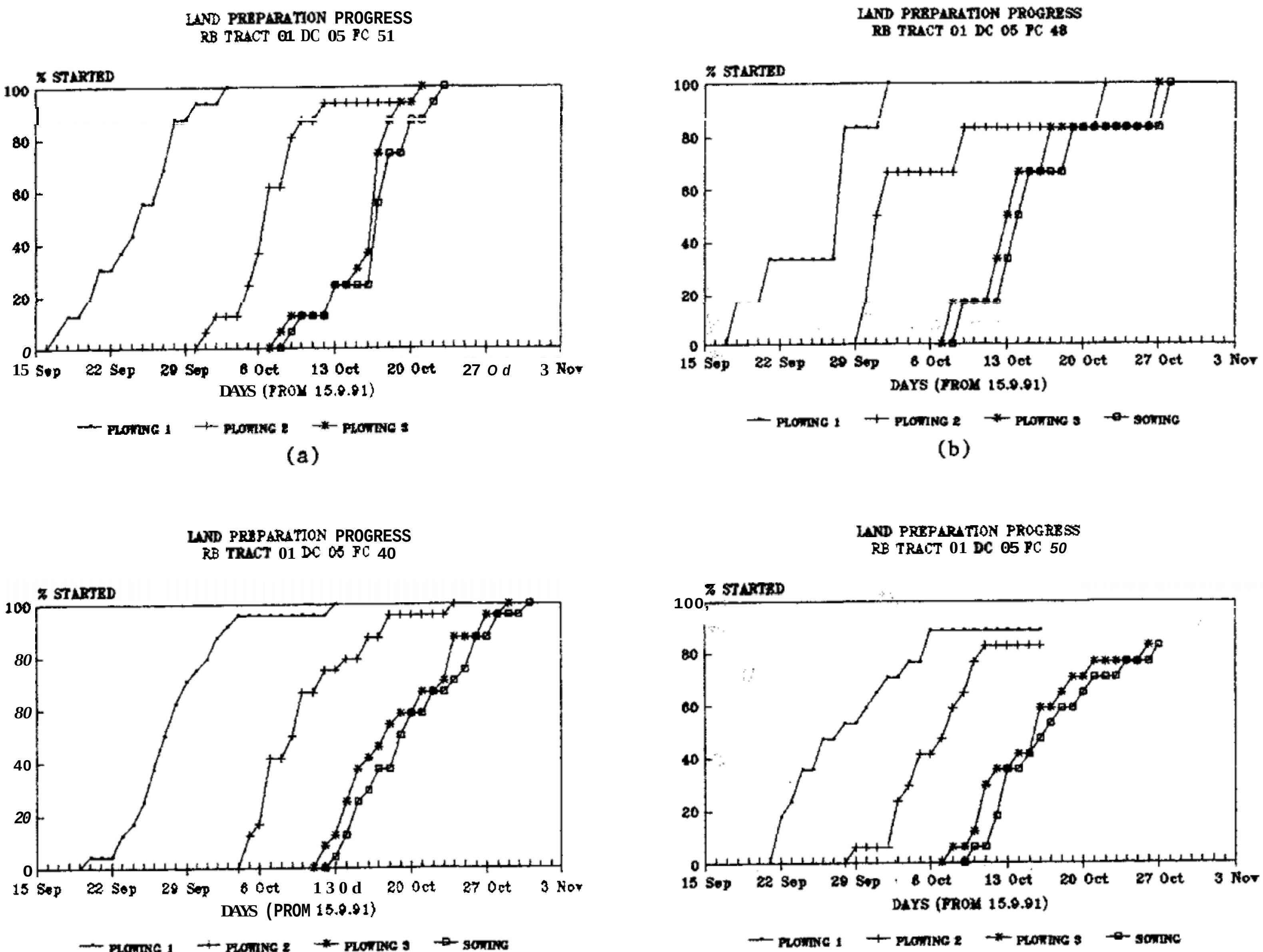


Figure *4.1*



LAND PREPARATION PROGRESS
RB TRACT 01 DC 05 FC 51
% STARTED
DAYS (FROM 15.9.91)
PLOWING 1
PLOWING 2
PLOWING 3
(a)
LAND PREPARATION PROGRESS
RB TRACT 01 DC 05 FC 48
% STARTED
DAYS (FROM 15.9.91)
PLOWING 1
PLOWING 2
PLOWING 3
SOWING
(b)
LAND PREPARATION PROGRESS
RB TRACT 01 DC 05 FC 40
% STARTED
DAYS (FROM 15.9.91)
PLOWING 1
PLOWING 2
PLOWING 3
SOWING
(c)
LAND PREPARATION PROGRESS
RB TRACT 01 DC 05 FC 50
% STARTED
DAYS (FROM 15.9.91)
PLOWING 1
PLOWING 2
PLOWING 3
SOWING
(d)

Figure 4.2

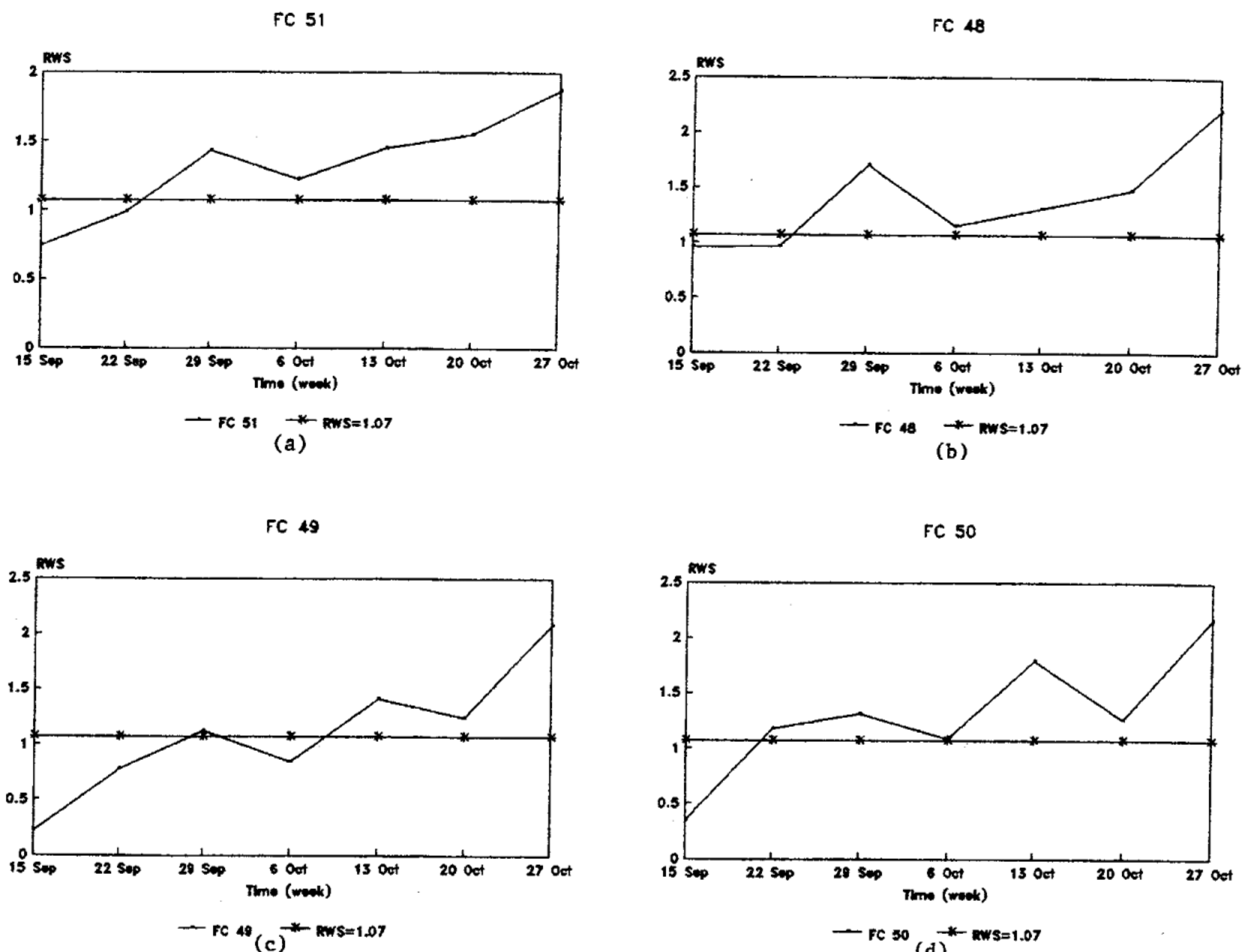


Figure 4.3 RWS for Land Preparation Period

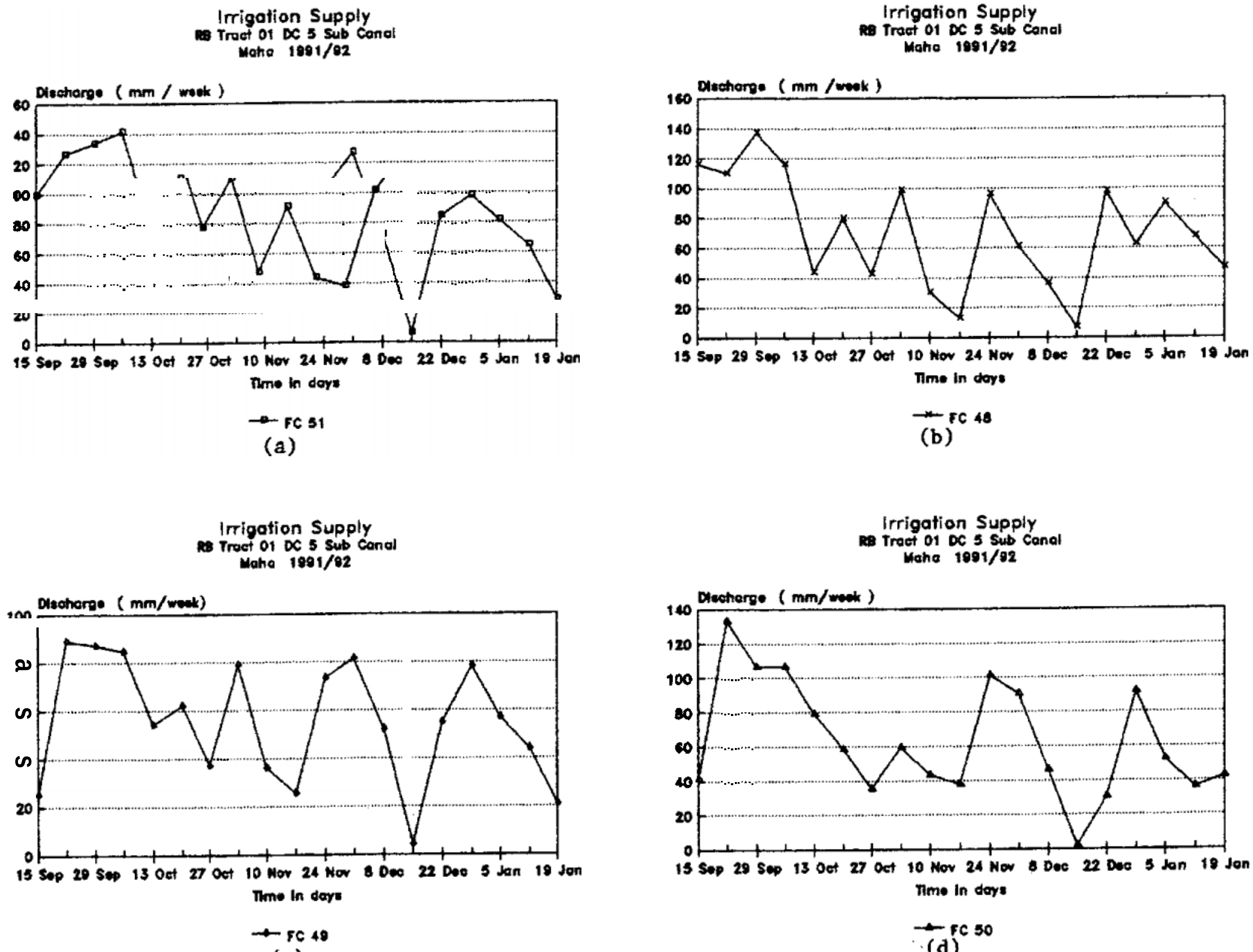
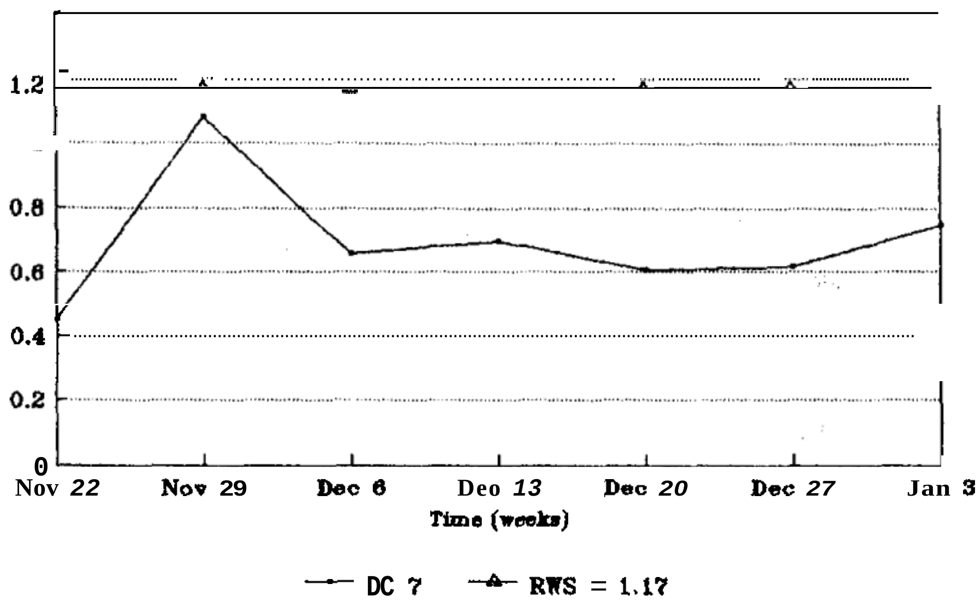

Irrigation Supply
RB Tract 01 DC 5 Sub Canal
Maha 1991/92
Discharge (mm / week)
Time in days
15 Sep 29 Sep 13 Oct 27 Oct 10 Nov 24 Nov 8 Dec 22 Dec 5 Jan 19 Jan
FC 51
(a)
Irrigation Supply
RB Tract 01 DC 5 Sub Canal
Maha 1991/92
Discharge (mm /week)
Time in days
15 Sep 29 Sep 13 Oct 27 Oct 10 Nov 24 Nov 8 Dec 22 Dec 5 Jan 19 Jan
FC 48
(b)
Irrigation Supply
RB Tract 01 DC 5 Sub Canal
Maha 1991/92
Discharge (mm/week)
Time in days
15 Sep 29 Sep 13 Oct 27 Oct 10 Nov 24 Nov 8 Dec 22 Dec 5 Jan 19 Jan
FC 49
(c)
Irrigation Supply
RB Tract 01 DC 5 Sub Canal
Maha 1991/92
Discharge (mm/week)
Time in days
15 Sep 29 Sep 13 Oct 27 Oct 10 Nov 24 Nov 8 Dec 22 Dec 5 Jan 19 Jan
FC 50
(d)

Figure 4.4



1.2
0.8
0.6
0.4
0.2
0
Nov 22
Nov 29
Dec 6
Deo 13
Dec 20
Dec 27
Jan 3
Time (weeks)
DC 7
RWS = 1.17

Figure 4.5

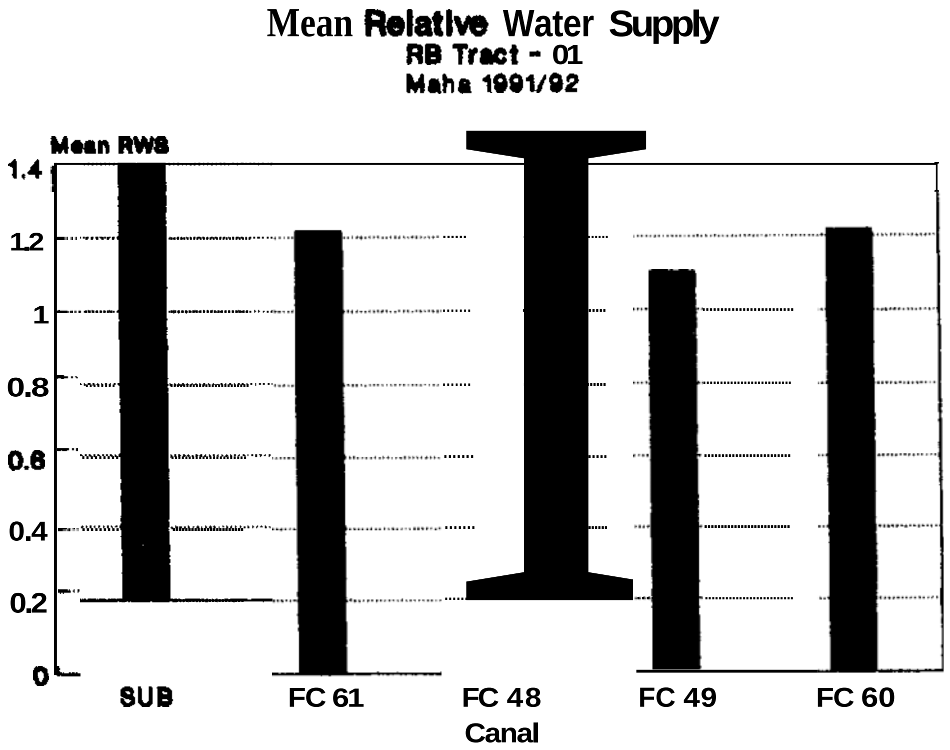

Mean Relative Water Supply
RB Tract - 01
Maha 1991/92
Mean RWS
1.4
1.2
1
0.8
0.6
0.4
0.2
0
SUB
FC 61
FC 48
FC 49
FC 60
Canal

Figure 4.6

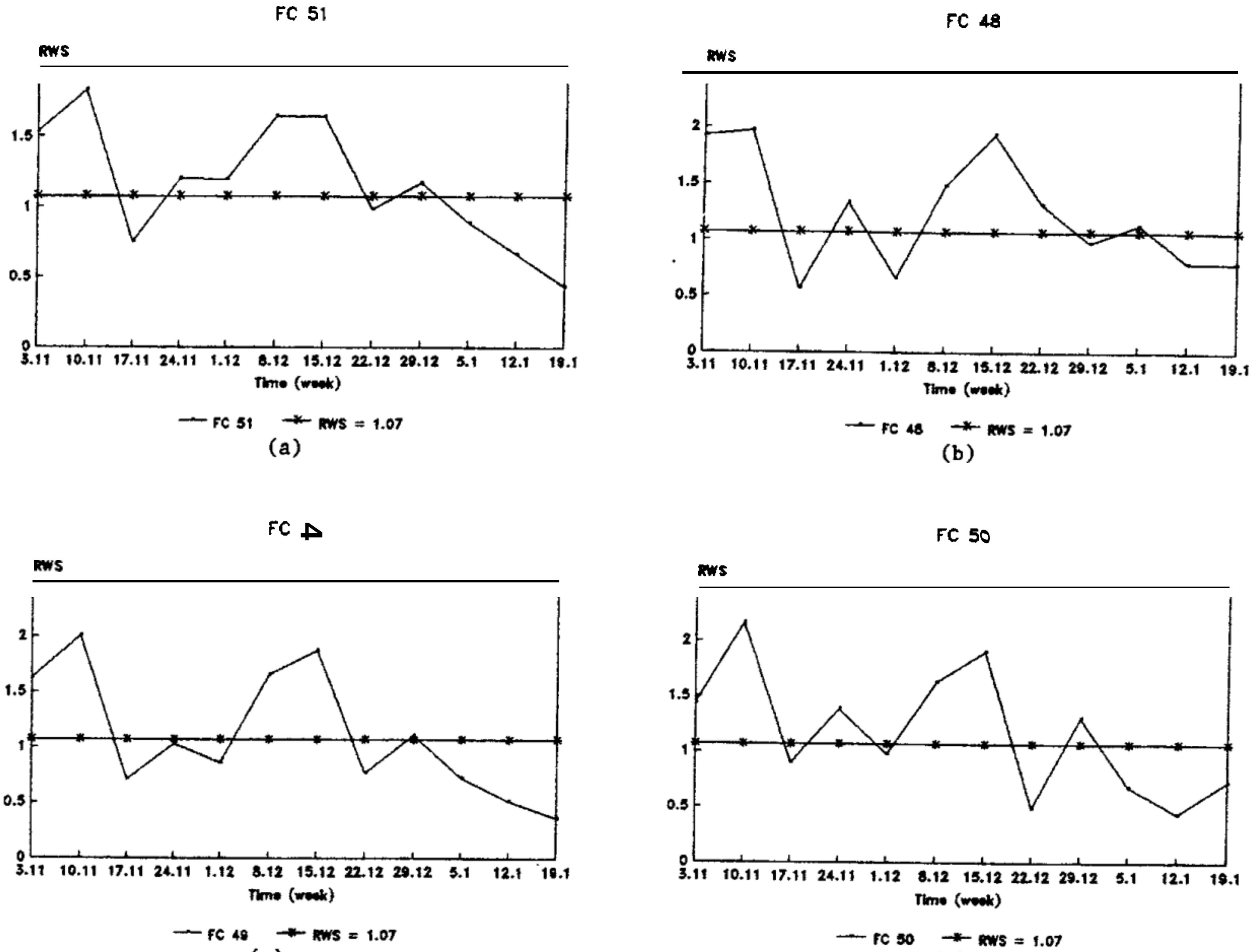


Figure 4.7 RWS for Crop Growth Period

Next >>

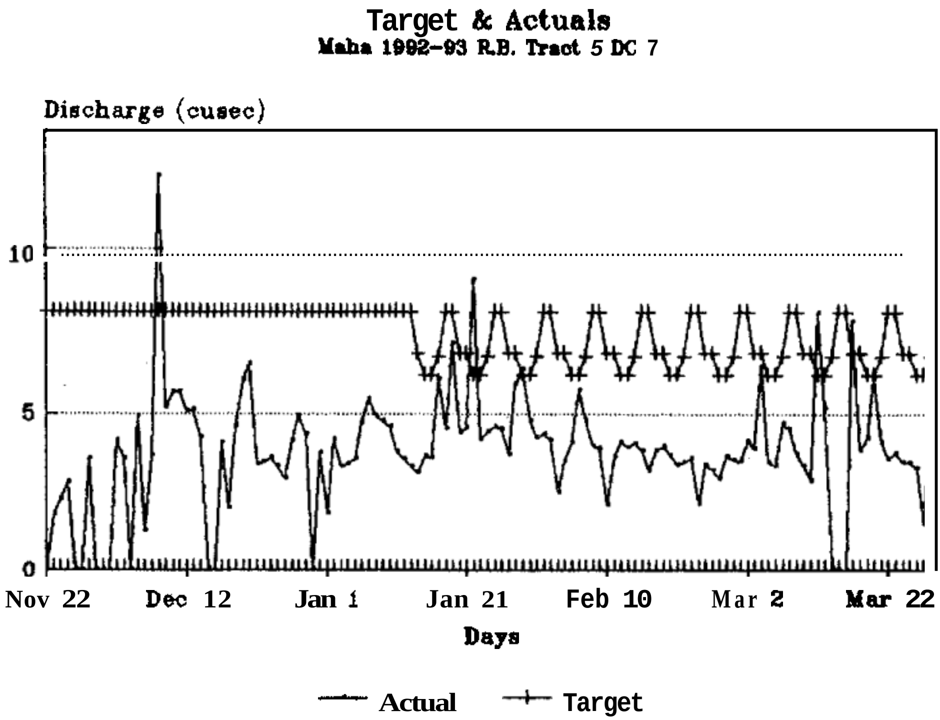

Target & Actuals
Maha 1992-93 R.B. Tract 5 DC 7
Discharge (cusec)
10
5
0
Nov 22
Dec 12
Jan 1
Jan 21
Feb 10
Mar 2
Mar 22
Days
Actual
Target

Figure 4.8

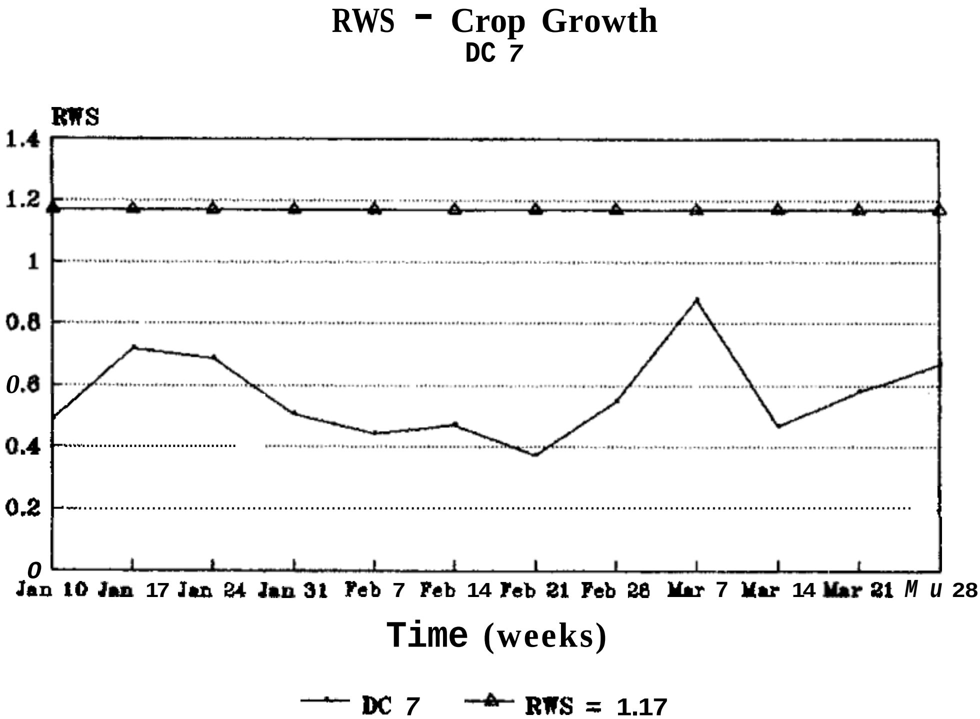

RWS - Crop Growth
DC 7
RWS
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan 10 Jan 17 Jan 24 Jan 31 Feb 7 Feb 14 Feb 21 Feb 28 Mar 7 Mar 14 Mar 21 Mar 28
Time (weeks)
DC 7
RWS = 1.17

Figure 4.9

CRWS - Crop Growth
DC 7

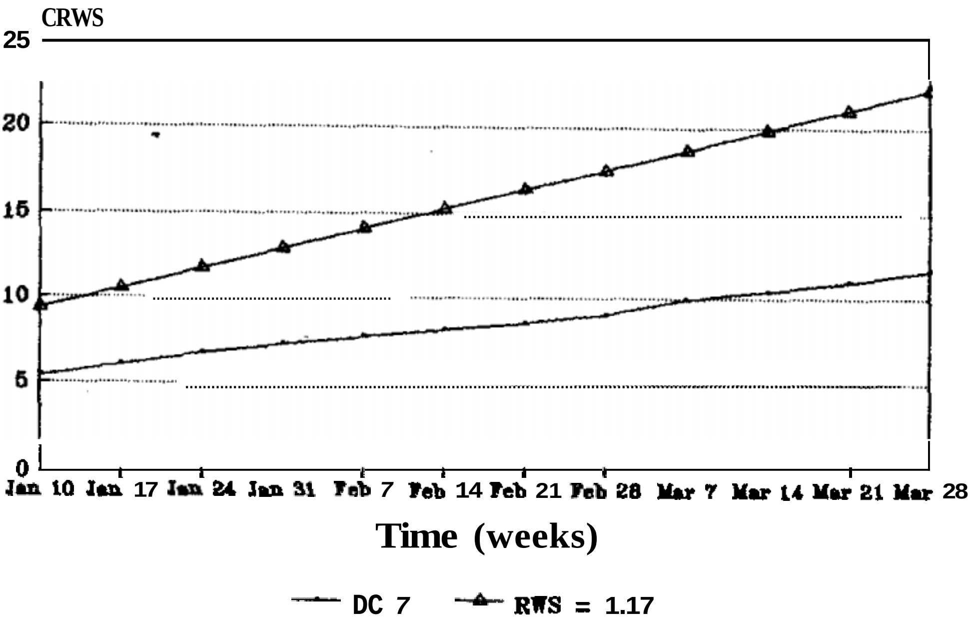
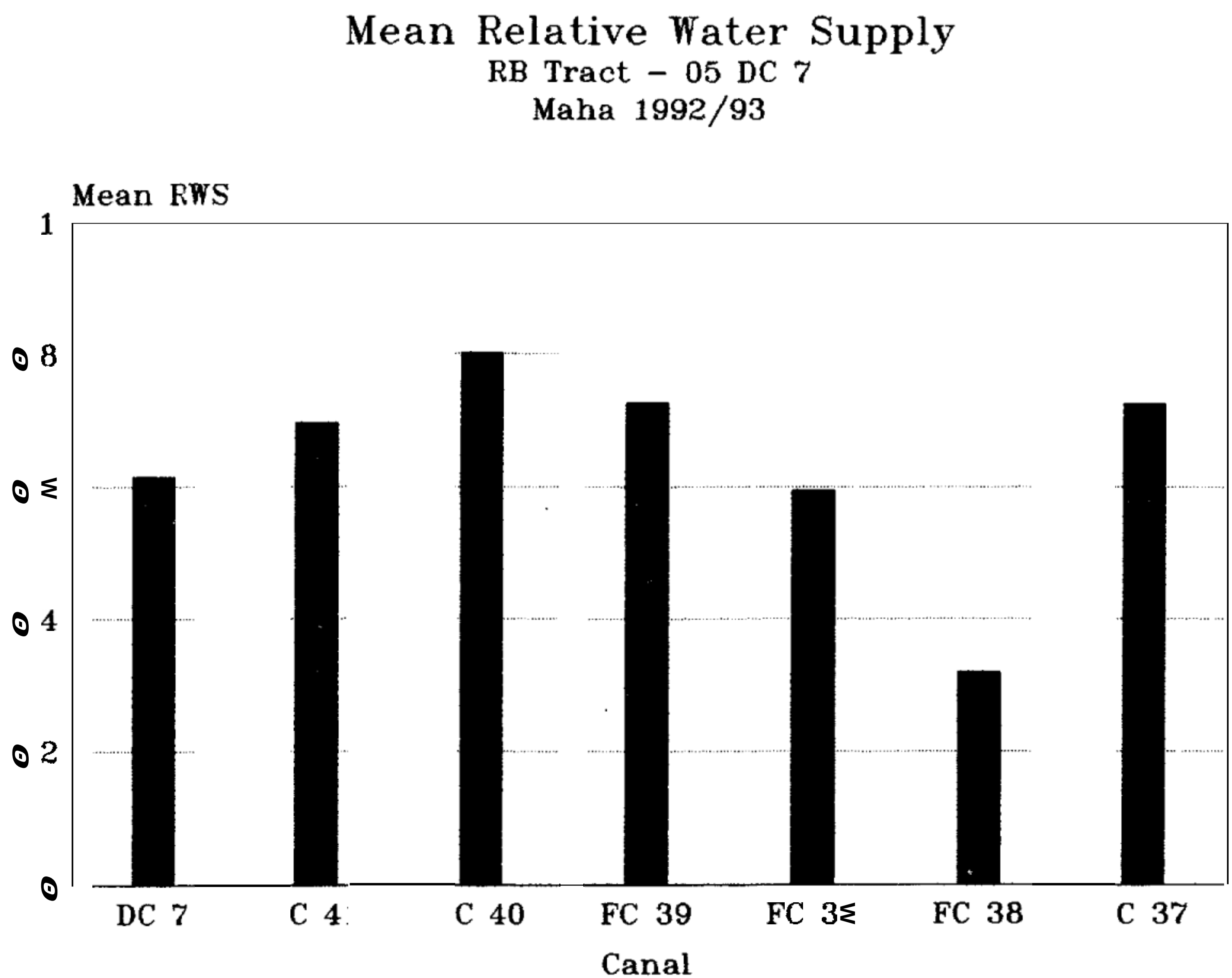


Figure 4.10


Mean Relative Water Supply
RB Tract - 05 DC 7
Maha 1992/93
Mean RWS
1
0 8
0 4
0 2
0
DC 7
C 40
FC 39
FC 38
C 37
Canal

re 4.11

CHAPTER 5

Diversification into Other Field Crops

5.1 BACKGROUND

Recognizing the overall water short character of the Kirindi Oya Irrigation and Settlement Project, the Ministry of Lands and Imgation planned to allocate the limited inflow from the Lunugamvehera Reservoir for the cultivation - as far as possible - of Other Field Crops (OFCs) on well-drained lands in the New Imgation System (NIS). The cultivation of paddy was to be confined to the poorly drained soils in the NIS and to the alluvial soils of the Ellegala Irrigation System (EIS). Optimum utilization of the land and water resource base through the adoption of appropriate non-paddy and paddy cropping systems for the respective seasons was thereby envisaged.

Various scenarios were proposed by the Salzgitter Consultants (1987) based mainly on theoretical considerations of crop water requirement, irrigation efficiencies, delivery performance, seepage and percolation losses. Many of the parameters especially seepage and percolation losses (S&P) and imgation efficiencies were grossly underestimated leading to underestimation of reservoir water releases. There was also no appreciation of the profitability of crops, market potential or availability of labor, and it was soon realized that none of the scenarios proposed by the consultants could be realized.

Initial attempts by the Department of Agriculture (DOA), the Irrigation Department (ID), the Irrigation Management Division (IMD) and Land Commissioners' Department (LCD) to introduce OFCs to farmers proved difficult. Farmers preferred to grow paddy by the conventional method of puddling on both well-drained and poorly drained lands. The first demonstration conducted by the Department of Agriculture, the Irrigation Department and the Irrigation Management Division during *maha* 1988/89 showed the profitability of cultivating OFCs on both well-drained and imperfectly drained soils and was well received by farmers. During yala 1989, an action plan for cultivating OFCs during yala 1990 was drawn up by a Task Force, coordinated by Mr. Ananda Wanasinghe, consultant to the Asian Development Bank.

Although crop diversification was addressed during the Phase I Study, only a limited number of issues which mainly focused on the economic performance of non-paddy crops were researched. The close involvement of IIMI staff in the planning and guiding of the 1990 yala action plan and the *maha* 1990/91 action plan for promoting OFCs in Tracts 6 and 7 of the Right Bank provided meaningful answers to some of the issues raised and helped to diagnose relevant problems pertaining to irrigated agriculture in the Project. During the Phase 2 Study, action research was undertaken to assist in implementing Phase I recommendations and to address research issues not considered during the Phase I Study.

In the Inception Report, activity six entitled "Efficient Use of Scarce Water to Maximize Production" focused on pilot testing practices for crop diversification in Tract 3 of the Left Bank. The approach was action orientated and was to be undertaken in close collaboration with agencies and farmers. It was suggested that settlers within the proposed pilot area be initiated into OFC cultivation during both maha and yala seasons and that all supporting measures essential to achieving this goal be tested. The main objective was to test the possibility of cultivating OFCs during both maha and yala seasons under irrigated conditions. The experience of this research is expected to be used in the NIS so that limited water resources can be stretched to maximum advantage for both water use efficiency and farmer incomes.

The experience gained during maha 1991/92 brought two new approaches: promoting non-paddy crops during both seasons on appropriate soils in the command area of all tracts in the NIS by making maximum use of seasonal rainfall (with or without supplementary irrigation) and cultivation of non-paddy crops with both residual soil moisture and limited rainfall during the yala season in the EIS.

The experience of farmer Jinadasa in Tract 1 DC 1 FC 19 of the Right Bank who has a well established OFC cultivation using water from a dug well has prompted agency staff to experiment with this method. During the 1992 yala season, agencies assisted 10 farmers to use this source of water.

A study on growing OFCs on limited extents using water from dug wells was also undertaken. This study was conducted in Tract 1 DC 1 FC 19 of the Right Bank during yala 1992 to asses incomes which could be obtained from OFCs using water from dug wells and to observe the behavior of the water table in dug wells. The study also examined the possibility of replicating the experience in other areas.

One of the more significant outputs envisaged in the Inception Report was "generating a series of recommendation for cultivating imgated OFCs in Kirindi Oya." Recognizing that results from the study in Tract 3 of the Left Bank alone could not provide these recommendations, it became essential for IIMI to assist the respective agencies evolve appropriate strategies for the adoption and testing of IIMI's institutional knowledge and past experience in irrigation management for crop diversification in the larger area of RB and LB Tracts.

The scope of the study was expanded beyond that outlined in the Inception Report to include the foregoing additional sub-activities starting yala 1990.

These activities are as follows:

1) Study the possibility of cultivating OFCs in EIS during yala season.

2) Study growing OFCs in NIS using water from dug wells.

5.1.1 Promotion of Non-Paddy Crops in NIS

The extent of OFCs grown in the NIS since yala 1990 is shown in Table 5.1.

Table 5.1. Cultivation of OFCs in Kirindi Oya New Irrigation System[a] by season (in hectares).

Crop	1990	1990191	1991	1991192	1992	1992/93
	Yala	Maha	Yala	Maha	Yala	Maha
Greengram	19	1200	18		Lack	766
Groundnut	140	95	7	49	of	191
Cowpea	40	392	11	114	rain	179
Chili	12	92	115	8	and	128
Onion	1	9	28	239	reservoir	5
Vegetahles	54	105	44		water	148
Others	1	50		11		51
Total	267	1943	223	421		1468

[a] Including homestead areas.

In a water short system, it is not possible to provide water to the whole command area (both new and old) during a maha season. The figures of percentage irrigated area for respective tracts, LB and RB for each maha season since 1987 is given in Table 5.2.

Table 5.2. Percentage irrigated extent in the new areas, by season.

Tract						
	1987/88	1988189	1989190	1990191	1991192	1992193
Right Bank						
Tract 1	100%	100%	100%	100%	100%	100%
Tract 2	100%	100%		100%	100%	100%
Tract 5	100%	100%		100%	100%	100%
Tracts 6&7					100%	
Left Bank						
Tract 1	100%	100%	100%	100%	100%	100%
Tract 2	100%	100%	100%	100%	100%	100%
Tract 3					100%	100%

While water supply would be inadequate for paddy in the **NIS** during maha, rainfall is generally adequate for raising either solely rainfed OFCs or raising OFCs using rainfall and supplementary irrigation. This was considered during seasonal planning and it was proposed that farmers in the **NIS** who did not receive water for paddy could cultivate OFCs on well-drained and imperfectly drained soils with rainfall and a few irrigation issues. This was tested during the 1992/93 maha season.

Yala cultivation in the **NIS** depends on the water available in the main reservoir. The first attempt at OFC cultivation with irrigation was during the 1990 yala season. In 1992, it has not been possible to do any yala cultivation due to lack of water. The implementation of the seasonal water allocation plan would allow an increase in the extent of OFC cultivation in yala seasons.

The possibility of OFC cultivation in the Ellegala during the 1993 yala season was initiated following the experience gained from Pihille Yaya in the Tissa wewa command. The cultivation of OFCs using residual soil moisture and limited yala rainfall was first monitored during yala 1992.

The lessons learned were useful in planning the seasonal water allocation plan. This experience was further tested during yala 1993 when OFCs were cultivated in other areas in the Ellegala. **IIMI's** study conducted during the 1993 yala season in the Ellegala was mainly concerned with economic returns and the constraint affecting cultivation of OFCs in the Ellegala.

5.2 STUDY AREA

5.2.1 Tract 3 of the Left Bank

Tract 3 is located at the tail end of the Left Bank Main Canal. This tract has 320 ha of irrigated land which is distributed among 335 farm settlers. Each settler holds approximately 0.81 ha of irrigated land and 0.61 ha of non-irrigated uplands located close to the irrigated area. The irrigation infrastructure had been designed for gravity irrigation suitable for paddy cultivation. The command area is serviced by three distributaries (DC 1 to DC 3) together with 31 field canals. The land under DC 1 has not been allocated to settlers because it has been encroached. The study was, therefore, confined to DC 2. DC 2 has 24 FC and 412 allotments and DC 3 has 6 FCs and 94 allotments.

The soils in this tract are well-drained reddish brown **earths** (RBE) and poorly drained low humic grey **(LHG).** Seventy-five percent **of** the total land area falls into these two soil categories.

Because of resource constraints, only two field canals in DC 2 - FCs 3 and 4 - were selected for IIMI's research. FC 3 has 19 allotments while FC 4 has 14 allotments. The command area of FC 3 consists 84 percent of well-drained soils. FC 4 has 95 percent well-drained soils.

Almost all farmers settled in this tract had come from the surrounding area. Most of these settlers had prior experience of rainfed non-imgated "chena" cultivation of a range of non-paddy crops. Some farmers had developed the lower part of Tract 3 for paddy cultivation using drainage water from the adjacent drainage canal. Most of these settlers were poor and the majority of them did not have adequate financial resources to cultivate high value cash crops under imgated conditions.

Institutional development commenced during the 1991 yala season. The Institutional Organizer from the Irrigation Management Division formed field canal level farmer groups and a DCO. The DC 2 organization was established before maha 1991/92. However, at the start most farmers did not have a clear understanding of participatory management.

There is a well established market for limited quantities of non-paddy crops in the area because the local market caters both to people in the area and local tourists. Surplus production is marketed in other areas. Private wholesalers play a major role in the market system. Government involvement in marketing is minimal. The main market for non-paddy crops is at Pannegamuwa where the market is open two days a week. In addition, middlemen are involved in the market structure.

Inputs such as fertilizer and chemicals are freely available on the open market but seed supply is limited. The Department of Agriculture is involved in supplying seed to farmers. Initially, settlers received free seed up to a value of Rs 1,325/- from project funds. Farmers were expected to produce their own seed thereafter or to purchase their seeds.

Settlers also received considerable assistance during the initial phase of settlement so they could settle in homesteads. The project provided financial assistance to build houses, latrines and fences. Fruit plants were distributed among the settlers for their homestead plots. Drinking water (60 gallons per family per week) is being provided until piped water is available.

5.2.2 The Ellegala Irrigation System

The old EIS was selected for the study of OFC cultivation during yala seasons. During the first season, yala 1992, the study was conducted in Pihille Yaya in the Tissa wewa command. During the following yala season, study locations included the Tissa wewa, the Weerawila wewa and the Yoda wewa command areas.

The canal system in the Ellegala is complicated. Most field canals lack regulators making water distribution in distributaries and main canals difficult. Farmers receive water from different sources: main canals, distributary canals, field canals, drainage canals and adjoining allotments. Tertiary level drainage canals do not exist in most places.

Farmers here are mostly tenant farmers, the majority of whom are well-established paddy farmers. Their main source of income comes from paddy cultivation during both seasons.

Pihille Yaya is located in the Tissa wewa command area. On one side it is bordered by the Yoda wewa feeder canal and on the other side by the homestead area. The cultivated area is 26.7 hectares (66 acres) and consists of 19 allotments. Some of these allotments are cultivated by more than one farmer. Of the 19 farmers, four farmers own their lands. The majority of farmers are second generation tenant farmers. Farm size varies from two to five acres.

The Pihille Yaya receives irrigation water from DC 4 of the Tissa wewa Left Bank Main Canal and from a drainage canal. The selected area of study is located at the tail end of this DC. The tail end portion of this canal receives drainage water from the upstream command area. Therefore, this canal acts as a drainage canal to upstream areas as well as a supply canal. Irrigation supply to Pihille Yaya depends on drainage contribution and direct supply to DC 4. Farmers said that even during normal maha seasons, supply from these canals was insufficient.

Soils in the Pihille Yaya area are mainly brown alluvial soils which have fairly good drainage properties and are suitable for OFC cultivation. The lower part of the area is made up of grey alluvial soils with poor drainage properties. Farmers here formed a farmer organization six years ago. Although this organization does not come under the Irrigation Management Division's system, it discusses decisions made at the Irrigation Management Division's farmer organizations and specific issues related to the Pihille Yaya. These farmers had prior experience of OFC cultivation during previous yala seasons when water was scarce.

5.2.3 Study Area for the Dug Well Program

This study area is located in Tract 1 DC 1 FC 19 of the Right Bank and forms part of the narrow belt of the river levee alluvium which is highly suitable for OFC cultivation.

Farmers have been living here for a long time, from before the start of the Lunugamvehera project and a few farmers received the same plots of land they had been cultivating before the project. They have long years of farming experience, including cultivation of OFCs.

5.3 RESEARCH APPROACH, OBJECTIVES AND ACTIVITIES

5.3.1 Research Approach

This research was designed and implemented with the participation of agency staff. Most of the work at field level was implemented by the agencies and the farmers. IIMI's role was to collect relevant data from a sample with a view to assess the impact of the innovation and to provide guidance based on research results. IIMI also played the role of facilitator.

A subcommittee was appointed to coordinate activities and to implement the program. This committee also reviewed progress and results. The subcommittee included the following members: the Assistant Director of Agriculture who was the Chairman; the Agricultural Officer; the Resident Engineer of the Left Bank; the Deputy Director, Lands; the Project Manager, Irrigation Management Division; and the Research Officer, IIMI.

Two workshops were held to discuss the action research program and to work out a detailed action plan. Finalized plans were discussed at subcommittee meetings before implementation.

Subcommittee meetings were held periodically to discuss problems, progress and results. Progress and results were presented at the Study Coordinating Committee meetings held twice a season. Activities were analyzed at the end of each season. Outcomes were used in planning activities for the following season. The seasonal research program and results were presented at the Study Advisory Committee.

5.3.2 Research Objectives

Pilot Study in Tract 3 of the Left Bank

The objective was to test cropping patterns and practices which would optimize use of the limited water supply, provide attractive incomes for farmers and come up with a practice which could be adopted elsewhere.

Specific objectives included:

* studying the feasibility of growing only OFCs during both the wet maha and the dry yala seasons,
* assessing incomes which could be derived from 0.81 ha of an irrigated allotment,
* documenting the most appropriate manner of harmonizing both irrigation management inputs and crop production inputs,
* developing an improved strategy for proper water delivery schedules at the turnout and an effective method of sharing water equitably below the turnout with respect to irrigated diversified cropping and
* identifying institutional arrangements required for crop diversification.

Study on OFC Cultivation in the Ellegala Irrigation System Utilizing Residual Soil Moisture and Limited Yala Rainfall

The objective was to determine how to maximize land use in a water scarce situation during the dry season.

Specific objectives included:

* studying the feasibility of growing OFCs during the yala season making use of the residual soil moisture from the preceding maha season and the limited yala rainfall,

* documenting the cropping pattern and identifying a suitable cropping plan and

* assessing incomes generated by OFC cultivation under these conditions.

Study on Growing OFCs Using Water from Dug Wells

The objective was to examine the possibility of using limited groundwater to maximize crop production.

Specific objectives included:

* examining the possibility of expanding OFC cultivation using water from dug wells and

* assessing incomes which could be generated by OFC cultivation using this source of water.

5.3.3 Research Activities

Tract 3 of the Left Bank - Pilot Study

Pilot testing of OFC cultivation in Tract 3 of the Left Bank was conducted during maha 1991/92 and maha 1992/93. The program could not be implemented during yala 1992 due to the lack of water. During the 1993 yala season, cultivation of OFCs by a few farmers in FCs 3 and 4 was monitored.

During the two maha seasons studied, the following activities were carried out:

* developing a seasonal plan for cultivation,

* conducting crop demonstrations,

* training,

* irrigation scheduling and developing a water sharing practice,

* testing different land shaping and land preparation methods and

* assessing the economic performance of OFCs.

Seasonal Planning

The main purpose of this activity was to develop a seasonal plan for irrigated OFC cultivation taking into consideration limited irrigation supply, rainfall, choice of crops and provision of services and rainfed upland homestead cultivation.

Seasonal planning included determination of dates for commencing the season's cultivation, crop selection, irrigation schedules and provision of other services such as supply of seeds, credit and barbed wire, etc.

During the first maha season, the subcommittee decided that the first water issue should commence after sufficient rainfall (about 70 mm cumulative rainfall normally expected by mid October) had been received. The main reason for this was to maximize the use of the expected rainfall. The other reason was to provide farmers sufficient time to complete their upland rainfed homestead (one acre) cultivation. It was also proposed to issue two irrigations during the third week of October for final land preparation and crop establishment.

During the second maha season, since water in the tank was insufficient to ensure early irrigation issues, it was decided to utilize October rainfall to the maximum extent for land preparation and crop establishment without providing any irrigation supply during this month.

The Department of Agriculture made crop recommendations to farmers based on socio-economic and environmental conditions based on past experience of OFC cultivation, availability of family labor, irrigation supply, soil and drainage conditions and economic factors such as markets and cultivation costs.

During both seasons, the crops recommended were greengram, groundnut, soybean and cowpea in a larger extent of land and chili and vegetables in a smaller extent.

During maha 1991/92, barbed wire and water for establishing chili nurseries were supplied by the Land Commissioner's Department. The Irrigation Management Division arranged credit facilities through a state bank and the Department of Agriculture supplied the seed.

Crop Demonstration

During the maha 1991/92 season, the Department of Agriculture conducted a crop demonstration in FC 3 of DC 2. Thirteen farmers were selected for this program. The objective was to show farmers OFC cultivation methods under irrigated conditions. The Department provided seeds, fertilizer and chemicals.

Crops selected for the demonstration were greengram, soybean and chili. The extent of a demonstration plot was one acre (0.40 ha). Groundnut was not included in these demonstrations due to lack of groundnut seeds.

Activity	1991192 Maha	1992/93 Maha
Land Preparation	70 mm irrigation in two issues	Rainfall only
Crop growth period	8 irrigation issues during November to March	6 irrigation issues during January to March

A water sharing practice within FCs was introduced and tested where two farmers shared a one cusec flow for six hours. The leader of the FC prepared a water sharing schedule before each water issue and issues were made on request. Irrigation field staff verified requests for water by farmers.

Irrigation issues to FCs 3 and 4 were measured to estimate water consumption during the cultivation phase. Irrigation rotations were observed daily to see how water was shared.

Observations were made on how on-farm water management was carried out for different crops. Imgation problems faced by farmers were documented.

Testing Different Land Shaping and Land Preparation Methods

Two different land shaping methods were proposed. One method was to construct terraces at a gradient of 0.2 percent along the contour while the other was to construct terraces without a gradient. In the second method, boarder bunds were constructed along contours. Individual terraces were subdivided into 30'x 30' basins in both methods.

The two types of irrigation layouts that were tested are shown in Figure **5.1.** In the first method, an irrigation ditch was laid above ground level along the bund with sub-laterals along the main slope in each terrace. In the second method, the ditch was laid in the middle of the terrace with a sub-lateral along the main slope on either side of the ditch. Different land preparation methods for different crops were recommended by the Department of Agriculture. The recommended methods were raised beds for chili, corrugated beds for legumes and flat beds for vegetables.

Assessment of Economic Performance of OFC Cultivation

The economic analysis was carried out to assess the profitability of OFCs and farmer incomes which could be derived from OFC cultivation. Average income (the net returns to farmers) and gross value added were used as economic performance indicators. All self-supplied inputs were valued at market prices.

Gross value added is defined as the difference between gross revenue and the cost of inputs. Incomes were calculated as gross value added minus cost of hired labor. Family labor was not considered as cost but as income. Labor productivity was also used as a performance indicator.

Data collection was conducted by IIMI and the following data were collected from sample farmers:

* crop yields,
* input levels and costs and
* market information and prices.

Study on Feasibility of Growing OFCs in the Ellegala Irrigation System Using Residual Soil Moisture and Limited Rainfall During the Yala Season

The objective was to document and evaluate the performance of OFC cultivation using residual soil moisture and limited yala rainfall, During the 1992 yala season, the study was conducted in Pihille Yaya in the Tissa wewa command. Data for the analysis was collected from all 19

farmers. During the 1993 yala season, the study was conducted in the command of the four Ellegala tanks: the Tissa wewa, the Weerawila wewa, the Debara wewa and the Yoda wewa. Thirty farmers were selected from all four tanks.

Following research questions were raised:

* What was the best time to plant OFCs during the yala season to make the best use of both residual soil moisture and rainfall?
* What were the non-paddy crops best suited for cultivation during the yala season?
* What level of farmer income could be generated by OFC cultivation in this manner during the yala season?
* What problems did farmers face doing OFC cultivation?

Data on the following were collected:

* rainfall,
* date of crop establishment,
* type of land preparation,
* inputs,
* yields and
* income and cost of cultivation.

Study on the Profitability of Growing OFCs Using Groundwater

This study was conducted during the 1992 yala season in FC 19 of DC 1 Tract 1 of the Right Bank. The study program was organized jointly by the Department of Agriculture and the Irrigation Management Division. Twelve allotments were selected in FC 19 for this program.

This project was initiated after successful OFC cultivation by farmer Jinadasa using groundwater. He had been cultivating OFCs before the project started. During the season, the Irrigation Management Division and the Department of Agriculture initiated a program to expand OFC cultivation with water from dug wells. Twelve farmers were selected initially. These farmers were provided with loans for constructing wells. Farmers had to repay loans in four installments. In addition, bank loans of Rs 15,0001- each were arranged to purchase water pumps. Farmers were provided with barbed wire on loan. The Irrigation Management Division proposed to expand this program with NORAD aid.

Water level fluctuation in five wells were also studied. Data on costs and returns were collected to calculate incomes which could be generated from this type of cultivation,

5.4 RESULTS AND DISCUSSION

5.4.1 Pilot Test of OFC Cultivation in Tract 3 of the Left Bank

Seasonal Planning

The 1991/92 maha cultivation activities on irrigated lands commenced on 15 October with the release of irrigation issues for land preparation and crop establishment. Seventy mm of irrigation supply was given in two issues after receiving 70 mm of cumulative rainfall. The majority of farmers started work in the irrigated allotments soon after they had completed crop establishment in highland allotments. It was planned that farmers should complete crop establishment by the second week of November but farmers took a longer time because of sole dependence on family labor. Another reason was that since there had been no prior cultivation on these lands, farmers had to spend more time shaping the land and forming cross bunds.

The seasonal plan for the 1992/93 maha season was different to that of the 1991192 maha season. This was because of lack of water in the reservoir made it impossible to provide water to Tract 3 during October. It was thus decided to utilize rainfall received during this period to the maximum extent possible for both land preparation and crop establishment. The majority of farmers started land clearing in mid-September. Land preparation started in early October. Rainfall received in September (58 mm) was used to moisten the land before land preparation. About 69 percent of the sample farmers prepared their lands during this period. Crop establishment was done during the last week of October with rains received (104 mm) during the month. This activity continued up to the second week of November. The heavy rains which occurred during the second week of November proved unfavorable to the already established crops.

These results show that for the maha season it is feasible to start cultivation, especially of grain legume crops, with early maha rains in October. However, it is difficult to depend on rainfall alone to establish high value crops like chilies and onions because most of these crops need a very good standard of land preparation which is not possible under rainfed conditions. Also, chili plants have to be kept in nurseries for longer periods if crop establishment has to depend on rainfall. Again, if high rainfall is received soon after crop establishment, it could damage the chili plants. This shows that it is necessary to supply adequate irrigation during the initial stage of land preparation during early October if high performance crops like chili are to be cultivated.

The recommended crops were acceptable to farmers and almost all planted these crops during both seasons as shown in **Table 5.3.** Observations during both seasons show that chili,

groundnut and greengram are the preferred crops followed by cowpea and vegetables. No farmers cultivated soybean because of marketing difficulty. Some farmers cultivated onions and banana during maha 1992/93 on an experimental basis. The study highlights the importance of two water issues during the land preparation stage and regular water issues during the crop growth period for farmers to adopt better cultivation practices. However, rainfall should be taken into account when delivering irrigation issues.

The study also shows that the commencement of the maha season's cultivation on imgated lands is most appropriate after the completion of crop establishment in the homestead areas and that irrigation issues for land preparation should start after 70 mm of cumulative rainfall is received.

Table 5.3. Land utilization pattern in FC 3 and FC 4, by season (in hectares).

	1991/1992 Maha Season				1992/1993 Maha Season			
	FC 3	FC 4	Total	%	FC 3	FC 4	Total	%
Greengram	2.96	0.20	3.16	11.52	2.34	1.27	3.61	13.17
Groundnut	0.24	1.21	1.45	5.29	4.91	0.70	5.61	20.46
Soybean	1.42	-	1.42	5.18		-	-	-
Cowpea	0.20	-	0.20	0.73	0.26	-	0.26	0.95
Chili	6.17	5.57	11.74	42.82	4.87	5.16	10.03	36.58
Onion	0.04	-	0.04	0.15		-	-	-
Others	0.0	0.10	0.10	0.36	0.28	0.20	0.48	1.75
Not cultivated	0.95	1.52	2.47	9.00	0.94	2.80	3.74	13.64
Cultivated and abandoned	3.40	3.44	6.84	24.95	1.78		2.78	9.04
Paddy		-				1.21	1.21	4.41
Total	15.38	12.04	27.42	100.0	15.38	12.04	27.42	100.00

Irrigation Schedules and Water Sharing

Two different irrigation schedules were tested during the study period. During the 1991/92 maha season, 70 mm of water was issued for land preparation between 25 October and 11 November. Thereafter, eight imgation issues were decided for the crop growth period with the exception of utilizing rainfall during the season. Irrigation issues for the crop growth period began on 28 November and ended end March 1992. Water issues were made on farmers' requests.

During the 1992/93 maha season, only rainfall was used for land preparation. Due to the water shortage, six imgation issues were decided for the crop growth period. Water issues for the crop growth period started end October and continued until mid-March.

During the 1991/92 maha season, many farmers did not use irrigation water for land preparation since there was sufficient rainfall (110 mm) in October. However, most used the continuous water issues made between 25 October to 11 November to establish crops. During the 1992193 maha season, farmers did land preparation and crop establishment with rainfall only. However, land preparation was less intensive because of the low rainfall received during October (104 mm).

During the 1991/92 maha season, nine irrigation issues for the crop growth period were made as shown in Table **5.4.** Farmers were able to manage with one irrigation issue in November and December because rainfall contribution was high (575 mm) during this period.

Table **5.4.** Water consumption and area irrigated in **FC** 3 and FC **4** during crop growth period - Maha ***1991192*** **(in** hectares).

Period	Water Supply to FC 3 (mm)			E_o mm	Area irrigated	Water supply to FC 4 (mm)			E_o mm	Area irrigated
	Rainfall	Irrigation	Total			Rainfall	Irrigation	Total		
November '91	305	28	333	96	14.6	305	57	362	96	10.5
December '91	270	129	399	98	13.8	270	58	328	98	5.7
January '92	28	269	-	-	2.3	28	298	-		0.5
	-	210	507	164	6.1	-	174	500	164	2.7
February '92	-	122	-	-	5.6	-	127	-		1.9
	-	139	-	-	5.1	-	130	-		4.3
	-	128	389	198	5.2	-	108	365	198	5.1
March '92	-	157	-	-	5.8	-	137	-		6.2
	-	127	284	228	5.9	-	132	269	228	5.8
Total	603	1309	1912	784	-	603	1212	1824	784	-

Note: Total cultivated extent: ha in FC 3 15.38ha and in FC 4 12.04 ha. E_o is pan evaporation.

Two and three irrigation issues were made in January and February 1992, respectively. Irrigation issues made in February and March were mainly for chili. During the 1992/93 maha season, five irrigation issues were made for the crop growth period as shown in Table ***5.5.***

No irrigation was done during the 1993/94 maha season. It must be pointed out that the 1993194 maha season was an exceptional one because rainfall was very high - 400 **mm** - compared to normal maha seasons.

Imgation issues for the crop growth period started in January 1993. Only one irrigation issue was made during the month. Two irrigation issues were made in February and in March. Although a sixth irrigation issue was made at the end of March, farmers could not use this because water did not reach Tract 3.

In a normal season, rainfall contribution is about 600 to 700 mm. The average irrigation supply per hectare for the crop growth period was 1,300 mm during maha 1991/92 maha and 646 mm during maha 1992/93. However, these figures do not give an accurate estimate of the average imgation requirements of FCs 3 and 4. Water issues were made based not on the cultivated area but on the actual irrigated area and measurements taken at the head of each field canal. The results show that the area irrigated with each water issue is low during both seasons mainly because tail end farmers did not irrigate because their allotments had sufficient soil moisture throughout the season. The other reason was that most farmers did not irrigate groundnut and greengram crops. Almost all farmers imgated chili during every irrigation issue. Therefore, actual water duty depends on crop combination and on the proportion of different soil types constituting the imgated land.

Table *5.5.* Water consumption and **area** irrigated in **FC** 3 and **FC 4** during crop growth period - Maha 1992/93 (in hectares).

Period	Water Supply to FC 3 (mm)			E_o mm	Area irrigated	Water Supply to FC 4 (mm)			E_o mm	Area irrigated
	Rainfall	Irrigation	Total			Rainfall	Irrigation	Total		
October '92	104	-	104	194	-	104	-	104	194	-
November '92	409	-	409	111	-	409	-	362	111	-
December '92	141	-	141	115	-	141	-	141	115	-
January '93	43	133	176	145	-	43	125	168	145	-
February '93	-	138 80	- 218	- 184	6.5 9.7	-	71 216	- 287	- 184	4.0 4.5
March '93	10	188 107	- 305	- 162	2.0 7.0	10 -	44 91	- 145	- 162	0.8 3.2
Total	707	646	1,353	911		707	547	1,254	911	

During the 1991192 maha season, a water sharing within field canals was implemented. One cusec flow was shared by two farmers for six hours. It was observed that half a cusec flow was manageable by farmers. Most of the farmers practiced wild flooding for imgating their crops which caused wastage of water and over imgation of crops. This method was used because many farmers lacked knowledge of irrigation practices, had less experience in imgating OFCs and lacked knowledge of proper land preparation methods. Also, farmers received a limited number of irrigation issues at long intervals and so tended to flood their lands. The major

problem caused by wild flooding was over irrigation which took a longer time to wet the land.

To implement rotations, a reliable flow of water from the turnout is essential. Farmers had many problems sharing water due to the fluctuation in water level in the distributary, which made it difficult to imgate allotments within six hours. Fluctuation in water level during the 1991/92 maha season is shown in Figures 5.2 and 5.3. Fluctuations in the distributaries were also observed during the 1992/93 maha season. It was difficult to maintain a stable water level in the main canal due to illegal gate operations by upstream farmers. Many top end farmers found it difficult to wet their lands within six hours because they practiced wild flooding. However, these farmers got sufficient time to irrigate their crops since most tail end farmers did not take water. Tail end farmers received seepage water when top end farmers irrigated their crops. Lack of farmer participation was another constraint in implementing time-sharing practices in field canals. Farmer participation within the turnout distribution dropped further during the 1992/93 maha because there were less irrigation issues.

However, the participation of farmer organizations was obtained in water delivery at field canal level. Water issues were made on farmer requests. Whenever farmers felt that the soil was dry, they asked their representative to request water. Farmer participation during the 1992/93 maha Season was less compared to the 1991/92 maha season. Many farmers did not clean irrigation canals since there was no irrigation supply during the period from October to December.

In summary, this study indicates that rainfall can be utilized to the maximum for OFC cultivation during the maha season. However, it is difficult to limit the number of irrigation issues because high performance crops need water at frequent intervals. Water issues for land preparation and to establish crops and an assurance of frequent irrigations are necessary for farmers to adopt a higher standard of land preparation and use more inputs. Also, without a reliable water supply in distributary canals, it is difficult to implement a water sharing practice at the field canal level. Allocating a fixed time for imgation is not possible due to variations in crops cultivated and the drainage conditions of farm lots. It is difficult to obtain effective farmer participation for water sharing under supplementary irrigation conditions.

Land Shaping and Land Preparation

Two types of land shaping methods, bench terracing and contour graded terracing, were tested. It was not possible to evaluate the two methods based on crop performance due to the small size of the sample and variations in factors such as input application, level of crop care, quality of seed, etc. However, contour graded terracing seemed to be more appropriate than bench terracing. It was observed that there were many patches of stunted OFCs cultivated on bench terraces. The other advantage of contour graded terraces was that it provided more flexibility for on-farm water management.

Two types of irrigation layouts were introduced to farmers as indicated in Figure 5.1. It was observed that farmers adopted different layouts including the recommended ones. During the 1991/92 maha season, three farmers prepared land for chili crop according to the first method

while 13 farmers prepared their lands for chili according to the second method. During the 1992/93 maha season, almost all farmers did not follow recommended land preparation methods because they had to depend on rainfall for land preparation. Water issues for the crop growth period was also limited.

It was observed that the first method requires more labor than the second method - 75 man days verses 57 man days per ha. In the first method, it was also observed that farmers had difficulty in maintaining the configuration of the farm ditch laid along the terrace. This ditch tended to break frequently while irrigating.

During the study, some factors were identified as constraints in the adaptation of proper land preparation methods. Observed factors include lack of cash to hire labor, time taken for land preparation and number of irrigation issues promised to farmers at the beginning. Many farmers did not have sufficient money to hire labor for intensive land preparation. Many of them could not obtain loans from banks during the 1992/93 maha season because they had not settled loans obtained during the previous maha.

Another reason was lack of irrigation supply for land preparation and allocation of less number of irrigation issues for the crop growth period. Many farmers thought that evaporation of soil moisture was high when raised beds were formed. Therefore, during maha 1992/93, most farmers did not construct raised beds for chili. However, farmers faced many problems due to the absence of proper land preparation. The major problem created was how to drain off the excess water when high rainfall was received during November and December. Also, farmers faced difficulties in irrigating the crops on unevenly prepared lands with flat beds when they received insufficient irrigation water.

Land preparation is very important for better crop performance under irrigated conditions. However, adoption of proper land preparation practices depends on many factors such as availability of cash, time of starting cultivation and number and time of irrigation issues allocated.

Assessment of Economic Performance of OFCs

Yield *Performance*. Four major crops - greengram, groundnut, soybean and chili -were tested. Average yields obtained are shown in Table **5.6** and indicate high variation in crop yields between the seasons. During both maha seasons, yields obtained were less than potential yields and average yields in other districts.

The greengram yield did not show a big variation between the seasons. However, compared to potential yields, farmers obtained low yields during all the seasons. During the 1989 yala season, in demonstration plots, farmers obtained a higher average yield - 650 kg per ha. Average greengram yield under irrigated conditions in other districts varied from 800 kg per ha to 1,000 kg ha indicating that average yield was very close to potential yield. According to the

yield analysis by soil class, greengram planted on well-drained soils gave a higher yield **than** greengram planted on imperfectly and poorly drained soils (Table ***5.7).***

Table ***5.6.*** Average crop yields for selected crops in Tract 3 of the Left Bank, by season.

	Greengram	Groundnut	Soybean	Chili
1991192 Maha crop demonstrations:				
Average kgha	511		458	4884
Minimum kg/ha	420		366	3012
Maximum kgha	840		1245	9544
Farmers' own cultivation:				
Average kgha	420	932		1483
Minimum kgha	278	796		968
Maximum kgha	928	1984		5868
1992193 Maha crop demonstrations:				
Average kgha	475	1423		750
Minimum kgha	240	1042		84
Maximum kg/ha	860	2223		3982
Farmers' potential yield kgha'	1250	2000	2000	10000

[a] Farmers' potential yields were obtained from the Techno Guide of the Department of Agriculture.

Table ***5.7.*** Average yields and net income of other field crops by different drainage classes **- 1991192** Maha season.

	Chili				Greengram				Soybean			
	1991/92 Maha		1992/93 Maha		1991/92 Maha		1992/93 Maha		1991/92 Maha		1992/93 Maha	
	Yield Kg/ha	Income Rs/ha	Yield Kg/ha	Income Rs/Ha	Yield Kg/ha	Income Rs/ha	Yield Kg/ha	Income Rs/ha	Yield Kg/Ha	Income Rs/Ha	Yield Kg/Ha	Income Rs/Ha
Well-drained	5,395	73,469	2,342	32,994	543	1,133	554	6,083	393	- 26	-	-
Intermediate/ Poorly drained	2,668	32,139	123	-3,552	318	624	403	3,452	1,245	9,682	-	-
Overall average	4,884	65,720	750	5,234	511	875	475	4,466	458	2,550	-	-

Groundnut was not tested during the demonstration program due to the lack of seed. However, a few farmers grew groundnut outside the demonstration area. Average yield was 932 kg per ha, nearly 50 percent of potential yield. During the 1992/93 maha season, farmers obtained reasonable yields. The average yield was 1,423 kg per ha. This was around 75 percent of potential yield. Yield variation in groundnut ranged from 1,042 kgs to 2,223 kgs per ha. Groundnut performed well on well-drained soils.

Soybean was tested only in the demonstration area during maha 1991/92. The average yield was 458 kg per ha, around 25 percent of potential yield. This was because farmers were not able to get a supply of inoculum. Soybean planted in other area gave much lower average yield - 180 kg per ha. Farmers did not grow soybean during maha 1992/93 due to marketing difficulties. Soybean gave higher yields on imperfectly and poorly drained soils during maha 1991192. However, it was not possible to test this during maha 1992/93 since farmers did not grow soybean.

The average yield of green chili varied from 4,884 kg per ha to 750 kg per ha during the study period. The highest average yield - 4,884 kg per ha - was obtained during crop demonstrations. This amount was below the potential yield of 10,000 kg per ha but comparable with the average yield obtained during crop demonstrations, during yala 1989. The average yield of chili during maha 1988/89 was 5,000 kg per ha. Green chili yield under irrigated conditions cultivated during yala seasons in other districts ranged from 4,800 kg per ha to 6,400 kg per ha. There were many reasons for the low chili yields in Tract 3, including cultivation of local varieties, low level of fertilizer application and the Occurrence of pests and diseases. Chili planted on well-drained soils gave higher average yields compared to chili planted in other soil types as shown in Table *5.7.* Poor yield during maha 1992/93 was due to leaf-curl disease and high rainfall during November.

Results show a high yield variation in OFC cultivation between seasons and within seasons. Yield variation within seasons was mainly due to soil and land variations and different levels of crop management. Yield variation between seasons was due to weather conditions and occurrence of disease. Other reasons were low levels of fertilizer application, less intensive land preparation and use of low yielding crop varieties.

Input Use

Labor Utilization. In general, most OFC cultivation is labor intensive. Labor used for OFC cultivation in the sample area is shown in Table **5.8.** In 1991/92 maha season, labor utilization in the demonstration area was high due to intensive land preparation and intensive crop care methods. If the labor utilization is compared across the seasons, except for chili, labor utilization in 1992/93 was higher than during the 1991/92 maha season. The extra labor was used for clearing land which had become covered with weeds and shrubs since there was no cultivation during the previous yala season. The chili crop utilized less labor during the 1992/93 maha season because land was less intensively prepared resulting in a low yield.

Table 5.8. Labor use in other field crop cultivation in FC 3 and FC 4, Tract 3 of the Left Bank, by season (labor days per hectare).

	Chili		Greengram		Groundnut	
	Days	%	Days	%	Days	%
1991/92 Maha Season						
Demonstration plots						
Family	477	73	88	62	116	89
Hired	180	27	53	38	13	11
Total	657	100	141	100	129	100
Farmers' own cultivations						
Family	159	64	72	86	65	71
Hid	88	36	I2	14	27	29
Total	247	100	83	100	92	100
1992/93 Maha Season						
Family	132	82	95	81	92	14
Hired	29	18	22	19	33	26
Total	161	100	117	100	125	100

In general, the labor requirement for high value OFCs is high compared to paddy. The data show that during both seasons, farmers depended on family labor. If more intensive cultivation practices were to be adopted, the labor requirement would increase and farmers would have to use more hired labor. Also, if the percentage of high performance crops such as chili, onions or gherkins is increased, total labor demand would be further increased and a labor shortage could be created. An increase in labor demand above the current level might result in an increase in wages, which would further reduce the profitability of OFC cultivation.

In the long run, the labor market would adjust itself to accommodate an increase in demand. In the short run, however, it is quite likely that the introduction of labor intensive crops on a wide scale would be constrained by the labor available on the local labor market.

Capital Requirement. Capital requirement is defined as total current input cost plus fixed capital and hired labor costs. Capital required for most high value crops like chili is higher than for paddy. Capital required during maha 1992/93 was more realistic because land preparation was done by the agency during maha 1991/92. During crop demonstrations, the capital required for chili was four times more than for other crops. During maha 1992/93, capital investment for chili was low compared to the previous season mainly because local seed varieties were used and cash was lacking. Also, farmers were reluctant to apply fertilizer and chemicals under supplementary imgation conditions and, in any case, local chili varieties do not require much fertilizer.

Capital required for greengram and groundnut was comparable with that for paddy. When these crops were cultivated during crop demonstrations, a higher capital investment was required than when cultivated by farmers mainly due to the lack of fertilizer use. The average capital required for the cultivation of greengram and soybean during maha 1991/92 under farmer management was **Rs** 3,669/- and **Rs** 5,641/- per ha, respectively. During maha 1992/93, capital required was **Rs** 5,0771- and **Rs** 5,927/- per ha, respectively.

During the 1991192 maha season, farmers depended on bank loans but during the 1992/93 maha season, only **30** percent obtained bank loans. Therefore, farmers found it difficult to find the required cash for cultivation which in turn resulted in low applications of inputs like chemicals and fertilizer. Many farmers could not settle bank loans because they did not earn sufficient income from maha 1991192 cultivation and the majority of them did not earn any income during the yala season since there was no cultivation in irrigated allotments.

Economic Returns. To assess economic returns, gross value added and farmer incomes were used as indicators. Economic returns to farmers are presented in Tables **5.10, 5.11 and 5.12.** **Gross** value added and farmer incomes generated from **OFCs** are estimated to assess incomes to farmers. Economic returns from **OFCs** planted in demonstration plots are analyzed separately and the results presented in Table ***5.9.***

Economic Returns in Demonstration Plots. Among the crops tested, chili gave the highest average gross value added and average farmer income as indicated in Table ***5.9.*** The average **gross** value added and average farmer income for chili was **Rs** 82,487/- and **Rs** 65,7201- per ha, respectively. Low returns were reported for greengram and soybean. The average gross value added and farmer income for greengram was **Rs** 6,174/- and **Rs** 875/- per ha, respectively. The average gross value added and farmer income for soybean was **Rs** 4,359/- and Rs 2,550/- per ha, respectively.

Economic Returns Under Farmer Management. During the study period - maha 1991/92 and maha 1992/93 - chili proved the most profitable crop. However, the economic performance of chili during the 1992/93 maha season was very low compared to its performance during maha 1991/92. The average farmer income from chili was Rs 18,540/- during maha 1991/92 and **Rs** 5,2341- during maha 1992193. This was mainly due to a low average yield during the 1992/93 maha season. It is interesting to **see** that current input cost has declined by nearly 50 percent during the 1992193 season. The low application of inputs may have contributed to the low level of yields. Decline in price of green chili during the 1992193 maha season also contributed to the decline in economic returns.

Performance of greengram did not change much over the study period. Gross value added and farmer incomes during the 1991192 maha season were **Rs** 7,331/- and **Rs** 6,409/- per ha, respectively.

Table 5.9. Yields, labor requirements, and costs and returns of other field crops under irrigated conditions in other field crop demonstration, Tract 3 of the Left Bank -1991192 Maha season.

	Chili	Greengram	Soybean
Average yield (Green chili Kg/ha)	4,884	511	458
Price (Rs/Kg)	21.35	22.14	20.00
Gross revenue (Rs/ha)	104,266	11,320	9,160
Factor costa (Rs/ha)			
Current inputs:			
Seed	679	988	1,383
Fertilizer	10,059	2,470	2,470
Chemical	11,779	1,688	948
Sub-Total:	21,779	5,146	4,801
Fixed capital	355	406	165
Labor:			
Family	59.151	12,666	15,069
Hired	16,412	4,893	1,644
Total:	75,564	17,559	16,714
Value added (Rs/ha)	82,487	6,174	4,359
Farmers' income (Rs/ha)	65.720	875	2.550
Land and surplus (Rs/ha)	6,569	-11,790	-12,538
Labor productivity (Rs/day)	159	80	70
Water productivity (Rs/M³)	5.70	1.24	1.00
Water requirement M³	15,600	9,130	9,130

Value added	=	Gross revenue (Cost of current inputs).
Farmers' income	=	Gross return (Cost of current inputs + fixed capital + cost hired labor).
Land and surplus	=	Gross return (Total factor costs).
Labor productivity	=	Gross revenue/Total labor.
Water productivity	=	Gross revenue/Total water requirement.

Table 5.10. Yields, labor requirements, and costs and returns of other field crops under irrigated conditions in farmer-owned fields, Tract 3 of the Left Bank, 1991192 Maha season.

	Chili	Greengram	Groundnut
Sample size	25	1	6
Yield (Green chili Kg/ha)	1,483	420	932
Price (Rs/kg)	23.08	24.00	18.00
Gross revenue (Rs/ha)	34,237	10,078	16,776
Factor costs (Rs/ha)			
Current inputs:			
Seed		807	2,500
Fertilizer	1,333	0	0
Chemical	4,793	1,940	115
Sub-Total:	6,126	2,747	2,615
Fixed capital	333	0	0
Labor:			
Family	19,772	9,547	9,416
Hired	9,238	922	3,026
Total:	29,011	10,496	12,442
Value added (Rs/ha)	28,111	7,331	14,161
Farmers' income (Rs/ha)	18.540	6.409	11.135
Land and surplus (Rs/ha)	-1.232	-3.138	1.719
Lahor productivity (Rs/day)	139	121	182

Table 5.11. Yield, labor requirements, and costs and returns of other field crops under supplementary irrigation conditions, Tract 3 of the Left Bank - 1992/93 Maha season.

	Chili	Groundnut	Greeneram
Sample size	25	14	13
Yield (Green chili Kg/ha)	750	1,423	475
Price (Rs/kg)	18.00	23.00	23.00
Gross revenue (Rs/ha)	13,500	32,729	10.925
Factor costs (Rs/ha)			
Current inputs:			
Seed	466	2,070	2,027
Fertilizer	1,151	0	0
Chemical	2,118	479	750
Sub-Total:	3,735	2,549	2,777
Fixed capital	1,842	1,577	1,382
Labor:			
Family	11,225	7,779	8,641
Hired	2,689	3,378	2,300
Total:	13,914	11,157	10,941
Value added (Rs/ha)	9,765	30,180	8.148
Farmers' income (Rs/ha)	5,234	25,225	4.466
Land and surplus (Rs/ha)	-5,991	17,446	-4,175
Labor productivity (Rs/day)	84	262	93

During 1992/93, it was **Rs** 8,148/- and **Rs** 4,446/- per ha, respectively. Results show that there was a slight decline in farmers' income over the period despite higher yield. This is mainly due to decline in output prices and land preparation cost during 1992/93.

Economic returns from groundnut improved during the 1992/93 **maha season. Gross** value added increased from Rs 14,161/- during maha 1991/92 to **Rs** 30,180/- during maha 1992/93. Farmer incomes rose from **Rs** 11,135/- per ha to **Rs** 25,225/- per ha during the same time period. This improvement was mainly due to increases in yield and prices. The price **of** groundnut rose from **Rs** 18/- per kg to **Rs** 23/- per kg during the study period.

The variation in economic returns of OFCs during the 1991/92 maha season was also analyzed by soil type and is presented in **Table 5.7.** Chili and greengram performed well on well-drained

soils. Farmer incomes from chili and greengram cultivated on well-drained soils gave a 50 percent higher return than when these crops were cultivated on imperfectly drained soils. Soybean performed better on imperfectly drained soils. Crops planted on ill-drained soils were completely destroyed by excess water during maha 1991/92. These results suggest that in-seasonal variation in the economic performance of OFCs is due mainly to variations in soil type and indicates that the cultivation of most OFCs in imperfectly and ill-drained soils during maha seasons would be uneconomical.

In summary, the study shows that there is high variation in the economic performance of OFCs within seasons and between seasons. In-seasonal variations are mainly due to variations in soil and drainage conditions while seasonal yield variation is mainly due to variations in weather conditions and the Occurrence of diseases. Also, poor crop management practices and inadequate land preparation methods and low application of fertilizer, particularly for chili, resulted in low yields.

However, under the given conditions, chili is the most profitable crop of all OFCs tested during the study period, although performance in the study area was not satisfactory compared to performance in other regions. However, there is potential to improve performance through the adoption of better land preparation methods, adequate fertilizer application and use of improved seed varieties. It should be noted that there is high risk in cultivating chili on imperfectly drained soils during the maha season. Soybean seems to be more suitable to imperfectly drained soils. However, market constraints exist for this crop. Groundnut seems to be a more appropriate crop than greengram and soybean in terms of yield and economic returns. Finally, the study shows that there are less opportunities for cultivating OFCs for farmers with imperfectly and poorly drained soils.

Extension of Maha Cultivation into the Yala Season. During the 1992 yala season, a few farmers planted a second crop during the months of February and March, soon after harvesting the maha crop. Although the extent cultivated was negligible, the cultivation season extended into yala 1992 with water from dug wells. The percentage extent cultivated in FCs 3 and 4 was three percent of total extent in these FCs. During the 1993 yala season, 16 of the 33 farmers (48.5 percent) in FCs 3 and 4 extended their maha cultivation into yala. Most of these cultivations were done in the middle section of the FCs due to the availability of groundwater closer to the surface in these reaches. Cultivation of OFCs in other FCs was negligible. Data was collected to assess incomes which could be generated from yala cultivations.

Groundnut and lima beans were the major crops cultivated by farmers. A few cultivated onions and vegetables on small extents. The average extent cultivated was 0.27 ha for groundnut and 0.21 ha for lima beans, roughly 33 percent of the allotments.

Crops were established with the rain received during March. The final irrigation issue of the maha season was used to establish the crop. Rainfall received during March and April was very useful for crop growth. The observations made on water levels in dug wells indicate that there

was sufficient well water to hand water crops up to July. However, it is not possible to say whether all farmers could utilize water from dug wells for yala cultivation.

Farmers used the last water issues made during the maha season to establish groundnut crops, and as no irrigation issues were made during yala, the crop matured under rainfed conditions. Water from dug wells was used only to hand water vegetables like onion and beans.

Yields and Economic Returns from the Yala 1993 Cultivation. Yields and costs and returns are shown in Table 5.12 and indicate farmers obtained reasonable yields from groundnut under rainfed condition. The low extent of land cultivated could be one reason for achieving better yields. Low cash input, low production and higher prices increased profits. It was observed that yield and profit variations were low.

Table 5.12. Yield, costs and returns of other field crop cultivation in Tract 3 of the Left Bank - 1993 Yala season.

	Groundnut	Lima beans
Yield (Kglha)	611	1,254
Price (Rs/kg)	28.00	6.30
Gross income (Rslha)	17,108	7,500
Inputs (Rslha)	3.013	479
Hired labor (Rslha)	792	-
Farmers' income (Rslha)	13,303	7,421
Average extent cultivated (ha)	0.27	0.21
Farmers' income (Rs)	3,552	1,558

Incomes generated from the yala cultivation provided extra cash to farmers. Total income received per farmer was low due to the low extent cultivated per farmer. It is not possible to suggest whether all farmers could earn additional income by extending maha cultivation into yala under present conditions. However, this kind of yala cultivation could be further improved by providing a few irrigations.

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5.4.2 Other Field Crop Cultivation In the Ellegala Irrigation System During Yala 1993

The objective was to test the possibility of growing OFCs in the Ellegala during yala when water is short. The study was conducted in Pihille Yaya in the Tissa wewa command during yala 1992 and in Tissa wewa, Weerawila wewa and Yoda wewa during yala 1993.

Seasonal Planning During Yala 1992 - Yala 1992 was a water short season for the whole Kirindi Oya System, so a meeting was organized by the Project Manager of the Irrigation Management Division during the first week of April to inform farmers that the water situation in the reservoir was critical and irrigation supply during the season doubtful. He requested farmers in Pihille Yaya to grow short duration OFCs. The Pihille Yaya farmers' organization agreed but other farmers in the Ellegala did not expecting sufficient inflow later during the season to permit a paddy cultivation.

Cultivation - Land preparation in Pihille Yaya began during the latter part of April. Land preparation took one day per ha. Almost all farmers used four-wheeled tractors with harrows. Residual soil moisture was sufficient for this operation. Land preparation was rudimentary and no furrows or beds were constructed. Tractor costs for harrowing was about Rs 1,729/- per ha and was done for crops such as greengram and cow pea.

The majority of farmers had established their crops by the last week of April, making use of late April rains. Fifty percent of the extent cultivated was planted with greengram. Other crops included vegetables like long beans - the major vegetable cultivated - and tomato, okra, etc. A few farmers cultivated cowpea. Only two farmers planted chili.

Greengram seeds were sown on harrowed land. This took less than half a day for two acres. The high plant density reduced the weed problem to a great extent. Cowpea was planted with some spacing. Chili plants were planted in some fields and drains constructed around and across the large liyaddas. Vegetables were also planted with some spacing.

Crop care was minimal with very few labor days spent on weeding. Almost all farmers used chemicals for pest control. The mosaic virus which normally affects greengram did not occur during the season.

Irrigation - No surface imgation was possible and crops matured using residual soil moisture and yala rainfall. Rainfall in May exceeded the 50 percent probability level.

Many farmers used water from shallow dug wells to water their vegetable plots.

Rainfall received during this period is given below.

Month	Rainfall (mm)	Rainfall at 50% Probability (mm)
April	74	91.44
May	119	60.96
June	18	22.86
July	13	15.24
Total	224	190.5

Seasonal Planning During Yala 1993. Water available in the main reservoir was 10,000 acft at the beginning of April. It was estimated that 3,500 acft would be needed for late paddy cultivations in Tracts 1 and 2 of the Left Bank. At the Project Management Committee meeting, farmer leaders were told that it would be impossible to carry out a total paddy cultivation in the whole of the Ellegala with the available water. Officers proposed that part of the Ellegala should be cultivated with OFCs. They also proposed that the available water should be allocated to each tank based on their command areas instead of on a priority basis.

A special meeting was held with farmer leaders to discuss how water should be allocated. During the meeting it was agreed to share available water according to command area. Farmers in each tank were to discuss and select areas for both paddy and OFC cultivation. Several farmer meetings were held to discuss a seasonal plan and finally it was agreed that water would be allocated to the five tanks according to command area and that both OFCs and paddy be cultivated.

Cultivation. According to the decision made at the Kanna meeting, water issues for paddy were to commence by the first week of May. However, water issues started much later due to disagreements over yala cultivations.

Areas selected for paddy and OFCs under each tank were as follows:

Tank	Paddy	OFC
Debara wewa	Low level MC	High level MC and Western and Eastern high level MCs
Tissa wewa	Low level MC	Pihille Yaya
Yoda wewa	High level MC	Low level MC
Weerawila wewa	DC6 to DC12	DCI to DC5
Pannegamuwa	Other area	DC1, DC2 and DC3
Gamunupura	-	All

In the sample area, the majority of farmers (23) cultivated greengram. Other farmers cultivated groundnut and blackgram. One farmer reported cultivating red onion.

Time of crop establishment is shown below:

Tank	Period
Weerawila wewa	3rd to 4th week of Mav
Tissa wewa	2nd to 3rd week of May
Pihille Yaya	4th week of April to 1st week of May
Yoda wewa	1st to 2nd week of May

The results show that Pihille Yaya farmers started cultivation at the correct time. Weerawila and Tissa farmers established their crops much later than farmers in other areas. The main reason for this is that Pihille Yaya and Yoda wewa farmers are more experienced in cultivating OFCs during yala. According to proper agronomic practice, greengram should be planted before mid-May to avoid the virus disease.

Rainfall received during the season is given below:

Month	Rainfall
April	30
May	120
June	33
July	46
Total	229

During yala 1992, farmers could not utilize rain for crop establishment because they **started** cultivation late. However, rainfall received during the fourth week of May (25 mm) was utilized for crop establishment.

It was agreed that few irrigations would be given for OFCs, but since farmers were not interested in receiving these water issues, distributaries and field canals were not cleaned. Weerawila farmers who had lands close to the main canal were at an advantage because they could get water from the main canal when water was being conveyed to paddy cultivated areas.

Many farmers said that they needed water for greengram at the latter stage. In most places, the greengram crop died after the first harvest due to lack of water.

Crop *Performance During Yala 1992*

Greengram performed well during the season. Average yield was 997 kg per ha, very close to the potential yield of 1.2 tons per ha. Five of the 15 farmers received very high yields - over 1,000 kg per ha. Yield variation was low during the season and ranged from 548 kg per ha to 1,286 kg per ha.

Most vegetable crops did not perform well due to pest attacks. Chili cultivation was negligible. Only two farmers grew chilies in a small extent. Chili crops failed due to lack of water and minimal crop care.

Crop Perfonnance During Yala 1993

Data on greengram, groundnut and cowpea were collected to evaluate crop performance. Since the majority of farmers cultivated greengram, sample areas for other crops were small. Crop yields and yield distribution collected from the intensive sample and large scale survey are presented in Table **5.13.** In general, both sets of data show low crop yields.

Greengram yields were low everywhere. Average yields in the intensive and survey samples were 562 kg per ha and 420 kg per ha, respectively. In the intensive sample, yields varied from 99 kg per ha to 1,186 kg per ha. As during yala 1992, Pihille Yaya farmers obtained higher yields compared to farmers in other areas. Four farmers obtained very higher yields above 1,000 kg per ha. **Three** were from Pihille Yaya and the other from Yoda wewa. These farmers had established their crops during late April.

Table 5.13. Yield **distribution of crops by area - 1993 Yala season.**

Tank	Crop yield (kg/ha)					
	Intensive sample			Survey data		
	Green-gram	Ground-nut	Cow pea	Green-gram	Ground-nut	Cow pea
Weerawila	308	494	247	352	636	-
Tissa wewa	647	-	-	374	443	-
Pihille Yaya	770	-	-	-	-	-
Yoda wewa	554	-	-	510	-	-
Gamunupura	-	-	-	66	494	-
Total	562	494	247	420	546	

Average groundnut yields in the intensive and survey samples were 494 kg per ha and 546 kg per ha, respectively. Farmers in the intensive sample reported that the main reason for low yields was crop damage by seepage water and poor drainage.

The main reason for crop failure of greengram during yala 1993 was a high occurrence of pests and diseases. Many farmers in Weerawila said their crops were damaged by seepage water from the main canal.

Another reason for low yield was that many farmers lacked experience and knowledge about drainage and, therefore, found it difficult to select suitable areas for cultivation of OFCs. To some extent salinity also affected crops, particularly in the Yoda wewa area. Crops died in patches and white patches were observed indicating salinity. These patches appeared where there were micro depressions.

Economic Returns from OFC Cultivation

The economic performance of **OFCs** during 1992 and 1993 yala seasons are shown in **Table 5.14.** According to the data farmers received higher economic returns from greengram in 1992 yala season than that in 1993 yala season (**Rs** 20,600 per ha versus **Rs** 6,940). This was mainly because farmers received a higher yield and a higher price **in** 1992 yala.

Returns from cowpea during yala 1992 were low compared to greengram - Rs 11,791/- per ha. Net return from cowpea was nearly 50 percent less than that from greengram. But returns during yala 1992 were better than for greengram during yala 1993. Farmers could not get a good return from cowpea during yala 1993. The two farmers who cultivated cowpea received negative returns.

Cultivation of long bean was a loss to farmers. The average loss was Rs 2,371/- per ha. Many farmers had problems marketing their vegetables. The main problem they faced was low prices. The average price for this vegetable was Rs 5/- per kilo with some farmers getting only Rs 3/- per kilo.

Table 5.14. Costs and returns of other field crops under supplementary irrigation cultivated in the Old Ellegala System during 1992 and 1993 Yala season.

	1992 Yala		1993 Yala		
	Greengram	Cowpea	Greengram	Groundnut	Cowpea
Average yield (Kg/Ha)	997	873	562	494	247
Sample size	19	3	23	2	2
Price (Rs/Kg)	28.5	19.00	25.00	24.00	18.00
Gross revenue (Rs/Ha)	28,415	16,591	14,050	11,856	4,446
Factor costs (Rs/Ha)					
Current inputs:					
Seed			862	2,418	808
Fertilizer					
Chemical			1,128	724	2,300
Implements			1,669	1,615	1,782
Labor			3,451	4,545	1,482
Total cash cost (Rs/Ha)	7.815	4,800	7,110	9,302	6,444
Farmers' income (Rs/Ha)	20.600	11,791	6.940	2,554	-1,998

Income from groundnut under rainfed conditions was very low compared to greengram. However, despite low yields, groundnut was profitable. Farmers were able to get an average income of Rs 2,554/- per ha from higher prices and the low cost of cultivation. Total income per farm family was low (Rs 1,532/-) because area cultivated was low with average area under groundnut 0.6 ha.

Constraintsfor Crop Diversification in the Ellegala. Results show that even with poor yields, farmers can earn a profitable income from OFCs, though it is difficult to draw any conclusion on the profitability of OFC cultivation in the Ellegala during yala based on the above results.

This is because this was the first season OFCs were cultivated on a large scale and many farmers did not have sufficient knowledge on how to cultivate OFCs on irrigated lands. One of the main reasons for poor yields during the season was late cultivation due to delays in decision-making at project level.

Cattle was another problem. Many farmers said that dates fixed for removing cattle from fields were too close to the date fixed for first water issue. Kanna meetings should be held in early April to avoid this problem.

All lands alongside main canals were selected and so farmers whose lands were not suitable also cultivated OFCs. It was observed that OFCs failed in lands containing light textured soils because these lands received seepage water from the main canal.

Major economic constraints were fluctuations in output price and yield variation. Farmers received low prices compared to the previous yala season. Since this is most probably due to increase in production, there is danger in increasing OFC cultivation during yala. Profitability also depends on payment of land rent. If farmers have to pay rent they may not be willing to cultivate OFCs.

5.4.3 OFC Cultivation Under Dug Wells

Under the dug well program, farmers constructed 17 wells but only 10 were operated. Water levels in five of these wells were monitored weekly. Most wells had sufficient water for pumping at the beginning. Only eight wells had sufficient water for irrigation between August and October. Weekly water levels in five wells are given in **Table 5.15.** The data shows no significant reduction in water levels. During November and December, water levels rose due to high rainfall and increased water in the reservoir.

The presence of water in dug wells during the drier months is due to their location close to the reservoir and to the river. It is doubtful similar conditions exists in other downstream tracts but many farmers in other tracts cultivated OFCs during yala using water from dug wells constructed on the axis of the valleys. A detailed study is necessary to evaluate the possibility of tapping groundwater in other tracts during the yala season. It may also be possible to tap groundwater in other tracts during the yala season. It may also be possible to tap groundwater during maha in downstream tracts when water is flowing in the main canal. This could provide an opportunity for farmers to cultivate OFCs during maha when they do not receive water for paddy.

Crop Performance

Most farmers got low yields compared to farmers in other locations such as Tract 3 of the Left Bank. Average chili yields were nearly 50 percent lower than average yields in Tract 3 during maha 1991/92. Average chili yield was 23 percent of potential yield and average big onion yield was 27 percent of potential yield.

Table 5.15. Fluctuation of water table in dug wells - 1992 Yala season (in feet).

Date	302	305	307	309	312
1 Jul '93	10.6	12.2	14.1	14.8	15.0
7 Jul '93	10.7	13.2	14.7	15.6	14.8
14 Jul '93	11.0	15.1	15.0	15.6	14.2
21 Jul '93	11.1	14.9	15.2	15.1	14.9
30 Jul '93	10.3	14.2	15.6	15.1	14.4
9 Aug '93	10.8	14.5	15.2	15.0	14.3
15 Aug '93	10.6	14.6	14.9	15.1	14.5
22 Aug '93	10.4	14.8	14.3	15.4	14.6
28 Aug '93	10.6	na	16.0	16.5	na
9 Sep '93	10.9	16.0	16.2	16.5	14.6
19 Sep '93	11.0	16.3	16.7	16.5	15.0
30 Sep '93	na	16.7	16.4	16.7	na
9 Oct '93	11.6	17.9	16.1	11.3	na

Note: Water table measured from the ground level. na = not available

The main reasons for low yield were high occurrence of diseases, low input application and minimal crop care. Fertilizer application for chili was nearly 50 percent less than in Tract 3 during maha 1991/92. Chemical application for chili was Rs 7,6441- per ha, nearly Rs 4,000/- less than during maha 1991/92, mainly because farmers lacked cash to apply chemicals and fertilizer. Lack of experience also could have contributed to low yields.

Economic Performance of OFCs

The economic performance of **OFCs** under the dug well program **is** shown in **Tables 5.16 and 5.17. Table 5.16** shows that the economic performance of all crops during the season was unsatisfactory mainly due to poor yields and low output prices. Of the four crops, ash pumpkin gave the highest income to farmers. Producer prices for chili and big onion were low. Green chili price during maha 1991/92 was Rs 21.35/- per ha. The low price for big onion was due to over production in other areas.

Table 5.17 shows whole farm analysis. Seven farmers of 16 cultivated more than one crop. Cultivated extent varied from 0.13 to 0.7 ha. Five farmers got negative returns and losses were high.

From he results of the study, it is difficult to conclude that OFC cultivation under dug wells was uneconomical when the success of farmer Jinadasa is considered. Although no input output information was obtained from him, it was observed that he obtained a good income.

Table 5.16. Performance of non-rice crops cultivated using water from dug well in Tract 1 of the Right Bank - 1992 Yala season.

	Chili	Big onion	Brinjol	Ash pumpkin
Yield (kg/ha)	2.285	5.558	11.940	-
Average price (Rs/kg)	17.00	12.00	8.00	-
Gross revenue (Rdha)	36,975	63,603	95,520	2,160
Cost of cultivation (Rslha):				
seeds	Free	Free	-	-
Fertilizer	4,461	4,631	8,522	1,081
Chemicals	7,641	11,276	19,489	489
Fuel	4,249	7,101	5,009	1,772
Fixed capital	-	-	-	-
Hired labor	20,209	40,199	37,080	2,979
Net income to farmer (Rdha)	412	396	25,420	15,279

His success which seems to be based on experience, high input use, high level of crop management and timely cultivation. Timely cultivation seems to be a key factor but in the case of dug well cultivation, there is no constraint on time of planting since cultivation does not depend on irrigation water. However, paddy cultivation during maha could prevent early planting of OFCs. Farmer Jinadasa opted to cultivate OFCs even during the maha season. He studied market behavior in making decisions on time of planting and crop selection. He also has a sound economic base and can go for high risk OFC cultivation. Although farmer Jinadasa is an exception, he proved that OFCs can be successfully cultivated through optimum utilization of available resources.

In summary, cultivation of OFCs in the newly developed area during yala is possible using dug wells. However, it may be not possible to cultivate the entire extent in a tract because groundwater may not be available in allotments away from the river or main canal. Since the groundwater table improves during maha, farmers in the newly developed area, who do not cultivate paddy could cultivate using dug wells. During yala, farmers with lands close to the reservoir or river could cultivate OFCs.

Farmer	Total extent	Chili		Onion		Brinjal		Beans		Ash pumpkin		Total	
		Cost	Net income	Cost	Net income	Cost	Net income	Cost	Net income	Cost	Net income	Cost	Net income
Sumanapala	0.20	3890	1478	-	-	-	-	-	-	-	-	3890	1478
Jayathilaka	0.30	9010	-766	-	-	-	-	1350	900	-	-	-	-
Drensis	0.13	-	-	-	-	-	-	-	-	1125	1675	1125	1675
Piyadasa	0.34	-	-	2755	-355	16240	7297	-	-	-	-	18995	6962
Pathmasiri	0.70	18400	-10785	24230	3270	-	-	-	-	-	-	42630	-7515
Dharmadasa	0.20	5862	1035	-	-	-	-	-	-	-	-	5862	1035
Wilson	0.70	13695	-131	-	-	-	-	-	-	2090	6410	1585	6279
Mahinda	0.20	8060	2103	-	-	-	-	-	-	-	-	8060	2103
Wilson	0.50	14682	-2463	-	-	18400	8430	-	-	-	-	33082	5967
Chandradasa	0.20	-	-	-	-	13860	5324	-	-	-	-	13860	5320
Paliakkara	0.20	5005	5113	-	-	-	-	-	-	-	-	5005	5113
Chandrasiri	0.30	8000	1107	-	-	-	-	-	-	-	-	-	-
Abeyasinghe	0.20	5130	-38	-	-	11240	4400	-	-	-	-	5130	-38
Piyadasa	0.26					10680	6920			300	3000	11540	7400
Nanayakkara	0.50	4675	1325				-					15355	11245
Piyadasa	0.20	11232	-431									11232	431

5.5 A COMPARATIVE ANALYSIS OFC CULTIVATION IN KIRINDI OYA

The Inception Report (Sections 3.5 and 3.7; p 57) indicated that the following outputs would be realized at the end of the Phase II study.

a) The feasibility of growing **OFCs** during both the maha and yala seasons in **NIS.**

b) Harmonizing irrigation management inputs and crop production inputs would be better understood.

c) Improved strategies for proper water delivery at turnouts and methods of sharing water equitably below the turnout with respect to irrigated diversified cropping would be worked out.

d) Farmer incomes which could be derived from two acres **of** irrigated lands where only irrigated **OFCs** are grown would be ascertained.

e) Recommendations for cultivating irrigated **OFCs** would be made.

Except for c, significant results were obtained in respect of the other four and conclusions can be drawn from the results reported earlier.

5.5.1 Feasibility of Growing OFCs During Both Maha and Yala Seasons in the NIS

The seasonal planning procedure which is now well integrated into the main system management component ensures a rational allocation of the available seasonal supply to the three proposed zones: Zone 1 - Tracts 1 and 2 of the Right Bank, Zone 2 - Tracts 5, 6 and 7 of the Right Bank and Zone 3 - Tracts 1 and 2 of the Left Bank. This zoning is based on probable inflow into the main reservoir and entails a ceratin proportion of the command area of the **NIS** (those areas which do not receive water for paddy) cultivating **OFCs** during the maha season by maximizing use **of** rainfall with supplementary irrigation whenever necessary.

Cultivation of OFCs During Maha Season

The extent of **OFCs** cultivated in the different tracts during the three maha seasons of 1991/92, 1992/93 and 1993/94 is given in Table **5.18.**

Taking into consideration the fact that prior to maha 1991/92 land in the command areas of all the tracts listed in Table **5.18** had remained fallow during the maha season, the emerging trend of making use of rainfall and supplementary irrigation during the maha season can be considered a positive development.

The increase in **OFC** extent since **1992/93** maha is mainly due to the introduction of the seasonal water allocation plan. However, much of the **OFCs** cultivated in **LB** Tracts **1** and **2** during the **1992/93** maha season was destroyed due to the early issue of water for paddy. During **1993/94** maha season, **LB** Tracts **1** and **2** farmers had to grow **OFCs** according to the seasonal water allocation plan. However many farmers did not want to grow **OFCs** expecting water for paddy cultivation as during the maha **1992/93.**

Cultivation of OFCs During ***Yala Season.*** Extents of **OFCs** cultivated in corresponding tracts over yala **1990, 1991, 1992** and **1993** are given in **Table 5.19.**

Unlike during the maha season, there is a severe constraint of irrigation supply during the dry yala season. The data in **Table 5.19** should therefore be viewed against the high variability in shortage making it impossible to plan cultivation of **OFCs** in any part of the NIS. The small extents of **OFCs** cultivated during the yala seasons were done with supplementary irrigation from dug wells.

Table 5.18. Extent of OFCs cultivated in different Tracts during Maha 1991192, Maha 1992/93 and Maha 1993/94.

	Maha 1991/92	Maha **1992193**	Maha 1993/94
Right Bank			
Tract 1		**90.5**	**6.4**
Tract **2**	**44.1**	**1.4**	**0.2**
Tract 5		1.1	1.7
Tracts 6 **&** **7**		55.5	4.5
Left Bank			
Tract 1	**20.0**	**64.2**	**79.0**
Tract **2**		**256.9**	**112.3**
Tract **3**	**77.9**	**92.2**	68.8
Total	**142.0**	**561.8**	262.9

In the long-term, cropping intensity in the NIS during maha, made up of both irrigated paddy and rainfed **OFC** cultivation with supplementary irrigation, could be 85 to **90** percent. This cropping intensity could be achieved through full cultivation of paddy in tracts which receive irrigation during maha and the extents of well-drained soils in the remaining tracts which would receive the normal maha rainfall plus supplementary irrigation for **OFCs.**

Table 5.19. Extent of OFCs cultivated during yala 1990, 1991, 1992 and 1993.

	Yala 1990	Yala 1991	Yala 1992	Yala 1993
Right Bank				
Tract 1	-	-	45.8	18.3
Tract 2	-	-	29.0	19.2
Tract 5	na	-	2.4	6.1
Tract 6 & 7	na	-	2.9	90.5
Left Bank				
Tract 1	na	na	17.5	33.6
Tract 2	na	na	20.6	34.8
Tract 3	-	-	1.2	14.4
Total	249.8	239.8	118.3	216.2

Note: na = not available

Cropping intensity during yala seasons would however be determined by the water available. Whenever there is a significant supply available in the Lunugamvehera by late January, the tendency has been for tracts which did not receive irrigation during maha to do a 'meda' paddy from late February to June. Present cropping patterns are expected to change with the introduction of the seasonal water allocation plan which would allocate 20 percent of yala inflow from the main reservoir to the NIS for a yala cultivation. The water is expected to provide supplementary irrigation for OFC cultivation. Supplementary irrigation and water from dug wells should be sufficient to bring cropping intensity to at least 25 percent. This could be further improved by bringing more lands under semi-permanent crops such as banana which need few irrigations between June and August. Banana cultivation should, however, be limited to upper tracts like Tracts 1 and 2 of the Right Bank and Tracts 1 and 2 of the Left Bank.

Use of Rainfall. **Figure 5.4** gives the monthly 75 percent rainfall probability based on 96 years of unbroken records **for** Tissamaharama. As the figure **shows** and as indicated in **Table 5.20,** only the months of October, November nd December have rainfall values nearer to evaporation values and in all other months, evaporation outstrips rainfall values, thus indicating the importance **of** irrigation for these months.

Figure 5.5 gives the 1:1 confidence limits of rainfall based on 3-weekly moving totals indicating weeks where a large range of confidence limits exit. As one an see, it is only in maha, that a considerable amount of rainfall can be used for growing OFCs while in yala, farmers need

to supplement with irrigation or else the soil must have sufficient residual moisture left over from Maha for use during Yala in conjunction with Yala rainfall.

Apart from the lack of water during Yala, many farmers face problems protecting their **OFCs** from stray cattle. By bringing more farmers into Yala cultivation, this problem could be limited to some extent. However, a permanent solution to the cattle problem is expected in the near future.

Table **5.20:** Climatic Data - Tissamaharama

Month	Rainfall (1872-1987) **Mean** Monthly mm	**75%** Probability mm	Evaporation (Penman) - 20 Year Average mm
January	101	51	132
February	36	15	157
March	75	38	171
April	93	69	153
March	61	31	165
June	23	10	185
July	15	5	201
August	12	0	215
September	34	10	210
October	141	**84**	167
November	223	155	121
December	154	94	120
Total	968	562	1997

5.5.2 Pilot Testing of OFCs in Tracts in the **Left** Bank

In order to maximize the use of the limited inflow, every attempt should be made to optimize the use of the seasonal rainfall. Bearing in mind the high variability in rainfall both during the season and between seasons, maximum use should be made of weekly probability values of past seasonal rainfall. This has been done with the weekly rainfall data for Tissamaharama available for the period 1872 to 1967.

Based on rainfall probability, it was proposed that cultivation of <u>low performance crops</u> like groundnut and greengram should commence with the onset of seasonal rains during the first and second weeks of October. To avoid moisture stress during the crop growth period, irrigation issues should be made during the latter weeks of December or **early** January, depending **on**

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rainfall. Commencement of cultivation of low performance crops after receiving 70 mm of cumulative rainfall is most appropriate. Most of the rainfall during November and December should be used for the crop growth period and only a few (two to three) irrigation supplies should be allocated. Only two irrigations were issued in November and December during Maha 1991192. No irrigation supply was made in November and December during Maha 1992193. Low performance crops can be raised without irrigations during November and December, but chili would need at least two irrigation supplies during November and December. Three to four irrigations should be made in January because rainfall during January **is** negligible.

For high performance crops, it would be necessary to supply adequate irrigation during land preparation in early October to prepare proper quality seed beds. Further, irrigations are needed beyond January and February for longer duration crops like chili. Assured regular irrigation supply is necessary for better performance of high value crops to increase fertilizer application and to use improved high yielding and short duration varieties. However, irrigation supply could be limited to three irrigations in November and December since rainfall is high during this **period.** These crops need irrigation for a longer period compared to low performance crops. Irrigation supply should continue up to the end of March in the case of improved varieties of chili.

An innovation developed by farmers was extending the Maha cropping season beyond the conventional date of termination. These innovative farmers made use of water issues in March to establish a second crop. These crops matured with residual soil moisture and rainfall received in April and May - 150 mm during Yala 1993. However, cultivation was limited to the middle and lower reaches of field canals.

Shallow dug wells were used only to irrigate vegetables and onions. Most of the wells were located in the middle and lower reaches of field canals. Further studies should be made to examine the availability **of** groundwater to expand dug wells into other areas. Also, this innovation should be further improved by supplying a few irrigations during dry periods of the Yala season and cultivation should be expanded into the upper section of field canals as well.

It has been clearly demonstrated that cultivation of OFCs during the Maha season should be confined to well-drained soils. Crops such as soybean and groundnut can be grown on imperfectly drained soils if proper surface drainage is provided. It has also been demonstrated that crop establishment should be completed well in advance of November rainfall.

Although it was not possible to confirm through studies on economic returns, the present practice of raised-bed cultivation for chili and onions and row seeding for groundnut and greengram on graded terraces is recommended. Further studies should be done to establish the economic advantage of furrowed basins.

The economic analysis of OFC cultivation in Tract 3 of the Left Bank during Maha 1991192 Maha and Maha 1992/93 Maha shows that economic performance of both low performance and high performance crops were low due to low yields. Yields from OFCs obtained during the two

seasons were far below potential yields. Among the low performance crops, groundnut performed well during both Maha seasons. Compared to greengram, it gave a much higher return with lower risk. Since there is no market, soybean is not recommended. High performance crops like chili need higher input application, crop care and regular irrigation to obtain higher yield and give a much higher return compared to paddy. Low performance crops give a little higher or similar returns as paddy and need less inputs.

Crop combinations depend on farmers' resource base. However, irrigation supply should be planned to include *25* percent high performance crops like chili which will increase **total** farmer incomes.

One of the constraints for OFC cultivation during Maha seasons is the soil factor. Farmers who have farm lots in the lower reaches of field canals face a higher risk growing OFCs due to drainage problems. Cultivation of high performance crops **is** not possible without construction **of** drainage canals and farm drainage. This would increase cost of cultivation and hence reduce incomes. One other disadvantage is the limited number of crops which can be cultivated on these lands.

5.5.3 OFC Cultivation in the Old Ellegala System by Using Residual Soil Moisture and Yala Rainfall

Aithough farmers in the Old Ellegala System claim 100 percent paddy cultivation during Maha and 100 percent in Yala, past cropping intensity data shows 100 percent cropping intensity during Maha for paddy and only 40 percent cropping intensity for paddy during Yala. Weerawila has a large storage capacity and larger catchment compared to Tissa wewa and Yoda wewa. Therefore, cropping intensity in the Weerawila **is** higher during Yala compared to the other tanks.

The overall strategy should be to give the same amount of water to the **Old** Ellegala System as in the past to irrigate 100 percent paddy during Maha and a certain proportion during Yala. Experience in Pihille Yaya during Yala 1992 and in other Ellegala areas during Yala 1993 shows the possibility of OFC cultivation on brown alluvial soils during the Yala season. Major crops cultivated during these seasons were greengram and groundnut which can do with minimum land preparation and other inputs. However, the time of planting **is** most important in obtaining higher yields from greengram. The performance of greengram in Pihille Yaya during both Yala seasons was better than in the command area of other tanks since farmers established the crop before the end of April and **the** crop was not affected by **the** yellow mosaic **virus.** Also, the Pihille Yaya is located where no seepage water affects crop. Therefore, advance Yala seasonal planning is essential to identify areas with brown alluvial soils anti to set dates for commencement of the season.

However, if the proposed seasonal water allocation plan is implemented, the Old Ellegala System would receive 80 percent of Yala inflow from the main reservoir. The total allocation would be allocated to the five tanks based on command area. This water should be sufficient for paddy

cultivation in 60 percent of total command. With cultivation of OFCs in 20 percent of the balance extent, a total of 80 percent cropping intensity could be obtained during Yala.

However, other institutional arrangements should be made to settle land tenure arrangements for OFC cultivation and make landowners agree to the crop diversification program during Yala. Other major institutional supports necessary to promote OFC are agricultural extension and marketing services.

5.6 LESSONS LEARNED

1. To maximize the use of limited inflow to the Lunugamvehera Reservoir, seasonal rainfall had to be effectively utilized in raising OFCs. Because of the high variability in rainfall both during the season and between seasons, weekly probability values of past seasonal rainfall based on long-term records were used to plan and implement OFC program in the pilot project area.

2. Based on economic returns, crops other than paddy grown in the Kirindi Oya system can be grouped into high-performance crops and low-performance crops. Chili and big onion come under high-performance crops while greengram, cow pea, vegetables, soybean and groundnut come under the category of low-performance crops.

   Cultivation of low-value crops like groundnut and greengram should commence with the onset of seasonal rains during the first and second weeks of October. The commencement of cultivation of low-value crops after receiving 70 mm of cumulative rainfall **is** found to be appropriate. To avoid moisture stress during the crop growth period, irrigation issues should be made during the latter weeks **of** December or early January, depending on rainfall. Only two irrigations were issued in November and December during Maha 1991/92. No irrigation supply was made in November and December during Maha 1992/93.

3. For high-value crops, at least two irrigations are necessary during land preparation in early October to prepare proper quality **seed** beds and establish crops. Assured regular irrigation supply is necessary during the crop growth period for better performance of high-value crops to increase fertilizer application and use of improved high yielding and shorter duration varieties. However, irrigation supply could be limited to three irrigations in November and December since rainfall is adequate during this period. Further irrigations are needed beyond December and up to March for crops like chili. **A** minimum of 10 waterings should be planned for chili, two for crop establishment, three during the rainfall period of November and December and five beyond December.

4. The present practice of raised-bed cultivation for chili and onions and row seeding for groundnut and greengram with graded terraces is found suitable.

5. A water-sharing practice of 1 cusec for two farmers at a time is found to be appropriate and is adopted by farmers. However, allotting a fixed and uniform time for each one of the farmers under a turnout did not work due to soil type and geographical location of the plot in the turnout.

6. There is a high variation in the economic performance of **OFCs** within seasons and between seasons. In-seasonal variations are mainly due to variations in soil and drainage conditions while seasonal yield variation is mainly due to variations in weather conditions and occurrence of diseases. Also, poor crop management practices and inadequate land preparation methods, and low application **of** fertilizer, particularly for chili, resulted in a low yield.

7. During Maha season, chili and greengram performed well on well drained soils. Farmer incomes from chili and greengram cultivated on well drained soils gave **a** 50 percent higher return than when these crops were cultivated on imperfectly drained soils. Soybean performed better on imperfectly drained soils, Other field crops planted on poorly drained soils were completely destroyed by excess seepage, drainage water and rainfall.

a. Among the crops tested, chili gave the highest average gross value added and average farmer income. All other crops tested gave average income similar to that of paddy. In the case of chili, the input cost in terms of labor, fertilizer and chemicals ranges between **2** to ***3*** times those for other OFCs. Capital required for greengram and groundnut was comparable with that for paddy.

9. Extending the Maha cultivation into the Yala season is a new innovation introduced by the Tract ***3*** farmers. Most of these innovations took place in the middle reaches of FCs where groundwater is available closer to the surface. Crops were established with rain received during March and/or with one or two waterings received for Maha crop. These crops effectively utilized the rainfall received during March and April for crop growth. Water from dug wells was used only to water vegetables like onions and beans. Although the area cultivated is small under this innovation, it demonstrates the potential for farmers to earn additional income by extending Maha cultivation into Yala.

10. In Ellegala System, the study demonstrated that **OFCs** can be grown in the brown alluvial soils utilizing residual moisture left over from the Maha **season** coupled with April and May Yala rains. The crops grown were: greengram, cow pea, groundnut and vegetables. To get better yields and be free from pest attacks and diseases, cultivation, especially that of greengram should **start** early, preferably in April.

11. The on-farm distribution system in **EIS** is not conducive to better **flow** controls. In many turnouts, irrigation is from field to field and a number of fields use water from drainage canals for raising their paddy crop. Under these conditions, raising highly profitable

crops such as chili, onion, etc., is risky and farmers are not willing to venture raising these crops.

12. Cultivation of OFCs in the newly developed area is possible using dug wells. However, Yala cultivation can be carried out only in those places where groundwater is available in sufficient quantity for a considerable length of time. This include such areas as riverine alluvial deposits, valley axes and areas adjoining main irrigation canals. Since the groundwater table improves during Maha, especially in areas adjoining to main canals, farmers in the newly developed area who do not cultivate paddy could cultivate OFCs using dug wells.

13. In the NIS, during a wet Maha, farmers prefer to grow paddy with very little area going for OFCs. On the other hand, in a dry Maha, farmers make use of rainfall and supplementary imgation to grow OFCs. This is a positive development. In Maha 1992/93, 562 ha of OFCs have been grown with rainfall and irrigation. This area can be increased to about 1000 ha.

14. During Yala, the NIS farmers are reluctant to go for OFCs due to the high variability in irrigation supply. The seasonal allocation planning procedure, which is now well integrated into the main system management component, ensures a rational allocation of the available seasonal supply to the NIS. With this assured canal supply in conjunction with rainfall and dug well supplies, it would be possible to increase the OFC cultivation from the 250 ha now being cultivated to about 1000 ha. This area could be further improved by bringing more lands especially from Tracts 1 and 2 of RB and LB under semi-permanent crops such as banana which need few irrigations between June and August.

15. The results of diversification of crops in Kirindi Oya show that even with poor yields, farmers can earn a profitable income from OFCs, if they can avoid problems such as late cultivation and the stray cattle menace and if they can acquire sufficient knowledge on how to cultivate OFCs on irrigated lands. The two major economic constraints observed in this system were fluctuations in output price and yield variation within and between seasons.

5.7 CONCLUSION AND RECOMMENDATIONS

Kirindi Oya Imgation and Settlement Project (KOISP) includes three distinct environmental situations:

1) Newly developed command area of KOISP, namely LB Tracts 1 and 2; and RB Tracts 1, 2, 5, 6 and 7 made up of lands with undulating relief and residual soils occurring in a drainage topo-sequence.

2) Old command area of the Ellegala subsystem located in a flat alluvial plain with an incised drainage and mainly alluvial soils.

3) Pilot research site in LB Tract 3, made up of gently undulating relief and residual soils.

5.7.1 Recommendations for the New Irrigation System

1. In a wet Maha season, a 100% cropping intensity of paddy can be achieved. In a dry Maha season 85 to 90 percent of cropping intensity could be achieved through cultivation of OFCs in the third zone which would not receive water for paddy cultivation. OFCs should be confined only to well drained area. Groundnut and soybean can be grown on imperfectly drained soils with high level of drainage facilities.

2. It is recommended that only low-performance crops such as groundnut, greengram, cowpea and vegetables be grown. Cultivation of recommended crops should commence with the onset of seasonal rainfall during the first and second week of October. Two or three irrigation are recommended during the months of December to January. Other short-term OFCs such as vegetables and pulses could be grown with water from shallow wells only where groundwater could be tapped.

3. Measures should be taken to protect the crop from stray cattle and wild elephants.

4. Irrigation for raising OFCs during Yala season is not possible now. However with 20 percent of Yala inflow allocated to NIS it would be possible to go for low-value OFCs to the extent of 25 percent of the new area. This can be achieved by effective and integrated use of canal water with rainfall and well water.

5.7.2 Recommendations for Old Ellegala System (OES)

1. OFCs cultivation is possible on brown alluvial soils during Yala season. This constitutes about 20 percent of the OES area.

2. Time of planting is most important to obtain higher yield and to utilize residual soil moisture and Yala rainfall. It is recommended that the crops should be established before end of April.

3. Only low-performance crops such as greengram, groundnut, cow pea and vegetables are recommended for OES, in view of inadequate flow control at the on-farm level.

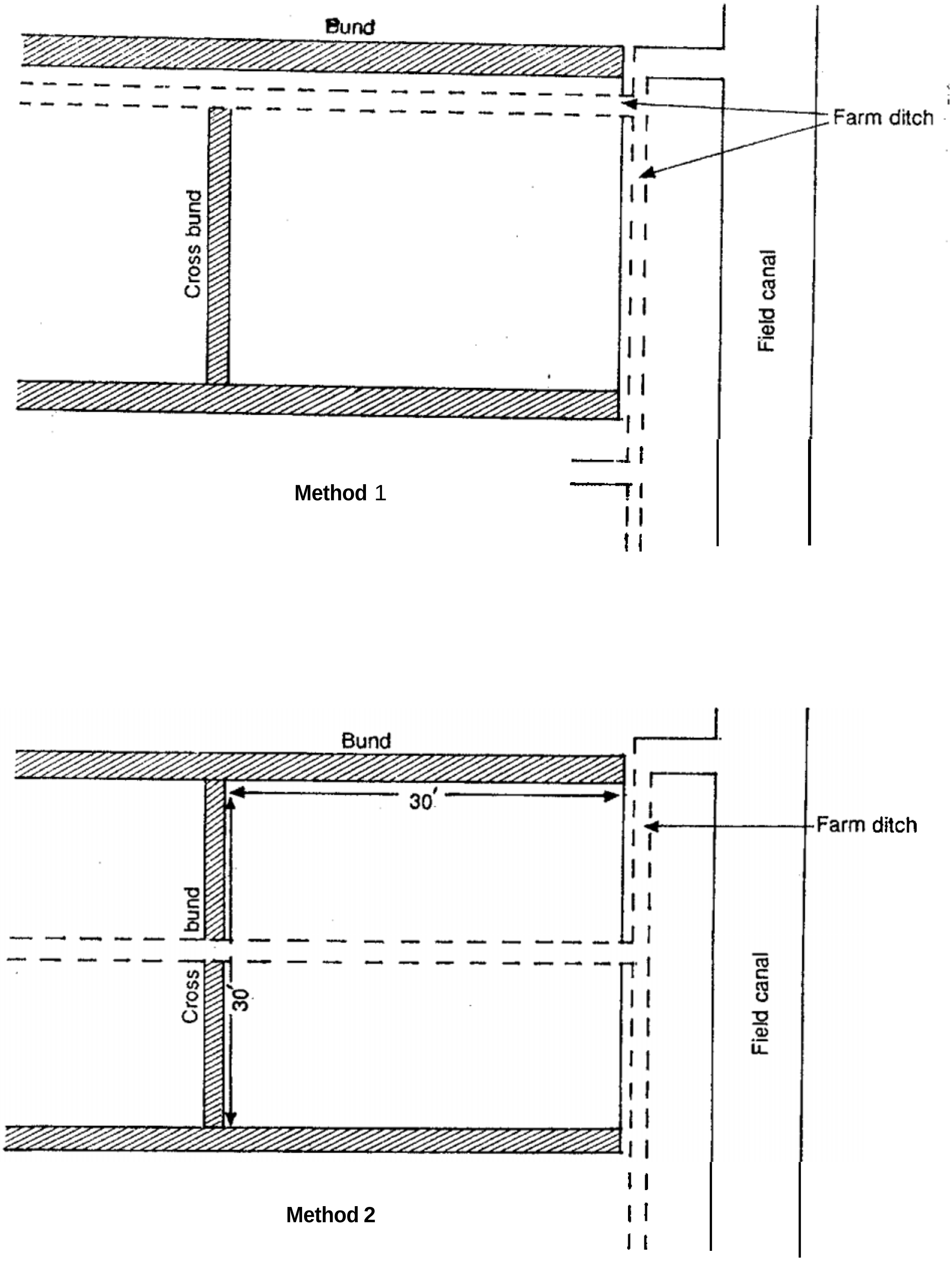

Figure 5.1. Method of Land Preparation

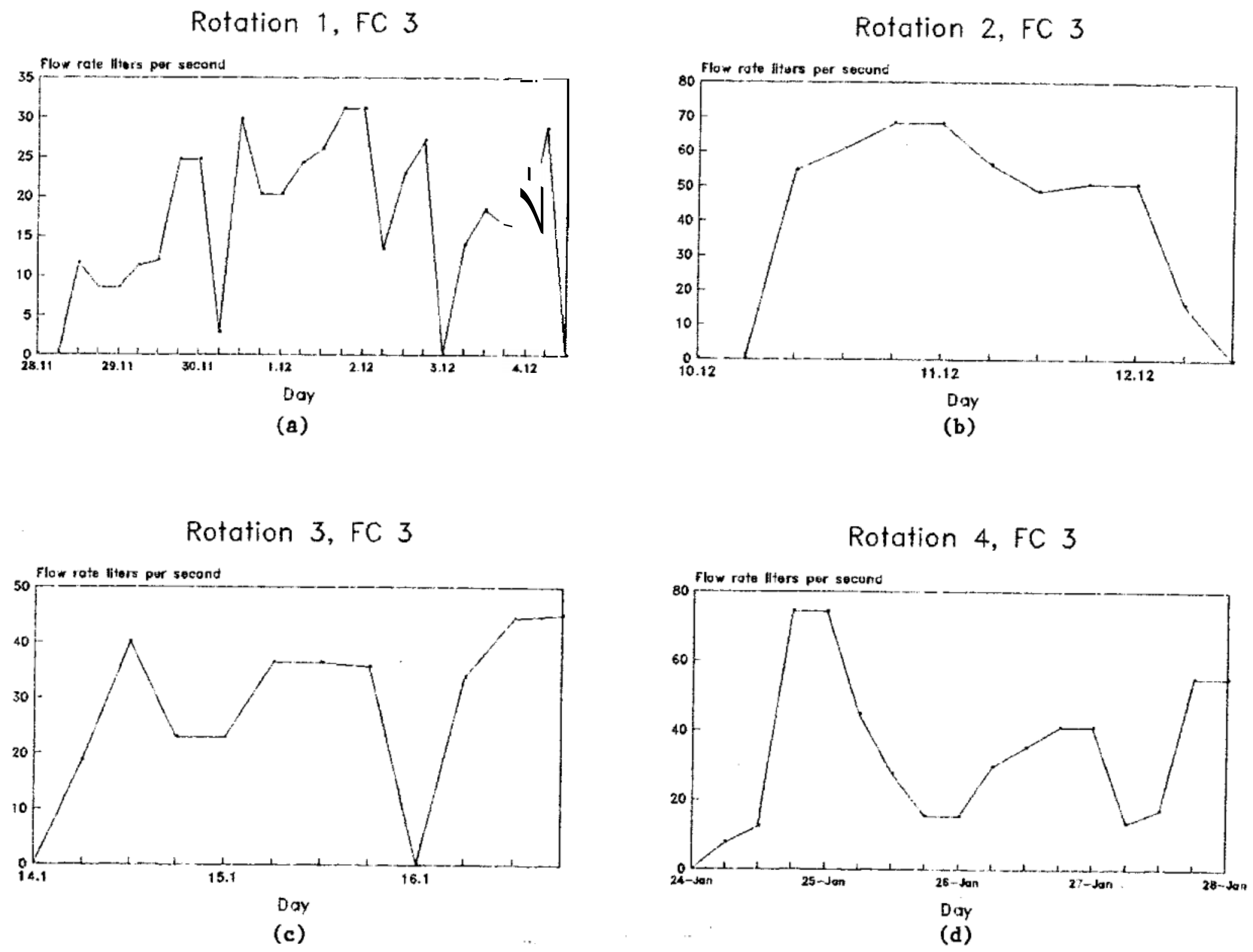
Rotation 1, FC 3
Flow rate liters per second
35
30
25
20
15
10
5
0
28.11
29.11
30.11
1.12
2.12
3.12
4.12
Day
(a)
Rotation 2, FC 3
Flow rate liters per second
80
70
60
50
40
30
20
10
0
10.12
11.12
12.12
Day
(b)
Rotation 3, FC 3
Flow rate liters per second
50
40
30
20
10
0
14.1
15.1
16.1
Day
(c)
Rotation 4, FC 3
Flow rate liters per second
80
60
40
20
0
24-Jan
25-Jan
26-Jan
27-Jan
28-Jan
Day
(d)

Figure 5.2

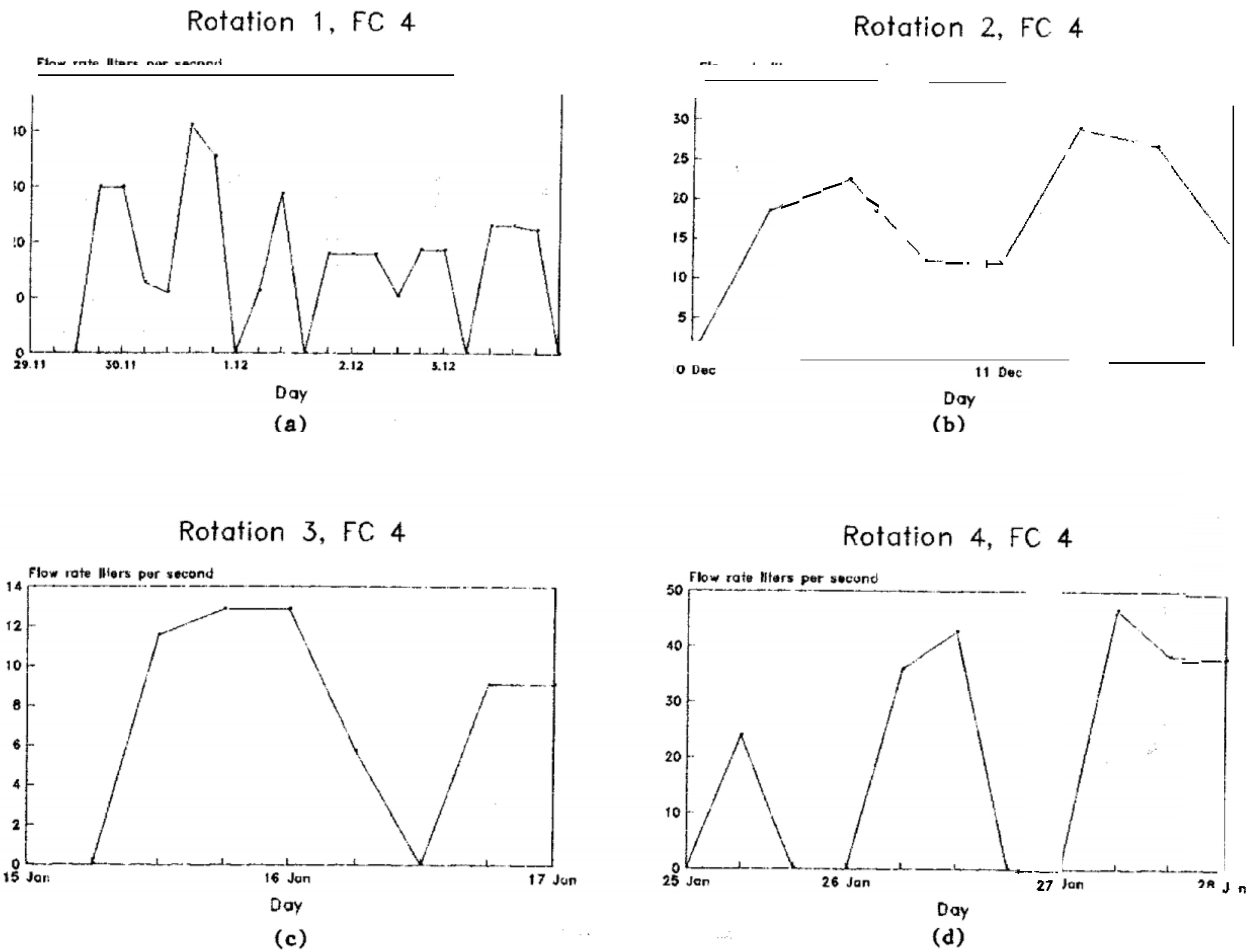
Rotation 1, FC 4
Flow rate liters per second
29.11
30.11
1.12
2.12
3.12
Day
(a)
Rotation 2, FC 4
30
25
20
15
10
5
10 Dec
11 Dec
Day
(b)
Rotation 3, FC 4
Flow rate liters per second
14
12
10
8
6
4
2
0
15 Jan
16 Jan
17 Jan
Day
(c)
Rotation 4, FC 4
Flow rate liters per second
50
40
30
20
10
0
25 Jan
26 Jan
27 Jan
Day
(d)

Figure 5.3

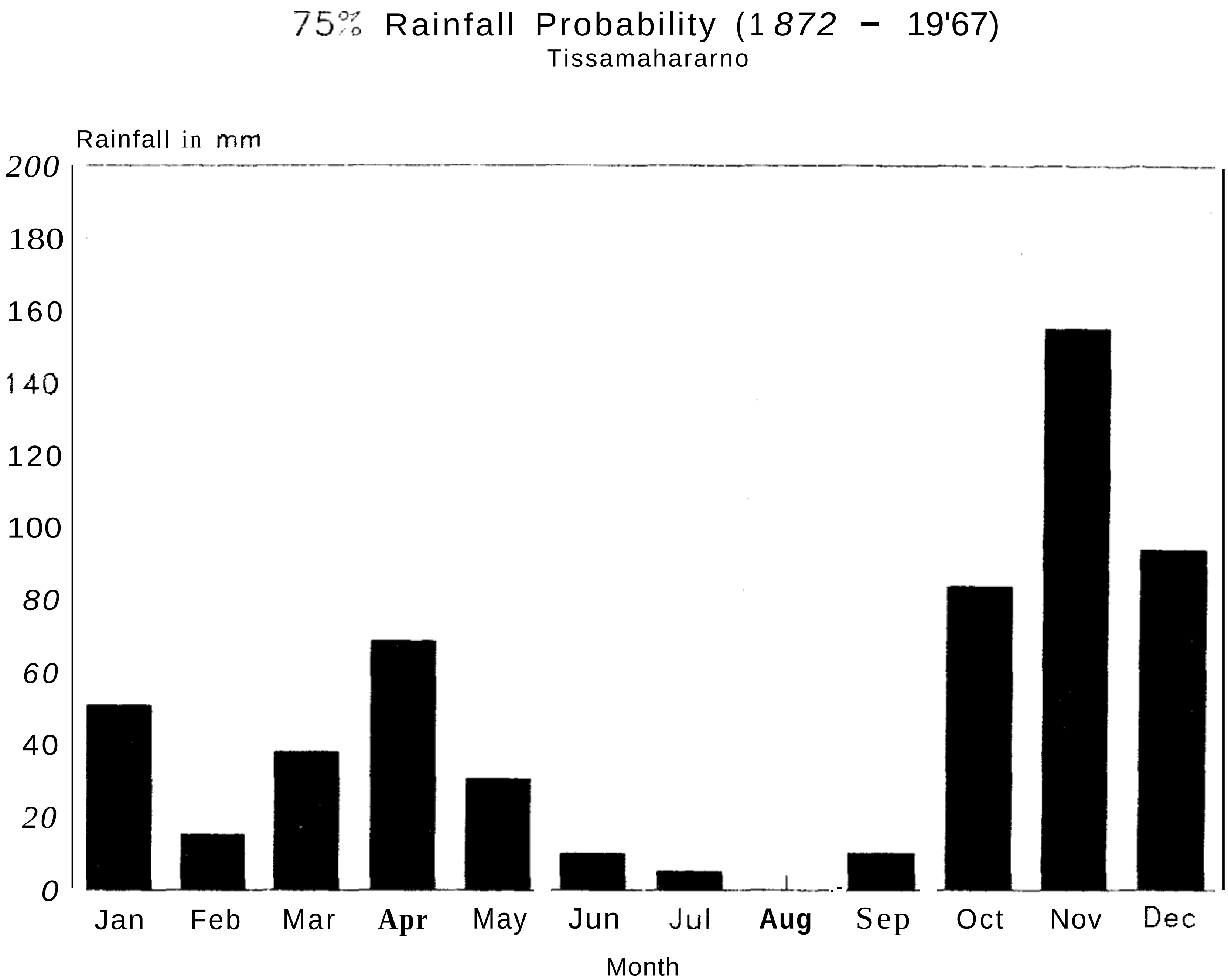

Figure 5.4 Monthly 75 percent rainfall probability

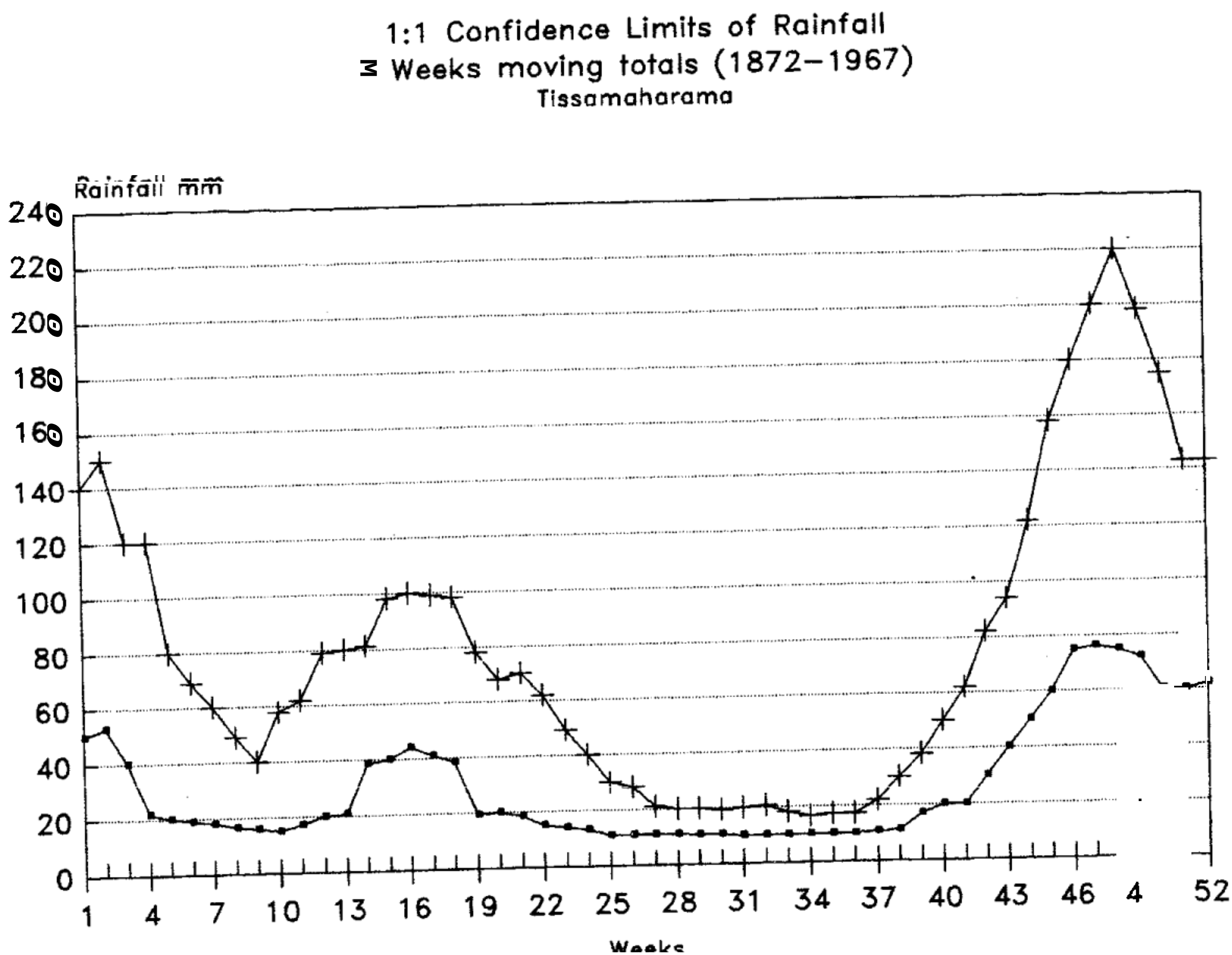

Figure 5.5 Confidence limits of Rainfall

Annexure 3.1.1

Form (i) and (ii) of Booklet for Field Staff

Form (i)

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.... යාය

ගේට්ටු අංකය	වේලාව	සිපින්ඩල් උස	ජල මට්ටම	
			ඉහළ	පහළ/වියරය

Form (ii)

දිනපතා ගේට්ටු මෙහෙයුම

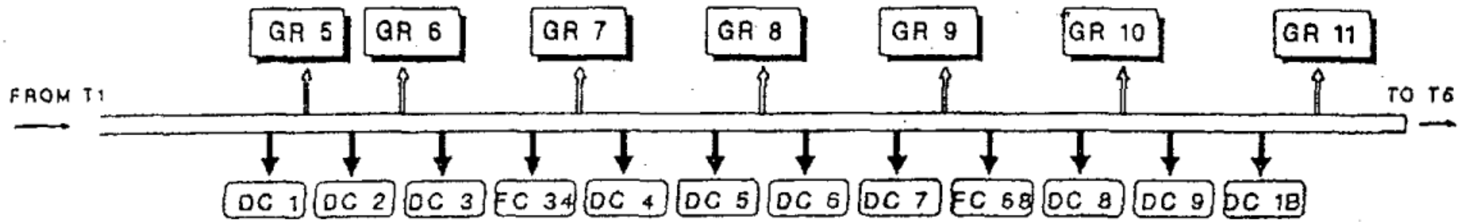
ජල බෙදුම්කරු ______ යාය ______ දිනය ______

ගේට්ටු අංකය	මෙහෙයුම 1				මෙහෙයුම 2				මෙහෙයුම 3				මෙහෙයුම 4			
	වේලාව	සිපින්ඩල් උස	ජල මට්ටම		වේලාව	සිපින්ඩල් උස	ජල මට්ටම		වේලාව	සිපින්ඩල් උස	ජල මට්ටම		වේලාව	සිපින්ඩල් උස	ජල මට්ටම	
			ඉහළ	පහළ/වියරය			ඉහළ	පහළ/වියරය			ඉහළ	පහළ/වියරය			ඉහළ	පහළ/වියරය

Display Board in Work Supervisor's office

RBMC WATER ISSUES - TRACT 2

SEASON :



COMMAND AREA(Ha)												
APPROVED FLOW (CUSECS)												
DAY												
DAY												
DAY												
DAY												
DAY												
DAY												
DAY												
DAY												

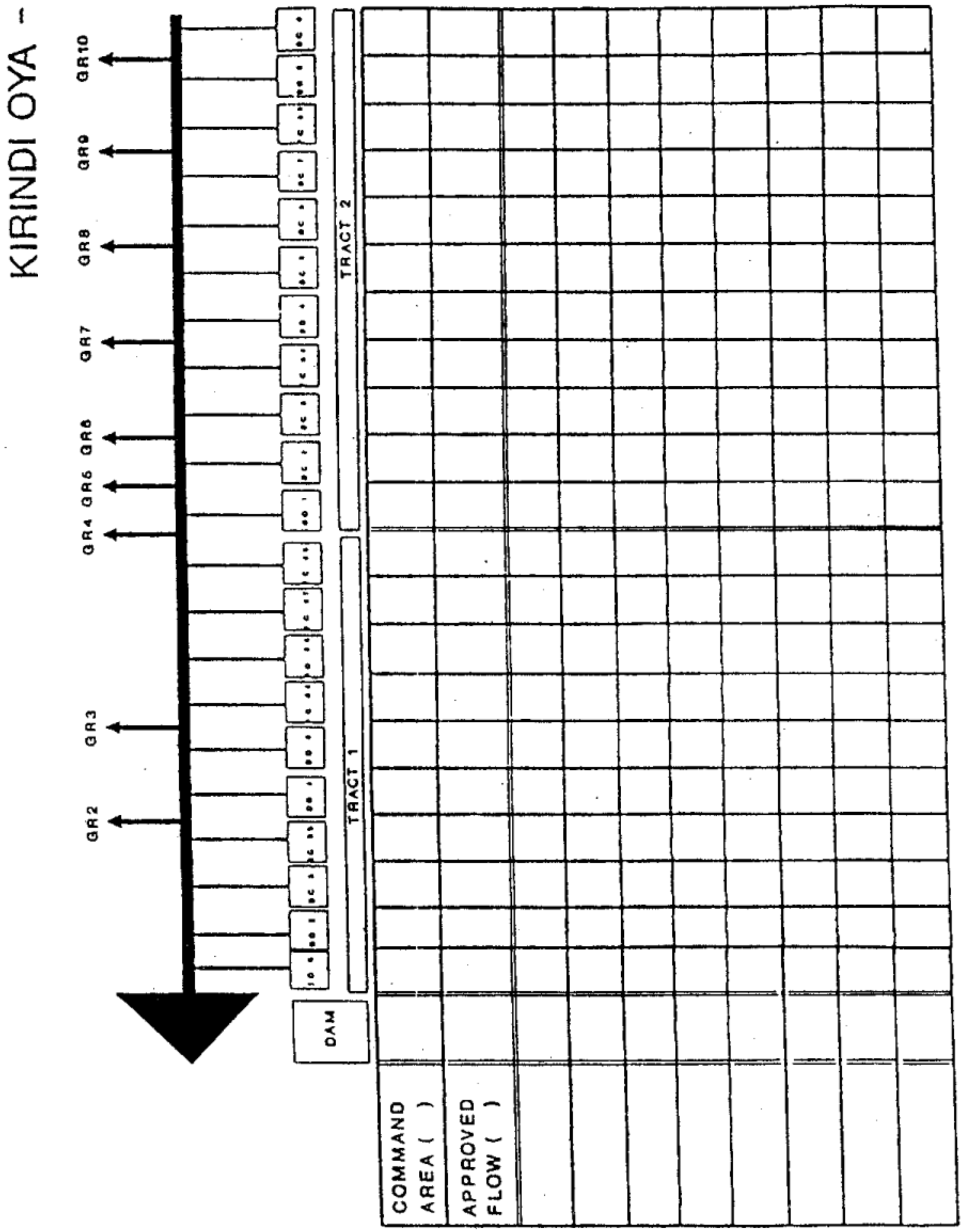
දකුණු ඉවුර - ගේට්ටු සැකසුම යාය 2

කන්නය:
දිනය:

දත්ත රැස් කලේ :
දත්ත සටහන් කලේ :

Off-takes/Gated Regulators	Time	Water Level (cm)		Head Over Weir (cm)	GATE – Sp Hts (cms)					Computed Discharge (cusecs)
		Up	Down		G1	G2	G3	G4	G5	
DC 01										
GR 5										
DC 02										
GR 6										
DC 03										
FC 34										
GR 7										
DC 04										
DC 05										
GR 8										
DC 06										
DC 07										
GR 9										
FC 68										
DC 08										
GR 10										
DC 09										

Display Board ***in Resident Enginee*** ***office***



MAINTENANACE PROGRAMME FOR 1992.
WEERAWILA WEWA

TRACT NO

IRRIGABLE AREA

ALLOCATION

HEAD 300
HEAD 301

=======

	YALA	MAHA
FIRST DATE OF WATER ISSUE	10.03.92	15.09.92
LAST DATE OF WATER ISSUE	10.07.92	15.01.93

NAME OF T.A. R.A.DHARMASENA
NAME OF W.S. B.G.WIJETUNGA

NO. OF POSSIBLE MAN DAYS 1280

RANGE SOUTHERN

DIVISION TISSA

ITEM	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
HEAD WORKS												
WEEDING / CLEARING SLOPES AND RESERVATIONS REMOVAL OF ANT - HILLS	********	**	****	********	********	********	****		****	********	********	********
MAIN CHL.												
WEEDING CANAL BED WATER PLANTS		******	****				****	********	****			
WEEDING CANAL SLOPES AND ROAD RESERVATION.	********	**	****	********	********	********	****		****	********	********	********
REPAIRS TO STRUCTURE.		******	****				****	********	****			
GREASING AND OILING CONTROL MECHANISMS.									****			
APPLICATION OF PAINT/ EMULSIONS TO STRUCT/ CONTROL GATES.									****			